THE TREASURY BILL MARKET IN PORTUGAL
PROFIT MARGINS OF FINANCIAL INSTITUTIONS
An econometric analysis*

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1. INTRODUCTION

This work examines the process of formation of market participants' profit. The results of this work are not obtained within the context of a bidding model for Treasury Bills (TB). Since in our view there is no realistic theoretical model of a TB auction, it is not possible to derive an equilibrium bidding strategy. Thus, the results of this work are based on some of the major implications of the standard theory of common value auctions(1). Other related works are Bikhchandani and Huang (1989), Cammack (1991), Jegadeesh (1993), Umlauf (1993) and Bikhchandani *et al*. (1994).

TB are one of the most important domestic public debt instruments (see Adão and Luís (1996)). TB are sold at auctions. Considering the relevance of these securities in the context of public debt and the fact that public debt interest contribute decisively to the budgetary deficit(2) it seems important to analyse the Treasury's revenue within the scope of the methodology chosen to sell TB. This issue is even more important taken into account that Portugal's entry into stage three of EMU depends on the reduction of both the deficit and the public debt, in percentage of GDP.

TB prices in the primary market are influenced by a wide range of factors. Since the Treasury carries out regular TB auctions, the secondary market may have available close substitutes for the TB to be issued (i.e., securities with terms to maturity similar to those of T-bills to be issued)(3) which can have an effect on primary market prices. TB primary market prices can also be affected by the issuing of short-term private bonds, in particular, commercial paper.

The Portuguese TB market has already been studied, although from other perspectives, in Branco (1994). This work examines the format of "independent values" auctions (auctions where each bidder values the object at auction independently of other bidders' valuation) with price discrimination when some bidders have only public information and others have private information in addition. The major result is that when less informed bidders are authorised to submit non-competitive bids (only competing for quantities at a given price), the Treasury is able to obtain higher revenue than at auctions in which all bidders sub-

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The opinions of this paper represent the views of the author, they are not necessarily those of the Banco de Portugal.

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(1) For example, Milgrom and Weber (1982).

(2) In 1995, public debt interest surpassed the public deficit, amounting to PTE 1,005 billion, which compares to a PTE 896.5 billion deficit.

(3) For example, when 91-day TB are auctioned, the 182-day TB auctioned 91 days before also have a 91-day period to maturity.

mit competitive bids (competing for quantity and price simultaneously).

Another study on the Portuguese TB market may be found in Gordy (1993), who considers the utilised method as being an auction of a divisible good in which the reservation price[4] is fixed before the auction takes place. This study does not use secondary market data and assumes that TB auctions follow the independent value auctions model. Gordy (1993) concludes that the Treasury would have obtained a lower revenue if the reserve price were fixed after the Treasury was informed of the bids.

The next section presents the major implications of the common value theory for the TB market. The third section presents a regression equation for profit margins. The fourth section displays the major results of the econometric analysis and the last section shows the main conclusions.

2. THE IMPLICATIONS OF THE COMMON VALUES THEORY IN THE BEHAVIOUR OF BIDDERS IN TB AUCTIONS

In this section we intend to present the implications of the models of TB auctions which shall be analysed in a brief and heuristic manner. The auction theory usually distinguishes between two models: the common value auctions (CV) and the independent private value auctions (IPV).

In a CV auction, it is assumed that the value of the objects being auctioned is the same for all the bidders. This does not mean that the bidders know *ex-ante* the value of the objects being auctioned, but instead, that whoever the bidder acquiring the objects may be, he will obtain the same resale price. Moreover, every bidder receives private and imperfect information on the value of the objects, on which their bids are based. In an IPV auction, bidders know the value of the object being auctioned has for them but their valuations are independently distributed. For instance, the auction of an art masterpiece may resemble an IPV auction.

Private and imperfect information of the bidders in a TB auction is obtained from different sources: own forecasts on the term structure of interest rates, on the inflation and the exchange rates, own liquidity surpluses and amounts of the acquisition orders submitted, prior to the auctions, by institutional investors, such as pension funds.

