The Primary Market of Italian Treasury Bonds: An Empirical Study of the Uniform-Price Auction

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ABSTRACT

This paper examines the Italian primary market of Treasury bonds by considering the uniform-price auctions for CCTs and BTPs held during the three-year period of 1998-2000. In particular, it analyses the demand structure and the bidders' behaviour, and investigates whether the auction mechanism adopted is efficient or not. Throughout the period under analysis, the number of bidders in auction decreased, nevertheless the demand was steadily superior to the offer. The concentration on the primary market resulted not irrelevant, whereas the analysis of bidders' behaviour found information to be asymmetric among bidders according to their size. Moreover, the examination of the auction stop-out prices showed a significant presence of underpricing with respect to current prices on the secondary market. Neither the bidders' behaviour nor the analysis of the determinants of underpricing came up against auction theory univocally.

Keywords: *winner's curse, market power, asymmetric information, underpricing.*
JEL Classification Numbers: *D44, G10.*

Since 1992 the Italian State engaged in a rigorous policy of improvement of public finances through a strong action of reduction in the public budget deficit and in the public debt to GDP ratio. Still, Italian public debt placements remain consistent, and the Italian Treasury bonds market is one of the largest in the world. The interest rate expenditure also remains high, pushing the Treasury to undertake all initiatives directed to containing such an expenditure. In this perspective the choice of

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efficient placement mechanisms is very important in order to induce correct pricing of Government securities, also with respect to the secondary market.

To this aim, the study of auction mechanisms is essential to identify those more adequate for the Italian reality together with the analysis of the basic features of primary and secondary markets. Indeed, a typical question always arises on actual issuance techniques: whether altering the auction format would yield greater revenues for the Treasury. Traditionally theoretical and empirical literature has focused on revenue-raising abilities of uniform-price and discriminatory auctions, which are the most used worldwide. The empirical evidence has shown that Government security auctions have usually faced *underpricing*: the prices at which Treasury notes, bills and bonds are sold in auction are lower than the when-issued or secondary market prices.

This paper contributes to this debate by analysing the performance of the uniform-price auctions run by the Italian Treasury to sell notes and bonds, specifically the Certificati di Credito del Tesoro (CCT) and the Buoni del Tesoro Poliennali (BTP), along with an examination of the demand structure and the bidders' behaviour. As more recent papers, e.g. Keloharju, Nyborg and Rydqvist (2005) and Goldreich (2003), relate to auctions held in periods ending in 2000, respectively 1992-1999 and 1991-2000, this paper considers the uniform price auctions held during the three-year period of 1998-2000. Moreover, this paper covers a lack of knowledge on the subject since the last available studies on Italian Treasury auctions date back to 1997, namely Scalia (1997) and Drudi and Massa (1997). More importantly, the auctions under analysis are not conditioned, with respect to those of the later period, by factors exogenous to the auction mechanism per se, such as the tightening of market requirements for the primary dealers or the introduction of the practice of granting the best primary dealers the right to syndicate longer term and index linked Treasury bonds and participation in specific debt management operations, which could have affected the auctions outcome. Thus, the period chosen is the most appropriate for the purpose of this analysis.

The rest of the paper is organized as follows. The characteristics of the Italian Treasury bond primary market are described in Section I. The auction theory is surveyed in Section II with an emphasis on the *market power* theory of uniform-price auctions and on its implications for the bidders' behaviour and the auction outcome. Section III examines the bidders' behaviour and the auction outcomes looking at the participation, the degree of concentration, the bids distribution, the presence of *asymmetric information* among bidders and the auction pricing with respect to the secondary market. Moreover Section III tests the auction theory. Section IV concludes.

I. The Institutional Features and the Operation of the Italian Primary Market[1]

The uniform-price auction is the mechanism chosen by the Italian Treasury to sell notes and bonds as the CCTs and BTPs. The uniform-price auction provides for bidders being awarded to pay all the same price for each security, i.e. the *stop-out* price. The *stop-out* price is determined by satisfying bids starting from the highest price until the total amount of bids accepted equals the amount offered. The price of the last successful bid is the *stop-out* price[2]. If the amount allocated at the *stop-out* price is higher than the amount offered, then the bids submitted at the *stop-out* price will be rationed on a pro-rata basis. All the bids being awarded are settled at the *stop-out* price. Each bid specifies the quantity of the security sought and a price. All entities admitted to the primary market may submit a maximum of three bids differing from each other by at least one basis point[3], for their own accounts or on behalf of their customers. The minimum request is 500,000 Euros[4], while the maximum amount to be requested is equal to the quantity offered by the Treasury in the auction. All the bids are entered through a *network based system*, an electronic system introduced in the early 1990s for processing auction bids, based on the National Interbanking Network. Bids can be amended as often as bidders like, given that the system will only consider valid the last chronological bid submitted before the deadline. Bids should be entered into the system before 13:00 a.m. of the auction day[5]. After this deadline the system rejects automatically any bid and the accepted bids are decrypted. The auction results are announced around twenty minutes after the auction closes through the main financial information providers. The settlement takes place two business days after the auction.

The operators allowed to participate to Treasury security auctions are banks and investment firms registered with the Bank of Italy. Although all these firms may bid at auctions, participation is typically concentrated among a small number of these firms, the *Specialists* in Italian Treasury Bonds that get an average of 60-70% of total nominal amount of Treasury securities issued. The Department of the Treasury selects the *Specialists* among the *Primary Dealers*[6] and requires them

[1] Laws and regulations mentioned in this section refer to the period 1998-2000. Today they could have changed.
[2] In order to avoid speculative requests, an exclusion price is calculated, below which subscription requests are not considered.
[3] For 30-year BTPs the minimum tick is five basis points.
[4] Until the end of year 1998 the minimum request was equal to 50,000 Euros.
[5] Starting from the 28th of June 2000 this deadline was set at 11.00.
[6] *Primary Dealers* are market makers selected by MTS S.p.A., the firm managing the official wholesale secondary market for Treasury securities, on the basis of specific prerequisites concerning their patrimonial stability and the volume traded on that market.

to participate meaningfully in both the primary and the secondary market of Treasury securities[7]. As a reward, *Specialists* are entitled to participate to a second round specifically reserved for them[8].

The MTS S.p.A provides wholesale electronic markets for a variety of Italian public debt issues, all denominated in euro, which includes CCTs and BTPs. The MTS market is a quote driven market. The minimum lot to transact is equal to 2.5 millions of Euro. It is open from 8:15 a.m. to 17:30 p.m. Transactions on new Treasury issues are possible from the day before the auction and the settlement takes place three business days after a transaction is made.

All the Treasury issues follow a regular schedule of auctions. Since 1994, in September of each year the Treasury releases the annual auction calendar for the following year. This calendar contains the announcement, the auction and the settlement dates concerning the issuance program of the year. This information allows investors to know well in advance when a security is expected to be auctioned by the Treasury. In addition each quarter the Treasury publishes a periodic issuance program to announce the new securities to be issued in that period of time. Table 1 shows the monthly scheduled auctions for each kind of security[9].

Table 1

Type of security	1st half	2nd half
3-year BTP	x	x
5-year BTP	x	x
10-year BTP	x	
30-year BTP		x
7-year CCT	x	

Instead of issuing a new security each time, the Treasury systematically adds to or reopens an existing issue so as to increase its outstanding amount and foster liquidity.

II. The Auction Theory and its Implications on Bidders' Behaviour

The presence of a liquid and efficient wholesale secondary market for the Italian Treasury securities greatly affects bidders' behaviour in auction and their information structure. Indeed,

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[7] The main requirement for the *Specialists* is to buy at least three per cent of the amount offered in auction. Starting from 2000 the Italian Treasury began to discriminate the *Specialists* auction performance in order to rank them. Indeed, three score classes were introduced: 0 points to an auction share between 3% and 4.99%, 3 points to an auction share between 5% and 6.99%, and 4 points to an auction share equal to 7% or higher. In the following years such a practice became even tighter.

[8] Reopenings reserved to the *Specialists* are set up for a maximum equal to 25% of the amount offered in the first issue of a new security and to 10% for the following placements of the same security. Until mid-October 1998, this percentage was equal to 10% also for the first issue.

[9] Starting from July 2000 the 5-year BTP is auctioned only in the second half of each month.

bidders are considered as "intermediaries", who operate on the primary market to buy Treasury securities to sell to final investors on the secondary market[10]. Auction theory formalizes this context with *common value* models, which assume bidders' valuations are correlated and complemented with each other through the secondary market. Indeed, the price of reference is the same for each bidder, i.e. the resale price on the secondary market. This implies that the reserve price of each bidder is not statistically independent from those of others, but instead it is necessarily correlated. Each bidder tries to estimate such a price not known *a priori* on the basis of his own information. Bidders information is asymmetric, since it is assumed that bidders receive different signals[11]. The "traditional" auction theory, based on models which do not take into account the quantitative aspect of the Treasury auction bids, characterizes the *winner's curse* and the auction participation as the main factors which determine the outcome of an auction. More recent contributions employ models which explicitly incorporate the quantitative aspect of the Treasury auction bids by formulating them in terms of demand schedules[12]. In particular, the *market power* theory shows that the uniform-price auction is subject to equilibria characterized by *stop-out* prices arbitrarily lower than those on the secondary market and independently from the factors pointed out by the "traditional" auction theory, such as the number of participants, the degree of concentration and the private information held.

