ANNALS OF ECONOMICS AND FINANCE **20-1**, 199–220 (2019)

Overpricing in Spanish Treasury Auctions*

Francisco Alvarez and Cristina Mazón†

We find evidence of overpricing in Spanish Treasury auctions: the average price paid by bidders at the auction is higher than the secondary market price of the bond at the auction time. Overpricing is related to overbidding, a problem of the primary dealer structure used in the Euro area to guarantee the liquidity of bonds: on average, bidders bid 52% of quantity demanded at prices higher than the lowest ask price on the secondary market at the time of the auction. Using a panel regression analysis, we find that overpricing increases with overbidding and decreases with secondary market volatility; is related to secondary market price distortions on the auction day, and increases with the bond duration. Finally, the change in regulation concerning the way in which market makers were evaluated, decreases overpricing. We use individual bidding data for 29 auctions held between 2005 and 2007, identifying bidders throughout the auctions.

Key Words: Multi-unit auctions; Treasury auctions; Spanish format; Overpricing; Overbidding.
JEL Classification Numbers: D44, G28.

1. INTRODUCTION

Auction theory predicts that bidders do not expect to make a loss by bidding in an auction. This prediction is a natural consequence of an assumption that underlies most of the theoretical literature: the auction is considered in isolation, with no other payments than those derived from the auction itself. If this is the case, bidders would be willing to participate in an auction only if they expect to have profits.

* We thank E. Martín Quilis and S. Nuñez, both from Secretaría General del Tesoro, for providing the auction data and for insightful conversations. We also thank A. Barge and A. Díaz for helpful comments. Usual disclaimer applies. Both authors have been partially supported by grant ECO2014-56676-C2-2-P, from Ministerio de Economía y Competitividad.

† Alvarez: Department of Economic Analysis and ICAE, Universidad Complutense, 28223 Pozuelo de Alarcon, Madrid, Spain; Mazón: Corresponding author. Department of Economic Analysis and ICAE, Universidad Complutense, 28223 Pozuelo de Alarcon, Madrid, Spain. Email: cmazon@ccee.ucm.es.

1529-7373/2019

In this paper we consider Treasury auctions, that are multi-unit multi-bid auctions; given the complexity of the auction model itself, the auction is usually considered in isolation. The theory predicts that bidders shade their bids, bidding at prices below the expected value of the good, in order to have positive profits; that is, bidders expect to win bonds in the auction at a lower price than the prevailing price in the secondary market. This is usually termed as *underpricing*. Empirical papers present evidence of underpricing in Treasury auction for the U.S., Mexico, Sweden and Finland.[1]

However, there is some evidence of *overpricing*[2] in the Euro area, with the auction price higher than the secondary market price at the time of the auction. Overpricing has been reported for Italy, Austria and Germany.[3] A possible explanation of why bidders are willing to buy at the auction if there is overpricing, is the existence of institutional rules that entail privileges and duties for certain bidders. It follows that a theoretical model of *just the auction* might be neglecting an important aspect of Treasury auctions in Europe, and that the connections between the auction and other markets matters.

In this paper we use an empirical approach to provide evidence of overpricing in Spanish Treasury auctions for bonds, and we do an *ad hoc* panel data regression analysis to determine the potential determinants of overpricing, and to determine if the 2006 policy change concerning the evaluation of bidders was effective in reducing overpricing.

Reporting evidence of overpricing requires to compare auction to secondary market prices, and there are two things to consider at this respect. First, if the auction is not uniform, overpricing is a bidder specific property, and therefore individual allocations and payments per bidder are needed to measure it. This is the case for our data, since the Spanish Treasury uses an hybrid system of uniform and discriminatory auction formats: all bids above the quantity weighted average price of winning bids (WAP) pay the WAP, while winning bids below the WAP pay the bid price. Then per bidder average overpricing could be positive for some or even for all bidders, even if the secondary market price is above the stop-out auction price, the lowest winning bid. Second, in common value auctions, theoretical models assume that the value of the good is unknown at the time of bidding. To accommodate that uncertainty, the prediction from the theory is not that the bidder does not make a loss, but that he does not *expect* to make a loss. According to that prediction, if we observe a bidder's performance over time, we might observe overpricing for some but not for *too*

[1] See Goldreich (2007), Umlauf (1993), Nyborg et al. (2002), and Keloharju et al. (2005) respectively.

[2] This term is from Pacini (2009).

[3] See Pacini (2009), Elsinger and Zulehner (2007) and Rocholl (2006), respectively.

many auctions. Thus, to test the prediction we need to track each bidder's overpricing path over time.

We use data of Spanish Treasury auctions of 3, 5, 10 and 30 year bonds held in 2005 to 2007. We have data for 29 auctions, and for each auction we have all individual bid schedules, with a total of 564 observations. Furthermore, bidders are identified throughout all auctions, so that we can track each bidder's performance over time.

To understand overpricing, we explore the institutional aspects, and the links between the auctions and the secondary market. One key difference between the Euro area and the rest of the world is that debt management offices in the Euro area depend on primary dealers to guarantee the liquidity in their government bonds markets. Primary dealers or market makers are financial institutions whose purpose is to cooperate in the diffusion of government debt; they comply with this arrangement in return for privileges such as exclusive access to recently issued bonds and managership in syndications.[4] These privileges involve profits for the bidders. For example, Coluzzi (2011) prices the exclusive access to recently issued bonds in Italian Treasury auctions as a call option, finding that the option has a value significantly different from zero, a fact that could explain overpricing.

As Dunne et al. (2006) point out, the primary dealers structure leads to market distortions. On the one hand, it leads to *overbidding* in auctions, with dealers often bidding above the market price at the time of the auction in order to fulfill their bidding obligations.[5] If the auction format is uniform, as it is the case for three euro-zone countries for some of their issues,[6] with all bidders paying the same price for all the units at the auction, the stop-out price, overbidding could not be a problem, if the stop-out price paid is low enough.[7] However, if the auction format is discriminatory, with bidders paying their price bid, as it is the case for most of the euro-zone countries,[8] or an hybrid between the uniform and the discriminatory formats, as in the Spanish case, overbidding could result in overpricing, with auction participants paying a higher price at the auction that the one they

[4]See Arnone and Iden (2003) for a comprehensive analysis of the role of primary dealers in the management of government debt.

