Bidding Strategies in Brazilian Treasury Auctions[*]

Anderson Caputo Silva[**]

Abstract

Most empirical work in treasury auctions use aggregate auction results to examine bidding behavior. We investigate the strategies of bidders in Brazilian treasury auctions using both aggregate and bidder level data and find that more detailed information allows great improvements in the understanding of bidding behavior in treasury auctions. Classifying bidders according to characteristics regarding their institutional category and their nationality, we find evidence of distinct bidding behavior across types of bidders. Moreover, in line with previous evidence in auctions of Japanese government securities, we find that foreign bidders seem to obtain higher profits than those of national institutions. These results suggest that caution should be exercised in the interpretation of tests of bidding behavior that do not take differences in bidders' characteristics into account and (or) that assume that treasury securities are pure common-value goods. We find that Brazilian auctions are relatively illiquid as higher competition yields lower bidders' discounts. Contrary to theoretical predictions of both common- and private-value auctions, we also find that bidders obtain lower profits in auctions with higher dispersion in bidders' valuations.

Key Words: Bidding behavior, treasury auctions, bidders' profitability, bidders' heterogeneity, common values .

JEL Code: D44 .

Resumo

A grande maioria dos estudos sobre leilões de títulos governamentais utiliza dados agregados com respeito ao resultado dos leilões quando da análise do comportamento de licitantes. Neste estudo, além da abordagem tradicional, utilizam-se dados referentes às propostas de cada licitante (dados individuais) para investigar suas estratégias em leilões de títulos do tesouro brasileiro. O maior grau de detalhamento dos dados permite melhora substancial no entendimento do comportamento destes agentes. Evidências de comportamento distinto entre diferentes tipos de licitantes são encontradas ao classificá-los de acordo com características relacionadas a sua categoria institucional e nacionalidade. Além disso, em linha com resultados encontrados em leilões de títulos do governo japonês, a análise apresentada neste trabalho indica que licitantes estrangeiros alcançam maiores lucros em comparação aos obtidos por instituições nacionais. Estes resultados sugerem cautela na interpretação de testes sobre o comportamento de licitantes que não levem em conta diferenças nas características dos mesmos e (ou) que assumam que títulos do tesouro são bens de puro valor comum. O trabalho aponta, ainda, redução do lucro dos licitantes na presença de maior competição, sugerindo que leilões de títulos brasileiros possuem relativamente baixa liquidez. Em contraste aos preceitos teóricos de leilões, tanto de bens de valor comum como de privado, os resultados indicam que os licitantes obtém menores lucros em leilões com maior dispersão na precificação dos títulos.

1. Introduction.

Government securities auctions are the type of auctions most widely examined empirically in the finance literature and a challenge to auction theorists. Despite the great amount of attention, bidding behavior in treasury auctions is still not satisfactorily understood.

With very few exceptions [Gordy (1999) and Nyborg, Rydqvist and Sundaresan (1998)], most empirical work employ aggregate level auction data that ignores, implicitly, that bidders in treasury auctions are usually allowed to present multiple price-quantity bids. These studies therefore fail to take into consideration that bidding strategies have several dimensions.

More specifically, each bidder may choose the number of bids to be submitted, the dispersion among these bids and the price-quantity of her bids. To the extent that these decisions are not directly observed in aggregate data, a better understanding of bidding behavior requires the use of information on individual bids level.

In this paper we present a thorough examination of bidding behavior using both aggregate and individual bids data from Brazilian treasury auctions. Conducting the analysis with aggregate data allows us to draw comparisons to results from other studies in the literature and also help in establishing links and gaps to the more accurate conclusions provided by the examination with data on individual bids. The investigation of commonly tested predictions regarding the effects of competition and dispersion in bidder's valuations is our central point of interest.

Another potential problem to the conclusions and interpretations of several studies in the literature regards the assumption of a common-value framework in which, to all bidders, the expected value of the securities auctioned equals their expected resale price. This assumption rules out the possibility that some private components in bidders' valuations may differ across bidders and ultimately affect their final valuations. High costs of transactions in secondary markets and heterogeneity in bidders' types regarding significant differences in reserve requirements, for example, may lead to distinct bidding behavior among auction participants.

In this context, a second objective of the paper is the investigation of systematic differences in bidding behavior across

bidders' types. We distinguish among different categories of bidders regarding the type of institution (commercial banks, investment banks and brokers) and their nationality (Brazilian and foreign institutions). To our knowledge, the questions we address in this study have not yet been examined with this level of detail in the empirical literature.

We find that, in comparison to our analysis with aggregate data, the investigation conducted with individual bids level information significantly improves our conclusions. Moreover, we present evidence of distinct bidding behavior across different categories of bidders, suggesting that upon examining the strategies of auction participants one should take into account their characteristics. Consistent with this argumentation we find that foreign institutions obtain higher profits than those achieved by national bidders. Hamao and Jegadeesh (1998) also document that U.S banks have higher profits than Japanese banks in auctions of government securities in Japan. Determining whether this result holds in other countries is an interesting topic of research that we leave for future work

Our tests of theoretical predictions about the effects of competition on bidding behavior indicate that bidders tend to shade less their bids in more competitive auctions. According to auction theory this result indicates that Brazilian auctions are relatively illiquid. Evidence suggests that bidders also present lower discounts in periods of higher dispersion in their valuations. This finding contrasts with predictions of traditional models of common- and private-value auctions that bidders should shade more their bids in these circumstances.

The paper is organized as follows: Section 2 provides a

review of the empirical literature of treasury auctions in several countries. Institutional details regarding the auctions of Brazilian treasury securities and a brief description of the data is presented in section 3. Using aggregate data we start our empirical examination of bidding behavior in section 4. Section 5 presents an analysis with individual bids level data. Possible differences in bidding strategies across different categories of bidders are examined in section 6. Section 7 concludes the paper.

2. Treasury auction literature.

Auctions are of fundamental interest to researchers in economic theory. For researchers in finance, the most important set of auctions are the national auctions of government securities. Classic theoretical work on auctions (Carson (1959), Friedman (1959) and (1963), Goldstein (1962), Rieber (1965) and Smith (1966)) has influenced the design of Treasury auctions, which in turn has led to further examination of those auctions theoretically and empirically.

In spite of theoretical developments, no model of multiple-price, multiple-goods auctions encompasses the complexities of government securities auctions analyzed in our paper or in other studies in this area. Instead, it is common practice to test whether some of the predictions of single-good auction theory hold in a more general setting[1].

Among the predictions arising from typical auction models are the fact that increases in competition (number of bidders

---

[1]See, for example, Milgrom and Weber (1982) and Engelbrech-Wiggans, Milgrom and Weber (1983).

relative to number of goods at auction) will reduce bidders' profits and a higher dispersion of valuations of the good will reduce the bids of participants[2]. The first prediction applies to auctions with a finite number of bidders, as profits converge to zero with strong competition. The latter prediction arises in a variety of ways: in private values models it is caused by the increased likelihood of a "shaded" bid winning the good. In common values models the phenomenon of the "winner's curse" can reinforce the bid reduction as bidders rationally expect that the winner may be basing his bid on information which is unrealistically optimistic relative to the information possessed by the population as a whole[3]. Hendricks, Porter, and Boudreau (1987) and Hendrix and Porter (1989), for example, find no support to the theory when examining auctions of OCS oil-lease. Evidence on how bidder profitability is affected by the level of competition and by the winner's curse in Treasury auctions is inconclusive.

A number of studies have examined these issues in the context of US Treasury auctions. Cammack (1991) covers the 1973-1984 period and finds a positive relation between bid shading and information dispersion in the 3-month Treasury bill market. However, after dividing the whole sample into four subperiods she observes that this positive relation is strongest in the early part of the sample. In fact, the coefficient of her measure of information dispersion is not significant in the last sub-

---

[2]Bidder's profits in a common value setting may increase with competition if winner's curse concerns dominate a bidder's incentive to bid higher (due to a reduction in her probability of winning) under fiercer competition. Wilson (1979) argues that in most cases competition will lead to higher bids.

[3]In the presence of experienced bidders. See McMillan, Rothschild and Wilson (1997) and Hendrix, Pinkse and Porter (1999) for a discussion.

period that extends from October/82 to December/84. Cammack also failed to find any relationship between measures of competition and profitability.