A. The "Traditional" Auction Theory

The main conclusions of the traditional auction theory come from considerations based on the analogy between the multi-unit auctions and the single-unit auctions[13], i.e. the results obtained for the latter are extended to the former, or from models which assume that each bidder demands only one unit of the item put in auction[14]. In particular the traditional auction theory shows that the fact that the value of the item to be auctioned is the same for each bidder (i.e. a *common value* context) combined with the assumption of *asymmetric information* among bidders causes the phenomenon known as the *winner's curse*[15]. This phenomenon has considerable negative effects for the

[10] It is said they follow a *buy and sell strategy* (see Bikchandani and Huang [1993]).
[11] For example this could be the case of the *order flows* which bidders collect.
[12] Ausubel e Cramton (1998) show that in a context of *common value* with affiliated private signals the uniform-price auction for multiple homogeneous items allows multiple equilibria and that all the outcomes of such equilibria have an upper bound in the outcome of the second price sealed bid auction for a single item.
[13] McAfee e McMillan (1987).
[14] In particular Milgrom (1989) and afterwards Bikhchandani and Huang (1993), Chari and Weber (1992) and Smith (1992).
[15] In the auction theory of multiple homogeneous items this is called by Ausubel (2004) the *champion's plague*, or *generalized winner's curse*.

auctioneer, since it raises the issuance costs, driving the *stop-out* price away from the secondary market prices. This comes from the differences among bidders' estimates, which are made on the basis of their own information: even if such estimates are assumed unbiased, some of them will be higher than the "true" value and some others will be lower. Therefore, the winners in the auction will be those who will have offered the highest prices, thus risking to be awarded with securities at prices higher than the resale price on the secondary market. Should this be the case, they will incur in monetary losses in the intermediation activity between primary and secondary market. The risk of running into such losses greatly affects the bidders' strategic behaviour in auction. Bidders will then offer prices lower than their own reserve price, leading to *stop-out* prices lower than the resale prices on the secondary market[16]. Hence, the *winner's curse* turns into the auctioneer's curse. However, the *winner's curse* has a different impact depending on several factors, such as the degree of bidders' risk aversion, the presence of difficulties in placing the whole amount of securities put in auction[17], the number of bidders and the auction format. In particular, the uniform-price auction mitigates the *winner's curse*, i.e. the risk to be awarded with securities at prices higher than the resale price on the secondary market, and favours a more aggressive bidding behaviour and a higher degree of competition in auction by encouraging the participation of less informed traders and discouraging explicit collusive behaviours among participants.

B. The Market Power Theory

The more recent contributions to multi-unit auction theory drop the restrictive assumption of each bidder asking the same quantity of securities and model bidders' strategies in terms of demand schedules, then giving a strategic value also to the quantitative aspect as well as to the price. If on one hand, Ausubel and Cramton (1998) show that in a context of *common value* with affiliated private signals the upper bound of all the symmetric equilibria of the uniform-price auction is higher than the upper bound of all the symmetric equilibria of the discriminatory auction, on the other hand Ausubel and Cramton (2002) show that the uniform-price auction is often subject to inefficiencies which lead to poor revenue-raising performances. Hence, the revenue ranking of the

[16] This qualitative prediction is afterwards confirmed by the multi-unit auction theory (in particular see Ausubel [2004]), which proves that a generalized *winner's curse*, the *champion's plague*, drives bidders to reduce the quantity demanded at a given price and it has the same effect of lowering the *stop-out* price. Indeed, the *champion's plague* implies that the more a bidder wins, the worse news it is for him.

[17] This aspect determines the bidders' perception to the risk of being rationed in auction. If bidders expect difficulties for the Treasury in placing the whole amount of securities, they will have a low perception of such a risk and vice versa. In turn this perception affects the degree of aggressiveness of bidders in auction and then the *stop-out* price.

uniform-price auction and the discriminatory auction is ambiguous and determining the better pricing rule is necessarily an empirical question.

Wilson (1979) was the first to note that the uniform-price auction for multiple units is subject to manipulation by the bidders, with the consequence of lowering the *stop-out* price and then the auction revenues. Such a manipulability of the uniform-price auction is what Back and Zender (1993) describe as collusion, generalizing Wilson's result. The main point of Back and Zender (1993)'s article is that multi-unit auctions are very different from single-unit auctions, or more generally from auctions in which each bidder wants only one unit of the item put in auction. Then, the results valid in the latter do not generalize in auctions where bidders want more units, since, while the marginal cost for the first unit to buy equals the price, the marginal cost for further units may exceed the price. Indeed, in the uniform-price auction each bidder pays the same price per unit, then the marginal cost is endogenous since it depends on the supply curve each bidder faces. This corresponds to the residual supply, namely the total supply less the aggregate demand of all the other bidders, thus making each bidder's marginal cost dependent on his competitors' strategies. If each bidder submits a downward-sloping demand schedule, each of them will face an increasing residual supply curve and then a price-quantity trade-off, making them monopsonists with respect to such a residual supply. The outcome after each bidder has maximized his profit against the residual supply he faced is an *underpricing* equilibrium. Equilibria with *underpricing* are multiple and are characterized by a sort of *implicit* collusion among bidders, since they are uncooperative, to give each other a monopsonistic *market power*. Such equilibria are different from those exemplified by Friedman for the discriminatory auction, which are due to a high degree of market concentration and an explicit coordination of bidders' strategies. In a *common value* context with private information[18], Back and Zender (1993) demonstrate the existence of a particularly onerous class of equilibria for the Treasury[19], since bidders can make *stop-out* prices arbitrarily lower by submitting very steep demand curves. The steep portion of such curves are based on consistent *inframarginal* bids which are costless because of the uniqueness of the award price and the rigidity of the Treasury supply. Moreover such a bidders' behaviour is optimal independently from the number of participants and their private information. However, there may be cases in which it is unrealistic to suppose that all the bidders in a Treasury auction will be able to coordinate on such equilibria, except for the dominant bidders. The latter will consider bids of others as random, then making the

[18] When bidders possess private information, one should expect auction *underpricing*, namely the seller's expected revenues is less than the expected value of the securities being auctioned. This is a direct consequence of the bidders obtaining informational rents from their private information (Ausubel and Cramton 1998).

[19] The Theorem 1 demonstrates that for each $p^* \in [p^L, v^L]$ exists a pure-strategy symmetric equilibrium, in which the *stop-out* price is $p = p^*$, each bidder receives the quantity Q/n and bidders' strategies do not vary with the their signals (where p^L is the reserve price of the auction, v^L is the lower bound of all the possible resale prices on the secondary market, Q is the total quantity offered by the Treasury and n is the number of participants).

actual supply uncertain. Despite such an uncertainty, Back and Zender (1993) demonstrate that there are still equilibria characterized by *underpricing* and robust to randomness in the behaviour of non-strategic bidders[20]. In the following section I analyse the Italian Treasury auctions in terms of the demand structure, the bidders' behaviour and the auction mechanism performance, interpreting and comparing the empirical results, as I obtain them, in the light of the above auction theory predictions.

III. Empirical Results

The analysis considers all the auctions held between January 1998 and November 2000, that is 219 auctions grouped between CCTs (32), 3-year BTPs (63), 5-year BTPs (58), 10-year BTPs (35) and 30-year BTPs (31)[21]. Data available per each of these auctions concern the aggregate bid distribution, the total quantity demanded and awarded per each bidder and the respective weighted average price[22]. The statistics calculated are in Table 2.

Table 2

analysis of	statistics
participation	number of participants
	cover ratio
concentration	first bidder's share
	first 5 bidders' share
	first 10 bidders' share
	first 15 bidders' share
	first 20 bidders' share
	Herfindhal index
	Entropy index
	Gini index
price distribution	standard deviation
	kurtosis coefficient
	skewness coefficient
	difference between the weighted average price of the awarded quantity and the stop-out price
asymmetry	difference between the weighted average price of the 10 smaller and 10 larger bidders per awarded quantity
	standard deviation of the prices of the 10 smaller bidders per awarded quantity
	standard deviation of the prices of the 10 larger bidders per awarded quantity

Most of them consider as character both the demanded and awarded quantity, and are intended to investigate the demand structure of the primary market in terms of auction participation, degree of concentration, bid distribution and *information asymmetry*. Moreover, I measure the auctions performance by comparing *stop-out* prices and current prices on the secondary market and I study its determinants with respect to the relevant auction theory.

[20] See Theorem 4 in Back and Zender (1993). Afterwards Kremer and Nyborg (2004a) has demonstrated the uniqueness of the equilibria of Back and Zender (1993)'s Theorem 4.
[21] All the auctions held between mid-October and December 1999 are missed.
[22] The individual demand schedule was not available.

A. The Participation in Auction

The number of participants and the cover ratio[23] are the statistics considered to assess the participation in each auction. Table 3 reports the average values per type of security. The number of participants has shown a decreasing trend from 1998 to 2000 for all the securities, more remarkably for longer-term securities. At the beginning of 1998 the participants per auction were on average 60 for all the securities, while they fall to around 35/40 for CCTs, BTP3s and BTP5s, and to around 25/30 for BTP10s and BTP30s. Such a decrease may be explained by the frequent aggregations which have characterized the Italian banking system at the end of the 90's. Paragraph F will verify if this decreasing trend has had any effects on *stop-out* prices according to the predictions of the "traditional" auction theory. Comparing the number of participants with the number of those awarded, on an average three results to be the number of participants which do not get anything.

Table 3

security	number of auctions	total awarded quantity	number of bidders	number of awarded bidders	cover ratio
CCT	32	€ 50.350.644.000	46,2	41,9	2,52
BTP3	63	€ 112.451.288.000	47,5	44,0	2,20
BTP5	58	€ 103.217.744.000	48,1	44,6	2,06
BTP10	35	€ 77.512.856.401	45,8	42,1	2,00
BTP30	31	€ 46.318.544.400	41,4	38,3	1,76

The cover ratio does not show any trends in the period under analysis, but a slightly increasing one for CCTs and BTP3s at the end of 2000. However, there is a remarkable variability of this index, between 1.5 and 4.5 for CCTs, between 1 and 3.5 for BTP3 and BTP5, and between 1 and 2.5 for BTP10s and BTP30s[24]. The average values go from 1.8 for BTP30s to 2.5 for CCTs and they result higher than those of studies related to previous periods. These values show that the total demanded quantity was always superior to the quantity offered by the Treasury, and so the risk of being rationed for the bidders[25]. Nevertheless, the cover ratio for BTP30s is always higher than one, but not so remarkably as for the other types of security.

Summing it up, during 1998-2000 the Italian primary market for medium-long term Treasury securities has shown:

- a decrease in the number of participants of 40% on average;
- a demand steadily superior to the offer.