[5]See `http://www.privatizationbarometer.it/news.php?lang=en&id=9389` for an example of overbidding for Greek bonds: "A hugely overbid Greek government bond auction Tuesday triggered the anger of some primary dealers but also revealed the huge competition among banks for business from euro-zone governments."

[6]Finland, Italy and The Netherlands.

[7]Goldreich (2007) compares underpricing for uniform and discriminatory Treasury auctions in the U.S. and finds that underpricing is reduced by half with the uniform format relatively to the discriminatory format.

[8]Austria, Belgium, France, Germany, Greece, Ireland, Luxembourg and Portugal.

could have paid buying exactly the same bond at the same time in the secondary market, and therefore, incurring losses at the auction stage.[9]

On the other hand, overpricing could be related to price distortions on the secondary market for government debt. One of the dealers' obligations is to guarantee the liquidity of the secondary market, having listing obligations, and they could have incentives to distort the secondary market price. Pacini (2009), for Treasury auctions in Italy and France, documents the existence of a v-effect, secondary market prices on the auction date that move with a V-shape, with the lower price at the auction time. If there is a v-effect, the Treasury could use his discretion in choosing the quantity awarded to set a stop-out price higher than the secondary market price, resulting in overpricing.

Our main results are as follows. First, we provide evidence of overpricing for Spanish Treasury bond auctions: on average, bidders pay 0.33 Euros more for a 1,000 Euros bond at the auction than the price of the same bond on the secondary market at the time of the auction. Furthermore, in all auctions but two in our sample, overpricing is positive for all bidders. We also find evidence of overbidding: on average, bidders bid 52% of the quantity demanded at prices higher than the lowest ask price on the secondary market at the time of the auction, and for 36% of our observations overbidding is 100%. Next, we consider other possible determinants of overpricing, besides overbidding: secondary market volatility and the v-effect. Results from Alvarez and Mazón (2016) indicate that bidders increase bid shading as volatility increases, and as a consequence overpricing decreases; we provide graphical evidence that this is the case for our sample. We also provide graphical evidence that overpricing increases with the v-effect. Finally we do a regression analysis to determine the determinants of overpricing, exploiting the panel structure of the data. We find that overpricing increases with overbidding and with the v-effect, and decreases with secondary market volatility, as expected. Overpricing is positively related to the percentage of the quantity won as non-competitive bid, since for that quantity bidders pay the highest price, the weighted average price of winning bids, and therefore have the maximum overpricing. Overpricing increases with the bond duration, and the change in regulation concerning the way in which market makers are evaluated, decreased overpricing.

[9] All but 3 of the auctions in our sample are reopenings, so that exactly the same bond is sold at the auction and at the secondary market. Going back to the Greek example, "The Greek Public Debt Management Agency (PDMA) sold EUR 1.2 billion of 3.6% 10-year bonds at an average weighted price of 97.421, or 48 cents above the market price for the bonds just before the auction.(. . .) The reason for the overbidding, say dealers, is that this was the final 10-year bond auction of the year and provided one of the last opportunities for banks to improve their position in the PDMA's 2006 dealer rankings, which are produced in January."

Our paper relates to the literature analyzing the primary dealers structure, mainly empirical papers with different auction formats. Pacini (2009) explores how the institutional details to place Government securities adopted by Eurozone countries affects both the secondary market and the auctions, in 12 countries using different auction formats, including Spain. Using data for 2004, he finds evidence of overpricing for 97% of all the auctions considered. He uses an empirical *ad hoc* estimation to identify the determinants of overpricing, concluding that overpricing is not a success of the issuing technique or the result of the discretion enjoyed by some Treasuries, but rather a consequence of the Treasuries bundling the securities auctioned with a number of commodities, such as the syndication rights. The main differences with our paper is that he uses aggregate data for each auction for 12 countries in one year, while we use individual bidder data for Spanish Treasury auctions for three years, so that we have a measure of each bidder's overpricing over time. Also Sareen (2009), using data from Treasury auctions in Canada, finds that the participation in the auctions depends critically on other compensations, suggesting that a model of commodity bundling is needed to understand government Treasury auctions.

Our paper also relates to the literature that analyze jointly dealers' trades in the secondary market and bids in the primary market for Treasury bonds, as Drudi and Massa (2005) does for the Italian market, using data from September 1994 to February 1996. They provide evidence of price manipulation in the secondary market: primary dealers use the more transparent market (the secondary market) to manipulate prices in the less transparent one (the auction). They find that informed dealers place sell orders in the secondary market when they have a higher information advantage. At the same time, the aggressively place bids in the auction, and buy back in the secondary market when the auction closes. This strategy generates losses in the secondary market for the period when the primary market is open, then produces gains once it closes. They use a unique data set of the Italian bond market. For the secondary market they have all transactions, with detailed information including the identification of the dealer who originated the transaction. Unfortunately, we do not have such detailed information for the secondary market.

Some empirical papers document the existence of an "auction cycle", in which bond yields show an inverted V-shaped pattern around the auction date, related to the inventory management operations of the primary dealers. Fleming and Rosenberg (2007) and Lou et al. (2013) find an auction cycle in the US treasury bond market, and Beetsma et al. (2016) for Italy, mainly observed for the crisis period since mid-2007, with volatility as the main driving factor. Note that this is different than the v-effect that we consider, that is on the auction day, and explained by market manipulation.

Alvarez and Mazón (2016), using data for Spanish Treasury auctions held in 2003 to 2007, test empirically the implications of two multi-unit common value models with private information with an analytical characterization of the equilibrium strategies. Specifically, they analyze how uncertainty about the value of the good, measured by the secondary market of government debt price's volatility, affects bidding behavior and the auction's outcome. They provide evidence that, as the theoretical models predict, the heterogeneity of bidders' bid shading increases with volatility and that, on average across auctions, bid shading and bidders' profit also increase with volatility.[10] In contrast, in this paper we investigate the determinants of overpricing, and exploit the fact that we have individual bidding data and can identify bidders through the auctions.