Spindt and Stolz (1992) examined the same 3-month Treasury bill market using data from 1982 to 1988 and tested for the effects of dispersion in valuations and competition. A main difference between their work and Cammack's, however, regards their methodology to compute bidders' profitability. While Cammack compares auction prices to the mean of bid-ask prices, Spindt and Stolz compares auction prices to three different price measures. These measures reflect different investment strategies regarding bidders' intention to buy and hold, buy and sell simultaneously (using the when issued market) or buy and sell in the secondary market. They find that conclusions are highly dependable on the measures that they adopt as they observe both positive and negative correlation between bidders' profits and dispersion in valuations. Their proxy for competition also yields distinct results according to the methodology used to compute profits.

Jegadeesh (1993) investigates auctions of US Treasury notes conducted from January/86 to June/91. He finds no relation between his proxy for dispersion of opinion and bidder's profitability. An interesting result in Jegadeesh's analysis is that, contrary to predictions of auction literature, fiercer competition yields higher bidders' profitability in auctions of US Treasury notes.

Out of the US markets, Umlauf (1993) examines auctions of Mexican Treasury bills in the 1986-1991 period. He finds evidence that corroborate Jegadeesh's results with respect to

the effect of competition. In other words, Umlauf observes a positive significant relationship between bidder's profitability and the level of competition in Mexican auctions. This result, however, does not appear to be robust to different proxies of competition[4]. Umlauf reaches apparently stronger conclusions in the examination of the effects of dispersion in valuations. His measure of price uncertainty presents highly significant and positive coefficients in his regressions of bidders' profitability.

Scalia (1997) studies the Italian Treasury bond market in the 1995-1996 period and finds that both the levels of competition and information dispersion are negatively related to bidder's profitability. His results are in severe contrast with Umauf's evidence in Mexican Treasury auctions, suggesting that changes in the level of competition and information dispersion yield distinct reactions from bidders in Italian and Mexican Treasury bond markets. In section 4, we use analogous methods to those employed by Umlauf and Scalia to test how bidder's profitability are affected by competition and uncertainty in auctions of Brazilian government securities.

Another example of study of Treasury auctions in markets outside the US is Hamao and Jegadeesh (1998). The authors examine auctions of 10-year Japanese Government Bonds (JGB) using data from April 1989 to November 1995. They find that neither competition nor uncertainty significantly af-

---

[4]Umlauf finds a significant positive coefficient when using the number of bidders as his proxy for competition. Adopting a different proxy, the ratio of the number of bidders to the total quantity of bonds offered, he finds insignificant coefficients. The proxy to competition most widely used in the literature, including the three studies on the US Treasury markets mentioned above, is the ratio of the amount of bids tendered in an auction to the total value of securities offered.

fect auction profits, consistent with the theoretical prediction that expected profits in sufficiently large markets are driven to zero and that the levels of competition and uncertainty have no effect on ex-post profitability[5].

Regarding the analysis of auctions of Brazilian government securities, to the extent of our knowledge, the only empirical study that examines the determinants of bidders' profitability is Kahn and Silva (2000)[6] . The authors use a sample of 164 auctions of Brazilian Treasury and Central Bank securities and compare bidders' profitability in auctions of the two institutions. While Kahn and Silva fail to find differences in profitability in the two sets of auctions, their findings suggest that bidders pay a premium on securities in periods of interest rate volatility. As discussed above, this result is in line with Scalia (1997), but it is in deep contrast with Umlauf (1993) and theoretical predictions. Also according to their results, competition does not significantly affect bidders' profits.

Table 1 below summarizes the empirical evidence, discussed thus far, on how bidder profitability is affected by the levels of competition and dispersion in valuations (uncertainty) in Treasury auctions. Note that empirical results vary considerably within the US as well as between countries.

---

[5]The Japanese government securities market is the second largest in the world, see Hamao and Jegadeesh (1998).

[6]The only other empirical studies of Brazilian auctions that we know of are Rezende (1997) and Silva (2003). None of these studies, however, cover the issues investigated in this paper. Resende uses a limited sample of auctions of Central Bank securities to try to explain dispersion in bids and the usefulness of a structural model based on single-unit auction theory. The work of Silva (2003), on the other hand, mainly consists of a methodology to conduct structural analysis in auctions of multi-unit objects with dominant bidders, using data on Brazilian Treasury auctions as an example of such type of auctions.

Table 1 – Evidence of the effects of competition and dispersion
in valuations on bidders' profitability

Author	Data and Sample	Measure of competition*/ Result	Measure of uncertainty**/ Result
Cammack (1991)	3 month US T-bills, from 1973-1984	Cov.Ratio (insignificant)	Tail (positive and signif.)
Spindt and Stolz (1992)***	3 month US T-bills, from 1982-1988	Cov.Ratio (negative and signif.) or(insignificant)	Volatility (positive and signif.)or (negative and signif.)
Jegadeesh (1993)	2-,5-,7-and 10-year US T-notes from 1986-1991	Cov.Ratio (positive and signif.)	Range (insignificant)
Umlauf (1993)	30-day Mexican T-bills form 1986-1991	Number of Bidders (positive and signif.) No.of Bidders/Quantity (insignificant)	Volatility (positive and signif.) Bid Variance (insignificant)
Scalia (1997)	3-,5-and 10-year Italian fixed coupon bonds and floating rate bonds	Cov.Ratio (negative and signif.)	Volatility (negative and signif.) No. of Bidders (negative and signif.)
Hamao and Jagadeesh (1998)	10-year Japanese Government Bonds from 1989 to 1995	Cov.Ratio (insignificant)	Range (insignificant)
Kahn and Silva (2000)	Treasury and Central Bank fixed-rate securities(different) maturities	Demand;Number of bids and Cov.Ratio (all insignificant)	Volatility (negative and signif.)

*Cov.Ratio=demand/supply

**Tail=highest-average winning bid; Volatility is based on measures of dispersion in the interest rates; and

Range=highest-lowest winning bid,

***Their results, as mentioned previously, depend on the measure of profitability considered.

Even though one should not necessarily expect to find an indisputable set of evidence across these studies, the wide array of results described above point out to some limitations in the extant literature. These tests were conducted using aggregated auction data that assume, implicitly, that bidders present only one bid at the auction. However, as discussed previously, bidders in treasury auctions are usually allowed to present multiple price-quantity bids. This implies that it would be more efficient to use individual bidding strategies in the testing of auction theory predictions.

A problem commonly faced by researchers is that data at the individual bids level is many times unavailable. To the extent of our knowledge, the only studies that directly investigate how bidders choose the quantities demanded, disperse and shade their own bids are Gordy (1999) and Nyborg, Rydqvist and Sundaresan (1998). We use both of these studies as baselines in the empirical examination presented in section 5.

Gordy (1999) is, to date, the most comprehensive empirical study on how uncertainty and competition affect bidders' multiple price-quantity choices. The author examines a total of 474 auctions of Portuguese Treasury bills conducted between June/88 and April/93. He finds that the number of bids submitted by a bidder as well as the dispersion among his bids is positively related to measures of uncertainty and competition. Gordy also finds that the Treasury's revenue increases when bidders submit (on average) a higher number of bids, which according to the author is consistent with the hypothesis that bidders are willing to incur in a cost to hedge against the winner's curse.

Nyborg et al. (1998) investigate 458 Swedish Treasury auctions in the period between 1990 and 1994. In line with Gordy's results the authors find that intra-bidder dispersion increases with volatility. Moreover, after showing that bidders tend to

reduce their demand in the presence of increased uncertainty they conclude that volume is another important dimension of the winner's curse problem. A significant innovation of their study is that they use the actual distribution of winning and losing bids (instead of only the winning bids) when examining the effects of information dispersion on bidders' discounts. They find that discounts tend to be larger for securities with higher duration, but no relation is found between discounts and volatility in the daily yield quotes for the 90-days rate (a proxy for information dispersion). We use a similar methodology when examining bidders' discounts in sections 5 and 6[7].

The two recent studies described above make the usual assumption common to most empirical work in Treasury auctions that, to all bidders, the expected value of the securities auctioned is equal to its expected resale price. The common-value framework rules out the possibility that some private components in bidders' valuations may differ across bidders and ultimately affect their final valuations.