[23] The cover ratio of an auction is calculated as the ratio between the total amount demanded by bidders and the total amount offered by the Treasury.

[24] Auctions on BTP10s show two peak values superior to 4, due to two reopenings in January and June 1998, characterized by an offer largely inferior to its average.

[25] A demand steadily superior to the offer influences bidders' perception of the risk of being rationed and then the degree of aggressiveness in auction, conditioning the *stop-out* price determination (see also note 17).

B. The Degree of Concentration in Auction

The concentration indexes calculated differentiate between those which relate to a particular group of bidders and to all the bidders, and between those which consider as character the demanded quantity and the awarded quantity. Table 4 reports the average shares of demanded quantity by the first *n* bidders[26]. On average the first bidder demands from 14% (BTP10s) to 18% (CCTs) of the total amount demanded, whereas the average share of the first ten bidders is always superior to 70% of the total amount demanded for each type of security. These values are higher than those of previous studies, highlighting an increase of the weight of larger bidders.

Table 4

bidders' share of demanded quantity							
study	**period**	**security**	**first one**	**first 5**	**first 10**	**first 15**	**first 20**
Pacini	1/98-11/00	BTP3	17,11%	50,93%	74,22%	88,68%	96,20%
		BTP5	16,64%	49,83%	73,49%	87,98%	95,87%
		BTP10	13,88%	47,03%	70,32%	85,69%	94,60%
		BTP30	14,38%	46,38%	70,40%	86,84%	96,22%
		BTP	15,91%	49,11%	72,63%	87,60%	95,80%
		CCT	17,79%	53,50%	74,95%	87,84%	95,70%
Drudi/Massa	2/94-3/96	BTP	13,99%	43,65%	64,81%	-	88,00%
		CCT	11,78%	38,60%	59,76%	-	84,27%
Buttiglione/Drudi	9/91-11/92	BTP	13,20%	46,20%	69,20%	82,40%	90,50%
		CCT	12,20%	42,30%	65,00%	80,10%	89,10%

Considering as character the awarded quantity (Table 5), the concentration results superior to that found for the demanded quantity. The first bidder on average is awarded with between 18% (BTP30s) and 25% (CCTs) of the total quantity awarded, whereas the average share of the first ten bidders is always superior to 75% of the total amount awarded for each type of security. These values, being appreciably higher than those related to the demanded quantity, show a better ability in estimating the possible *stop-out* price by the larger bidders. This aspect will be further investigated in Paragraph D. As Table 4, Table 5 reports the results of two previous studies, i.e. Drudi and Massa (1997) and Buttiglione and Drudi (1994), thus allowing to compare different periods. In particular, an increase has occurred in the concentration of awarded quantity, especially for CCTs.

[26] The values in Table 4 and 5 are calculated by considering the shares demanded by and awarded to bidders to whom the largest shares of the demanded and awarded quantity per each auction are attributable. The share of the first *n* bidders then refers to that of those bidders which got the largest shares per each single auction and not in all the auctions. Therefore these bidders may vary from auction to auction, i.e. not being the same for each auction.

Table 5

bidders'share of awarded quantity							
study	period	security	first one	first 5	first 10	first 15	first 20
Pacini	1/98-11/00	BTP3	18,97%	52,55%	76,98%	92,42%	98,07%
		BTP5	18,14%	53,67%	77,99%	92,90%	98,09%
		BTP10	19,82%	53,48%	76,63%	91,56%	97,85%
		BTP30	17,66%	51,52%	76,78%	92,40%	98,44%
		BTP	18,65%	52,90%	77,19%	92,41%	98,09%
		CCT	24,82%	59,89%	81,51%	94,53%	98,55%
Drudi/Massa	2/94-3/96	BTP	18,44%	53,16%	74,82%	-	93,62%
		CCT	15,80%	48,10%	71,00%	-	92,60%
Buttiglione/Drudi	9/91-11/92	BTP	17,90%	55,90%	77,50%	87,60%	93,00%
		CCT	16,70%	50,50%	72,70%	84,90%	91,60%

During the period 1998-2000 the share of the first *n* bidders, both demanded and awarded, were stable. However, there are frequent cases in which a single bidder gets an abnormal share of securities, that is above 40%: four times both in CCTs and BTP10s auctions, two times both in BTP3s and BTP5s auctions, and once in BTP30s auctions. Notably, there is no correspondence between these peak values in the awarded quantity shares and similar peak values in the demanded quantity shares; this most likely indicates that in those auctions the relevant bidder was particularly aggressive in order to get a very large share of securities. These events may cause phenomena such as *squeezes*[27] on the secondary market, altering its regular functioning and conditioning the security pricing. This occurs right when one or more bidders try to get a very large share of securities in the auction, and after the submission of the bids, they behave aggressively on the secondary market. Hence, especially in the presence of imperfectly competitive markets, the bidders who need to buy the securities auctioned in order to meet the order flows or to close short positions, are obliged to make it at much higher prices by getting their supplies of securities on the secondary market right from those bidders who were able to obtain in auction an abnormal quantity of securities.

Further analyses on the degree of concentration are carried out by calculating indexes which refer to the whole bidders instead of considering only groups of bidders, namely the Herfindahl[28], Entropy[29] and Gini[30] indexes. They consider both demanded and awarded quantity as well.

[27] A *squeeze* occurs when a bidder gets such a large quantity to afterwards be able to manipulate the prices on the secondary market. The Salomon *squeeze* occurred in a US 2-year note auction in 1991 is perhaps the most well-known example of such a manipulation.

[28] The Herfindahl index is calculated by adding the shares of all the bidders squared. It ranges between $1/n$, where n is the number of the auction participants, and 1, i.e. the case with maximum concentration, when a bidder gets all the securities.

[29] The Entropy index is equal to the sum of the shares multiplied by their logarithm, and it takes negative values between 0, when the concentration is at the maximum, and the negative of the logarithm of the number of the auction participants. The Entropy index adjusts the weight given by the Herfindahl index especially to the largest shares.

[30] The Gini index examines if a transferable character is evenly shared or not. It is equal to: $G = \Sigma(p-q)/\Sigma(p)$, where q is the ratio between the amount of the character held by the i smallest units and the total amount of the character, p is the ratio between the i smallest units and the total units, and Σ operates until $n-1$. It ranges from 1, i.e. the case of maximum concentration where all the character is held by a unit, and 0, i.e. the case of perfect even distribution of the character among all the units.

Table 6

study	period	security	demanded quantity			awarded quantity		
			Herfindhal	Entropy	Gini	Herfindhal	Entropy	Gini
Pacini	1/98-11/00	BTP3	0,083	-2,833	73,21%	0,100	-2,720	75,10%
		BTP5	0,079	-2,863	72,76%	0,093	-2,725	75,70%
		BTP10	0,070	-2,940	68,36%	0,106	-2,689	74,17%
		BTP30	0,070	-2,912	65,12%	0,089	-2,728	70,19%
		BTP	0,077	-2,875	70,82%	0,097	-2,717	74,30%
		CCT	0,087	-2,799	73,08%	0,125	-2,551	78,42%
Drudi/Massa	2/94-3/96	BTP	0,061	-3,147	-	0,093	-2,863	-
		CCT	0,051	-3,285	-	0,073	-2,991	-

The indexes on Table 6 confirm the presence of a significant degree of concentration in medium-long term security auctions, as well as a higher concentration of the awarded quantity with respect to the demanded quantity and of the CCTs auctions with respect of BTPs auctions. During the period, the three indexes hold steady, being scarcely variable. Only BTP30s auctions experience a slight decreasing trend in the Entropy and Gini indexes.

Similar results are obtained by analysing the degree of concentration on an aggregate basis, i.e. not considering the auction separately[31]. Indeed, both the higher concentration of the awarded quantity with respect to the demanded quantity and of the CCTs auctions with respect to BTPs auctions, on average remains unchanged (the latter only for the awarded quantity).

Table 7

bidders' share of demanded quantity							
study	period	security	first one	first 5	first 10	first 15	first 20
Pacini	1/98-11/00	BTP3	10,45%	30,43%	49,01%	65,16%	78,91%
		BTP5	8,01%	29,47%	47,35%	63,90%	78,00%
		BTP10	7,28%	28,59%	48,56%	62,82%	75,84%
		BTP30	6,04%	28,27%	49,14%	64,01%	76,63%
		BTP	8,37%	29,43%	48,43%	64,14%	77,68%
		CCT	6,78%	30,91%	50,62%	64,06%	75,48%
Buttiglione/Drudi	9/91-11/92	BTP	9,60%	36,50%	57,10%	70,10%	80,20%
		CCT	9,30%	34,80%	54,00%	67,10%	77,30%

Table 8

bidders'share of awarded quantity							
study	period	security	first one	first 5	first 10	first 15	first 20
Pacini	1/98-11/00	BTP3	7,37%	30,26%	50,34%	67,15%	80,46%
		BTP5	7,29%	27,51%	49,64%	68,20%	81,73%
		BTP10	8,67%	34,56%	54,47%	70,08%	81,98%
		BTP30	8,85%	30,12%	50,65%	66,99%	80,48%
		BTP	7,83%	30,19%	50,95%	68,00%	81,14%
		CCT	8,09%	34,79%	54,75%	70,45%	82,28%
Buttiglione/Drudi	9/91-11/92	BTP	14,30%	44,70%	63,40%	74,90%	83,90%
		CCT	13,30%	41,40%	60,10%	72,10%	79,90%

The first bidder on average demands from 6% (BTP30s) to 10.5% (BTP3s) of the total demanded quantity (Table 7) and is awarded with between 7.4% (BTP3s) and almost 9% (BTP30s) of the total

[31] Unlike the shares reported in Table 4 and 5, the shares of the first *n* bidders in Table 7 and 8 are calculated considering the largest bidders relatively to the aggregate of auctions.

awarded quantity (Table 8), whereas the average share of the first ten bidders is around 50% of both the total amount demanded and awarded in each type of security. The difference is evident between these values and those reported in Table 4 and 5, which considered the bidders' demanded and awarded quantity per each auction. This suggests that bidders are not always the same to be awarded with the larger shares of securities and there is a turnover[32]. Moreover, this is even more definite if compared with that of the period of 1991-1992, as reported in Buttiglione and Drudi (1994). Finally, the whole analysis seems to be in contrast with the assumption of bidders' symmetry, one of the main characteristics of the equilibria in Back and Zender (1993) and in Ausubel and Cramton (1998), where all the bidders submit the same demand schedule.