The paper is organized as follows. Section 2 describes the institutional background and the data used, Section 3 presents evidence of overpricing and overbidding for Spanish Treasury auctions, and considers possible determinants of overpricing, and Section 4 presents the econometric implementation. Finally, Section 5 concludes the paper.

2. INSTITUTIONAL BACKGROUND AND DATA

The Spanish Treasury[11] uses a unique auction format to sell government bonds, the hybrid or Spanish auction, that combines elements of the uniform and the discriminatory format. In the uniform, discriminatory and Spanish formats bidders submit multiple price-quantity pairs as their bids. The bids are classified by descending order of price and the Treasury decides, on the basis of the last bid admitted, the stop-out price. All bids at or above the stop-out price are accepted,[12] and the prices paid depend on the auction format. While in the uniform auction bidders pay the stop-out price for every unit won, in the discriminatory auction bidders pay their bid for each unit won, and in the Spanish auction, bidders pay their bid for bids between the weighted average price of winning bids (WAP) and the stop-out price, and they pay the WAP for bids higher than the WAP.

Any investor can submit one or multiple bids for Treasury bonds in the auctions, although most bids are made by primary dealers.[13] Bids for bonds must be made for at least 1,000 Euros, or a multiple of this minimum amount, and are either competitive, specifying both the quantity desired

[10]Profit is defined as minus overpricing.

[11]This Section follows closely Alvarez and Mazón (2016); the data set that we use in this paper is part of the data set used in that paper.

[12]Unless quantity demanded exceeds quantity supplied at the stop-out price; in that case, a pro rata formula is used, affecting only bids made at the stop-out price.

[13]They bought, on average for our sample, 96.8% of issued bonds.

and the price, or non-competitive, specifying only the quantity desired. Non-competitive bids are accepted in full and pay the WAP.

To qualify as a primary dealer, institutions must apply to the Treasury and fulfill some requirements. One of them, probably related with overbidding, is that they have to present at each auction requests for a minimal nominal value of 3 per cent of the amount sold by the Treasury for each type of instrument, at prices not less than the stop-out price less 5 cents for three year bonds, 10 cents for five years, 15 cents for ten years and 30 cents for bonds with maturity over 10 years. Additionally, they have to guarantee the liquidity of the secondary market, with listing obligations. As a compensation, they may present requests on the day of the auction until the time of the auction. They also have exclusive access to the second rounds, carried out between the resolution of the auction and the twelve hours of the working day before the issue is put into circulation. The amount that each bidder can win on the second round depends on his participation in winning bids on that initial auction and the previous auction of similar characteristics. Bidders pay the highest auction price paid in the second round of the auction, the WAP. In the period considered, there were 20 primary dealers for bonds.

The Treasury may sell new securities or additional amounts of securities that are already traded on the secondary market, what is known as reopenings or issuance by tranches. There are reopenings until the issue size approaches 10 billion Euros to 15 billion Euros. Each security is identified by an ISIN code.

2.1. Auction Data

We use a data set supplied by the Spanish Treasury, which contains all the bids made by primary dealers in 29 bond auctions of 3, 5, 10 and 30 years held between January 2005 and December 2007, with a total of 564 observations.[14] For each auction the data includes an anonymous identification code for the bidder, quantity and price bids, quantity accepted, and price paid for each winning bid. Of the 29 auctions in our sample, only 3 are first tranch, so that the other 26 auctions are reopenings, with the Treasury issuing additional amounts of a previously issued bond.

2.2. Secondary Market Data

We use data from MTS, one of Europe's leading electronic fixed income trading markets, and from the Bank of Spain, that we describe below.

[14]There were 46 auctions for these types of bonds over that period; however, for 17 of them either we do not have reliable auction data or there were no secondary market transactions around the auction, so that we do not have a measure of overpricing.

2.2.1. *Data from MTS*

MTS is an electronic platform on the first-tier or *blind market*, in which trades are conducted without the knowledge of the counter party identity. Transaction size is a minimum of 5 million Euros. It is the platform with the highest volume of trading for Spanish government securities for 2005 and 2007. MTS provides data for Fills and Best Proposals. Fills contain information on trades carried out by MTS for all Spanish Treasury bonds. Best Proposals includes every submitted quote that improves price and/or size for the top three bid and ask prices in the market.

2.2.2. *Data from the Bank of Spain*

Data from the Bank of Spain include all spot transactions in single operations in *Mercado de Deuda Publica Anotada*.[15] For each issue and trading day, the Bank of Spain publishes information on the number of transactions, the nominal and effective traded volume, and the maximum, minimum and average price and yield at which trade takes place. The data includes both operations between market members and between market members and third parties.

3. OVERPRICING AND OVERBIDDING

We define overpricing as the difference between the bidder's average price paid at the auction and the secondary market price of the underlying security at the time of the auction. A precise definition of overpricing and all other variables is provided in Table 1. We set overpricing equal to zero for observations in which the bidder bids but do not win any bonds at the auction.[16] Overpricing is a bidder specific variable, and we denote by $OP(i, a)$ the overpricing of bidder i in auction a.[17]

Overpricing is positive for all bidders in all auctions but two.[18] Table 2, shows summary statistics of overpricing per bidder. Average overpricing

[15] `http://www.bde.es/webbde/es/secciones/informes/banota/series.html`, files `CONTYYYY.TXT`.

[16] On average, there are 2.8 bidders per auction in such a situation, with a total of 81, a mode of 2, a maximum of 7 (for a 30 years bond) and a minimum of 0. The regression analysis that follows is robust to the exclusion of these observations.

[17] In the panel data analysis that follows, the index a will play the role of time. Note that within our sample there are no two auctions held on the same day. However, we refer to auctions instead of time to emphasize that auctions are not equispaced along time.

[18] For two 10 year bonds; in bond ES00000120J8, tranch 4, held on 19-07-2007, overpricing is negative for all bidders, and in bond ES0000012783, tranch 14, held on 17-02-2005, overpricing is negative for 4 bidders.