The limitations above have been acknowledged in some of the studies cited previously. Hamao and Jegadeesh (1998) show that the winning shares of US dealers are positively related to auction profits, whereas the winning shares of Japanese dealers present a negative association. They argue that under the traditional view in the literature (that government securities auctions are best described as common value auctions) this evidence would suggest that US dealers have better bidding skills. However, they also recognize that their evidence is consistent with the view that bidders may have private value associated with purchasing bonds in the auctions.

Gordy (1999) acknowledges that a caveat in his discussion

---

[7]Nyborg et al., however, do not include measures of competition in their tests of bidder behavior.

of the use of multiple bids as a hedge against the winner's curse is that treasury auctions may not be purely common-value. According to the author, significant transaction costs in the secondary market may introduce a private component to bidders' valuations. To the extent that these transaction costs may be more relevant to some bidders than others, Gordy's statement suggests that it may be important to take differences in bidders' characteristics in account.

In line with this last argument Hortaçsu (2000) mentions a survey conducted by Alkan (1991) among a large number of participants in Turkish Treasury auctions. According to the survey, the main reasons for participating in those auctions are (in order of importance) to meet liquid asset reserve requirements monitored by the Central Bank and to resale in the secondary market. Moreover, the relative importance of these two motivations to buy Treasury securities seems to vary significantly among survey respondents. After developing a methodology that allows him to estimate the distribution of bidder's true marginal valuations for the Turkish Treasury securities, Hortaçsu finds that bidders tend to place an "outlier" bid that is almost certain to win. The author claims that this could be due to binding liquid asset reserve requirements that may cause bidders to value a certain minimum quantity of Treasury bills much higher than subsequent units. Hortaçsu 's study, however, focuses in methodological issues to compute bidders' valuations and thus does not explore empirically how differences in bidder types could affect their own strategies and auctions revenues as a whole.

In the analysis we conduct in section 6, we try to take into account that bidders may be heterogeneous with respect to their motivation to buy Treasury securities and thus are likely to exhibit distinct behavior. We classify bidders according to their institutional type (Commercial banks, investment

banks and Brokers) and their nationality (Brazilian and foreign banks). Previous empirical evidence, differences in investment objectives and the typically distinct amount of reserve requirements and deposits across these types of institutions provide a rationale for such classifications.

3. Brazilian treasury auctions and data.

Auctions of Brazilian treasury securities and public debt management are under the responsibility of the National Treasury Secretariat (NTS), within the Ministry of Finance. The NTS typically auctions more than one type of instrument simultaneously. In this paper we analyze a total of 83 discriminatory auctions of Brazilian treasury fixed-rate securities (the so-called Letras do Tesouro Nacional - LTN), executed from January 1998 to June 1999.

Treasury auctions are open to all institutions listed in the "Sistema de Liquidação e de Custódia" (SELIC), a clearance and settlement system managed by the Central Bank which among other things registers the transactions with government securities. Although approximately 560 institutions are listed in the SELIC, on average only about 45 institutions participated in each auction of fixed-rate government securities in the sample that we investigate (see table 2).

The amount of each security to be sold and its maturity are typically announced by the NTS two working days before the auction. On the auction date, each bidder is allowed to bid for the whole amount auctioned and to submit up to 5 different sealed bids before 1:30 p.m. After observing the bids the NTS decides whether to sell its securities entirely or to cancel the sale partially or totally. Auction results are released on the same day after 3:00 p.m. reporting the total amount sold of each security, the minimum and the weighted average price of the winning bids. Finally, in the first working day after the

NTS auctions, the newly issued debt is allocated to the winning bidders while their reserve accounts are debited by the Central Bank.

In the empirical investigation shown in the next sections we employ variables of common use in the literature of treasury auctions. These measures account for:(i) bidders' profitability; (ii) dispersion in bidder's valuation; (iii) bidders' participation; (ii) the amount pre-announced (supply); (iii) the maturity of the securities being auctioned; and (iv) a time trend.

Bidder's profitability (PROF) was computed by comparing the (quantity weighted) average winning price in each auction to the price projected by the futures market of interest rates at the end of the auction date. Such projection for each security is used as an approximation to its resale price. Given that secondary market operations are not very liquid and information about them started being published just recently[8], PROF is a good proxy in comparisons between auctions, though in absolute terms it may not accurately measure the level of profits actually obtained by the winning bidders.

Futures contracts of interest rates are not very liquid in Brazil, especially for long maturities. This lack of liquidity has limited to some extent our computation of the "resale" price projected by the futures market, thus also limiting the precision of our profitability measure. This sort of problem occurred more frequently when computing the resale price of securities with longer maturities, although even for these securities most liquidity problems occurred for contracts expiring in the last few months of remaining life.

---

[8]In order to stimulate secondary market negotiations and make it more transparent, the Brazilian Central Bank and the treasury among other measures created (in December, 1999) a system that displays secondary prices and trading volume of all government securities being negotiated.

In order to compute the resale price, we considered as sufficiently liquid only those monthly contracts for which the traded volume was above 1000 contracts[9]. In events that the longest liquid contract expired prior to the maturity of the security being auctioned, we repeated the forward rate of this last contract until it matched the life period of the security. This procedure was in fact widely used by practitioners and the treasury to price government securities during the period under analysis.

Our main measure of dispersion in bidders' valuations and resale risk is the volatility in the futures market of interest rates[10]. To circumvent futures markets liquidity problems this measure of volatility considers only the most widely traded contract during the five days prior to each auction date.

With the intent of making contracts of different maturities comparable we first transformed the prices of futures contracts into their corresponding annual interest rates. Secondly, we computed the daily volatility for each of the five days prior to the auction date. This measure corresponds to the ratio between the maximum and the minimum interest rate traded. Lastly, we considered the average of the daily volatility (AVVOL) in these five days as our volatility measure.

Other than PROF and AVVOL, the remaining variables that we adopt are based on auction results and characteristics. Demand, number of bidders and the ratio between demand and supply (denoted, Coverage Ratio) are our measures of bidders' participation. Supply reflects the amount of securities being

---

[9]We consider futures contracts of interest rates on interbank deposits. This is basically the only type of futures contracts of interest rates in Brazil that is sufficiently liquid for our purposes. Auction participants commonly use these contracts to price government securities. Futures contracts have face value R\$ 100,000.00 (approximately US\$ 40,000 as of April/2001)

[10]In section 4 we also use, as a measure of dispersion in valuations, the difference between the highest and lowest winning bids, that we denote as AMPL.

sold[11]. Maturity is measured in days.

Due to limited demand and (or) large bids' dispersion, the Treasury decided to cancel its auctions in 11 opportunities. To the extent that bidding behavior is likely to be very distinct in successful and canceled (unsuccessful) auctions, we conduct most of our analysis using only the set of 72 auctions that did not have rejected bids[12]. Table 2 presents the summary statistics of the variables described above.

Table 2 – Summary statistics of aggregate auction data

	All Auctions (83 obs.)			Successful Auctions (72 obs.)			Canceled Auctions (11 obs.)		
	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.
Supply*	398	1,933	6,642	398	1,924	6,642	662	1,993	3,338
Demand*	225	5,499	16,335	838	5,800	16,335	225	3,533	9,627
Cov.Ratio	0.13	3.12	13,99	1.16	3.37	13.99	0.13	1.50	3.63
Nbidders	3	45.0	90	6	47.4	90	3	29.3	77
Wbidders	0	18.9	52	2	21.8	52	0	0.0	0
Nbidds	3	128.0	262	12	135.7	262	3	77.5	228
Maturity	28	152.5	364	28	149.6	364	91	171.8	364
Amplitude	0.7	0.55	6.65	0.07	0.39	2.74	0.10	1.59	6.65
Avvol	0.007	0.022	0.061	0.007	0.018	0.059	0.013	0.043	0.061
Profits(%)	-0.056	0.288	2.931	- 0.056	0.232	1.447	0.057	0.657	2.931

*In December 2000 R$ million.

Note the striking differences between the sample of successful and canceled auctions, especially with respect to our measures of bidders' participation, dispersion in valuations and

---

[11]Both demand and supply have been adjusted to inflation and are in December/2000 Brazilian "reais" (R$). Comparing with the American dollar, R$ 1.00 was approximately US$ 0.50 in December/2000.