Briefly, the Italian Treasury primary market of medium-long term securities during the period of 1998-2000 exhibits:

- a not irrelevant level of concentration, especially for CCTs auctions;
- a group of about ten large bidders who hold a high share of the market;
- an increase of the level of concentration with respect to the past.

C. The Price Distribution

The price distribution relates to the demanded quantity and the statistics calculated are the standard deviation[33], the skewness coefficient[34] and the kurtosis coefficient[35].

[32] It may be interesting to verify if such a turnover exhibits some regularities, in order to detect the existence of explicit agreements among bidders to share the market.

[33] This was calculated on the awarded quantity as well.

[34] The skewness is measured by the third central moment. The skewness coefficient is the ratio between the skewness and the standard deviation cubed: $S = E(X-\mu)^3/\sigma^3$. In a standard normal distribution it is equal to 0. Moreover, it allows to compare distributions having different standard deviations. When different from 0, it signals that the distribution is not symmetric; in particular a positive value indicates that the asymmetry is towards the low prices.

[35] The kurtosis is measured by the fourth central moment. The kurtosis coefficient is the ratio between the kurtosis and the standard deviation raised to the power of four, minus three: $K = [E(X-\mu)^4/\sigma^4] - 3$. As for the previous coefficient, it is equal to 0 in a standard normal distribution and it allows to compare distributions having different standard deviations. When higher than 0, the distribution exhibits fat tails, due to high frequencies on extreme values. The kurtosis coefficient aims at checking how much a distribution is flat or Λ-shaped. Flat distributions with large tails are called *platicurtic* (negative kurtosis), whereas Λ-shaped distributions with small tails *leptocurtic* (positive kurtosis). A distribution with the same kurtosis of a normal distribution is called *mesocurtic*.

Table 9

study	period	security	standard deviation	skewness coeff.	kurtosis coeff.
Pacini	1/98-11/00	CCT	0,11	3,37	74,13
		BTP3	0,13	3,68	85,32
		BTP5	0,15	2,86	56,70
		BTP10	0,23	0,23	14,54
		BTP30	0,29	-0,18	5,90
		CCT,BTP	0,17	2,32	53,55
Buttiglione/Drudi	9/91-11/92	CCT,BTP,CTO	0,56	1,94	12,56

Table 9 shows that the price dispersion, measured by the standard deviation, increases with the lengthening of the maturity, varying from 0.11 (CCTs) to 0.29 (BTP30s). The results of the only previous study are also reported. The comparison between them shows a decrease in the price dispersion. During the three-year period the price dispersion exhibits some variability and the absence of any trends, but a decreasing one in CCTs. Still in CCTs auctions, at the end of the period the standard deviation calculated on awarded quantity is higher than that one on the demanded quantity, contrary to what found for all the other securities. The skewness coefficient on average varies between –0.18 (BTP30s) and 3.68 (BTP3s), whereas the kurtosis coefficient between 5.90 (BTP30s) and 85.32 (BTP3s). As opposed to what found for the standard deviation, both coefficients have increased with respect to the past.

The skewness and kurtosis coefficients are useful to investigate the presence of speculative behaviours as those described in Back and Zender (1993), which should be characterized by negative skewness along with a high level of kurtosis, then signalling asymmetric price distributions, with more weight on the high prices (the *inframarginal* bids) and less and less as the prices decrease[36]. From Table 9, only BTP30s auctions on average show negative skewness and positive kurtosis. In CCTs, BTP3s and BTP5s auctions the kurtosis coefficient is still positive but even higher, and the skewness coefficient is instead positive. BTP10s auctions are in-between. Despite BTP30s auctions get close to the equilibria of Back and Zender (1993) in terms of skewness and kurtosis, a further examination by comparing graphically the aggregate demand and the bid distribution of each BTP30s auction with the theoretical ones do not confirm what suggested by the two coefficients. By way of an example, Figure 1 and Figure 2 show respectively the actual aggregate demand and the bid distribution of a BTP30s auction and the theoretical ones according to Back and Zender (1993)[37].

[36] Due to non-available data on individual demand schedule per each auction it is not possible to employ the methodology developed by Keloharju, Nyborg and Rydqvist (2005) to test the *market power* theory more accurately.

[37] These are calculated according to Theorem 1, allowing bids to differentiate at least for five basis points and using the data of the auction reported in Figure 1, i.e. the BTP30 auction held on the 19 of August 1999. In particular, adhering to the notation of Back and Zender (1993), the highest and lowest closing bid price on the five days before the auction day are employed respectively for v^H and v^L, the *stop-out* price for $p*$, the number of auction participants for n and the Treasury offer for Q.

Figure 1

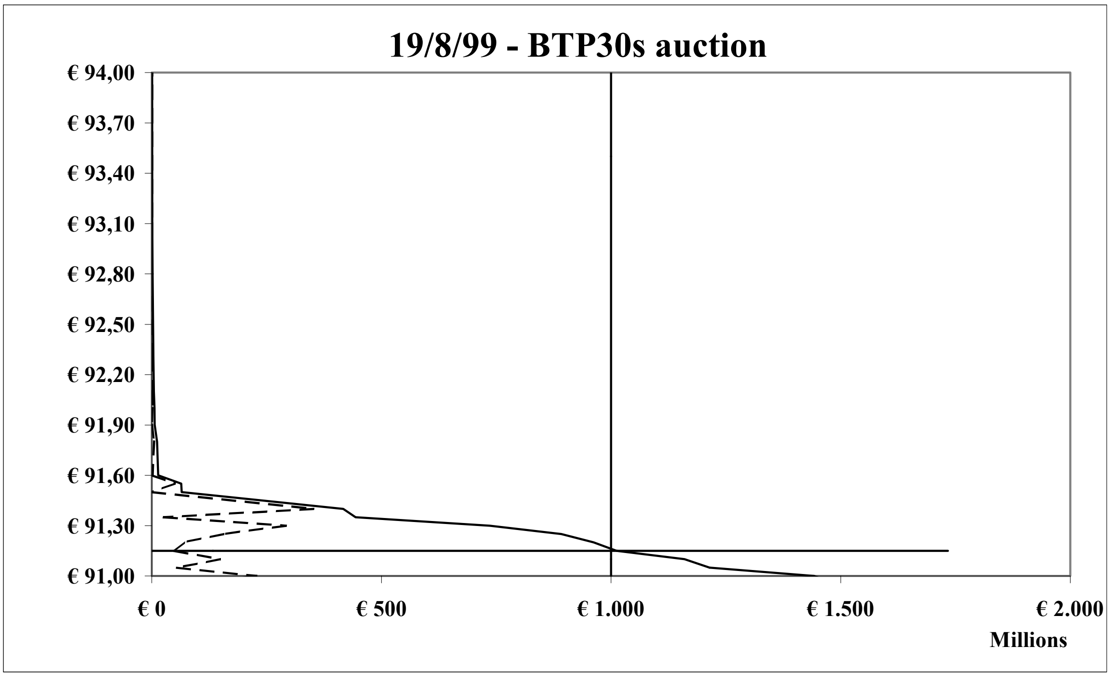
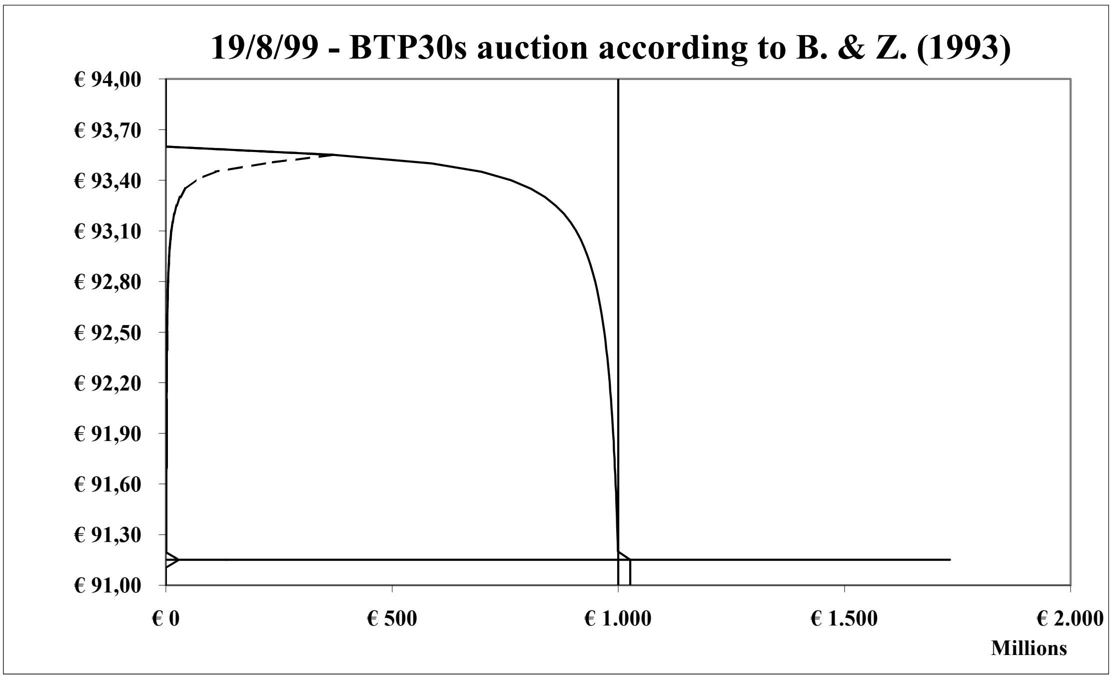


Figure 2



In Figure 1 and 2 the vertical line is the Treasury offer, the horizontal line the *stop-out* price, the bold line the aggregate demand and the remaining line the bid distribution. Figure 1 and 2 are a representative example of the distance between the aggregate demand of the auctions held in the period 1998-2000 and the respective theoretical aggregate demand function of the equilibria of Back and Zender (1993). In this example, the aggregate demand of the BTP30 auction held on the 19/8/99 in Figure 1 shows standard deviation, skewness coefficient and kurtosis coefficient equal to respectively 0.25, 0.56 and 7.05, whereas the corresponding theoretical aggregate demand function in Figure 2 takes values equal to 0.47, -3.40 and 11.63.