TABLE 1.

Definition of variables

Name	Notation	Definition
Overpricing	$OP(i,a)$	Auction price minus secondary market price at the time of the auction. For the auction price we use the bidder's quantity weighted average price paid on winning bids. For the secondary market price we use the price of the transaction closest to the auction time on the interval [−10 minutes, +10 minutes], using Fills from MTS. Since prices both for the primary and the secondary market are in percentages, and the bond denomination is 1,000 Euros, we multiplied by 10 overpricing, and we have, in Euros, the magnitude of overpricing per 1,000 Euros bond.
Overbidding	$OB(i,a)$	The percentage of the total quantity demanded by the bidder at prices above the lowest ask price in the secondary market at the time of the auction, using data from MTS Best proposals (AskPrice1).
v-effect	Dum$V(a)$	We use the lowest ask price from Best proposals from MTS (AskPrice1). We calculate the quantity weighted average price on five minute intervals; then we calculate the average on the 10 minutes around the auction $[-5,5)$. $DumV(a)$ is equal to 1 if the average price in the interval $[-10,-5)$ and in the interval $[5,10)$ are both greater than the average in the interval $[-5,5)$. We use only prices until 10 minutes after the auction because the announcement of the auction results are made in the interval $[+10,+20)$.
Volatility	$Vo(a)$	We use secondary market data from the Bank of Spain to construct a volatility time series for bonds. We estimate volatility as an ARCH(1) model of returns. There are 8 ISIN codes in our sample, and we estimate a different model for each of them. We assume that bond returns follow a random walk with constant drift a, $$\frac{P_t - P_{t-1} + A}{P_{t-1}} = a + e_t$$ where P_t is the bond price at time t and A is the one-day accrued interest for a coupon.

is positive for all bidders, with an average of 0.33 Euros per 1,000 Euros bond, a maximum of 1.13 and a minimum of -0.6; the average of the first quartile is 0.20 Euros. Figures 1 and 2 show the basic characteristics of overpricing. Bidders are labeled as $tb1$ to $tb22$.[19] The boxplot, Figure 1, shows the variability of overpricing across bidders. In addition, the heat map, Figure 2, shows that level of overpricing is stable over time for each

[19]Remember that there are 20 bidders at each auction, but in June 2006 one institution loss the market maker condition and was substituted for a different one.

FIG. 1. Boxplot of overpricing.

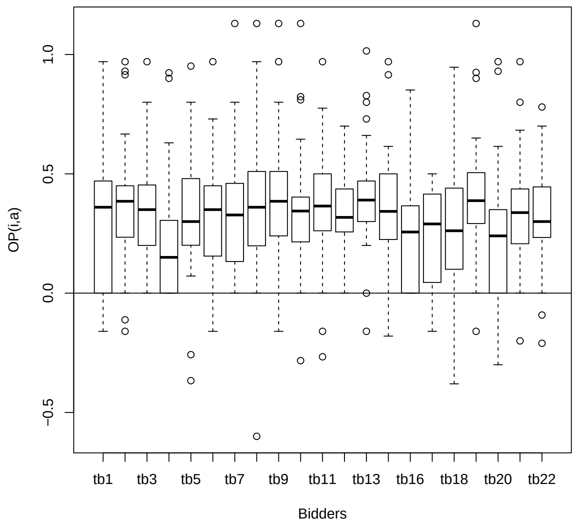
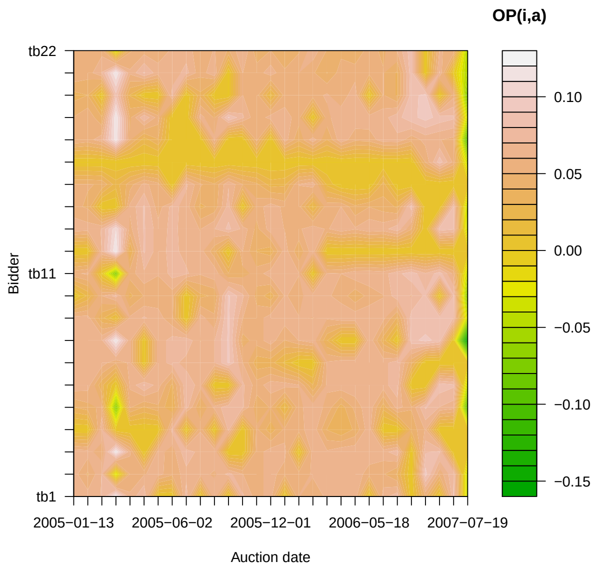


FIG. 2. Heatmap of overpricing.



bidder, as the color of each row, that correspond to a bidder, does not change much.

TABLE 2.

Summary statistics per bidder for overpricing

Bidder	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
tb1	−0.16	0.00	0.36	0.32	0.47	0.97
tb2	−0.16	0.23	0.39	0.38	0.45	0.97
tb3	0.00	0.20	0.35	0.34	0.45	0.97
tb4	0.00	0.00	0.15	0.21	0.30	0.92
tb5	−0.37	0.20	0.30	0.33	0.48	0.95
tb6	−0.16	0.16	0.35	0.32	0.45	0.97
tb7	0.00	0.16	0.33	0.34	0.46	1.13
tb8	−0.60	0.20	0.36	0.37	0.51	1.13
tb9	−0.16	0.24	0.39	0.41	0.51	1.13
tb10	−0.28	0.22	0.34	0.34	0.40	1.13
tb11	−0.27	0.26	0.36	0.37	0.50	0.97
tb12	0.00	0.26	0.32	0.32	0.43	0.70
tb13	−0.16	0.30	0.39	0.41	0.47	1.01
tb15	−0.18	0.23	0.34	0.35	0.47	0.97
tb16	0.00	0.02	0.26	0.27	0.36	0.85
tb17	−0.16	0.15	0.29	0.23	0.37	0.50
tb18	−0.38	0.10	0.26	0.28	0.44	0.95
tb19	−0.16	0.31	0.39	0.42	0.50	1.13
tb20	−0.30	0.00	0.24	0.24	0.35	0.97
tb21	−0.20	0.21	0.34	0.34	0.44	0.97
tb22	−0.21	0.23	0.30	0.32	0.45	0.78
Total	−0.60	0.20	0.33	0.33	0.45	1.13

These results are on line with Pacini (2009), that reports average overpricing for Treasury auctions in the European Economic Union in 2004, including Spain, and with Rocholl (2006), that for German Treasury auctions, reports a negative although statistically insignificant average maximum profit, defined as the difference between the secondary market price and the auction price for most auctions at bidding time.[20] Gordy (1999) also finds overpricing for Portuguese Treasury bill auctions.

