Journal of Financial Economics 35 (1994) 43-62. North-Holland

Markups, quantity risk, and bidding strategies at Treasury coupon auctions*

David P. Simon
Board of Governors of the Federal Reserve System, Washington, DC 20551, USA

Received April 1993, final version received June 1993

This study uses intraday when-issued rate quotes to examine the rewards and risks of the Treasury coupon auctions for bidders who face different tradeoffs between the winner's curse and quantity risk. The data indicate that markups of auction average rates over bid when-issued rates at auction times average 3/8 basis point. I also find that when-issued rates react as strongly to bidding aggressiveness at auctions before the auction results are announced as they do afterward, and that quantity risk is as important as the winner's curse.

Key words: Treasury auctions
JEL classification: G12; G14

1. Introduction

This study examines the rewards and risks of bidding at the 66 Treasury coupon auctions from January 1990 through September 1991 for bidders who face different tradeoffs between the winner's curse – the tendency of successful bidders to bid at lower rates than are necessary to receive securities – and quantity risk. Recent studies by Cammack (1991), Spindt and Stolz (1992), and Bikhchandani and Huang (1993) examine markups at three-month Treasury bill auctions over when-issued rates on the same bills. Cammack (1991) shows that auction average rates are four basis points higher on average than the mean of bid and ask when-issued rates at the close of business on auction days from 1973 through 1984. Spindt and Stolz (1992) find that auction average rates are on

Correspondence to: David P. Simon, Division of Monetary Affairs, Stop 73, Board of Governors of the Federal Reserve System, Washington, DC 20551, USA.

*The author thanks Joseph Malvasio of Cantor Fitzgerald Securities Corp. for the data, and Bradford Cornell (the referee), Darrel Duffie, Peter Kyle, David Lindsey, Vincent Reinhart, William Schwert (the editor), Suresh Sundaresan, and seminar participants at the University of Texas, Austin and the Federal Reserve Bank of Atlanta for helpful discussions. The author is especially grateful to Mark Fisher and Steven Lumpkin for insightful comments on various drafts of this paper. The views expressed are those of the author and do not necessarily reflect the views of the Federal Reserve Board or of any other members of its staff. Any errors are the author's own.

average somewhat less than 1½ basis points above bid when-issued rates roughly one-half hour before auctions from 1982 through 1988. Bikhchandani and Huang (1993) find that auction average rates are on average one basis point above bid when-issued rates from February 1986 through February 1988. These studies also demonstrate that auction average rates rise in relation to when-issued rates when uncertainty increases, but none of them consider the quantity risk faced by bidders who fail to receive securities at auctions.

For long-term investors who buy at auctions or short-term traders who sell securities they buy at auctions after auction results are announced, quantity risk is important only if not receiving securities at auctions results in foregone opportunities to buy them at a lower price than in the when-issued market or to earn possible trading profits. Dealers, on the other hand, are extremely vulnerable to quantity risk, because they typically go into auctions with large net short positions to cover. These short positions represent commitments to deliver securities to nondealers, established in the course of providing intermediation services to nondealers who do not want to incur the risks associated with bidding at auctions. When dealers are not awarded securities at auctions, they must cover their short positions in when-issued markets that are typically rallying if bidding is unusually aggressive. Market participants refer to this risk as the loser's nightmare.

The study's attention to the quantity risk dealers face at Treasury coupon auctions is well justified. The Joint Report on the Government Securities Market issued by the Treasury Department, the Securities and Exchange Commission, and the Federal Reserve Board following the May 1991 two-year Treasury note auction states that at the 66 Treasury coupon auctions from January 1990 through September 1991 that I examine here, primary dealer awards accounted for 95% of total awards to competitive bidders, with only about 20% of these awards representing bids submitted for customers. The Joint Report also states that in this auction sample, primary-dealer net short positions in the when-issued security at the close of business on the day before auctions averaged 40% of the total primary-dealer auction awards for their own accounts. Thus, dealers overwhelmingly are the major participants in these auctions and quantity risk is extremely important.

The squeeze at the May 1991 two-year Treasury note auction underscores the importance of quantity risk to dealers. Squeezes typically involve a few market participants bidding very aggressively for large amounts of securities and then augmenting these positions in the when-issued market before dealers who do not successfully cover their short positions at auctions learn about the aggressiveness of bidding.[1] Those attempting squeezes will not buy aggressively in the

[1]Squeezes need not and often do not occur either at auctions or through the deliberate behavior of market participants, although the term 'squeeze' is used here to describe situations in which a few market participants bid aggressively at auctions to reduce the supply of an issue to short sellers.

when-issued market before auctions because doing so might disclose their intentions, and because net long when-issued positions established before auctions count toward the 35% maximum of an issue that a single bidder may obtain at auctions. The 35% rule does not apply to when-issued positions established after auctions. Squeezes occur when the reduced supplies of securities available to dealers who need to cover short positions cause these dealers to bid aggressively in the when-issued market after auctions. Squeezers make profits by selling part of their long positions at elevated prices or by financing part of their long positions cheaply in the repurchase agreement market.

This study proceeds by providing background information on Treasury coupon auctions. I use intraday when-issued quotes from the trading screen of Cantor Fitzgerald, Inc., a major government securities broker, to identify markups of average accepted and stopout (highest accepted) rates at auctions over when-issued rates. I then examine whether markups are higher when uncertainty is greater, and whether market participants who are informed about the aggressiveness of bidding at particular auctions have an important advantage. Some dealers could gain such an advantage, because dealers exchange information about bids shortly after auctions [see Stigum (1990)] and because, by placing bids for customers, dealers observe the demand for auctioned securities. In addition, an information advantage might accrue to bidders who bid at rates below when-issued rates, perhaps in collusion with other bidders. I test for the presence of information advantages by examining whether changes in when-issued rates from the time of the auction until just before the results are announced incorporate information about the aggressiveness of bidding and whether the when-issued market reacts further after the results are announced. Finally, I assess the profitability of bidding strategies for bidders with different objectives and consequently different tradeoffs between the winner's curse and quantity risk.