Still looking at Table 9, positive values of the skewness coefficient and substantial positive values of the kurtosis coefficient go along with shorter maturities and higher auction participation (see the cover ratio and the number of bidders in Table 3). Then, the difference of the values of the two coefficients among the various types of security may be explained with the fact that in the shorter maturity security auctions (CCTs, BTP3s e BTP5s) there is a higher participation of bidders who demand a small quantity at prices relatively high with respect to the *stop-out* price, thus lengthening one of the distribution tail towards the higher prices. Since the kurtosis coefficient measures how the peak of a distribution distances from the tails, these bids do not change its sign, rather they strengthen it; on the contrary they may offset the bids made at lower prices and if particularly numerous they may change the sign of the skewness coefficient. In the longer term security auctions, as BTP10s and BTP30s, there is a lower participation of the small bidders, possibly due to the fact that they do not have at their disposal specific resources dedicated to advanced financial analysis necessary for a correct pricing of more volatile securities, such as BTP30s which are also the security more subject to speculation. As a consequence, the smaller bidders are less willing to directly participate in the auctions of such securities. The lower ability of the smaller bidders to price the securities in auction will be further analysed by comparing explicitly the behaviour of the large bidders with that of the small bidders in the following Paragraph.

D. The Information Asymmetries and the Size of Bidders

In this paragraph I consider the bidders' behaviour with respect to their size in the primary market in order to confirm some of the previous results, such as the *information asymmetry* suggested by the comparison between the concentration indexes on the demanded and awarded quantity, the absence of symmetry in bidders' behaviour and the causes of the difference of the values of the skewness and kurtosis coefficients among the various types of security. As a first analysis, I report two figures obtained by elaborating data in order to relate bid prices and bidders' size in auction. These concern two auctions, the first one for BTP3s and the second one for BTP30s, as examples for respectively shorter term security auctions and longer term security auctions. Both figures clearly show the difference of behaviour in auction among bidders, with respect to their size in terms of awarded quantity. In particular, Figure 3 highlights the difference between the prices offered by large bidders and those offered by small bidders: the first twenty bidders offer prices between the weighted average price of the awarded quantity and the *stop-out* price, whereas the following bidders, i.e. the smallest ones, offer prices higher than the weighted average price of the awarded quantity for some tens of cents of Euro. On average large bidders offer lower and homogeneous prices, whereas small bidders offer higher and more variable prices. Figure 4 points out that such a phenomenon is present at longer term security auctions as well, but less decisively due to a lower participation of small bidders.

Figure 3

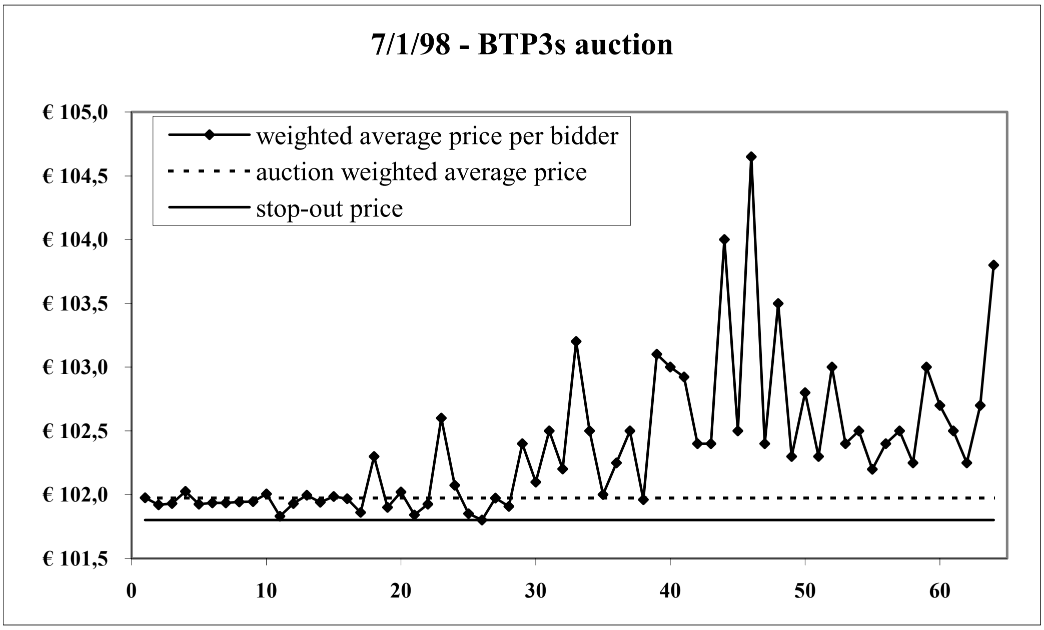
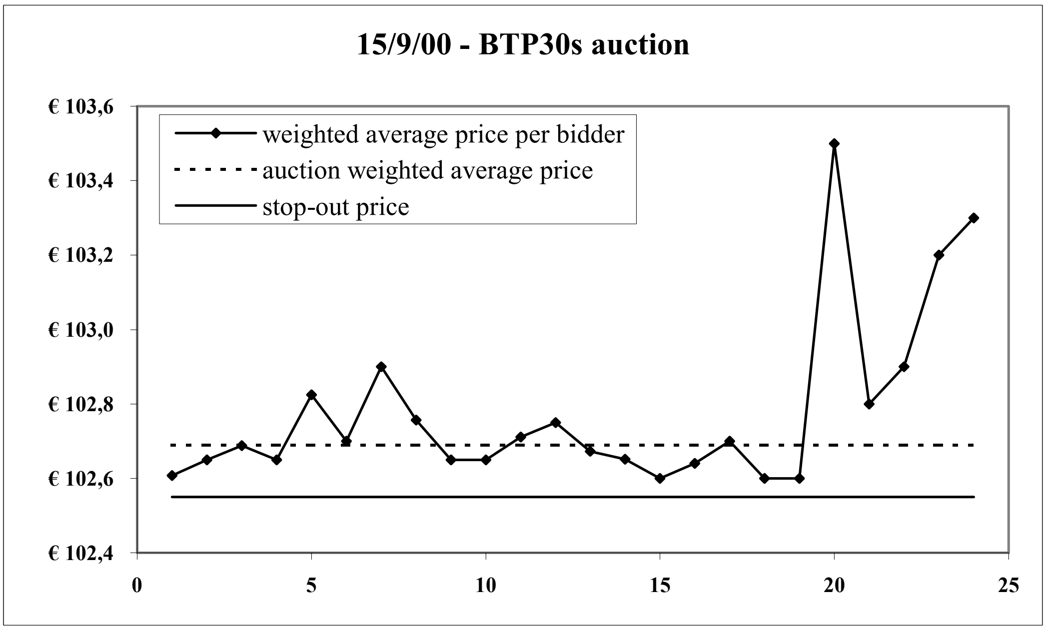


Figure 4



In Figure 3 and 4, the weighted average price of the awarded quantity per bidder is on the vertical axis. The *n*-th bidder is ranked on the horizontal axis, ordered decreasingly according to its size with respect to the awarded quantity. These figures are representative of what occurs in the auctions in the 1998-2000 period and are available for all of them.

Table 10, which reports the average difference between the weighted average price of the quantity awarded to the last ten bidders and to the first ten bidders (in terms of awarded quantity), confirms what anticipated by Figure 3 and 4. In order to have a deeper look at this phenomenon, I also report the average difference between the weighted average price of the awarded quantity and the *stop-out* price, the average difference between the weighted average price of the quantity awarded to the first ten bidders and the *stop-out* price, and the average difference between the weighted average price of the quantity awarded to the last ten bidders and the *stop-out* price.

Table 10

security	average difference			
	last 10 wap - first 10 wap	auction wap - stop-o.p.	first 10 wap - stop-o.p.	last 10 wap - stop-o.p.
CCTs	€ 0,522	€ 0,048	€ 0,038	€ 0,560
BTP3s	€ 0,637	€ 0,075	€ 0,062	€ 0,698
BTP5s	€ 0,674	€ 0,092	€ 0,079	€ 0,753
BTP10s	€ 0,673	€ 0,139	€ 0,137	€ 0,809
BTP30s	€ 0,637	€ 0,245	€ 0,244	€ 0,881

In Table 11, I report some statistics on the price dispersion, useful to examine the presence of homogeneity in bidders' strategies within the two subgroups made up of the first ten and last ten bidders, still in terms of awarded quantity.

Table 11

security	st. deviation prices first 10	st. deviation prices last 10	average difference between st. dev. prices last 10 and first 10
CCTs	€ 0,0376	€ 0,4000	€ 0,3625
BTP3s	€ 0,0373	€ 0,4595	€ 0,4223
BTP5s	€ 0,0491	€ 0,4948	€ 0,4458
BTP10s	€ 0,0646	€ 0,6465	€ 0,5819
BTP30s	€ 0,1079	€ 0,7346	€ 0,6267

Considering the subgroup of the largest bidders, there is a higher homogeneity in bidders' strategies, and then more similarity with the equilibria of Back and Zender (1993). Indeed, the first ten bidders, who individually demand a quantity on average superior to 4% of the total amount put in auction, offer prices which range from the *stop-out* price and the weighted average price of the awarded quantity and are quite homogeneous among them, showing a standard deviation between 3.7 (BTP3s) and 10.8 cents of Euro (BTP30s). On the contrary, the last ten bidders, who individually demand a quantity on average inferior to 0.1% of the total amount put in auction, offer prices far away from the *stop-out* price, on average above between 56 (CCTs) and 88 cents of Euro (BTP30s), and ten times more variable than the prices offered by the first ten bidders.