When a candidate raises his bidding price, he faces a dilemma between, on the one hand, a higher probability of his bid winning and, on the other hand, obtaining lower profit should the bid be accepted. In a CV situation, bidders may incur in the winner's curse. That happens if every bidder has a non-biased estimate of the price of the object, the winning bidders will be more optimistic as to the true value of the object. Therefore, obtaining the object at the auction may be disadvantageous for the purchaser, since this may mean that the bidder assigns an excessively high value to the auctioned object, while every other competitor assigns a lower value to the object, presumably closer to its true market value. The winner's curse has been detected in some auctions — for instance, in bids for authorisations for oil prospecting (see Capen *et al.* (1971)).

The winner's curse has consequences at the level of the optimal bidding strategy. Equilibrium bidding strategies in first and second price auctions[5] imply that the candidates should bid in a more conservative manner, below their *ex-ante* estimate on the true value of the object. This would permit that, on average, no *ex-post* losses would be recorded.

Secondly, *ceteris paribus*, when the number of bidders increases, the optimum behaviour may be to bid in a more conservative manner, since the highest of 100 estimates on a given variable is likely to be higher than the highest of 10 estimates. However, an increase in the number of bidders raises competition, in so far as it reduces the winning probability of any bid. Thus, the net effect of an increase in the number of bidders on the price offered (or on the profit margin) may be either negative or positive, depending on the nature of the equilibrium strategy and on the distribution of private information. Wilson (1988) shows that for some plausible examples,[6] on average, the profit

(4) Minimum selling price accepted by the Treasury.

(5) First price auctions are those where the price of sale is the highest value bidded. Second price auctions are those where the price of sale is the second highest value bidded.

(6) In cases in which the prices offered by the institutions participating in the auctions have normal or log-normal distributions.

margin of the bidders decreases in line with the number of bidders.

Thirdly, *ceteris paribus*, as uncertainty on the value of the object increases, the winner's curse is stronger, and bidders become more conservative, which leads to higher (*ex-post*) profits for the rational bidders(7). Henceforth, the seller may raise the sale price, should he commit himself in advance to make his private information available to bidders, so as to reduce uncertainty. Although this may seem to go against intuition, bidders have the highest profits when they have less information at their disposal(8). On the limit, if the true value is known to all participants, the expected profit will be null.

The presence of the above effects in the TB market, within the scope of CV auctions, will be analysed in the next section in which we attempt to evaluate the effect of uncertainty, of the number of candidates, of the competition levels and of other relevant variables on the profit margins of the institutions participating in the primary market.

3. A MODEL FOR PROFIT MARGINS ON THE TB MARKET

This section includes the results of the regressions of profit margins. The regression equation specified was the following:

$$MARGINS_t = \beta_0 + \beta_1 STD(O/N)_t + \beta_2\, SUBAMOUNT_t + \\ + \beta_3 VAR(RATE)_t + \beta_4\, INDAMOUNT_t + \\ + \beta_5\, SPREAD_t + \varepsilon_t$$

The dependent variable — MARGINS — was calculated as the ratio of profit to the bid price paid. Profits are the difference between the resale price and the purchase price, calculated as follows:

$$PRICE_{i_t} = \frac{36500}{36500 + RATE_{i_t} . TERM}$$

where

$PRICE_{i_t}$ = price in market *i* in the auction occurred in *t*.

i = primary market (*p*), secondary market (*s*).

$RATE_{i_t}$ = average interest rate (per auction) on date *t* in which an auction took place.

$TERM$ = term of TB auctioned (days).