The paper is organized as follows. Section 2 provides background information on Treasury coupon auctions and summarizes the data. Section 3 examines whether bidders are less aggressive when uncertainty is greater, and section 4 examines the reaction of when-issued rates to the aggressiveness of bidding both before and after auction results are announced. Section 5 examines the profitability of bidding strategies and provides evidence on the tradeoff between the winner's curse and quantity risk. Finally, section 6 summarizes the study's findings.

2. Background on Treasury coupon auctions and the data

The Treasury currently auctions two- and five-year notes every month and three-, seven-, and ten-year notes and thirty-year bonds every three months. During part of the sample period, it also auctioned four-year notes, which are

included in the study. The Treasury usually announces auctions about a week in advance and issues the securities about a week after auctions. After receiving bids, which are submitted in full basis-point increments, the Treasury allocates securities first to noncompetitive bidders, who are limited to $1 million over the sample period, and then to competitive bidders, starting with the lowest submitted rate and continuing until all of the securities are placed. Awards at the stopout (highest accepted) rate are prorated.

Active when-issued trading begins for delivery of the securities to be auctioned on their issuance dates as soon as the Treasury announces auctions. This forward market, which trades on a yield basis in increments of roughly $\frac{2}{10}$ of a basis point, performs an important price discovery function because buying securities in the when-issued market is a substitute for bidding at auctions, notwithstanding some important differences. In addition to the risk of the winner's curse at auctions, a major difference between bidding competitively at auctions and buying securities in the when-issued market is that the former involves quantity risk because bids may not be accepted. Quantity risk is heightened by the fact that until the auction results are announced, competitive bidders do not know whether their bids have been accepted and consequently do not know their exposure to changes in when-issued rates. In addition, some bidders may have better information than others between the auction and the announcement of the results about the aggressiveness of the bidding, either because of information sharing or because they are participants in squeezes. The length of this period is nontrivial; auctions occur at 1 p.m. and auction results are announced around 3:30 p.m. during the first half of the sample period and around 2 p.m. during the second half. Another important difference between bidding at auctions and buying securities in the when-issued market is that large long positions can be established and large short positions can be covered more quickly and anonymously at auctions.

Table 1 provides background information on auction and when-issued rates at the 66 Treasury coupon auctions in the sample. The data on auction results are obtained from Treasury press releases, and real-time when-issued rate quotes are obtained from Cantor Fitzgerald Securities Corp., a broker reported by Stigum (1990) to have the largest market share of brokered trading in the U.S. government securities market.

The data from Cantor Fitzgerald are a chronological record of all bid and ask when-issued quotes for securities on their auction days that were displayed on the Cantor Fitzgerald trading screen. These rates are the best quotes (lowest bid and highest ask rates) at any moment at which dealers making the market were committed to buy and sell through the Cantor Fitzgerald screen. The data include the exact time the quotes were displayed and the dollar amounts for which they were good. These dollar amounts typically range from $1 million to $20 million. Dealers can, for example, immediately sell a security by hitting a bid on the screen by calling a broker at Cantor Fitzgerald, who confirms the trade

Table 1

Summary statistics in basis points for the 66 Treasury coupon auctions between January 1990 and September 1991. When-issued (WI) rates are measured at the 1 p.m. auction time, unless otherwise stated. Auction average and stopout rates are the average and the highest rates accepted.[a]

	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups over bid rates
Markups of:			
Auction average over bid WI rates	0.37**	0.43**	0.52**
	(0.08)	(0.07)	(0.06)
Stopout over bid WI rates	1.07**	1.13**	1.21**
	(0.18)	(0.19)	(0.19)
Auction average over ask WI rates	0.75**	0.81**	0.89**
	(0.08)	(0.07)	(0.06)
Stopout over ask WI rates	1.45**	1.52**	1.58**
	(0.18)	(0.19)	(0.19)
Auction average over bid WI rates 5 minutes after auction result announcements	0.27	0.22	0.09
	(0.39)	(0.42)	(0.43)
Stopout over bid WI rates 5 minutes after auction result announcements	0.97*	0.92*	0.78
	(0.39)	(0.41)	(0.43)
When-issued bid–ask spreads:			
At time of auctions	0.38**	0.39**	0.37**
	(0.03)	(0.03)	(0.03)
5 minutes after result announcements	0.60**	0.60**	0.61**
	(0.05)	(0.05)	(0.05)

[a]Standard errors are reported in parentheses and one and two asterisks indicate statistical significance at the 5% and 1% levels, respectively.

with the broker of the dealer posting the bid rate. The transaction is flashed on the trading screen immediately. Because traders typically have several screens in front of them, quotes on different screens are closely linked. Thus, the when-issued quotes used in this study accurately represent the opportunity sets of dealers at any moment.

For dealers bidding at auctions to cover short positions established at the margin, the relevant spreads are auction average and stopout rates over bid when-issued rates, because short positions can be established immediately at the bid side of the when-issued market.[2] As shown in table 1, the average markup of

[2]Although dealers accumulate short when-issued positions during the entire when-issued period prior to auctions, this paper concentrates on decisions made at the margin at the time of auctions. It is possible, however, that average rates at which dealers establish short positions during the when-issued period affect markups at auctions.

auction average rates over bid when-issued rates at the 1 p.m. auction time is a statistically significant 0.37 basis points. The average markup between stopout and bid when-issued rates is a statistically significant 1.07 basis points because the tail – the spread between the stopout rate and the average rate accepted by the Treasury – averages 0.7 basis points. These markups do not represent dealers' profits because bids at stopout rates receive securities on a prorated basis, as do bids at auction average rates when they equal stopout rates. The effects of prorating on profits for different types of bidders are examined in section 5, below.