The statistics in Table 10 then confirm the presence of *information asymmetry* between large bidders and small bidders, and the better ability of large bidders to forecast the *stop-out* price, as suggested by Figure 3 and 4 and by the comparison made in Paragraph B between the concentration indexes on the demanded and awarded quantity. This asymmetry may be explained by the fact that small bidders rest their behaviour almost exclusively on public information. This is one of the evidences produced by Friedman to support the superiority of the uniform-price auction to the discriminatory auction. The uniform-price auction operates as it levels off the playing field, reducing the importance of the private information. However, the pricing differences between the two subgroups may stem from the fact that small bidders' offers are for the most part made to meet their order flows, thus at higher prices to be sure to be awarded.

Lastly, as supposed at the end of the previous paragraph, the difference of the values of the skewness and kurtosis coefficients among the various types of security seems it may be ascribed to the bidders' participation. Higher values of the cover ratio denote a larger volume of the demand with respect to the offer. This larger volume is due to a higher participation of small bidders, which primarily affects the bids submitted at higher prices (compare Figure 3 with Figure 4). Then, the shorter term securities (CCTs, BTP3s and BTP5s) register an increase of the kurtosis coefficient and the switch of the bid distribution from a negative asymmetry to a positive one, with respect to longer term securities.

In conclusion, the analysis of both the demand structure and bidders' behaviour in the medium-long term security auctions, provides some cues to examine the performance (which will be quantitatively measured in the following paragraph) of the uniform-price auction. On one hand, the analysis of the degree of concentration reveals the possibility of explicit collusive agreements among larger bidders who control the market, on the other hand the analysis of the price distribution does not seem to confirm the strategic behaviour of the equilibria of Back and Zender (1993). In particular, neither the symmetry of bidding strategies nor the submission of very steep demand schedules, both necessary conditions to support the implicit collusive equilibria characterized by *stop-out* prices lower than secondary market prices, seem to hold.

E. The Uniform-Price Auction Performance

In this paragraph, I examine the performance of the uniform-price auctions held by the Italian Treasury in the period of 1998-2000, checking for the presence of *underpricing* for the securities put in auction with respect to secondary market prices. The comparison with the secondary market prices, if liquid and efficient, is certainly the most appropriate way to evaluate the auction performance[38]. This comparison is possible not only for the reopenings but also for the initial auctions, given that the new securities are traded since the day before the auction[39]. To this aim, I calculate the difference between the price on the wholesale secondary market (MTS) and the *stop-out* price of the auction. The auctions here considered are the same of the previous analyses except for a BTP3s auction and a BTP5s auction, for which secondary market data are not available[40]. As reference price to measure the *underpricing*, I take the average of bid quotes at the MTS closing time[41], consistently with the assumption that bidders follow the *buy and sell strategy*, as documented by Scalia (1997)[42]. Three are the differences calculated: the first one is between the average of bid quotes at the MTS closing time of the auction day and the *stop-out* price (*undp1*), the second one between the average of the average bid quotes at the MTS closing time of the three days including the auction day and the *stop-out* price (*undp2*), the last one between the average of the average bid quotes at the MTS closing time of the fifteen days including the auction day and the *stop-out* price (*undp3*)[43]. Moreover, to make the auction prices homogeneous with those on the secondary market, I subtract the fee returned by the Treasury to bidders per each security awarded from the *stop-out* prices, which is equal to 25 cents of Euro for BTP3s auctions and 40 cents of Euro for all the other auctions[44]. Table 12 reports the average values of the three measures of *underpricing* and the respective one-sided *t-test* statistics on the difference from zero; in Figure 5 the phenomenon is divided in classes of frequency through histograms, whereas Figure 6 shows its fluctuation over the three-year period.

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[38] Secondary market prices are considered as the “true” value of the securities.

[39] On the official wholesale secondary market for Treasury securities, the MTS, settlement takes place three business days after the transaction is made, whereas it takes place two business days for the auction. Hence, if a bidder sells the securities to be issued the day before the auction and buys them afterwards in the auction, the settlement of both operations will coincide.

[40] They are two reopenings both held on the 2nd of April 1999.

[41] Buttiglione and Drudi (1994) and Drudi and Massa (1997) demonstrate how the *underpricing* does not vary significantly by measuring it in different times from the closing time on the auction day.

[42] See Table 6 page 24, Scalia (1997).

[43] For the initial auctions the third measure of *underpricing* considers the average of the averages bid quotes at the MTS closing time of the day before the auction day, the auction day and the seven business days following the auction day.

[44] This fee is paid out by the Bank of Italy, which operates on behalf of the Italian Treasury in the settlement and delivery process, in return for the bidders’ commitment to resell the awarded securities to their customers at the *stop-out* price, without any additional rises.

Table 12

underpricing	min	average	max	t-statistic	p-value
undp1	-1,610	0,084	2,170	2,645	0,0044
undp2	-1,210	0,077	1,930	2,734	0,0034
undp3	-0,874	0,119	4,528	3,747	0,0001

Figure 5

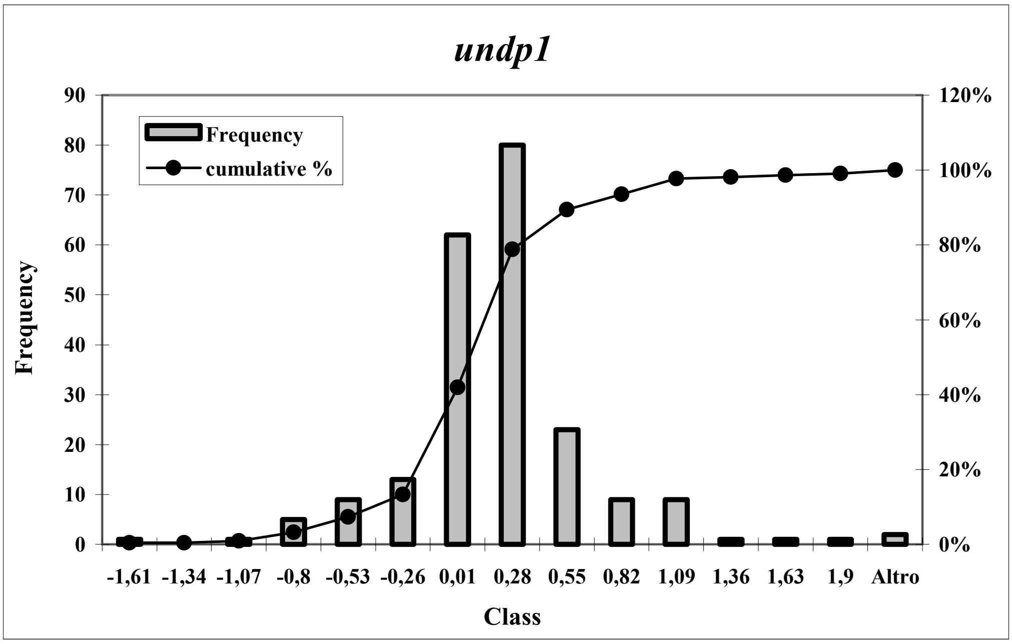
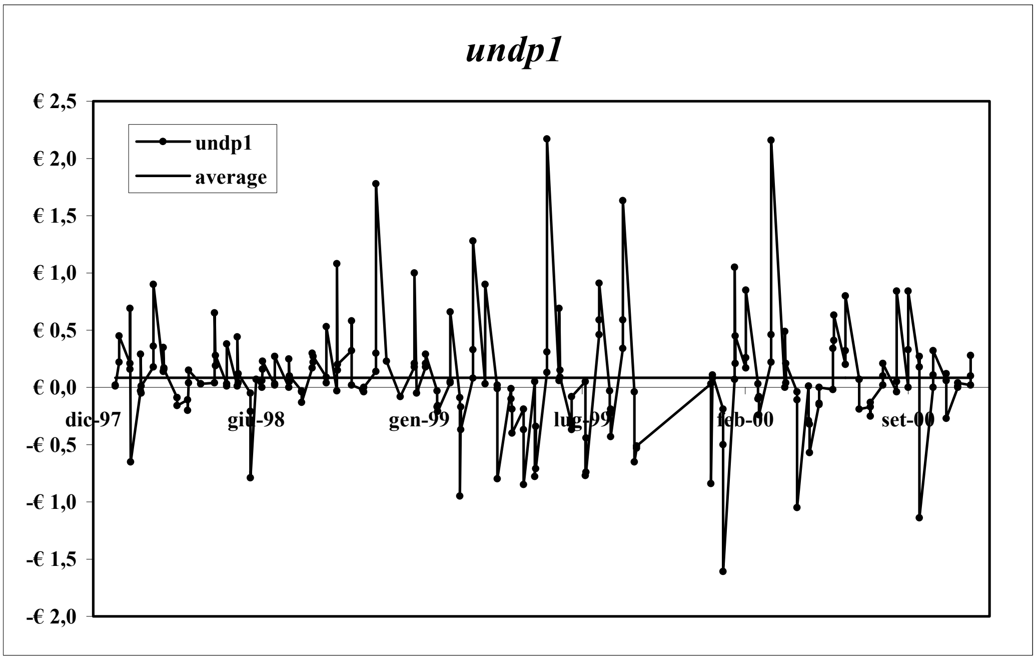


Figure 6



The *underpricing* is statistically significant in all the three specifications, with *p-values* inferior to 1%[45]. These results are in contrast with those found in previous studies on such a phenomenon in Italy, i.e. Scalia (1997) and Drudi and Massa (1997)[46]. This may be attributed to several factors, among which the decrease in the number of bidders, the bidders' skills improvement to deal with the uniform-price auction and the increase of speculative behaviours, suggested by the increase of the skewness and kurtosis coefficients with respect to the past (see Table 9). Numerous are the studies made on the uniform-price auction worldwide, not always concordant between them. In the U.S, Nyborg and Sundaresan (1996), Malvey and Archibald (1998) and Reinhart and Belzer (1997), find little evidence of *underpricing*, whereas Goldreich (2003) using a more detailed dataset finds a significant *underpricing*. Umlauf (1993) finds the *underpricing* not significant in the Mexican auctions, contrary to what was found by Bjønnes (2001) and Keloharju, Nyborg and Rydqvist (2005) respectively for the Norwegian and Finnish auctions. However, the presence of *underpricing* is consistent with the equilibria of Back and Zender (1993). I refer to the following paragraph for an exhaustive analysis on the causes of *underpricing*.