Since the information available on the secondary market is composed of monthly series, we had to assume the hypothesis that the interest rate of the secondary market in each auction ($RATE_{S_t}$) corresponds to:

$$RATE_{S_t} = (RATE^{M}_{S_t} \cdot DAY_t + (31 - DAY_t) \cdot RATE^{M-1}_{S_t}) / 31,$$

where

$RATE^{M}_{S_t}$ = secondary market rate in the month of the auction;

$RATE^{M-1}_{S_t}$ = secondary market rate in the month prior to the auction;

DAY_t = month day of the auction.

During the period under study institutions were subject to different reserve requirements schemes, with an impact on the prices of TB, since the inclusion of these securities and the respective repurchase agreements in the incidence basis of cash reserves during part of the period rose the costs of placement of TB to the public. This led banks to demand a relatively higher price for the sale of TB, and/or to cut their purchase price at auction. Though, the net effect of this element of the reserve requirements scheme is not totally clear-cut, the possibility that profit margins might have been affected is not to be rejected. As a result, margins were adjusted for the cost of the building up of cash reserves. Hence, the adjusted margins (MARGCORR) became the dependent variable (in basis points), calculated as follows:

$$MARGCORR = \frac{P^R - P^C - r^l . (r^{CO} - r^{RR}) P^R}{P^C}$$

where

P^R = resale price;

P^C = purchase price;

r^t = reserve requirement coefficient;

r^{co} = cost of opportunity rate;

(7) See Milgrom and Weber (1982).

(8) This result may also be considered expected. Generally, in the financial markets, a higher degree of uncertainty leads higher interest rates.

r^{RR} = rate of remuneration of reserve requirements, paid by the Banco de Portugal.

In the period under analysis, reserve requirements were remunerated at an interest rate that reflected the money market rates, so as to compensate the institutions for the cost of not having those reserves available for short-term investments. Taking into account the problems shown by money market rates, the standing absorption facility rate was selected as proxy for the opportunity cost (see Adão and Luís (1996)).

In order to measure the uncertainty effect introduced by the IMM, we used variable $STD(O/N_t)$ which consists in the standard-deviation of the IMM overnight rate in the week prior to the auction[9] (in basis points). The underlying concept is that, as supported by the common value theory, the higher is the *ex-ante* uncertainty, the higher will be the possibility that a bidder may incur in the winner's curse, and more conservative he will be in his bids. As a result, should this relationship occur, the standard-deviation of the overnight rate shall be positively correlated with the profit margins.

The $VAR(RATE)_t$ variable, which consists in the variance of the interest rates of bids accepted by the Treasury in each auction (in basis points), shall permit to measure uncertainty effects, other than that due to the interbank money market. It is expected that, should the winner's curse occur, the coefficient will be positive. In contrast, if the coefficient is negative, it may mean that price collusion situations have occurred, in which participating institutions increase their results reducing the range of their bidding rates.

It might firstly be considered that every type of uncertainty would be reflected in variable *VAR(RATE*), therefore it would not be necessary to use also $STD(O/N)_t$ variable. However, this latter variable does not reveal to be significant in the explanation of the former variable. On the other hand, the uncertainty effect is not necessarily reflected in $VAR(RATE)_t$, if collusive situations occur[10].

$SUBAMOUNT_t$ is the total amount of the bids submitted by the participants in each auction (in PTE billion). This variable measures the effect of the increase in the demand in TB auctions[11]. This means that if we have a negative coefficient, the market may be accepted to be competitive; therefore, the increase in demand implies a decrease in profits[12].

$INDAMOUNT_t$ is the indicative amount of TB to be auctioned, announced by the Treasury through the Banco de Portugal (in PTE billion). When the coefficient assumes a positive value, profits increase in line with the amount that the Treasury intends to auction. This relation can be envisaged as a result of the pressure put by borrowing requirements on primary market rates (and on profit margins) when the Treasury intends to obtain more financing[13].

$SPREAD_t$ is the differential between interest rates of credit to non-financial firms and individuals and time deposit rates (in percentage points). This variable is intended to measure the effect of the margins obtained by financial institutions from alternative products on TB market profit margins, and its coefficient should be positive.