For long-term investors who bid at auctions rather than buy when-issued securities, the relevant markups are auction average and stopout rates over ask when-issued rates at the time of auctions because market participants can buy securities immediately at the ask side of the when-issued market. These average markups are a statistically significant 0.75 and 1.45 basis points, respectively.

For short-term traders who bid at auction average and stopout rates and sell the securities they receive at the bid side of the when-issued market five minutes after the auction results are announced, the relevant average markups are a statistically insignificant 0.27 basis points and a statistically significant 0.97 basis points, reflecting an average tendency for bid when-issued rates to rise 0.10 basis points between the auction and the announcement of the results. The table shows, however, that ask when-issued rates tend to fall over the same interval as bid–ask spreads increase from 0.38 basis points to 0.60 basis points between the auction and five minutes after results are announced. The finding (not shown) that average absolute changes in when-issued rates increase from 0.3 basis points during the ten minutes before auctions to 0.9 basis points during the ten minutes centered on auction result announcements suggests that this widening of bid–ask spreads is consistent with asymmetric information models, such as Copeland and Galai (1983) and Glosten and Milgrom (1985), in which market makers quote wider bid–ask spreads when uncertainty increases. There is no evidence, however, that bid–ask spreads at the time of auctions are affected by the volatility of when-issued rates during the preceding half hour or that spreads around auction result announcements are affected by the volatility of when-issued rates between the auction and announcement of the results. Bid–ask spreads also are not significantly affected by the duration of the auctioned securities.

In examining these data, it is important to note that Solomon Brothers (1991) admits violating the Treasury's bidding regulations at five of these auctions. These violations involved submitting unauthorized bids for customers and not accurately reporting when-issued positions, which enabled Salomon at times to obtain more than the allowable 35% of the auctioned securities. As shown in column 2 of table 1, omitting these observations increases auction markups and reduces spreads of auction average and stopout rates over bid when-issued rates following auction result announcements only somewhat. Auction outcomes

were not always affected by Salomon Brothers' bidding violations because its bids often were accepted on a prorated basis. In addition, 8 of the 66 auctions in the sample were extremely aggressively bid, as reflected by negative spreads between auction average and bid when-issued rates. The April 1991 five-year note auction and the May 1991 two-year note auction are the only auctions in the sample at which Salomon Brothers violated bidding rules and markups were negative. The largest negative markups occurred at the May 1991 two-year note auction (− 2 basis points) and the March 1990 four-year note auction (− 1 basis point). Column 3 of table 1 shows that omitting these observations results in further small increases in markups at auctions over contemporaneous when-issued rates and further small decreases in markups over bid rates following auction result announcements.

3. Auction theory and markups

The data in the previous section demonstrate that average markups at recent Treasury coupon auctions over contemporaneous when-issued rates have been small – of the same order of magnitude as bid–ask spreads in the when-issued market. I now examine whether bidding is less aggressive when uncertainty around the time of auctions increases. Auction theory [see Milgrom (1989)] predicts that bidders maximize expected gains at auctions, taking into account the expected strategies of other bidders to avoid the winner's curse. According to theory, rational bidders take the winner's curse into account by bidding at higher rates when there is greater uncertainty about both other bidders' strategies and the demand for the auctioned securities. This occurs because, as the expected dispersion of bids increases for a fixed number of bidders, the probability decreases of not being awarded securities because others bid at slightly lower rates, which causes bidders to bid at higher rates.

The finding that bidders demand larger markups over when-issued rates when uncertainty increases could also owe to quantity risk. As uncertainty increases, when-issued rates are more likely to move sharply between the auction and the announcement of the results, when competitive bidders do not know whether they have been awarded securities and some bidders may have better information than others about the aggressiveness of bidding.[3] Uncertainty is represented by the standard deviation of bid-side when-issued rates during the half hour before auctions, calculated from four observations at ten-minute intervals. The mean of the standard deviation is 0.31 basis points (not shown).

[3]Unreported regression results do not indicate a tendency for markups to be higher during the first half of the sample period, when auction results were reported around 3:30p.m., than during the second half when auction results were reported around 2 p.m.

Table 2

Regressions of markups of auction average rates over bid-side when-issued rates at the time of Treasury coupon auctions from January 1990 to September 1991 on the standard deviation of when-issued rates calculated from observations at 10-minute intervals during the half hour before auctions and the duration of the auctioned securities. The regressions are estimated by ordinary least squares with White's (1980) correction for heteroskedasticity.[a]

Independent variables	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups
Constant	− 0.248	− 0.140	0.121
	(0.162)	(0.131)	(0.118)
Standard deviation of when-issued rates before auctions	0.834*	0.722*	− 0.823
	(0.338)	(0.324)	(0.281)
Duration of auctioned securities	0.085**	0.081**	− 0.057*
	(0.022)	(0.019)	(0.026)
$\bar{R}^2$	0.19	0.20	0.24
D.W.	2.06	2.15	2.30

[a]Standard errors are reported in parentheses. One and two asterisks denote statistical significance at the 5% and 1% levels, respectively.

I test whether markups increase with uncertainty by regressing the markup of auction average rates over bid-side when-issued rates on the standard deviation of when-issued rates during the half hour before auctions and on the (modified) duration of auctioned securities. If bidders demand higher markups when uncertainty increases, the coefficient on the uncertainty term should be significantly positive. The duration of auctioned securities is included in the model to reflect the possibility that markups rise as duration increases because of greater risk. In this case, the coefficient on duration also should be significantly positive. These regressions are run for the entire sample, excluding auctions with admitted rule violations and negative markups, using ordinary least squares with White's (1980) correction for heteroskedasticity.