[12]A particular reason to exclude canceled auctions is the fact that measures of profitability are less reliable in these auctions given that bidders may have presented some bids at unrealistic levels.

profitability. This suggests that volatility in the interest rates, possibly due to macroeconomic factors, played a major role in the entry decision of many bidders. It also implies that the treasury would have incurred in higher costs to rollover its debt had it accepted the bids presented in these "unsuccessful" auctions.

We observe that according to our measure of profitability, Brazilian auctions yield relatively high profits to bidders. The average of 23.2 basis points (median of 12.8 b.p.) is significantly higher than levels observed in other countries. There are several factors associated to this abnormal level of profitability. First, our sample covers a very turbulent period that includes major crises in emerging markets and a strong devaluation in the Brazilian currency. As a consequence, market demand for fixed-rate instruments was very limited forcing the treasury even to suspend issues of these types of securities between June of 1998 and March of 1999[13].

Consistent with the argument that bidders were very averse to interest rate risk over our sample period, auctions of securities with above median maturity yielded much higher profits than those of their short-term counterparts. The average profitability of bidders in auctions of longer-term instruments was 36.31 basis points, compared to 13.3 basis points for short-term securities. Although still high for international standards, we note this level of profitability in auctions of short-term securities is lower than the 14 basis points reported by Cherubini et al. (1993) in auctions of Italian fixed-rate securities.

Finally, but not less important, it is possible that our measure of profitability is overestimated. As mentioned previously, PROF does not necessarily reflect actual profits obtained by auction participants. Given that our main purpose is to use

---

[13]It is our intent in future work to extend our sample and cover fixed-rate auctions held from June 1999 to December 2000. We believe lower levels of profitability will be found after including this somewhat less volatile period.

this variable in the examination of relative changes in the level of profitability between auctions, this lack of accuracy is not likely to affect our conclusions. We do not intend to draw inferences regarding absolute levels of profitability in Brazilian auctions.

Besides the variables shown above, the analysis we conduct in sections 5 and 6 includes measures accounting for a bidder's choice of: (i) total quantity bid (QBIDi); (ii) the number of bids to submit (BIDCOUNT); (iii) dispersion among her own bids (BIDSPREAD); and (iv) discount in her bids (BIDDISCOUNT). BIDSPREAD corresponds to the (quantity weighted) standard deviation of prices bid by a bidder in each auction. On the other hand, BIDDISCOUNT is obtained by comparing at each auction the (quantity weighted) average price bid by a bidder to the resale price obtained with the methodology described previously. Table 3 reports the summary statistics of bidder level data.

Table 3 – Summary statistics of bidder level data

| | Successful Auctions | | |
| | (3389 obs.; 168 bidders; 72 auctions) | | |
	Min	Avg.	Max.
$QBID_i^*$	61	122,357	2,656,227
BIDCOUNT	1	2.87	5
BIDSPREAD	0	0.054	0.750
BIDDISCOUNT	-0.162	0.225	3.676
BIDPROFITS	-0.162	0.080	1.229
Participation	1	20.2	69

In December 2000, R$ thousand.

4. Empirical examination with aggregate level data.

In this section we use aggregate level data to conduct an examination of the determinants of bidders' demand and prof-

itability in the auctions of Brazilian Treasury securities. Our main objective is to draw comparisons to results from other studies in the literature that, in most part, also employed aggregate level information. Bidding behavior is examined in more detail in sections 5 and 6 using data on individual bids. Thus, the analysis presented below also allow us to examine some links and gaps that may arise when studying auctions using only aggregate as opposed to individual bids level information.

We start our investigation by using measures of bidders' participation (competition) as dependent variables in a set of OLS regressions against explanatory variables commonly used in the literature. These regressors account for information dispersion and auction characteristics, as described in more detail below. We then proceed to our ultimate objective, which is the analysis of the effects of these measures of competition and information dispersion on bidders' profitability.

As mentioned previously, out of our sample of 86 auctions, 12 auctions had all bids rejected by the treasury. To the extent that determinants of bidders' participation and profitability may have played different roles in these "unsuccessful" auctions, we focus our analysis on the sample of 74 "successful" auctions[14].

4.1. Models of bidders' participation.

The three measures of bidders' participation that we adopt correspond to the total number of bidders in each auction (NBIDDERS), the total amount bid (DEM) and the ratio between total demand and supply (COV.RATIO). These dependent variables are regressed against our proxy for uncertainty

---

[14]For the sake of comparison, we report the regression results including the whole set of 86 auctions only in the analysis of bidders' participation. This is of little use in the models of bidders' profitability, since measures of profitability in unsuccessful auctions are less reliable.

(AVVOL), the size of the auction (SUPPLY), the maturity of the securities auctioned (MAT) and a time trend (TREND). Given that volatility may have distinct effects in the demand for short-term and long-term securities, we also include an inter-action term between volatility and maturity (AVVOL*MAT). These predictors have also been used in previous empirical analysis to provide a rationale for the behavior of measures of bidders' participation in treasury auctions[15].

We control for endogeneity among the explanatory variables by first regressing (log) MAT and AVVOL against a time trend. These detrended variables are the measures of MAT and AVVOL that we adopt in all regressions that follow. Similarly, our measure of SUPPLY is represented by the residuals obtained from a regression of (log) SUPPLY against MAT, AVVOL, MAT*AVVOL and TREND.

One may conjecture that bidders' willingness to participate in treasury auctions for fixed income securities is lower under an environment of higher information dispersion about the levels of futures interest rates. In these circumstances, investors typically face greater risk of winning the auction by placing bids at prices that are too high compared to the average valuation of other bidders. This suggests we should expect a negative correlation between AVVOL and measures of bidders' participation.

In general, there is no theoretical prediction for the sign and significance of the MAT coefficient. However, given the high level of interest rate risk in Brazil, it is common knowledge among treasury auction participants that short-term securities are much more demanded than the long-term counterparts. Therefore, we predict a negative correlation between maturity

---

[15]Gordy (1996) and Nyborg, et al (1998) examine the determinants of quantity bid by bidders, using data on individual bids level. To our knowledge, there are no examples in the literature of a similar analysis with data at the aggregated level. Qualitative results, however, are likely to be similar under both settings.

and bidders' participation in auctions of Brazilian treasury securities.

We expect to find a positive correlation between SUPPLY and our bidders' participation variables. Larger auctions may lead to more active bidding due, for example, to the higher probability of winning the auction or the fact that securities issued in these auctions tend to be more liquid. Another important reason for this positive correlation, however, is that the treasury determines the amount of securities to allocate at its auctions only after consulting with potential bidders. In this respect, there is no clear causality between SUPPLY and measures of bidder's participation. This does not undermine the importance of SUPPLY for purposes of control in our models. Table 4 reports our OLS regressions of bidders' participation.

Table 4 – OLS of (log) demand, (log) number of bidders and (log) coverage ratio

Variables	"Successful" Auctions			"All Auctions"		
	DEM	NBIDDERS	COV.RATIO	DEM	NBIDDERS	COV.RATIO
Intercept	15.518**	3.786**	1.036**	15.385**	3.667**	0.906**
	(175.052)	(54.066)	(12.050)	(188.397)	(53.344)	(11.431)
AVVOL	-13.750	-14.828*	-13.782	-19.599**	-18.782**	-20.465**
	(-1.901)	(-2.478)	(-1.629)	(-4.699)	(-5.140)	(-4.636)
MAT	-0.780**	-0.367**	-0.123	-0.902**	-0.463**	-0.249
	(-6.51)	(-4.832)	(-0.913)	(-7.728)	(-5.468)	(-1.896)
AVVOL*MAT	10.734	-0.397	1.066	-16.982**	-13.92	-26.249*
	(0.511)	(-0.029)	(0.039)	(-1.772)	(-1.194)	(-2.247)
SUPPLY	0.621**	0.457**		0.670**	0.501**	
	(4.534)	(3.355)		(4.929)	(3.533)	
TREND	-8.72E-4	-1.08E-4	2.11E-4	-8.21E-4*	9.62E-6	2.81E-4
	(-3.336)	(-0.511)	(0.713)	(-2.00)	(-0.418)	(0.921)
R^2	0.61	0.45	0.06	0.69	0.59	0.40

t-statistics in parenthesis, based on white heteroskedasticity-consistent standard errors.