The specification submitted, however, does not include any dynamics in the relationship between the above variables. A way to surpass such problem consists in considering an auto-regressive be-

(9) A week was the period used taking into account the average reserve maintenance periods. In Umlauf (1993), the variance is used instead of the standard-deviation. However, variance shows a more volatile behaviour.

(10) Another case in which uncertainly might not be reflected in $VAR(RATE)_t$ is when increases in money-market rates lead to increases in the rates submitted in the auctions, but also to the acceptance by the Treasury of a reduced share of these bids, centred on the lowest rates.

(11) At first, as a replacement for this variable, the number of participants was tested in line with Umlauf (1993) and, afterwards, the ratio of the submitted amount to the indicative amount of the auction and the ratio of the submitted amount to the issued amount, in line with Cammack (1991) and Jegadeesh (1993), with worse statistical results (moreover, the utilisation of the first ratio would lead to a change in the meaning of the coefficient of the $INDAMOUNT_t$ variable, since this variable corresponds to the denominator of the ratio).

(12) In contrast, a positive coefficient may be interpreted as an implication of the winner's curse, since when we assume that, *ceteris paribus*, demand increases when the number of participants increases, the rise in the number of participants will lead to a more conservative optimal behaviour.

(13) The secondary market interest rates reveal more inertia than the primary market rates when there are changes in the short term interest rates, either upwards or downwards. In a collusive situation, a negative correlation may suggest the downfall of agreements between financial institutions in larger auctions.

haviour for the profit margins. This autocorrelation will result if institutions include past behaviour and results in their decision process.

4. ECONOMETRIC ANALYSIS OF THE PROFIT MARGINS OF CREDIT INSTITUTIONS

Data used concern all the bids submitted in every auction from January 1990 to December 1995[14]. The analysis was separately carried out for the three existing types of TB, every series having revealed stationarity, except *SPREAD*[15]. Out of the 754 auctions (275, 298 and 181 for TB at 91, 182 and 364 days, respectively), only 692 were considered (248, 279 and 165 for each of the those maturities), since the auctions in which no bids were accepted were eliminated[16].

The econometric work was based on the study of the regression previously presented, for the whole period and for every type of TB. The development pattern of profit margins strongly suggests the presence of an autoregressive component, an expectation which was confirmed by the improvement obtained in results after the introduction of the lagged endogenous variable[17].

We also had to take into account the influence of several phenomena of an extraordinary nature affecting the results obtained, in particular in the period of high volatility of the interest rates in 1990-1991 and in the periods affected by instability in the foreign exchange market. Therefore, we decided to introduce several dummy variables (defined in Appendix) permitting to identify those effects, covering a relatively short number of observations (14, 12 and 6 auctions of 91-, 182- and 364-day TB, respectively, always below 6 per cent of the total sample) which permitted to improve the statistical results, thus obtaining increases of approximately 0.1 in the adjusted R^2 [18].

As expected, the quality of the regressions revealed to be higher in longer maturities, since 91-day TB auctions are less frequently suspended on occasions of disturbances on the monetary and foreign-exchange markets and, therefore, the average rates of allocation are more volatile[19].

The major results obtained are listed in table 1. The regression with two lags on the endogenous variable seemed better for the 91-day maturity[20], while in the other maturities the second lag of the dependent variable did not prove statistically significant.

We may then state the following most significant conclusions:

– The uncertainty resulting from the IMM, measured by the standard-deviation of the overnight rates seems to have scarcely affect the profit margins of the bidders, since they only have statistical significance in the case

(14) Despite the information available on the auctions carried out since June 1988, the data base utilised for the econometric work was limited due to restrictions in the availability of information on the secondary TB market and on the interbank money market (whose series start in January 1990).