Table 2 shows that the coefficient on the uncertainty term is positive and statistically significant at the 5% level. The coefficient estimate implies that a 1 basis-point increase in the standard deviation of when-issued rates during the half hour before auctions is associated with a 0.83 basis-point markup increase at auctions. Unreported regressions indicate that the results are not qualitatively changed when the standard deviation of when-issued rates is calculated from observations at five-minute intervals during the half hour before auctions or when uncertainty is measured as the absolute change in when-issued rates during that period. Markups are affected significantly, however, by when-issued rate volatility during the half hour before auctions and not by volatility earlier in the day. The coefficient on duration also has the expected sign and is statistically significant, indicating that a one-year increase in the

duration of auctioned securities is associated with a 0.08 basis-point markup increase.

Columns 2 and 3 of the table show that excluding auctions with admitted rule violations and with negative markups over bid-side when-issued rates has little effect on the results. In addition, unreported regression results indicate that intercept dummy variables and slope dummy variables on the uncertainty term for auctions following the May 1991 two-year note squeeze do not enter the model significantly, suggesting that the squeeze did not affect markups at subsequent auctions in the sample. Also, although bidders may require higher markups when the when-issued market is weakening just before auctions, variables for when-issued rate changes during the half hour before auctions do not enter the models with statistically significant coefficients.

4. When-issued market reaction to bidding aggressiveness

This section tests whether some auction participants have an information advantage by examining the reaction of when-issued rates to the aggressiveness of bidding at auctions before the results are announced, rather than afterward. Fig. 1 shows the auction-day chronology of the when-issued rate and the auction average and stopout rate for the two-year Treasury note auctioned on May 22, 1991, which triggered investigations of Salomon Brothers' bidding violations at Treasury auctions. The auction was very aggressively bid, as evidenced by the 6.81% auction average rate, which was 2 basis points below the bid-side when-issued rate at the time of the auction, and the acceptance of only 14% of the bids submitted at the 6.83% stopout rate. Between the auction and the announcement of the results at 1:52 p.m., bid-side when-issued rates fell 3 basis points to 6.80%, perhaps reflecting the augmentation of long positions in the when-issued market by those informed about the aggressiveness of bidding at the auction. When auction results were announced, most of the information about the aggressiveness of bidding was already reflected in the when-issued market: during the interval from five minutes before to five minutes after the announcement, the when-issued rate fell only $\frac{1}{2}$ basis point to 6.795%. It closed lower on the day, however, at 6.78%.

Information advantages could stem from either information sharing or squeeze strategies. If information advantages typically do not exist at auctions, when-issued rates should not react systematically to the aggressiveness of bidding between the auction and announcement of the results. Alternatively, if information advantages do exist, the better informed market participants should trade on their information before the results are released, and the when-issued rate changes before the auction results are announced will probably reflect the aggressiveness of bidding.

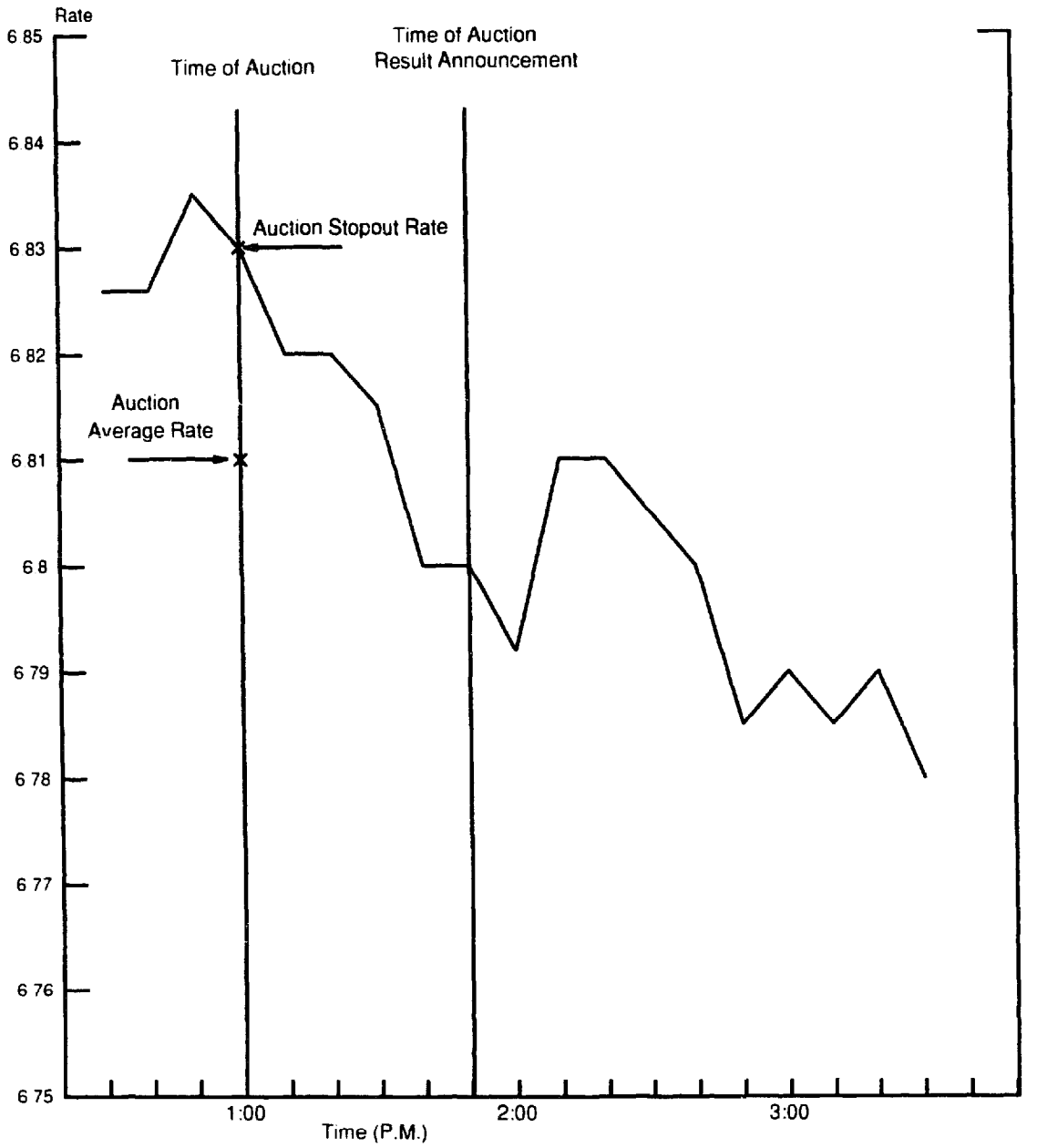

Fig. 1. Auction-day movements of bid-side when-issued rates and auction average and stopout rates on the two-year Treasury note auctioned on May 22, 1991. The squeeze at this auction triggered an investigation into bidding irregularities at Treasury auctions.