Overpricing is related to overbidding, the percentage of quantity demanded at price bids above the secondary market ask price at the time of

[20]Profit is minus overpricing. Maximum, because although Treasury auctions in Germany are discriminatory, Rocholl reports the difference between the market price of the security and the auction clearing price, lower than the quantity weighted price of winning bids that we use as the auction price.

the auction. We denote by $OB(i, a)$ the overbidding of bidder i in auction a. Table 3 provides some basic statistics on overbidding per bidder. On average, bidders bid 52% of quantity demanded above the lowest ask price at the time of time of the auction, and the third quartile is equal to 100 for 11 of the 22 bidders in our sample.[21]

TABLE 3.

Summary statistics per bidder for overbidding

Bidder	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
tb1	0.00	0.00	0.00	6.76	0.00	100.00
tb2	0.00	33.33	55.56	53.29	75.00	100.00
tb3	0.00	0.00	0.00	12.96	0.00	100.00
tb4	0.00	0.00	12.50	29.98	60.00	100.00
tb5	0.00	60.00	100.00	73.43	100.00	100.00
tb6	0.00	0.00	0.00	6.95	0.00	100.00
tb7	0.00	0.00	0.00	12.83	7.50	100.00
tb8	0.00	0.00	0.00	21.96	25.00	100.00
tb9	0.00	69.70	100.00	84.68	100.00	100.00
tb10	0.00	51.62	76.39	70.54	100.00	100.00
tb11	0.00	50.00	100.00	76.03	100.00	100.00
tb12	0.00	12.50	100.00	69.44	100.00	100.00
tb13	0.00	75.00	100.00	79.16	100.00	100.00
tb15	0.00	33.33	55.00	59.06	79.57	100.00
tb16	0.00	5.00	50.00	54.02	100.00	100.00
tb17	0.00	32.14	46.43	48.21	62.50	100.00
tb18	0.00	17.65	37.50	45.33	75.00	100.00
tb19	0.00	100.00	100.00	84.82	100.00	100.00
tb20	0.00	0.00	50.00	51.87	100.00	100.00
tb21	0.00	100.00	100.00	86.37	100.00	100.00
tb22	0.00	37.50	77.27	69.06	100.00	100.00
Total	0.00	0.00	52.98	52.00	100.00	100.00

It is plausible that bidders overbid to fulfill their bidding obligations. An additional reason for overbidding is that bidders are ranked by performance in the auction, and only the top ranked are chosen to carry out debt management deals. Specifically, the Spanish Treasury chooses the counter parties for debt management and allocation operations, such as syndicated issues, financial exchange transactions and foreign currency issues, among the top ranked bond primary dealers. According to Pacini (2009), the belief that overbidding was closely related with the aim of scaling up in the rank-

[21]Remember that market makers can place bids until the time of the auction.

ing was the reason of the change in the regulation concerning syndication in Spain in 2006. Until then, the top five or six institutions from the previous year were selected as book-runners. Starting from 2006, however, they were selected from the top ten, and the evaluation of the bidders changed, considering also the regularity of the participation. In the next Section, we investigate if the change in regulation had an effect on overpricing. Other privilege of market markets are participation on second rounds of the auctions, and part of the allocations on those second rounds also depend on the ranking.

Figure 3 illustrates the basic relationship between overbidding, represented on the horizontal axis, and overpricing, represented on the vertical axis. Note that of the 564 observations in our data set, most of them have the minimum or the maximum overbidding: overbidding is equal to 0 for 32% and is equal to 100% for 36% of the observations. For those observations, the rank of overpricing is large. The red line is the regression line, suggesting a positive correlation between overbidding and overpricing.

3.1. Other determinants of overpricing

Next, we consider other variables that could determine overpricing, besides overbidding.

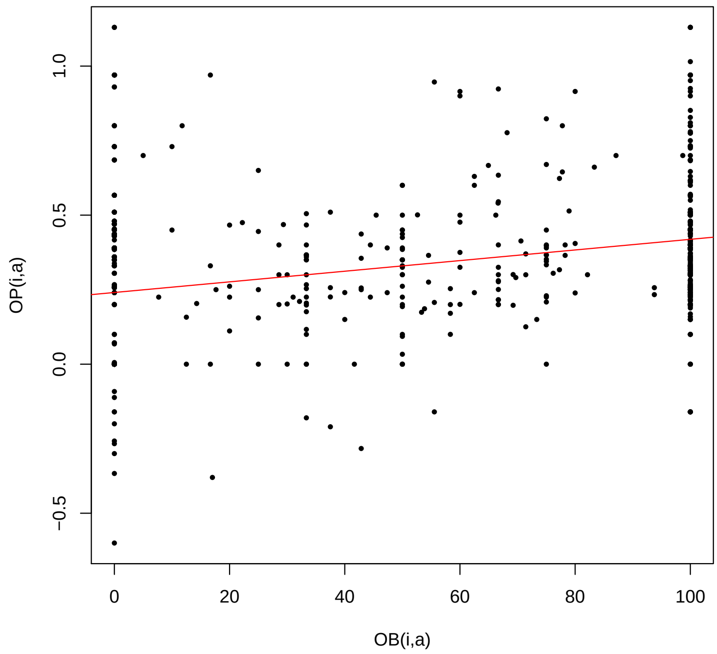
3.1.1. Secondary market volatility

Alvarez and Mazón (2016) find that bid shading or discount, the difference between the expected value of the good at the time of bidding and the price bids, increases with secondary market volatility. Since bid shading increases with volatility, overbidding decreases and therefore overpricing should also decrease. Therefore we expect a negative relationship between volatility and overpricing. To measure secondary market volatility, denoted by $Vo(a)$ for auction a, we follow a standard ARCH approach.[22]

Figure 4 decouples the histogram of overpricing in two, for auctions with low and high volatility, represented in blue and pink, respectively. Low and high volatility auctions are auctions in which the estimated volatility for the auction day is below the percentile 30% or above the percentile 70%, respectively. Note that there are two modes, one at zero, for bidders that do not win any bond at the auction, for which we have set overpricing equal to zero, independent of secondary market volatility; and one at a positive value of overpricing. The Figure illustrates that as volatility increases, overpricing increases for bidders that win a positive quantity of bonds at

[22]See Alvarez and Mazón (2016) and Keloharju et al. (2005).