*significant at 5% level

** significant at 1% level

Note that most coefficients present signs that are consistent with our predictions. Also observe that significance of most coefficients improves after including "unsuccessful" auctions in the analysis. This is somewhat expected given that the variables under investigation present greater fluctuations after including unsuccessful auctions, yielding stronger results.

Higher dispersion in bidders' valuations seems to reduce bidders' willingness to buy fixed rate securities in the primary market. Despite the limited significance in the first set of regressions, the coefficients of AVVOL are negative in all models shown above. The higher coefficients and significance levels in the second set of regressions indicate that abnormal volatility in futures interest rates, prior to unsuccessful auctions, was a major cause for lower bidders' participation in those events.

Short-term securities are relatively more demanded and attract a broader number of bidders, as suggested by the negative and significant coefficients of MAT in the regressions of DEM and NBIDDERS. However, that MAT is not significant in the coverage ratio regressions indicate that this higher demand for short-term securities does not necessarily translate into more competition (DEM/SUPPLY) for these securities. This is mainly due to the fact that, having good priors about investors' preferences for short-term securities, the treasury adjusts supply accordingly. Consistent with this latter argument, and in line with our expectations, results suggest that auction size is positively correlated to demand and to the number of bidders (SUPPLY is highly significant in all regressions).

4.2. Models of bidders' profitability.

We now proceed to the analysis of bidder's profitability emphasizing the investigation of the effects of dispersion in

valuations and of bidders' participation. In order to check whether conclusions are sensitive to the choice of regressors, we use two common measures of information dispersion (AVVOL and AMPL) and three different proxies for competition (DEM, NBIDDERS and COV.RATIO). The other explanatory variables are identical to the ones used in the analysis of bidders' participation presented above.

Assuming that the use of aggregate level data does not affect the reliability of our interpretations, if bidders behave according to auction theory predictions we would expect them to shade less their bids (have lower profits) in the presence of fiercer competition. This change in bidding behavior is likely to be more pronounced in less liquid markets. Thus negative and significant coefficients for our measures of bidders' participation would indicate that Brazilian treasury auctions are not sufficiently competitive.

Also according to auction theory, information dispersion among bidders' valuations should yield more conservative bidding. Thus if AVVOL and AMPL are good proxies for information dispersion, and the analysis with aggregate level data is adequate, a positive relationship between these variables and bidders' profitability would provide empirical support to the literature.

Table 5 shows the results of the OLS regressions of bidders' profitability. Note that, in comparison to the models studied in the previous subsection, the only differences in the set of explanatory variables are the use of AMPL (instead of AVVOL, in the last three columns) and the inclusion of proxies for bidders' participation. To control for endogeneity among regres-

sors, AMPL is treated as exogenous with respect to the other variables (in the same way as AVVOL), while the measures of participation are represented by the residuals obtained from their corresponding models in table 4[16].

Table 5 – OLS models of bidders' profitability

Variables	Profits	Profits	Profits	Profits	Profits	Profits
Intercept	0.259**	0.259**	0.258**	0.200**	0.200**	0.201**
	(6.974)	(6.948)	(6.867)	(5.980)	(4.083)	(5.771)
AVVOL	0.259**	-3.628	-3.629	-3.614		
	(-1.086)	(-1.094)	(-1.042)			
AMPL				0.186**	0.186*	0.186**
				(4.241)	(2.209)	(3.968)
DEM	-0.103			-0.104		
	(-1.445)			(-1.437)		
NBIDDERS		0.123			0.068	
		(-1.627)			(-0.915)	
COV.RATIO			-0.049			-0.040
			(-0.689)			(-0.640)
MAT	0.267**	0.267**	0.268**	0.295**	0.295**	0.296**
	(4.537)	(4.515)	(4.120)	(4.949)	(5.957)	(4.590)
AVVOL*MAT	-12.846	-12.844	-12.870			
		(-1.211)	(-1.233)	(-1.058)		
SUPPLY	-0.103	-0.103		-0.064	-0.070	
	(-1.895)	(-1.877)		(-1.150)	(-1.165)	
TREND	-1.62E-4	-1.62E-4	-1.65E-4	-2.11E-4	-2.12E-4	-2.14E-4
	(-1.218)	(-1.228)	(-1.247)	(-1.560)	(-1.565)	(-1.576)
R^2	0.35	0.35	0.36	0.36	0.33	0.36

t-statistics in parenthesis, based on white heteroskedasticity-consistent standard errors.

*significant at 5% level

**significant at 1% level

---

[16]If AMPL truly reflects dispersion in valuations among bidders, its level should be exogenous or depend very little on the size of the auction and on bidders' demand. This is a strong and unrealistic assumption, but we find that results are qualitatively unchanged if we treat AMPL as endogenous (i.e., using the residuals of a regression of AMPL against the remaining explanatory variables).

Observe that the two measures of information dispersion in bidder's valuations (AVVOL and AMPL) yield distinct conclusions. While the coefficients of AVVOL provide some weak evidence that bidders' profits are negatively affected by information dispersion, the positive and strongly significant coefficients of AMPL indicate the opposite. This result suggests that the common practice of using these two variables (or slight variations of each) interchangeably may be misleading. Before adopting any of these measures, one should conduct a careful evaluation of whether they are effective proxies for dispersion in bidders' valuations.

Given that futures interest rates are the main determinants in the pricing of government securities, we claim that AVVOL (or possibly other measures of volatility of interest rates) truly proxies for dispersion in bidders' valuations. On the other hand, we are skeptical about the adequacy of AMPL. Using the amplitude between the highest and the lowest winning bids as a proxy for dispersion in valuations is questionable due to its endogeneity with respect to bidders' strategies and auction characteristics, such as investors' demand and the amount of securities auctioned.

In this context, we interpret the results in table 5 as a (weak) indication that bidders' profits decrease with dispersion in valuations. This is in contrast to auction theory predictions and in line with the findings of Scalia (1997) in his study of Italian treasury securities. Moreover, this adverse effect of volatility seems to be stronger in auctions of long-term securities, as it is suggested by the negative coefficients of the interaction term between volatility and maturity.

Evidence that bidders' profits decrease with their level of participation is also weak. Although all measures of bidders' participation present negative coefficients, they have low critical levels. Lack of significance of these measures is usually

interpreted as an indication that auctions are relatively competitive. However, it is also possible that the weak results have been driven by the limited variation in these proxies of bidders' participation during the sample period. Conducting this test with a larger number of observations and (or) with bidder level data would be useful to make more accurate conclusions[17].

Finally, it is worth mentioning the consistently positive and strongly significant coefficients of maturity in all regressions of bidders' profitability. This additional piece of information supports the idea that bidders require a premium to buy securities of longer maturity. Our conclusions remain unchanged if we drop the interaction term between maturity and volatility.

The examination of theoretical predictions regarding bidding behavior presented above suffers from limitations that afflict most empirical studies in the literature of treasury auctions. As mentioned previously, participants in treasury auctions are normally allowed to present several bids. This multiple price-quantity context increases the complexities of bidding strategies considerably as bidders have now the flexibility to adjust to changes in auction settings in several dimensions. To cope with such limitations, we conduct an analysis of individual bidding strategies in the next section.

5. Analysis of bidding behavior at individual bids level.

Participants in treasury auctions establish their bidding strategy by individually choosing their total demand, their number of bids, the dispersion among these bids and their price-quantity levels. The examination of how these choices

---

[17]Including observations from unsuccessful auctions is of little use here, since measures of profitability in these auctions are less reliable. In these auctions bidders may have presented some bids at unrealistic levels, that even to their knowledge had very little probability of acceptance by the treasury.

are affected by variables accounting for valuation asymmetries and competition is the main focus of this section.

Considering only successful auctions, we run a set of panel data regressions in which AVVOL is the proxy for dispersion in bidders' valuations, while competition is represented by the three measures of bidders' participation used in the previous section (NBIDDERS; COV.RATIO; and DEM). The variable DEM is adjusted to represent, for the point of view of each bidder, the total demand of the remaining participants[18]. We define this modified measure of demand as DEM_{-i}.

5.1. Individual bidders' demand.

Table 6 reports the results of panel fixed effects regressions of individual bidder's demand (QBIDi) against the same independent variables used in the analysis with aggregated data. The only difference in the set of explanatory variables is the inclusion of measures of bidders' participation that allow us to draw inferences on how the quantity bid by individual bidders varies with increases in competition.