I test for information advantages by regressing changes in bid-side when-issued rates from the time of the auction to five minutes before the results are announced on the bidding aggressiveness, measured by the markup of auction average rates over contemporaneous bid-side when-issued rates, and duration. If information advantages exist, when-issued rates should fall over this interval

Table 3

Regressions of changes in when-issued rates from the time of auctions to 5 minutes before auction result announcements on the aggressiveness of bidding at auctions, measured by the markup at auctions or the spread between auction average rates and contemporaneous when-issued rates, and duration from January 1990 to September 1991. The regressions are estimated by ordinary least squares with White's (1980) correction for heteroskedasticity.[a]

Independent variables	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups
Constant	0.647	0.759	0.783
	(0.526)	(0.551)	(0.617)
Markups at auctions	1.52**	1.55*	1.21
	(0.559)	(0.712)	(0.945)
Duration of auctioned securities	− 0.227	− 0.267*	− 0.212
	(0.126)	(0.133)	(0.135)
$\bar{R}^2$	0.06	0.05	0.01
D.W.	2.19	2.41	2.18

[a]Standard errors are reported in parentheses. One and two asterisks denote statistical significance at the 5% and 1% levels, respectively.

when bidding is aggressive and rise when bidding is unaggressive and the coefficient on markups should be significantly positive.

Data on the time of auction result announcements are obtained from Telerate and reflect the minute the results were flashed on the Telerate screen. The Treasury announces auction results by distributing copies to reporters in the press room at the Treasury. As soon as every reporter has a copy of the results, the information is released. The major news services flash the average accepted rate, the stopout rate, and the percentage of total bids submitted at the stopout rate that receive securities, allowing market participants to determine their awards immediately. To guard against potential errors in measuring the exact timing of announcements, I measure when-issued rate changes before the release of auction results from the time of the auction to five minutes before the results are announced.

As shown in table 3, when-issued rates react significantly to the aggressiveness of bidding before auction results are announced. An increase in the aggressiveness of bidding, measured by a 1 basis-point decrease in the markup of auction average rates over contemporaneous bid when-issued rates, is associated with $1\frac{1}{2}$ basis-point decline in when-issued rates in the period between the auction and five minutes before the results are announced.

At least two hypotheses may explain the existence of information advantages. When-issued trading before auction results are announced may reflect the aggressiveness of bidding at auctions because dealers share information about their bids shortly after the auctions are complete. Alternatively, the when-issued

market might rally before auction results are announced when bidding is extremely aggressive because of buying pressure from squeezers augmenting their long positions in the when-issued market. Although distinguishing between these hypotheses is difficult, the information-sharing hypothesis implies that the reaction of when-issued rates to bidding aggressiveness should reflect both aggressively and unaggressively bid auctions. If on the other hand squeezes are responsible for the significant reaction of when-issued rates to bidding aggressiveness, when very aggressively bid and possibly squeezed auctions are omitted from the sample, when-issued rates should no longer react significantly. Column 2 of table 3 shows that when auctions at which Salomon Brothers admits violating rules are excluded from the sample, the coefficient on the term representing bidding aggressiveness is little changed and remains statistically significant, albeit at the 5% rather than the 1% level. But, column 3 indicates that when the eight auctions with negative markups are omitted, the reaction is no longer statistically significant. In addition, when the five least aggressively bid auctions are omitted, the coefficient on the term representing bidding aggressiveness remains significant (not shown). Thus, the finding that information advantages owe to aggressively bid auctions and not to unaggressively bid auctions is consistent with the view that squeezes play a role in explaining this phenomenon.

I examine whether when-issued rates react further to bidding aggressiveness following auction result announcements by regressing changes in bid when-issued rates from five minutes before to five minutes after auction results are announced on markups at auctions and on the duration of the auctioned securities. These regressions are run for the entire sample, excluding auctions at which Salomon Brothers violated auction rules and auctions with negative markups. Table 4 shows that the when-issued market reacts to the aggressiveness of bidding shortly after auction results are announced. A 1 basis-point decrease in auction markups is associated with a statistically significant 1 basis-point decline in when-issued rates in the ten minutes surrounding announcement of the auction results. Thus, for the entire sample, when-issued rates react to bidding aggressiveness to roughly the same extent before and after auction results are announced. This finding is little changed when the dependent variable is defined as changes in when-issued rates from five minutes before to fifteen minutes after auction results are announced (not shown), because reactions to announcements occur quickly. Similarly, omitting auctions at which Salomon Brothers violated auction rules and auctions with negative markups, as shown in columns 2 and 3 of table 4, has little effect on the results. The finding that when-issued rates react further to the aggressiveness of bidding following auction result announcements indicates that when-issued trading before the announcements does not fully reveal the aggressiveness of the bidding and suggests that those who are so informed can take further advantage of this information.