FIG. 3. $OB(i,a)$ vs. $OP(i,a)$. Each point in the Figure represents the value of these two variables for bidder i in auction a.



the auction. Additionally, note that volatility affects not only the first but also the second order moment of the overpricing distribution: the variance of overpricing is higher for auctions with high volatility. In the next Section we use panel data regressions to analyze the effect on overpricing of just the first order moment, and the Figure, contrary to the previous argument, suggest a positive estimated sign for the coefficient of $Vo(a)$.

3.1.2. V-effect

Overbidding, and therefore overpricing, could be related with the v-effect, that could be caused by market manipulation. As we have already mentioned, Pacini (2009) finds evidence of a v-effect in Treasury auction in the Eurozone, with secondary market price movements that show a V-shape on the auction day, with the lower price at the auction time; and

FIG. 4. Decoupling $OP(i,a)$ with $Vo(a)$.

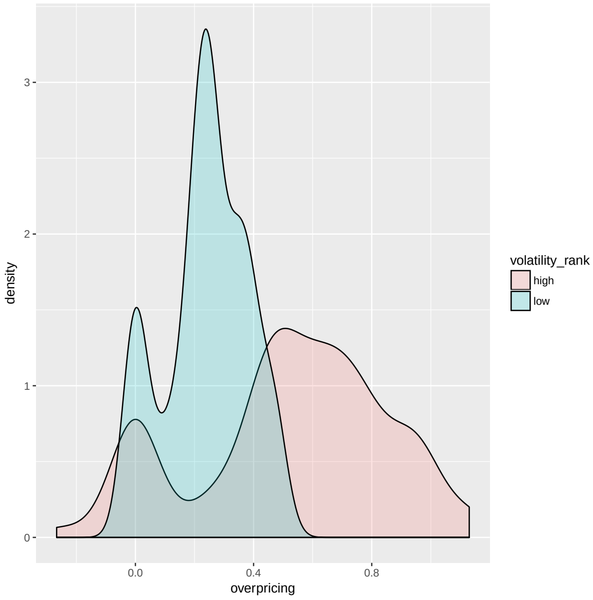
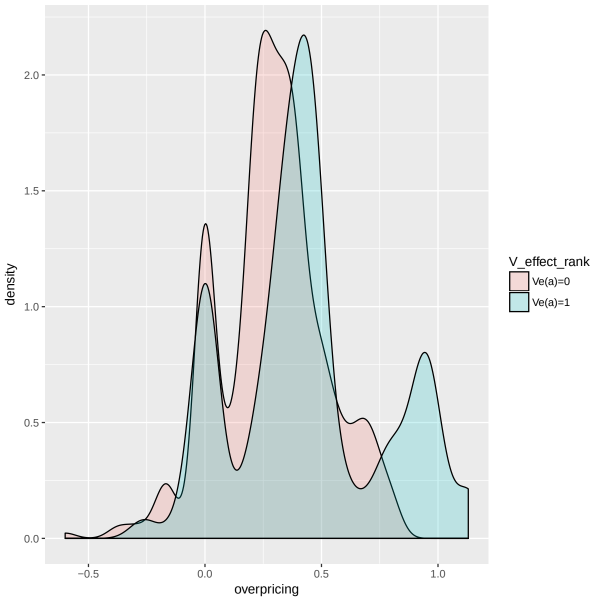


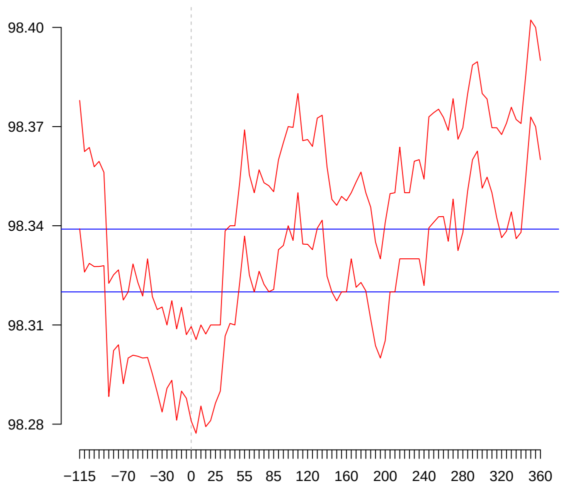
FIG. 5. Decoupling $OP(i,a)$ with $DumV(a)$.



Drudi and Massa (2005) provides evidence of price manipulation in the secondary market for Italian Treasury bonds.

As an example of the v-effect, Figure 6 plots bid and ask prices for a bond on the day of the auction, using data from MTS Best proposal, for a particular auction in our sample. The horizontal axis represents five-minute intervals around the auction time, and the vertical axis average price on the five minute intervals. The stop-out price and the weighted average price of winning bids are represented by horizontal lines, and the auction time by a vertical line at zero. For the bond considered, both bid and ask prices decrease prior to the auction time and increase afterwards, and the Treasury chose as the stop-out price a price higher than the ask price at the time of the auction.

FIG. 6. Bid and ask price the day of the auction. The horizontal axis represents five-minute intervals around the auction time. The stop-out price and quantity weighted average price are represented by horizontal lines and the auction time by a vertical line. (Bond code ES00000120E9, tranch 6.)