Note that in comparison to the analysis with aggregate data, the explanatory variables gain significance with the use of data on individual bids. Although results greatly resemble what has been shown in table 6, we are now able to draw enhanced conclusions.

Regarding the effects of competition, evidence suggests a positive correlation between the quantity bid by each bidder and our measures of bidders' participation. That is, $QBID_i$ tend to be higher whenever the number of bidders, coverage ratio or overall demand by other bidders increases. This result is somewhat expected, given that on average an individual

---

[18]That is, for each bidder, her own demand (QBIDi) is subtracted from DEM.

bidder's demand and her motivations to participate in a particular auction are likely to be linked to facts that are common to other bidders.

Table 6 – Panel fixed effects regressions of log $(QBID_i)$
(3389 observations; 168 bidders)

Variables	$QBID_i$	$QBID_i$	$QBID_i$
Intercept	11.168**	11.168**	11.168**
	(474.395)	(472.994)	(468.698)
DEM_I	0.378**		
	(9.854)		
NBIDDERS		0.498**	
		(8.807)	
COV.RATIO			0.228**
			(6.902)
AVVOL	-4.833**	-4.833*	-4.833*
	(-2.016)	(-2.010)	(-1.992)
MAT	-0.368**	-0.368**	-0.368**
	(-11.365)	(-11.332)	(-11.229)
AVVOL*MAT	15.302**	15.302**	15.302**
	(2.598)	(2.590)	(2.567)
SUPPLY	0.185**	0.185**	
	(5.601)	(5.584)	
TREND	-9.81E-4**	-9.81E-4**	-9.81E-4**
	(-10.894)	(-10.862)	(-10.764)

t-statistics in parenthesis.

*significant at 5% level

*significant at 1% level

In line with our previous findings, evidence in table 6 suggests that bidders' demand decreases with dispersion in valuations. However, we observe that the positive and significant coefficient of the interaction term above indicates that the impact

of volatility is stronger in auctions for short-term securities[19]. This may be explained by the fact that on average (keeping volatility constant) bidders' demand for long-term securities is very limited and consequently less sensitive to changes in volatility.

Also in agreement with previous results, the strong and negative coefficients of MAT shown above document the fact that bidders on average prefer short-term fixed-rate securities. Even accounting for the opposite sign of the interaction term, this result suggests that only at abnormally high levels of volatility would long-term securities present similar demand as short-term securities. Moreover, running regressions without the interaction term we find that the coefficients of MAT change very little and remain highly significant.

We finally note that the demand for fixed-rate securities decreased over the period under analysis (TREND is negative and strongly significant). This is probably related to the series of spikes in interest rate levels over the second semester of 1998 and first semester of 1999. As mentioned previously, uncertainty regarding the levels of interest rates became so pronounced in this period that the treasury in several instances was obliged to cancel auctions of fixed-rate securities and issue securities linked to overnight rates.

Although the use of individual bids level data enhanced our analysis of the determinants of bidders' demand to some extent, it is in the examination of bidder's discounts, intra-bidder dispersion and number of bids that rests the great advantage

---

[19]In fact, the overall effect of volatility on bidders' demand ceases to be negative for securities with approximately 170 days to maturity.

of using more detailed information. As we show below, the investigation of these decision variables provides a better understanding of biding behavior in treasury auctions and yields more accurate tests of theoretical predictions.

5.2. Bidders' discounts, intra-bidder dispersion and number of bids.

Following the methodology adopted in the analysis of bidders' demand, we run panel fixed effects regressions of: the number of bids submitted by each bidder (BIDCOUNT); the spread among these bids (BIDSPREAD); and their discount levels (BIDDISCOUNT). Besides the explanatory variables used so far, we include in our regressions the variable QBIDi as a measure of bidders' participation. However, given that this variable is endogenous with respect to the other explanatory variables, it represents the residuals of a regression of QBIDi against the other variables in the model. In other words, we use as an orthogonal measure of QBID its residuals obtained from the model that includes NBIDDERS and the other common explanatory variables presented in table 6. Table 7 shows the regressions that use NBIDDERS as a measure of participation[20].

Observe that most coefficients in the models of BIDCOUNT and BIDSPREAD present identical signs. This is somewhat expected, given that both variables essentially capture dispersion in the bids submitted by each bidder.

---

[20]The regressions that include DEM or COV.RATIO (instead of NBIDDERS) are omitted because they yield essentially identical conclusions.

Table 7 – Panel fixed effects regressions of
BIDSPREAD, BIDCOUNT and BIDDISCOUNT
(3389 observations; 168 bidders)

Variables	BIDSPREAD	BIDCOUNT	BIDDISCOUNT
Intercept	0.045**	2.986**	0.002**
	(29.713)	(111.966)	(44.481)
$QBID_I$	0.016**	0.729**	-1.09E-4**
	(13.788)	(36.611)	(-2.90)
NBIDDERS	0.013**	0.502**	-7.76E-4**
	(3.453)	(7.850)	(-6.470)
AVVOL	-0.301	-6.785*	-0.047**
	(-1.940)	(-2.499)	(-9.229)
MAT	-0.024**	-0.320**	-0.002**
	(-11.440)	(-8.717)	(32.164)
AVVOL*MAT	2.779**	25.077**	-0.105**
	(7.287)	(3.759)	(-8.360)
SUPPLY	-0.028**	0.250**	-001**
	(-13.158)	(6.674)	(-14.412)
TREND	5.20E-5**	-5.42E-4**	-1.18E-7
	(8.921)	(-5.318)	(-0.616)

t-statistics in parenthesis.

*significant at 5% level

*significant at 1% level

In line with Gordy's (1999) results in auctions of Portuguese treasury securities, the positive and significant coefficients of NBIDDERS in the BIDCOUNT and BIDSPREAD regressions suggest that a bidder increases the number of bids (and the spread among them) in more competitive auctions. Theory of common values auctions predicts that fiercer competition magnify winner's curse concerns. Thus, one may infer (as Gordy did) that by adopting this strategy bidders are in fact trying to hedge against the winner's curse. It is worth

mentioning, however, that this behavior may also be due to private components in bidders' valuations. The need to meet reserve requirements, associated with high transaction costs in the secondary markets, for example, may lead bidders to place some bids at high prices in order to assure that they will meet such requirements.

The negative correlation between NBIDDERS and bidders' discounts indicates that Brazilian auctions are relatively illiquid. This conclusion is supported by auction theory predictions that changes in the degree of competition should not affect bidder's discounts in highly competitive markets. Recall that the coefficients of our measures of bidders' participation are not sufficiently significant in the analysis with aggregated data presented in section 4. Therefore, that we are able to reach this conclusion shows that bidder level data provides more powerful tests of bidding behavior.

Regarding the effects of dispersion in bidders' valuations, evidence suggests that in periods of higher volatility in the interest rates, bidders tend to decrease the number of bids, the spread among them, and require lower discounts. The fact that bidders reduce their demand for treasury securities in periods of high dispersion in bidders' valuations is a possible explanation to the negative coefficients of AVVOL in the BIDSPREAD and BIDCOUNT models. Our result however contrasts with those obtained by Gordy (1999) and Nyborg et al. (1998) that find a positive correlation between measures of volatility of interest rates and intra-bidder dispersion (or number of bids). According to these authors this evidence indicate that bidders in Portuguese and Swedish auctions take the winner's curse into account, a conclusion that does not seem to be valid in auctions of Brazilian treasury securities.

That bidders' discounts decrease with information dispersion is also in great contrast to predictions from auction theory.

As discussed previously, higher dispersion in bidders' valuations should yield more conservative bidding under both common and private values settings. Thus, results in table 7 suggest that when valuations are disperse bidders either fail to adjust for the winners' curse or do not take advantage of the fact that they would be able to shade more their bids without hurting considerably their probability of winning the auction.

Although we are mainly interested in analyzing the effects of competition and dispersion in bidders' valuations, interpreting results of other variables brings additional insights to the understanding of bidding behavior in Brazilian treasury auctions.

Changes in the quantity bid by a bidder seem to yield similar behavior from auction participants as when they face higher competition. The coefficients of NBIDDERS and QBIDi have identical signs, but deserve distinct interpretations. That participants usually increase their number of bids (and the spread among them) when their quantity bid is higher is an intuitive result. Auction rules impose minimum limits to the amount a bidder is allowed to bid. This limitation may therefore constrain the submission of a greater number of bids when a bidder's demand is low. Also not surprising is the fact that participants shade less their bids when they have higher demand. Assuming that stronger demand is likely to be positively associated to bidders' willingness to win the auction, one should indeed expect bidders to lower the discounts (increase the prices) on their bids.