(15) In the ADF tests (with constant and without trend) done for the endogenous variable, the t-ratios of the lagged endogenous variable were always higher than 3.2 in absolute value, allowing to reject the null hypothesis of unit root, for significance levels around 2.5 per cent. In the test for the independent variables, the only figures for t-ratios below 3 were obtained for *SPREAD*. In this situation, the non-stationarity is probably due to the limited period covered by the sample, given that an interest rate spread has to be a stationary variable. Considering this point, the statistical relevance of *SPREAD* and the fact of having been obtained identical results for the remaining parameters in regressions without *SPREAD*, we decided to maintain this variable.

(16) As well as an auction in which the Banco de Portugal purchased the total amount auctioned and the interest rate of placement was not made known.

(17) It must be noted, once again, that though the markedly autoregressive behaviour (with estimations for the sum of the autoregressive coefficients consistently above 0.84) it is rejected the null hypothesis of unit root. The high t-ratios for the first lag are due to auto-regressive characteristics of the variable. It was also considered, as alternative, to specify the dependent variable in first differences, corresponding to imposing the constraint of unit root. This procedure provided similar results, though with a worse econometric fit. Consequently, we chose to specify the dependent variable in level and to use its lags as explanatory variables. In this issue, we benefited from the suggestions of José Ferreira Machado, Nuno Cassola, Nuno Ribeiro and Carlos Robalo.

(18) Additionally, we considered the fact that some of the regressors are not pre-determined variables. However, the Hausman specification test was carried out, and the null hypothesis of the consistency of estimators was not rejected for all the TB (the lowest p-value obtained equalled 0.791).

(19) We thank the comments made by Nuno Ribeiro on this subject.

(20) The selection of a model among those presenting distinct lags was developed according to the Schwarz criterion.

(21) Even in this case, the value of the t-ratio exceeds only marginally the value of the distribution function to a 5 per cent sinificance level.

Table 1

MAIN ECONOMETRIC RESULTS

	BT91	BT182	BT364
CONSTANT	2.0194	-3.4279	4.3765
	(1.617)	(1.628)	(0.933)
STD(O/N)	-0.0286	-0.0982	-0.1749
	(2.043)	(0.766)	(0.629)
SUBAMOUNT	-0.1279	-0.0708	-0.0533
	(9.743)	(7.168)	(3.521)
VAR(RATE)	1.5847	0.5311	1.0816
	(4.0807)	(3.903)	(3.192)
INDAMOUNT	0.1255	0.0957	0.0337
	(2.5151)	(3.044)	(0.754)
SPREAD	9.4336	14.4874	-0.3719
	(3.825)	(3.600)	(0.044)
MARGINS (t-1)	0.7359	0.9138	0.9175
	(19.775)	(56.354)	(43.331)
MARGINS(t-2)	0.1067	-	-
	(2.952)		
N	246	278	164
R^2 adjusted	0.914	0.943	0.940
Q(1)	0.247	0.001	0.083
Q(2)	0.250	0.048	2.894
Q(3)	0.806	0.102	4.602
Q(10)	3.087	5.796	11.113
ARCH Test	1.102	0.143	1.239
ChowTest	1.335	1.004	0.591
White Test	59.172	37.962	24.944

Notes:

T-values are in brackets.

N - Number of observations.

Q(p) - Statistic of Ljung-Box autocorrelation test of order (p). The low values obtained suggest that there is not autocorrelation of order (p).

ARCH test - Test of ARCH(1) residuals, consisting on the t-ratio of the parameter of the regression of the squared residuals on the lagged square residuals. The low values obtained suggest that there are not ARCH residuals.

Chow test - F-test of stability of the parameters. The low values obtained point to the stability of the parameters.

White test - test of heteroskedasticity of the residuals, depending on the exogenous variables. The values obtained are lower than those of the Chi-square distribution, with k(k-1)/2+2k degrees of freedom (k=number of parameters).

of 91-day TB[21]. Thus, it is not possible to conclude whether the profits of the institutions are affected or not by uncertainty on the IMM.