Unfortunately, the v-effect is not in all cases as clear as in Figure 6. To capture it, we define a dummy variable that takes the value 1 if there is a V-shaped secondary market price path around the auction time. We denote that variable by $DumV(a)$, where the notation emphasizes that it is a property of the auction. Within our sample, we have $DumV(a) = 1$ for nine of the 29 auctions.

If there is a v-effect, the Treasury could use his discretion to choose a stop-out price above the secondary market price at the time of the auction, and there would be overpricing. Figure 5 accounts for this fact. It presents the histogram of overpricing for the whole sample, decoupled in two: in pink and blue, respectively, for auctions with no and with v-effect, i.e., for auctions in which $DumV(a) = 0$ and $DumV(a) = 1$. Note that as with volatility in the previous Subsection, the histogram has two modes, one at zero and one at a positive value, and the mode at zero is independent of the path of the secondary market price. However, for bidders with positive overpricing, overpricing is higher in auctions with a v-effect. This suggests a positive sign of the estimated coefficient of $DumV(a)$ in the panel data estimation in the next Section.

3.1.3. Other variables

Additional variables of potential interest for the regression analysis, are as follows. First, note that in some auctions there are two types of bidder with the maximum overpricing, those that bid for all their winning bids at prices higher than the average price of winning bids (WAP), and therefore paid the WAP for all units, and those that only win the non-competitive bid, and also pay the WAP. To control for these two types of bidders, we include for each bidder the percentage of the quantity won as no-competitive of the total quantity won. For bidders that only win the non-competitive bid, that percentage is 100%. We denote the variable by $\%QNC(i, a)$, for bidder i in auction a. We expect the estimated coefficient to be positive.

Second, we include dummies, for bond type, generically denoted $DumBxx(a)$ for a xx year bond, and for the change in the regulation on the ranking of bidders, $DumReg(a)$. The dummy variable is equal to 1 for 2006 and 2007, with the new regulation, and 0 for the previous years.

4. ECONOMETRIC IMPLEMENTATION

We use panel data to control for the individual heterogeneity of bidders, using the plm package in R.

Table 4 presents the estimates for three different specifications, with overpricing, $OP(i, a)$, as the dependent variable. All three specifications include as regressors overbidding, $OB(i, a)$, and volatility, $Vo(a)$, and the dummy variables for bond type, $DumB5(a)$, $DumB10(a)$ and $DumB30(a)$, and for the change in regulation, $DumReg(a)$ and they differ in the inclusion of additional variables.

TABLE 4.

Regressions of overpricing

	Dependent variable:		
	$OP(i,a)$		
	Random Effects	Pooled OLS	Pooled OLS
	(1)	(2)	(3)
$OB(i,a)$	0.002^{***}	0.004^{***}	0.004^{***}
	(0.0003)	(0.0002)	(0.0002)
$Vo(a)$	-0.566^{*}	-0.699^{***}	-0.753^{***}
	(0.335)	(0.233)	(0.228)
$DumB5(a)$	0.060^{**}	0.081^{***}	0.072^{***}
	(0.027)	(0.022)	(0.022)
$DumB10(a)$	0.277^{***}	0.313^{***}	0.307^{***}
	(0.062)	(0.044)	(0.044)
$DumB30(a)$	0.685^{***}	0.812^{***}	0.798^{***}
	(0.238)	(0.170)	(0.170)
$DumReg(a)$	-0.148^{***}	-0.139^{***}	-0.138^{***}
	(0.019)	(0.015)	(0.016)
$QNC(i,a)$		0.004^{***}	0.004^{***}
		(0.0002)	(0.0002)
$DumV(a)$			0.055^{***}
			(0.010)
Constant	0.246^{***}	0.072^{***}	0.071^{***}
	(0.040)	(0.023)	(0.022)
Observations	564	564	564
R^2	0.292	0.520	0.527
Adjusted R^2	0.284	0.514	0.520
F Statistic	38.217^{***} (df = 6; 557)	86.077^{***} (df = 7; 556)	77.192^{***} (df = 8; 555)

Note: * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$

For the three specifications we estimate a fixed effect model, OLS, a random effects model and a pooled model, and run test to choose between the different models. We present a random effect model for the first specification, and a pooled model for the other two, as we explain later.

For the three regressions, the estimated coefficients of the common regressors are robust to all specifications. Overbidding, $OB(i,a)$, has a significant and positive estimated coefficient, as expected: the higher the percentage of total quantity demanded at prices above the ask price at the time of bidding, the higher the overpricing. The fact that bidders place high bids, probably to fulfill their requirements as market makers, results in overpricing.

The estimated coefficient for the uncertainty about the value of the good being auctioned, proxied by volatility, $Vo(a)$, has the predicted negative sign, that is significantly different than zero. Alvarez and Mazón (2016) predict that bidders increase bid shading as volatility increases, hedging the winner's curse.[23] As a result, overpricing decreases with volatility.

Also common to the three specifications, the dummy variables for bond types have positive and significant estimated coefficients: overpricing is increasing in the bond duration, and is higher for 30 years bonds than for 10 years bonds, that in turn is higher than for 5 years bonds, that in turn is higher than for 3 years bonds. Finally, the dummy variable for the change in regulation, $DumReg(a)$, has a negative and significant estimated coefficient: overpricing decreased when the Treasury started considering also the regularity of the participation to rank market makers.

In the first specification, we present the random effect model, with heteroskedasticity consistent standard errors. The reason is that when comparing the fixed effect model to the OLS estimation, the F test for individual effects, with a p-value of 0.001, states that individual effects are significant; and the Hausman test of fixed versus random effects, with a p-value of 0.61 accepts the null hypothesis that both models are consistent, and the efficient model is the random effect model.