F. The Determinants of Underpricing

Once established the statistic significance of *underpricing*, I further investigate its determinants with relation to the strategic behaviour of bidders in auction. To this aim, it is useful to recall auction theory to identify those variables which more than others may explain the *underpricing*. However, since I do not have explicit equilibria to test, I focus on drawing out qualitative empirical predictions from the models relevant to the Italian context, i.e. *common value* models with private information. The "traditional" models, which assume all the bidders demand the same quantity of securities, point out that a liquid and efficient secondary market brings about the *winner's curse*. In this context, as stressed in the review made in Section II, the value of the securities in auction is the same for all the bidders, since it coincides with the resale price on the secondary market. This value is unknown when bidders submit their bids, which are made on the basis of their own private information. Even assuming that all the bidders' estimates are unbiased, some bidders will estimate values higher than the resale price, while some others lower values. Those bidders who come out

[45] Moreover, I calculate one-sided *t test* statistics on the difference of the *underpricing* both between the different types of security and between the initial auctions and the reopenings. These never show *p-value* inferior to 20%, except for BTP30s auctions which show *p-value* equal to 5.16%, 6.51%, 7.17% and 15.61% from the comparison with respectively CCTs, BTP3s, BTP5s and BTP10s.

[46] See Table 1 page 10 in Scalia (1997) or Table X page 1896 in Keloharju, Nyborg and Rydqvist (2005) for further comparisons with other previous studies.

awarded then risk to have overestimated the resale price and to incur losses in the intermediation activity between the primary and the secondary market. The *winner's curse* draws bidders to bid prices lower than their expected values, because of the fear of overestimating the value of the securities, thus causing systematically lower *stop-out* prices than secondary market prices. In this direction, Milgrom and Weber (1982) suggest that when the signals received by bidders are less precise, namely there is a higher dispersion of bidders' expectations on the securities value, the *winner's curse* is more severe and then the auction expected outcome for the Treasury will be lower. Indeed, the higher the degree of information dispersion, the higher the risk of overestimating the securities with respect to other bidders, the more likely the risk of being awarded at prices higher than those on the secondary market. Therefore, bidders will be more cautious in auction. The expected sign of this first explanatory variable on *underpricing* is then positive. According to an alternative interpretation, if bidders are particularly sensitive to the risk of not being awarded with a sufficient quantity of securities, i.e. the risk of being rationed, the expected sign of this explanatory variable should instead be negative, since in this case a higher information dispersion makes bidders' behaviour in auction more aggressive, which in turn lowers the *underpricing*. This may indeed be the case for the uniform-price auction in which the uniqueness of the award price mitigates the perception of the *winner's curse*.

Still considering "traditional" models, Bikhchandani and Huang (1989) and Wilson (1977) both place great emphasis on bidders' participation. In particular, the first ones adopt the ratio between the total demanded quantity and the total offer as a measure of participation (i.e. cover ratio) and show how an increase in it directly influences the *stop-out* price and then inversely the *underpricing*, given its discipline effect on the speculative behaviours. Wilson (1977) takes rather the number of participants as a measure of participation and shows how an increase in it weakens the *winner's curse*, then driving the *stop-out* price towards the "true" value. The expected sign of both these explanatory variables is negative.

Some empirical works, in particular Drudi and Massa (1997), give instead prominence to the degree of concentration of the primary market. Indeed, when the primary market is highly concentrated, the occurrence of explicit collusive behaviours among bidders is more likely, which will determine *stop-out* prices unfavourable for the issuer[47]. According to this view, an increase of the concentration indexes would have a positive effect on *underpricing*. The expected sign of this explanatory variable is then positive[48].

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[47] Nevertheless, a concentrated market does not necessarily mean low competition. For example, the Dutch banking market is highly concentrated but also one of the most competitive worldwide.

[48] See the results obtained by Drudi and Massa (1997), who find that the degree of concentration, measured by the same indexes calculated in Paragraph B Section III, significantly affects the size of *underpricing*.

Going back to auction theory, the more recent contributions, which express the strategic behaviour of bidders as actual demand functions, and in particular Back and Zender (1993), show how the uniform-price auction is exposed to manipulation from bidders (*market power* theory). Such a manipulation is put into action through the submission of consistent *inframarginal* bids, which make the aggregate demand schedule very steep and lie at the bottom of a sort of implicit collusive agreement which in turn bring about *stop-out* prices inferior to secondary market prices. The *inframarginal* bids may be identified by a high dispersion of the winning bids. This is then the last explanatory variable I consider as a possible determinant of *underpricing*, with a positive expected sign. Moreover, some of the equilibria found by Back and Zender (1993)[49] occur independently of some of the variables suggested by the "traditional" theory, i.e. the cover ratio and the number of bidders, for which a not significant effect on *underpricing* is expected.

Collecting all the explanatory variables identified above, I run the following regression:

$$undp1 = \beta_0 + \beta_1 * disp + \beta_2 * cover + \beta_3 * num + \beta_4 * conc + \beta_5 * mplz + \varepsilon \qquad (1)$$

where *disp* is a measure of the price volatility of the securities on the MTS over the seven days before the auction, *cover* the cover ratio, *num* the number of bidders in auction, *conc* the share of securities awarded to the first fifteen bidders and *mplz* the standard deviation of the prices of the awarded quantity.

[49] I refer to the equilibria of Theorem 1, which assume bidders have private information. Indeed, the *underpricing* of the equilibria of Theorem 4 are instead negatively affected by the number of bidders, but such equilibria do not assume bidders have private information.

Table 14

Regressors	*i*	*ii*	*iii*	*iv*	*v*	*vi*	*vii*	*viii*	*ix*	*x*	*xi*	*xii*	*xiii*	*xiv*	*xv*
constant	-1,72*	-2,20**	-0,37	-0,32	-0,34	-1,68*	-2,03**	-2,50	-2,48	-0,94	-0,19	1,41	-10,51**	-10,83*	-0,34
disp	-0,13	-0,52*	-0,06	-0,52	-0,53	-0,04	-0,32	-0,02	0,49	0,30	0,91	1,00	-1,25**	-1,42**	1,22***
cover	0,01	0,01	-0,01	0,03	0,05	-0,02	-0,02	0,11	-0,04	0,00	-0,17	-0,13	0,41	0,59	0,00
num	0,00	0,01	0,01*	0,00	0,00	0,01	0,01	0,00	0,02**	0,02**	0,02	0,01	0,03*	0,04*	0,00
conc	1,40	1,76*	0,17	0,12	-0,08	1,48	1,72*	1,43	1,81	0,33	0,09	-1,47	8,69	8,56	0,36
mplz	3,26***	3,05***	-0,56	0,80	0,71	1,68*	1,64	6,11***	-0,72	-1,79	-5,81*	-5,02	6,41***	8,10**	0,34
btp3		0,03	0,02	0,05	0,20		0,03		0,08						
btp5		0,04	0,03	0,08	0,25		0,04		-0,05						
btp10		0,18	0,12	0,14			0,15		0,08						
btp30		0,39**	-10,14***				0,28		2,02***						
*disp*dummy*			-1,19**	1,43*	1,75**										
*cover*dummy*			0,42	-0,20	-0,05										
*num*dummy*			0,03**	0,02*	0,00										
*conc*dummy*			8,52**	-0,04	0,44										
*mplz*dummy*			6,97***	-6,61**	-0,37										
R sq.	0,11	0,14	0,34	0,14	0,07	0,04	0,06	0,62	0,80	0,17	0,20	0,18	0,52	0,39	0,37
Adj. R sq.	0,09	0,11	0,29	0,08	-0,01	0,01	0,01	0,54	0,72	0,01	0,06	0,02	0,42	0,26	0,25
F test	3,08**	2,79***	7,16***	2,76***	2,47***	1,79	1,74*	8,64***	10,29***	1,23	1,41	1,12	5,33***	2,94**	2,51*
LM test for heterosk.								1,14	0,84		0,12	1,67	0,01	0,69	
LM(1) test for serial corr.								0,39	0,66		0,00	0,03	0,00	0,00	
n. obs	217	217	217	186	151	184	184	33	33	31	35	31	31	29	32

Regressions: All the regressions take as dependent variable *undp1* and are estimated by *OLS*. The first seven regressions have *standard errors* estimated with the methodology of *Newey-West*, while (*x*) and (*xv*) employ the *Huber-White sandwich estimator of variance*. The other regressions are reported along with the statistics relating to the *Breusch-Pagan* test on the presence of eteroschedasticity and to the *Breusch-Godfrey* test on the presence of serial correlation of the first order on the error distribution. The estimates or test-statistics marked with *, ** and *** denote a significance respectively of 10%, 5% or 1%. The regressors *btp3*, *btp5*, *btp10* and *btp30* are *dummies* which identify the type of security. **Specifications:** the first three regressions, (*i*), (*ii*) and (*iii*), relate to all the auctions, while the following four, to all the auctions without the BTP30s auctions, (*iv*), without BTP30s and BTP10s auctions, (*v*), without the initial auctions, (*vi*) and (*vii*). Moreover, in order to verify if some type of security behaves in a different way from the others, in (*iii*), (*iv*) and (*v*) I add to the model the initial regressors multiplied by a *dummy* which takes the value of one in connection with BTP30s auctions in (*iii*), with BTP10s auctions in (*iv*), with CCTs auctions in (*v*), and zero otherwise. The regressions (*viii*), (*ix*) and (*x*) refer to the initial auctions. Furthermore in (*x*) the BTP30s auctions are excluded. The last six regressions refer to BTP10s auctions, (*xi*) and (*xii*), to BTP30s auctions, (*xiii*) and (*xiv*), and to CCTs auctions, (*xv*) and (*xvi*). In (*xii*), (*xiv*) and (*xvi*) the relating initial auctions are excluded.