- Demand at auctions, measured by the total amount of the bids submitted, also seems to have negatively affect profit margins in every maturity. It may then be acknowledged that the TB market is competitive, since an increase in demand implies a decrease in profit margins[22].
- The variance of the rates on the bids accepted seems to positively affect profit margins. This means that the institutions respond to uncertainty with other than IMM origin, in the way forecasted by the common value theory, becoming more conservative in order to avoid the winner's curse.
- The indicative amount announced by the Treasury is also positively correlated with profit margins. Therefore, the behaviour of participants in the Portuguese TB markets does not allow for the rejection of the hypothesis that the Treasury may reduce its financing costs through a decrease in the amounts auctioned per session, with an increase in the number of auctions. According to Bank of England (1995) this result was already observed in Australia, Canada and United Kingdom, as regards medium- and long-term debt.

5. FINAL REMARKS

This work presents the econometric results on the trend of profit margins in the Portuguese TB market and respective determinants, under the light of the common value auction theory, in the period from 1990 to 1995. The results obtained are consistent with the hypothesis of the winners' curse, i.e., that profits raised by bidders increase as the uncertainty increases. Thus, it seems that the Treasury may improve its results if it manages to decrease uncertainty at auctions (for instance, by

(22) This conclusion may also be obtained if the variable "number of participants" is utilised, albeit with lower overall statistical results. Therefore, we seem to obtain a conclusion similar to that of Wilson (1988), that when the number of participants increases, margins decrease.

supplying information on its behaviour or on the overall behaviour of the participants in previous auctions). Evidence was also obtained that the Treasury may benefit from the widening of the range of potential participants in the primary market[23][24]. In fact, the market seems to be competitive, since there is a negative correlation between the number of participants and the margins.

An additional conclusion is that the profit margins of financial institutions seem to be positively correlated with the indicative amounts to be auctioned, which means that the Treasury may try to reduce its net financing costs through an increase in the frequency of the auctions[25].

(23) For instance, to Investment Funds or other investors not connected with banking groups (insurance companies, pension funds, large non-financial companies with huge cash balances).

(24) This possibility of a wider participation in public debt auctions was already authorised, for instance, in the United Kingdom, where non-financial firms and individuals have access to the medium- and long-term primary market, with the minimum acquisition amount set at £500,000 (nominal value of the stocks), as mentioned in Bank of England (1993).

(25) The Treasury has already been doing it, as mentioned above.

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Appendix

Meaning of the dummy variables

91 TB

$D1_i$ *(i=1, …,9)* — dummy variables assuming the unit value in the observations in which the residuals of the same regression, albeit without artificial variables, have anomalous values (in the auctions on 21 and 28 June 1990; 27 August 1992; 2 October 1992; 17 December 1992; 6 May 1993 and 20 May 1993; 30 June 1993 and 1 July 1993; 8 July 1993 and 12 and 25 May 1994, respectively).

$D2_i$ *(i=1, 2)*—dummy variables assuming the unit values in the observations in which the explanatory variable *VAR(RATE)* has anomalous values (on 5 July 1990 and 5 May 1994).

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$D1_i$ *(i=1, …,10)* — dummy variables assuming the unit value in the observations in which the residuals of the same regression, albeit without artificial variables, have anomalous values (in the auctions on 5 March 1990; 2 April 1990; 9 July 1990; 6 April 1992; 24 August 1992; 1 April 1993; 8 June 1993; 23 June and 5 July 1993; 7 September 1993 and 26 May 1994, respectively).

D2 assumes the unit value in an observation in which the *INDAMOUNT* variable takes an anomalous value (7 October 1991).

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$D1_i$ *(i=1, …,6)* — dummy variables assuming the unit value in the observations in which the residuals of the same regression, albeit without artificial variables, have anomalous values (in the auctions on 5 June 1991; 26 August 1992; 21 October 1992; 24 March 1993; 26 May 1993 and 14 July 1993, respectively).