To control for the fact that on each auction there are possibly two groups of bidders with the maximum overpricing, specification (2) includes the percentage of the quantity awarded as no-competitive, $\%QNC(i,a)$, as an additional regressor. For this specification, the F test for individual effects, with a p-value of 0.37, indicates that there are no individual effects: the additional variable captures them. We present the pooling model, heteroskedasticity consistent standard errors, given that the estimated variance of individual effects is negative in the random effect model. As expected, the estimated coefficient for $\%QNC(i,a)$ is positive and significantly different than zero: overpricing increases with the quantity awarded as no-competitive bid.[24]

Finally, specification (3) includes the dummy variable for the v-effect, $DumV(a)$, as a regressor. As in the previous case, we present a pooling

[23] In common value models with private information, the bidder's conditional expected value is decreasing in the number of units that he wins. Hence bidders shade their bids to adjust *ex ante*.

[24] Results are similar when we include instead the quantity demanded over the quantity awarded for each bidder.

model, given that there are not individual effects and the estimated variance of individual effects is negative in the random model. The estimated coefficient for $DumV(a)$, as expected, is positive and significant: overpricing is higher in those auction with a v-effect.

The results that we have presented are robust to other specifications. First, we have explored the effect of including duration as an additional regressor. Duration is not significant, and the results on the sign and significativity of the other variables do not change with respect to the results presented above. Second, since volatility and duration have a correlation coefficient of 0.96, we orthogonalized the volatility measure, regressing volatility on duration, and included the estimated residuals, orthogonalized volatility, as a regressor, instead of volatility. The estimated coefficient of orthogonalized volatility in the three specifications is also negative, but is not significant at the standard significant levels.

5. CONCLUDING REMARKS

The price paid by market makers for bonds at Treasury auctions in Spain is higher than the price at the secondary market price of exactly the same bond at the time of the auction.[25] Bidders are willing to pay those prices and bid at high prices probably because they want to fulfill the requirements of the Treasury to keep their status as market makers, and some of them, to get a good ranking that allows them to have additional privileges. We agree with Pacini (2009) that a possible explanation for this behavior is the *commodity bundling* hypothesis, so that bidders are bidding both for the bonds auctioned and for the privileges attached to the market makers condition.

Overpricing could be thought as good news for the Treasury, given its ability to cover the borrowing requirements at a low cost, at least compared to the secondary market at the time of the auction. However, it has two potential problems. On the one hand, the Treasury has to compensate market makers. If they are willing to participate in the market makers structure, for sure it is profitable for them, so that the system has a price for the Treasury. On the other hand, even if participation at the auctions is open to all investors, overpricing expels other type of investors, that prefer to buy at the secondary market, so that competition at the auction decreases, probably with a cost to the Treasury.

[25] Even if our data is from 2005 to 2007, recent conversations with the Treasury state that overbidding, and therefore overpricing is still a problem.

As a final comment, we think that this paper calls for a theoretical model of commodity bundling, and for a better understanding of the relation between primary and secondary markets for bonds.

REFERENCES

Alvarez, F. and C. Mazón, 2016. Price volatility in the secondary market and bidders' heterogeneous behavior in spanish treasury auctions. *Empirical Economics* **50 (4)**, 1435.

Arnone, M.and G. Iden, 2003. Primary Dealers in Government Securities: Policy Issues and Selected Countries Experience (EPub). International Monetary Fund.

Beetsma, R., M. Giuliodori, F. De Jong, and D. Widijanto, 2016. Price effects of sovereign debt auctions in the euro-zone: the role of the crisis. *Journal of Financial Intermediation* **25**, 30-53.

Coluzzi, C., 2011. The pricing of the option implicitly granted by the italian treasury to the specialists in the reserved auction reopening. *Rivista di Politica Economica* **1**, 189-221.

Drudi, F.and M. Massa, 2005. Price manipulation in parallel markets with different transparency. *The Journal of Business* **78 (5)**, 1625-1658.

Dunne, P. G., M. Moore,and R. Portes, 2006. European government bond markets: Transparency, liquidity, efficiency. Tech. rep., CEPR Research Report.

Elsinger, H.and C. Zulehner, 2007. Bidding behavior in austrian treasury bond auctions. *Monetary Policy and the Economy* **Q 2**, 109-125.

Fleming, M.and J. Rosenberg, 2007. How do treasury dealers manage their positions? Tech. Rep. 299, Federal Reserve Bank of New York Staff Reports.

Goldreich, D., 2007. Underpricing in discriminatory and uniform-price treasury auctions. *Journal of Financial and Quantitative Analysis* **42**, 443-466.
`http://journals.cambridge.org/article_S0022109000003343`

Gordy, M. B., 1999. Hedging winner's curse with multiple bids: Evidence from the portuguese treasury bill auction. *The Review of Economics and Statistics* **81 (3)**, 448-465.

Keloharju, M., K. G. Nyborg, and K. Rydqvist, 2005. Strategic behavior and underpricing in uniform price auctions: Evidence from finnish treasury auctions. *Journal of Finance* **60 (4)**, 1865-1902.
`http://ideas.repec.org/a/bla/jfinan/v60y2005i4p1865-1902.html`

Lou, D., H. Yan,and J. Zhang, 2013. Anticipated and repeated shocks in liquid markets. *The Review of Financial Studies* **26 (8)**, 1891-1912.

Nyborg, K. G., K. Rydqvist, and S. M. Sundaresan, 2002. Bidder behavior in multiunit auctions: Evidence from swedish treasury auctions. *Journal of Political Economy* **110 (2)**, 394-424.

Pacini, R., 2009. Auctioning government securities: The puzzle of overpricing, sSRN Electronic Journal.
`https://www.researchgate.net/publication/251248554_Auctioning_Government_Securities_The_Puzzle_of_Overpricing`

Rocholl, J., 2006. Discriminatory auctions with seller discretion: evidence from german treasury auctions. Tech. Rep. 15/2005, Deutsche Bundesbank, Kenan-Flagler Business School, University of North Carolina at Chapel Hill.

Sareen, S., 2009. Commodity bundling in government securities auctions: An analysis of the primary dealer model in canada, available at SSRN 1377370.

Umlauf, S. R., 1993. An empirical study of the mexican treasury bill auction. *Journal of Financial Economics* **33 (3)**, 313-340.
`http://www.sciencedirect.com/science/article/pii/0304405X93900109`