The significant coefficients of MAT indicate that bidders' strategies differ in auctions for short-term and long-term securities. Investors tend to submit a lower number of bids (reduce the spread among them) and require higher discounts in auctions of long-term instruments. Once again we believe that the lower intra-bidder spreads and number of bids are due to

the reduced demand for long-term securities. This limited demand and the higher interest rate risk of instruments of longer maturity are possible reasons to the additional premium that investors require in order to buy these securities.

The interaction term coefficients mitigate the effects of AVVOL and MAT in the BIDSPREAD and BIDCOUNT regressions[21]. Taking this interaction into consideration, high volatility seems to significantly reduce the number of bids submitted by a bidder only in auctions of short-term securities. This is in line with the argument that the negative coefficients of AVVOL in those regressions are being driven by higher demand for short-term securities. Similarly, the overall effect of MAT ceases to be significant at high levels of volatility. This is consistent with the fact that, in periods of high volatility, demand for fixed-rate securities is so limited that the difference between the average number of bids presented by bidders in auctions of short-term and long-term securities turns out to be very low.

Finally, we note that the negative coefficient of the interaction term in the BIDDISCOUNT model indicate that the observed reduction in bidders' discounts in periods of high volatility is more pronounced in auctions of long-term bonds. In fact, the typically higher discounts for long-term securities tend to disappear in environments of abnormal volatility.

6. Bidder heterogeneity.

In this section we examine whether different categories of bidders exhibit distinct bidding behavior in Brazilian treasury auctions. Previous studies have suggested that bidding strategies may depend on characteristics of auction participants (see

---

[21]The negative coefficients of AVVOL and MAT in these models turn positive for securities of at least 150 days to maturity, or for AVVOL greater than 0.025, approximately.

Hamao & Jegadeesh (1998) and Hortaçsu (2000), for example), but to our knowledge this is the first paper to address this issue in more detail.

We begin by dividing the set of auction participants according to their institutional category. Commercial banks (CBANKS), investment banks (IBANKS) and brokers are treated as separate groups in the analysis we present in subsection 6.1. The fact that bidding behavior may depend on the nationality of bidders is investigated in subsection 6.2., as we classify banks into national and foreign institutions.

For each category of bidder mentioned above we run panel fixed effects regressions of the type presented in the previous section. Understanding how these groups of bidders react to competition and dispersion in valuations is, once again, our main point of interest. For this reason, we focus our attention in the discussion of the coefficients of AVVOL and NBIDDERS in the models that we present below.

6.1. Differences in strategies of commercial banks, investment banks and brokers.

Commercial banks(CBANKS),investment banks(IBANKS) and Brokers are likely to have distinct motivations to participate in treasury auctions and ultimately present dissimilar strategies. More specifically, the fact that commercial banks usually have larger amounts of deposits indicates that buying treasury securities to hold in their portfolios is an important reason for their participation in the auctions. On the other hand, it is possible that IBANKS and specially brokers are mainly interested in buying these securities to resale in the secondary markets. Table 8 presents the results of our panel regressions of $QBID_i$, BIDCOUNT, BIDSPREAD and BID-DISCOUNT for these three institutional categories.

Results suggest that competition yield little variation in bidding behavior across the three types of bidders. Although there is some evidence that under higher competition brokers (compared to the other two categories of bidders) show lower increases in their spreads and stronger reductions in their discounts, most coefficients of NBIDDERS are too close to discern any distinct patterns in the behavior of these institutions.

It is with respect to dispersion in valuations, however, that these institutions seem to present different bidding strategies. Investment banks are the only category of bidders that reduce their demand significantly during periods of high volatility in the interest rates. The coefficient of AVVOL for IBANKS in the model of QBIDi is much higher (in absolute terms) and significant then the coefficients of the other two types of participants. Note also that, consistent with previous evidence reported throughout this study, discounts of all three types of institutions decrease with volatility. These two pieces of evidence suggest that IBANKS are less afflicted by the lower profits achieved by bidders in auctions with high dispersion in bidders' valuations.

That the demand of CBANKS is relatively inelastic with respect to changes in the volatility level may be due to the possibility that these institutions are mainly interested in buying these securities to hold. For these banks, the risk of incurring in ex-post losses by buying securities in the primary market is very low, given the high amount deposits and fixed-rate investment funds that they offer to their clients. Additionally purchasing securities at the auction may be preferable for CBANKS, considering that the secondary market of these securities is relatively illiquid in Brazil, especially during volatile periods.

Lack of liquidity in the secondary markets may be, for different reasons, also an explanation for the inelastic demand of Brokers. These institutions may find advantageous to buy secu-

rities to resale in the secondary market during volatile periods because lower liquidity and inelastic demand of other investors may help them to extract higher spreads. An alternative explanation relates to the fact that these institutions many times submit bids on behalf of their clients. These clients (pension funds, for example) may be mainly interested in buying these securities to hold in their portfolios and avoid high transactions costs in the secondary market.

In sum the results of our investigation show that it is relevant to take into account that auctions participants may have different investment objectives. We note that, although an improvement over studies with aggregate level data, the analysis that we conduct in section 5 using individual bids data does not yield sufficiently precise conclusions. There is much to gain in the understanding of bidding behavior by analyzing different categories of bidders separately.

6.2. Differences in strategies of Brazilian and foreign banks.

Using analogous methods to the previous subsection, we conduct next an investigation of differences in bidding behavior of Brazilian (NBANKS) and foreign bidders (FBANKS). Bidding behavior may depend on the nationality of a bidder for several reasons, such as differences in their customer base or in their investment style[22]. Table 9 reports our regression results.

Competition seems to yield different reactions from national and foreign bidders. Note that higher competition lead

---

[22]As mentioned previously, Hamao and Jegadeesh (1998) find evidence in Japan that is consistent with this hypothesis. According to the authors their results may be due to several sources of private valuations, correlation in customer demand across Japanese banks or the fact that these banks may use similar instruments to analyze information.

Brazilian banks to spread relatively more their bids and to reduce less their discounts. That NBANKS disperse their bids relatively more than FBANKS do under fiercer competition may be related to some suggestive evidence that their demand also tend to increase in higher proportions than that of FBANKS. However this argument does not seem to be supported by the almost identical coefficients of NBIDDERS in the models of BIDCOUNT[23]. Running regressions of BIDSPREAD against dummies for bidders' nationality (results not shown) we find that on average intra-bidder spreads of FBANKS are higher than that of NBANKS. This fact may be a simpler explanation to the comparatively stronger reaction of NBIDDERS to changes in competition.

The fact that discounts of national banks and foreign banks are reduced in different proportions in more competitive auctions suggest that these two types of institutions may usually place bids at distinct discount levels. More specifically, that foreign banks reduce more their discounts in competitive auctions may signal that on average these institutions shade more their bids.

According to the coefficients of AVVOL in our models, NBANKS (in comparison to FBANKS) react to volatility in interest rates by reducing more their demand, spreading less their bids and presenting a lower number of bids. These three actions are clearly interdependent as lower spreads and number of bids may be in fact due to lower demand. In turn, the higher reduction in demand of national banks for fixed-rate securities may reflect that these institutions are more averse to interest rate risk than are their foreign counterparts.

We also find some evidence that in periods of higher dis-

---

[23]Note also that to foreign banks, their own quantity bid (and not competition, per se) seems to be a more significant factor in their decision to spread more their bids.

persion in bidders' valuations FBANKS tend to present comparatively stronger reduction in discounts. This reinforces our suspicion that the discount levels of these two types of institutions may differ.

In order to examine the issue mentioned above, we run regressions of bidders' discounts against dummies for national and foreign banks[24] and find that discounts of foreign banks are indeed comparatively higher than those observed for national banks. Moreover, after considering auctions of short-term and long-term securities separately, we find that this difference increases with the maturity of the instrument being auctioned.