Table 4

Regressions of changes in when-issued rates from 5 minutes before to 5 minutes after auction result announcements on the aggressiveness of bidding at auctions, measured by the markup at Treasury coupon auctions or the spread between auction average rates and contemporaneous when-issued rates, and duration from January 1990 to September 1991. The regressions are estimated by ordinary least squares with White's (1980) correction for heteroskedasticity.[a]

Independent variable	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups
Constant	− 0.405	− 0.527*	− 0.720*
	(0.242)	(0.262)	(0.003)
Markups at auctions	1.05*	1.25*	1.66*
	(0.458)	(0.530)	(0.653)
Duration of auctioned securities	− 0.030	− 0.022	− 0.043
	(0.060)	(0.067)	(0.067)
$\bar{R}^2$	0.18	0.20	0.24
$D.W$	2.03	2.09	2.03

[a]Standard errors are reported in parentheses. One and two asterisks denote statistical significance at the 5% and 1% levels, respectively.

5. The profitability of bidding strategies

This section examines the rewards and the risks of bidding strategies for three types of risk-neutral bidders who do not know in advance whether bidding will be unusually aggressive at particular auctions: long-term investors who bid at auctions to establish long positions, short-term traders who sell the securities they are awarded at auctions shortly after the auction results are announced, and dealers who bid at auctions to cover short positions. Because these bidders are assumed, partly for illustrative purposes, to have different objectives, they face different tradeoffs between the winner's curse and quantity risk. The bidding strategies assume that bids are placed at one rate, despite the probability that risk may be diversified by bidding at different rates, as suggested by Scott and Wolf (1979). In addition, bidders are assumed to be small, so that their bidding strategies do not affect auction outcomes.

Long-term investors are assumed to bid at auctions because auction average rates are typically higher than contemporaneous when-issued rates. These investors attempt to maximize the markup of their auction bids over the contemporaneous ask-side when-issued rates, subject to their bids being accepted. When long-term investors bid at higher markups, they earn higher markups when their bids are accepted, but face greater risk that their bids will be rejected or accepted on a prorated basis. The consequence to long-term investors of having bids rejected is mild, however; they merely forgo the opportunity to lock in markups over contemporaneous ask-side when-issued rates. For this reason, they are not vulnerable to squeezes. In fact, long-term investors who

Table 5

Average markups and returns of bidding strategies for long-term investors who bid at Treasury coupon auctions rather than buy securities at the ask-side of the when-issued market at the time of auctions from January 1990 to September 1991. Markups with prorating and returns from bidding strategies assume that long-term investors earn markups on only the fraction of bids accepted.[a]

	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups
Markup between auction average and ask WI rates at time of auctions	0.75** (0.08)	0.81** (0.07)	0.89** (0.06)
Markup between stopout and ask WI rates at time of auctions	1.45** (0.18)	1.52** (0.19)	1.58** (0.19)
Markup between auction average and ask WI rates at time of auctions (with prorating)	0.60** (0.08)	0.66** (0.07)	0.73** (0.06)
Markup between stopout and ask WI rates at time of auctions (with prorating)	0.80** (0.13)	0.84** (0.14)	0.89** (0.15)
Return from bidding at next full basis point above ask WI rates	0.47** (0.03)	0.48** (0.03)	0.51** (0.03)
Return from bidding one basis point higher than previous strategy	0.44** (0.07)	0.47** (0.08)	0.51** (0.08)

[a]Standard errors of the mean are in parentheses. One and two asterisks denote statistical significance at the 5% and 1% levels, resoectively.

obtain securities at auctions may profit further in the event of squeezes by financing long positions at below general collateral repurchase agreement rates, or special rates. See Sundaresan (1992) for evidence on special repurchase agreement rates around auction cycles.

Table 5 shows the relevant markups again for convenience and the returns from bidding strategies for long-term investors. Bids below the stopout rate are accepted in their entirety and long-term investors are assumed to earn the markup of the bid rate over the contemporaneous ask-side when-issued rate; bids at the stopout rate are assumed to earn this markup only on the prorated allocation; and bids above the stopout rate are assumed to earn nothing, as they are rejected entirely. Rows 1 and 2 of table 5 show again for convenience average markups of auction average and stopout rates over ask-side when-issued rates at the time of auctions. These average markups for the entire sample are statistically significant 0.75 and 1.45 basis points, respectively. These markups do not represent incremental yields earned by long-term investors who successfully bid at auction average and stopout rates, however, because bids submitted at the stopout rate receive securities on a prorated basis. Average markups that reflect the effects of prorating are shown in rows 3 and 4. For the entire sample, average

markups with prorating earned from bidding at average and stopout rates decline to statistically significant 0.60 and 0.80 basis points, respectively. These results demonstrate that the incremental return from successfully bidding at stopout rates rather than at auction average rates is considerably less when quantity risk is taken into account. Prorating always occurs at stopout rates, whereas it occurs at average accepted rates only when they equal stopout rates.

I now examine the returns to long-term investors who follow the strategy of bidding at the next full basis point over ask-side when-issued rates at the time of auctions. This strategy minimizes quantity risk, subject to earning positive markups over contemporaneous when-issued rates when bids are accepted. Row 5 of table 5 shows that this strategy earns a statistically significant 0.47 basis-point average return over ask-side when-issued rates for the entire sample. The next strategy involves bidding 1 basis point above the rate implied by the previous bidding strategy. Long-term investors now earn higher returns when bids are accepted, and consequently are less vulnerable to the winner's curse, but are more exposed to quantity risk because their bids are rejected or accepted on a prorated basis more frequently. Row 6 of the table indicates that bidding 1 basis point higher than previous strategy has little effect on returns – the higher markups earned when bids are accepted are offset by the more frequent rejections. These results suggest that quantity risk is as important as the winner's curse in the relevant range of bidding for long-term investors.

I now look at the profitability of bidding strategies for short-term traders. Because short-term traders sell the securities they are awarded at auctions shortly after the results are announced, their concern is whether the securities can be sold profitably then. To maximize their profit, short-term traders attempt to maximize the spread between the rates they bid at auctions and bid-side when-issued rates five minutes after auction results are announced, subject to bids being accepted. Like long-term investors, short-term traders do not suffer explicit losses when their auction bids are rejected, but merely forgo the possibility of earning trading profits. The winner's curse for these bidders is receiving securities at an auction that can be sold only at a loss shortly after the auction results are announced. Short-term traders can limit the risk of the winner's curse by bidding at higher markups over when-issued rates, but doing so increases their risk of forgoing profitable trades because bids are rejected.