Table 14 reports the estimates of sixteen different specifications of (1), depending on the inclusion of *dummies* relating to the type of security or on the exclusion of one or more types of security and/or the initial auctions. The specifications from (*i*) to (*vii*) show that, considering the auctions all together, the theory is not able to clarify the determinants of *underpricing*, also when excluding the relative initial auctions, i.e (*vi*) and (*vii*), and they suggest that some type of security, in particular BTP30s, BTP10s and CCTs, are to be considered individually, i.e. (*iii*), (*iv*) and (*v*). The specifications relating to all the initial auctions only, i.e. (*viii*), (*ix*) and (*x*), at first seem to relate *underpricing* to bidders' manipulation, (*viii*), but once the two BTP30s auctions are excluded as suggested by (*ix*), it follows that *underpricing* is instead significantly and positively influenced (at 5%) by the number of bidders, in contrast with both the "traditional" theory, which predicts a negative relation, and the *market power* theory, which predicts no significant effect. Considering some type of security individually, I find the *underpricing* of BTP10s auctions is not affected by what implied by the theory at all, (*xi*) and (*xii*); the *underpricing* of CCTs auctions is strongly affected by the information dispersion according to Milgrom and Weber (1982), i.e. by the *winner's curse*, (*xv*), and robust to the exclusion of the initial auctions, (*xvi*); the *underpricing* of BTP30s auctions is significantly related to the presence of the manipulation *à la* Back and Zender (1993) and inversely influenced by the information dispersion, suggesting that bidders are particularly sensitive to the risk of being rationed, even in the presence of the lowest values of the cover ratio with respect to the other types of security, (*xiii*). It is puzzling, as found for the initial auctions, the positive relation between *underpricing* and the number of bidders, even if significant at 10% instead of 5%. As for CCTs auctions, such findings are robust to the exclusion of the initial auctions, (*xiv*).

Regarding the main specifications, i.e. (*v*), (*x*), (*xii*), (*xiv*) and (*xvi*), I conclude, in relation to the different factors pointed out by the auction theory, that:

1. The measures of auction participation, namely the number of bidders and the cover ratio, seem to reject the "traditional theory", whereas they are ambiguous with respect to the *market power* theory. On one hand, the cover ratio is consistent with the latter, being never significant. On the other hand, the number of bidders shows contradictory evidences since it is not significant in (*v*), (*xii*) and (*xvi*), while it is positively in (*x*) and (*xiv*).
2. The results relating to the *winner's curse* are problematic for the "traditional" theory, since it is present in CCTs auctions (*xvi*), but it is not in those auctions in which the uncertainty on the value of the securities is higher, either because at the first issuance, (*x*), or because of the high volatility peculiar to the type of security, (*xiv*).
3. The concentration has no room.

4. The manipulation referable to the *market power* theory is absent, except for BTP30s auctions, where yet there is the inconsistent role of the number of bidders with respect to this theory.

IV. Conclusions

After a preliminary exam of the institutional features and the operation of the primary and secondary markets for Italian Treasury medium and long term securities, and a review of the main contributions of the auction theory, I focus on the primary market analysing the demand structure, the auction bidders' behaviour and the performance of the uniform-price auction adopted by the Italian Treasury. The analysis refers to 219 uniform-price auctions for Certificati di Credito del Tesoro (CCTs) and Buoni Poliennali del Tesoro (BTPs), held during the three-year period of 1998-2000. The statistics considered examine the participation, the degree of concentration, the bid distribution, the presence of *information asymmetries* among bidders, the pricing performance of the auction mechanism and the main determinants of the *stop-out* prices, interpreting and comparing the empirical results, as I obtain them, in the light of the auction theory, in particular the *market power* theory.

Over the period under analysis, the number of participants decreases on average 40%, while the demand remains permanently above the offer. The concentration indexes denote a not irrelevant level of concentration, especially for CCTs auctions, a group of about ten large bidders who hold a high share of the market and an increase of the level of concentration with respect to the past. The analysis of the bid distribution shows differences between shorter term security auctions (CCTs, BTP3s and BTP5s) and longer term security auctions (BTP10s and BTP30s). The former exhibit a bid dispersion equal to the half with respect to that one of the latter, positive kurtosis coefficients, significantly higher than those of the latter, and a positive asymmetry in the bid distribution, instead absent for the latter. This last finding do not combine well with the *market power* theory, in particular with Back & Zender (1993), where equilibria are characterized by demand functions having negative asymmetry. Also, the qualitative analysis made through graphic comparison shows the distance between the theoretical demand functions and those occurred in the Italian Treasury auctions. The examination of bidders' behaviour with respect to their size in terms of awarded quantity reveals that on average large bidders offer lower and homogeneous prices, while small bidders offer higher and more variable prices. This confirms the presence of *information asymmetries* between the large and the small bidders and a better ability of the former to forecast the *stop-out* price. Hence, the analysis of the demand structure and bidders' behaviour provides some cues to examine the performance of the uniform-price auction. On one hand, the analysis of the degree of concentration indicates the possibility of explicit collusive agreements among larger bidders who control the market, on the other hand the analysis of the price distribution does not seem to support the bidders' strategic behaviour of the equilibria of Back and Zender (1993). In particular, neither the symmetry of bidding strategies nor the submission of very steep demand schedules, both necessary conditions to sustain the implicit collusive equilibria characterized by *stop-out* prices lower than secondary market prices, seem to hold.

The comparison between the *stop-out* prices and the secondary market prices proves the existence of *underpricing*. This is a sign of inefficiency. The *underpricing* is statistically significant for all the three measures made, with *p-values* inferior to 1%, and distances from the main studies made right before 1998 on the Italian Treasury uniform-price auctions, i.e. Scalia (1997) and Drudi and Massa (1997). On the other hand, it is consistent with more recent studies, such as Goldreich (2003), Bjønnes (2001) and Keloharju, Nyborg and Rydqvist (2005), which relate to respectively the U.S., Norwegian and Finnish Treasury auctions. However, a conclusive assessment of the whole efficiency of the primary market cannot prescind from an evaluation of the *Primary Dealership* system too, namely an economic quantification of all those aspects which condition the profitability of the main bidders, such as the privileges and obligations coming from the status of *Specialist*. For example, among the privileges, it is the case of the right of buying an additional quantity of securities in the reserved reopenings the day after the auction or the access to syndicated issues. From the obligations-side, the main associated costs relate to the attainment and maintenance of the market requirements, both on the primary and secondary market.

In analogy with several works based on auction theory, I investigate the determinants of *underpricing*, following and verifying what suggested by both the "traditional" theory and the more recent *market power* theory. In particular, the auctions relating to some types of security, i.e. CCTs and BTP30s, show some significant results, but only for CCTs auctions consistent with the theory. Indeed, CCTs *underpricing* is strongly affected by the *winner's curse*, while for BTP30s I find a number of factors, such as the number of bidders, the risk of being rationed and the possible manipulation described by the *market power* theory. However, in the latter the interpretation of the positive significance of the information dispersion variable as evidence of the presence of the risk of being rationed is problematic given that the BTP30s auctions are those with the lowest values of the cover ratio. Furthermore, the number of bidders is positively significant, thus in contrast with both the "traditional" theory (see Wilson 1977) and the *market power* theory (see Back e Zender 1993). On the whole, considering that CCTs and BTP30s auctions represent simply 30% of all the auctions, the theory lacks a confirmation in the remaining 154 auctions and is not able to fully catch the underlying dynamics of Treasury auctions yet.

Underpricing may be rather traced back to the repeated character of the Treasury auctions. Indeed, games theory proves that for infinitely repeated games it is even easier to support collusive equilibria if these already exist in the same game not repeated. Moreover, the repeated character of the Treasury auctions is one of the possible explanations left, especially in those cases where it is more difficult in the individual auction to sustain equilibria with *underpricing*, as for example in Kremer and Nyborg (2004a), who demonstrate how in a discrete setting, equilibria with *underpricing* in the uniform-price auction are impossible if the minimum price tick is "small" relative to the quantity multiple. Therefore, in order to protect itself from *underpricing*, the issuer should necessarily resort to mechanisms expressly studied to play an active role in auction, acting strategically and looking at Government security auctions as a part of a repeated game between the Treasury and the *Specialists*. This is the case of the Finnish Treasury which, as documented by Keloharju, Nyborg and Rydqvist (2005), acts strategically availing itself of the right of reducing *ex-post* the quantity initially put in auction[50], that is after having received all the bids, thus *de facto* enjoying the right to set the *stop-out* price. In Mexico, Switzerland and Germany too, as reported by Umlauf (1993), Heller and Lengwiler (1998) and Rocholl (2005) the Treasury enjoys the same right..

Finally, *underpricing* may be nothing else but a visible effect of the complex interplay between the auction, the secondary market and the *repo* market. Indeed, auction theory considers a stand-alone auction, which cannot lead to a complete understanding of this important auction environment, as it is evident from this work. Focusing on how the auction market can interact with the secondary and *repo* market and how susceptible the current mechanism for selling Treasury securities is to manipulation by bidders should be one of the most profitable directions to take for further works. Indeed, the possibility of manipulating the bidding may affect the *repo* or secondary market. The visible effects of such a manipulation may be either *mispricing* in auction, *repo specials*, or secondary market *squeezes*.

[50] Back and Zender (2001) prove that such a right operates as a deterrent for the *implicit* collusive behaviours found by the *market power* theory, at the basis of *underpricing*. In particular it prevents the submission of the *inframarginal* bids, responsible for the higher steepness of the demand schedules (see also Lengwiler [1999], LiCalzi and Pavan [2002] and McAdams [2002]).

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