A related and important question that arises from the discussion above is whether foreign banks realize higher profits than national banks. Using similar methods to the one employed for bidders' discounts, our regressions of profitability confirm that foreign institutions obtain significantly higher profits in auctions of long-term securities[25]. That national banks have lower profits in treasury auctions seem also to be true in Japan (see Hamao and Jegadeesh,1998). Therefore, finding out whether this result hold in other countries is an interesting topic deserving of further investigation in the empirical literature of treasury auctions.

7. Conclusion.

Most empirical studies in the literature of auctions of treasury securities use data on aggregate auction results to examine bidding behavior and to test theoretical predictions. Using

---

[24]Bidder's profitability differs from discount levels in the extent that it only considers winning bids into its computation. Results of our regressions are not shown, but available on request.

[25]We do not find significant differences in the profitability level of national and foreign bidders in auctions of short-term securities. This may be explained by the fact that winning bids in these auctions usually have lower price dispersion.

both aggregate and individual bidder level data to investigate Brazilian treasury auctions we show that more detailed information provides enhanced conclusions and a better understanding of the strategies pursued by bidders in these auctions.

We examine how bidding behavior is affected by the degree of competition and by dispersion in bidders' valuations. Our analysis of the effects of competition suggest that in more competitive auctions bidders tend to reduce their discounts, present a higher number of bids, increase the dispersion among their own bids and demand more securities. The existence of significant negative correlation between discounts and competition indicates that Brazilian auctions are relatively illiquid. On the other hand, that the number of bids (and the dispersion among such bids) increases with competition is in line with previous evidence in Portuguese auctions and consistent with bidders' willingness to hedge against the winner's curse. We argue that this later result may also be due to the existence of private components in bidders' valuations or that it is simply a consequence of their higher demand in more competitive auctions.

Regarding the effects of dispersion in bidders' valuations, evidence suggests that bidders' discounts are lower in periods of higher volatility in the interest rates. This is in sharp contrast to theoretical predictions that in these circumstances bidders should bid more conservatively due to the severe risk of winner's curse or to the fact that there is a greater likelihood of winning the auctions with a shaded bid. We also find that in general bidders tend to lower their quantity bid, present fewer bids and narrow the spreads among their bids in periods of higher dispersion in their valuations.

The later piece of evidence mentioned above, however, does not seem to be robust to all types of bidders. Classifying bidders according to their institutional type and their nationality we find that bidders' reactions to changes in the level of disper-

sion depend on their own characteristics. To the extent that it is common practice in the literature to disregard differences in bidders' types when examining bidding behavior, our result indicates that one should take careful consideration of whether her conclusions apply to distinct categories of auction participants.

We find that foreign institutions obtain higher profits than those achieved by national institutions in Brazilian treasury auctions. This fact is in line with previous evidence in Japan and confirms the relevance of taking differences in bidders' categories into account. Whether national institutions also present significant lower profits elsewhere besides Brazil and Japan is an interesting question deserving of investigation that we leave for future work.

We note that some of our results provide serious doubts to the usual assumption of a common-value framework in treasury auctions. Lower profits under higher dispersion in valuations and the fact that there exist systematic differences in bidding behavior and profitability levels across types of bidders suggest that private components in bidder' valuations may play an important role in Brazilian auctions. As mentioned by Gordy (1999) and Hortaçsu (2000), binding reserve requirements and high transaction costs in secondary markets are examples of possible sources of private valuations that may affect bidders' valuations. Although our conclusions are not definite rejections of the common-value assumption, it is in line with a growing set of evidence in the empirical literature that put its validity into question.

It is worth mentioning that it is our objective to implement some improvements and extensions to our present analysis of bidding behavior. First we intend to include observations from auctions of fixed rate securities held in the Jun/99-Dec/00 period. Besides improving our results a larger sample size will

allow us to examine bidding behavior within groups of short-term and long-term instruments. An interesting extension that we wish to address regards the possible interrelations and differences in bidding strategies across auctions of fixed-rate and floating-rate instruments, usually held simultaneously by the Brazilian treasury.

Submitted in April 2003. Revised in May 2003.

References

Alkan, A. 1991. Treasury Domestic Debt Auctions (Hazine Iç Borç Ihaleleri). Technical Report, Bogazici University.

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

Carson, D. 1959. "Treasury Open Market Operations". *Review of Economics and Statistics*, **41**, 437–442.

Cherubini, U.,C. Govino & R. Hamaui 1993. Liquidita ed efficienza informativa sul mercato dei BTP, In: V. Conti and R. Hamaui (eds.), Il mercato dei titoli di Stato in Italia, Blogna, Il Mulino.

Engelbrecht-Wiggans, R., P. Milgrom & R. Weberr 1983. "Competitive Bidding and Proprietary Information".*Journal of Mathematical Economics*, **11**, 161–169.

Friedman, M. 1959. Constructive Suggestions for Reconciling and Simultaneously Obtaining the Three Objectives of Maximum Employment, Adequate Rate of Growth, and Substantial Stability of the Price Level, In: U.S. Congress, Joint Committee Hearing, Employment, Growth and Price Levels, Part 9A, 86th Congress, First Session.

⸻. 1963. "Price Determination in the United States Treasury Bill Market", A Comment. *Review of Economics and Statistics*, **45**, 318–320.

Goldstein, H. 1962. "The Friedman Proposal for Auctioning Treasury Bills". *Journal of Political Economy*, **70**, 386–92.

Gordy, M. B. 1999. "Hedging Winner's Curse with Multiple Bids: Evidence from Portuguese Treasury Bill Auction". *Review of Economics and Statistics*, **81** (3), 448–465.

Hamao, Y. & N. Jegadeesh 1998. "An Analysis of Bidding in the Japanese Government Bond Auctions". *Journal of Finance*, **53** (2), 755–772.

Hendricks, K. & R. Porter 1989. Collusion in auctions. Working paper (Northwestern University, Evanston, IL).

Hendricks, K., J. Pinkse & R. Porter 1999. Empirical Implications of Equilibrium Bidding in First-Price, Symmetric Common Value Auctions. The Center for the Study of Industrial Organization, Working paper 8, Northwestern University.

Hendricks, K., R. Porter & B. Boudreau 1987. "Information, returns, and bidding behavior in OCS auctions: 1954-1969". *Journal of Industrial Economics*, **35**, 517–542.

Hortaçsu, A. 2000. "Mechanism Choice and Strategic Bidding in Divisible Good Auctions: An Empirical Analysis of the Turkish Treasury Auction Market". Mimeo.

Jegadeesh, Narasimhan 1993. "Treasury auction bids and the Salomon squeeze". *Journal of Finance*, **48**, 1403–1419.

Kahn, C. & A. Silva 2000. A comparative analysis of Brazilian Treasury and Central Bank auctions. Mimeo.

Mcmillan, J., M. Rothschild & R. WILSON 1997. "Market Design and the Spectrum Auctions". *Journal of Economics and Management Strategy*, **6** (3), 425–430.

Milgrom, P. & R. Weber 1982. "A Theory of Auctions and Competitive Bidding". *Econometrica*, **50**, 1089–1122.

Nyborg, K., K. Rydqvist & S. Sundaresan 1998. "Bidder be-

havior in multiple unit auctions: evidence from Swedish Treasury auctions". *Journal of Political Economy*, **110** (2), 394–424.

Rezende, L. 1997. Três artigos sobre leilões de títulos. Dissertação de Mestrado, Departamento de Economia, Pontifícia Universidade Católica do Rio de Janeiro.

Rieber, M. 1965. "Collusion in the Auction Market for Treasury Bills". *Journal of Political Economy*, 72, 509–512.

Scalia, A. 1997. Bidder Profitability under Uniform Price Auctions and Systematic Reopenings: The Case of Italian Treasury Bonds. Banco de Italia, No. 303.

Silva, A. 2003. Structural analysis of multi-unit auctions: recovering bidders' valuations in auctions with dominant bidders. Série Textos para Discussão, Departamento de Economia, Universidade de Brasília, Texto no. 272.

Smith, V. 1966. "Bidding Theory and the Treasury Bill Auction: Does Price Discrimination Increase Bill Prices". *Review of Economics and Statistics*, **48**, 141–146.

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

Umlauf, S. 1993. "An empirical study of the Mexican Treasury bill auction". *Journal of Financial Economics*, **33**, 313–340.

Wilson, R. 1988. Strategic analysis of auctions. Working paper (Stanford University, CA).

Anderson Caputo Silva

Anderson Caputo Silva