Table 6 shows the relevant spreads and the profits of bidding strategies for short-term traders. Bids submitted below the stopout rate are accepted entirely and short-term traders are assumed to earn the spread between the bid rate and the bid-side when-issued rate five minutes after the auction results are announced; bids submitted at the stopout rate are accepted on a prorated basis and short-term traders are assumed to earn this spread only on the share of bids accepted. They are assumed to earn zero spreads both on the rejected portion of the prorated bids and on bids submitted above the stopout rate, which are

Table 6

Average spreads and profits of bidding strategies for short-term traders who bid at Treasury coupon auctions and sell awarded securities at the bid side of the when-issued market 5 minutes after auction result announcements from January 1990 to September 1991. When bids are accepted on a prorated basis, profits or losses are assumed to be earned only on the percent of bids accepted.[a]

	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups
Spreads between auction average and bid WI rates 5 minutes after auction result announcements	0.27 (0.39)	0.22 (0.42)	0.09 (0.43)
Spreads between stopout and bid WI rates 5 minutes after auction result announcements	0.97* (0.39)	0.92* (0.41)	0.78 (0.43)
Spreads between auction average and bid WI rates 5 minutes after auction result announcements (with prorating)	0.13 (0.27)	0.08 (0.30)	− 0.04 (0.31)
Spreads between stopout and bid WI rates 5 minutes after auction results announcements (with prorating)	0.29 (0.20)	0.25 (0.21)	0.19 (0.22)
Profit from bidding at next full basis point over bid WI rate and selling in WI market 5 minutes after auction result announcements	− 0.14 (0.23)	− 0.15 (0.25)	− 0.17 (0.26)
Profit from bidding one basis point higher than previous strategy	− 0.11 (0.07)	− 0.12 (0.08)	− 0.13 (0.08)

[a]Standard errors of the mean are in parentheses. One and two asterisks denote statistical significance at the 5% and 1% levels, respectively.

rejected entirely. Rows 1 and 2 of the table show again for convenience that average spreads of auction average and stopout rates over bid-side when-issued rates five minutes after auction results are announced are statistically insignificant 0.27 basis points and statistically significant 0.96 basis points for the entire sample. Rows 3 and 4 show that, when prorating is taken into account, short-term traders who bid at auction average and stopout rates earn statistically insignificant average spreads. Again, the effects of prorating are much greater for bids submitted at the stopout rate.

Of course, without advance knowledge that bidding at particular auctions will be unusually aggressive, short-term traders probably will not bid aggressively at aggressively bid auctions and profit from the tendency of when-issued rates to decline after aggressively bid auctions. Row 5 of table 6 shows the average profit earned by short-term traders who bid at the next full basis point above bid-side when-issued rates at the time of auctions and sell awarded

securities at bid-side when-issued rates five minutes after auction result announcements. This bidding strategy results in a statistically insignificant average 0.14 basis-point loss for the entire sample. When short-term traders bid 1 basis point higher than the rate implied by the previous strategy, and consequently incur greater quantity risk but less winner's curse risk, average losses are little changed. These results show that following simple bidding strategies that do not assume advance knowledge of how aggressive the bidding will be and selling the securities awarded after the auction results were announced would have been unprofitable during the sample period. The results also suggest that quantity risk is about as important as the winner's curse for short-term traders in the relevant range of bidding.

The final type of bidders examined here are dealers who are assumed to bid at auctions to cover short positions established in the when-issued market at the time of auctions. When dealer bids are rejected, dealers are assumed to cover their short positions in the when-issued market five minutes after the auction results are announced. Of the three types of bidders examined in this study, only dealers are exposed to the loser's nightmare of having to cover short positions in rallying when-issued markets when their bids are rejected or accepted on a prorated basis. If some market participants more than occasionally bid very aggressively at auctions and squeeze dealers with short positions, dealers who are uninformed about whether the bidding will be aggressive at particular auctions will probably get caught often in squeezes and will not earn profits on average at auctions. In determining their bidding strategies, dealers make tradeoffs between the winner's curse and the loser's nightmare. When they bid at higher rates, they earn larger profits if their bids are accepted, but incur greater risk that their bids will be rejected and that they will have to cover their short positions in rallying when-issued markets.

Table 7 shows the relevant spreads and profits for dealers at auctions. Dealer bids below the stopout rate are fully accepted and dealers are assumed to earn the spread between the bid rate and the bid-side when-issued rate at the time of the auction. Bids at the stopout rate earn the spread between the stopout rate and the bid-side when-issued rate on the prorated share of bids accepted. Because short positions not covered at auctions are assumed to be covered five minutes after the auction results are announced, dealers earn the spread between the ask-side when-issued rate five minutes after the auction results are announced and the bid-side when-issued rate at the time of the auction on the percentage of bids rejected. Bids above the stopout rate are rejected completely and dealers are assumed to cover their entire short positions in the when-issued market, thus earning the spread between ask-side when-issued rates five minutes after auction result announcements and bid-side when-issued rates at the time of auctions. Rows 1 and 2 of table 7 show again for convenience that average spreads of auction average and stopout rates over bid-side when-issued rates at the time of auctions are equal to statistically significant 0.37 and 1.07 basis

Table 7

Average spreads and profits of bidding strategies for dealers who bid at auctions to cover short positions established at the bid side of the when-issued market at the time of auctions from January 1990 to September 1991. If bids are rejected or accepted on a prorated basis, dealers cover the part of short positions not covered at auctions by buying securities at the ask side of the when-issued market 5 minutes after auction results are announced.[a]

	Entire sample	Excluding auctions with rule violations	Excluding auctions with negative markups
Spread between auction average and bid WI rates at the time of auctions	0.37** (0.08)	0.43** (0.07)	0.52** (0.06)
Spread between stopout and bid WI rates at the time of auctions	1.07** (0.18)	1.13** (0.19)	1.21** (0.19)
Profit from shorting WI at time of auctions and bidding at auctions average rate (with prorating)	0.14 (0.19)	0.19 (0.21)	0.28 (0.21)
Profit from shorting WI at time of auctions and bidding at stopout rate (with prorating)	0.49 (0.42)	0.19 (0.31)	0.18 (0.46)
Profit from shorting WI at time of auctions and covering at auctions at next full basis point above WI rate or in WI market if bids are rejected	− 0.28 (0.29)	− 0.17 (0.29)	0.05 (0.29)
Profit from bidding one basis point higher than previous strategy	− 0.47 (0.40)	− 0.36 (0.42)	0.09 (0.24)

[a]Standard errors of the mean are in parentheses. One and two asterisks denote statistical significance at the 5% and 1% levels, respectively.

points, respectively, for the entire sample. The next two rows show the effects of prorating on profits earned by dealers who bid at auction average and stopout rates, respectively. Dealers who bid at these rates earn statistically insignificant average profits of 0.14 and 0.49 basis points. Thus, the risk of receiving securities on a prorated basis and consequently having to cover part of a short position in a rallying when-issued market cuts substantially into profits.

Of course, dealers would not set up short positions at the time of auctions if they knew those auctions would be very aggressively bid. The first bidding strategy examined minimizes the risk of the loser's nightmare, subject to earning a positive spread when bids are accepted by bidding at the next full basis point over bid-side when-issued rates at the time of auctions. This strategy does not result in large enough profits when bids are accepted to offset the results of the loser's nightmare when bids are rejected, as shown in row 5 of table 7. This strategy results in a statistically insignificant average loss of 0.28 basis points for the entire sample. The next strategy assumes that dealers bid 1 basis point higher

than the rate implied by the previous bidding strategy, which makes them less vulnerable to the winner's curse but more prone to the loser's nightmare. This strategy results in an average statistically insignificant loss of 0.47 basis points for the entire sample, about twice the average loss of the previous strategy, although not statistically significantly different. This finding suggests that the loser's nightmare is at least as important as the winner's curse in the relevant range of bidding for dealers.

6. Conclusions

This study shows that markups of auction average rates over bid- and ask-side when-issued rates at the times of the 66 Treasury coupon auctions from January 1990 through September 1991 average 0.37 and 0.75 basis points, respectively, and that these markups tend to rise when the when-issued rate is more volatile during the half hour before auctions. The study also finds that when-issued rates react as strongly to bidding aggressiveness before auction results are announced as they do afterward. This finding reflects very aggressively bid auctions: when auctions with auction average rates below contemporaneous when-issued rates are omitted from the sample, the when-issued market no longer reacts significantly before the auction results are released. Because information sharing among dealers should be as prevalent after unaggressively bid auctions as after aggressively bid auctions, whereas squeeze strategies would be at work only at very aggressively bid auctions, the results are consistent with the view that squeeze strategies play a role in explaining the when-issued market response.

This study extends the empirical literature on Treasury auctions by assessing the importance of quantity risk. For some bidders, quantity risk merely represents foregone opportunities to lock in higher rates or to earn potential short-term trading profits. But, for dealers, who are by far the most important bidders at Treasury auctions and who typically bid at auctions with large short positions to cover, quantity risk is extremely important. Dealers who do not successfully cover their short positions at auctions because the bidding is extremely aggressive face the loser's nightmare of having to cover them in rallying when-issued markets. Findings on the profitability of bidding strategies indicate that, although long positions could have been established more cheaply at auctions than in the contemporaneous when-issued market, the securities awarded frequently could have been sold only at a loss shortly after the auction results were announced. For dealers shorting when-issued securities and bidding at auctions to cover their short positions, the bidding strategies examined here would have been unprofitable because of the loser's nightmare. Overall, the profitability of bidding strategies suggests that quantity risk is at least as important as the winner's curse.

References

Bikhchandani, Sushil and Chi-Fu Huang, 1993, The Treasury bill auction and the when-issued market: Some evidence, Working paper (MIDAMERICA Institute, Chicago, IL).

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

Copeland, Thomas and Dan Galai, 1983, Information effects of the bid-ask spread, Journal of Finance 38, 1457–1459.

Glosten, Lawrence R. and Paul R. Milgrom, 1985, Bid, ask and transactions prices in a specialist market with heterogeneously informed traders, Journal of Financial Economics 14, 71–100.

Joint report on the government securities market, 1992 (Department of the Treasury, Securities and Exchange Commission, and the Board of Governors of the Federal Reserve, Washington, DC).

Milgrom, Paul R., 1989, Auctions and bidding: A primer, Journal of Economic Perspectives, 3 22.

Salomon Brothers, 1991, Statement of Salomon Inc. submitted in conjunction with testimony of Deryck C. Maughan before the Subcommittee on Oversight, Committee of Ways and Means, United States House of Representatives, Sept. 24th.

Scott, James H. and Charles Wolf, 1979, The efficient diversification of bids in Treasury bill auctions, Review of Economics and Statistics 61, 280–287.

Spindt, Paul A. and Richard W. Stolz, 1992, Are US Treasury bills underpriced in the primary market?, Journal of Banking and Finance 16, 891–908.

Stigum, Marcia, 1990, The money market (Dow Jones-Irwin, Homewood, IL).

Sundaresan, Suresh, 1992, An empirical analysis of U. S. Treasury auctions: Implications for auction and term structure theories, Working paper (Columbia University, New York, NY).

White, Halbert, 1980, A heteroskedasticity-consistent covariance matrix estimator and direct tests for heteroskedasticity, Econometrica 48, 817–838.