

Endogenizing Bidders Choice in Divisible Goods Auctions*

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Abstract

Many financial assets, especially government bonds, are issued by an auction mechanism. An important feature of the design is the auction pricing mechanism: Uniform vs. Discriminatory. Theoretical papers do not provide a definite answer regarding the preference of one mechanism over the other. Experimental papers investigated the issue under an exogenous equal number of bidders. We investigate the bidders' choice and the impact of that choice on the outcome of the auction by letting them choose between the two alternative systems. The majority of the bidders in the survey have chosen the uniform method. Those that prefer the uniform auction bid, on average, more aggressively than those that choose the discriminatory one. On average the revenues to the issuer were higher under the uniform price mechanism.

JEL classification: G1, F3

Keywords: Uniform auction, discriminatory auction, Treasury bonds, T-bills

1. Introduction

Many financial assets such as treasury bonds, corporate bonds and stocks are issued to the public via auctions. Currently there is no consensus neither in the academic literature nor in practice what is the appropriate pricing mechanism to use, should it be uniform pricing or discriminatory pricing.¹ This paper reports and analyzes the survey results of potential bidders. Specifically, we report the preferences of potential bidders for a uniform price auction vs. a discriminatory one. To the best of our knowledge, our study is the first attempt to offer participants a choice, though through experiment, between auction systems and learn about their preferences.

Friedman (1960) has argued (in the context of Treasury Auctions) that the discriminatory format will drive out uninformed participants because of the “winner’s curse”. A discriminatory mechanism draws better informed, typically large players and will be more susceptible to collusion. Hence he predicted that the discriminatory auction will lead to lower revenue.

More recent work in the theory of divisible-unit auctions investigates the trade-offs that the central planner faces in the use of the different mechanisms.² These papers raise the following question: When the central planner (the auctioneer) sets the rules, given N exogenous participants, which mechanism will maximize his revenue? They show that there exist non-cooperative equilibria under the uniform-price format that support collusive outcomes. They also show that these outcomes are not supported by discriminatory auctions. These models predict that the uniform price mechanism may result in multiple equilibria. Also, in a uniform auction the participants may collude, in which case the revenue to the seller may be lower under the uniform price mechanism than under the discriminatory one. Thus, in the case of divisible units the theory is inconclusive, it does not tell us whether the uniform auction will generate higher revenue

¹ In the **Uniform Price Auction (also known as Single Price Auction)**, the objects are awarded to the bidders that bid above the market clearing price. All bidders pay the same price, the market clearing price, for the entire quantity that they are awarded. In the **Discriminatory Price Auction (also known as Pay Your Bid Auction or Multiple Prices Auction)**, the objects are also awarded to the bidders that bid above the market clearing price. However, each bidder pays the price that he bid.

² See, for example, Wilson (1979), Back and Zender (1993), Ausubel and Cramton (2002) or Wang and Zender (2002) for theoretical evidence on strategic bidding in multi-unit auctions. A survey article on auction theory by Das and Sundaram (1996) discusses the lessons from theoretical models for Treasury securities auctions, and presents some empirical evidence.

than the discriminatory auction or lower ones. This remains an empirical issue that our research is trying to contribute to.

There is a growing strand of research in experimental economics investigating divisible good auctions³. The main advantage of this literature is the ability to compare the different mechanisms in a controlled environment. In these recent experimental works the number of participants was set in advance and the bidders had to participate in a specific pre-determined auction, without being asked what type of auction they prefer to participate in. In actual auctions, however, the results may depend upon the auction mechanism coupled with the number of participating bidders.⁴ Thus, there is a need to investigate which mechanism would be preferred by potential bidders and to endogenise the number of bidders in the comparison. In addition to the academic contribution, our research question has practical implications as well. Given that the financial markets have become more global and barriers to financial transactions have decreased dramatically, as manifested in the growing foreign participation in Treasury auctions around the world (e.g. Finland)⁵, a central planner that would like to attract global participation can no longer act as a monopolist, and needs to take into account the preferences of potential bidders. We investigate bidders' choice in **divisible** goods auctions which is the appropriate setting for the auctioning of financial assets.⁶

It is essentially impossible to get relevant data regarding bidders' actions and their preferences for specific auction mechanisms, while controlling for other effects. Therefore, using surveys to learn about the preferences of potential bidders seems a natural alternative.

We conducted a survey among a variety of potential bidders and business educated people. We surveyed financial professionals, advanced business undergraduates, MBAs which had a few years of work experience and Executive MBAs in 6 different countries

³ Starting from the early papers by Smith (1967), Miller and Plott (1985), Cox, Smith and Walker (1985) to the more recent papers by Goswami, Noe, and Robello (1996) and Sade, Schnitzlein and Zender (2006).

⁴ See, for example, Engelbrecht-Wiggans, List, and Reiley (2006) and Bulow, and Klemperer (1996)

⁵ See, for example, the evidence from Finland, "The introduction of the euro has boosted market volumes as well as numbers of active counterparties and final investors. Already during the first year of the euro, domestic banks lost much of their earlier dominant position as the share of foreign demand increased to 75%, and the share is still increasing", Salavirta and Taipalus (2003, pp 44).

⁶ There have been attempts, in the single unit auction literature, to investigate empirically and experimentally bidders' choices among existing mechanisms and to theoretically incorporate the notion that the sellers in the auctions may need to compete for the buyers. See, for example, Ivanova-Stenzel and Salmon (2004), McAfee (1993), Levin and Smith (1994)

(US, Israel, Norway, South Africa, Luxembourg and Switzerland), receiving 220 qualified answers.⁷ The survey focused on, their preference for a specific auction design; do the participants have a strong preference for either a uniform auction or a discriminatory one.

The main findings are: First, 90.9% of the participants are not indifferent with respect to the pricing rule of the auction. Second, most prefer to participate in a uniform price auction (65.5% of those who are not indifferent). This is true regardless of the country, and type of education (MBAs, executive MBAs, undergraduates or professionals).

Consistent with previous empirical research that focused on event studies our survey results suggest that by using the uniform price mechanism countries may obtain higher revenues since the combination of the large number of bidders with their aggressive bidding strategies should yield higher revenues to the issuer.^{8,9}

The paper is organized as follows. Section 2 describes the hypotheses relating to bidders' choices and discusses the design of the survey. In Section 3 we present the survey results. Section 4 provides concluding remarks.

2. The Hypotheses and Survey Design

2.1. Hypotheses about Bidders' Choices

As discussed above the existing theory does not provide us with a definitive answer regarding the pricing rule that an issuer of financial assets should choose in designing an auction. One possible alternative is to try to get a reading of the preferences of potential bidders. An experiment conducted by the U.S. Treasury between 1992 and 1996 compared the two auction systems. The results (see Malvey, Archibald and Flynn (1995) and Malvey and Archibald (1998)) are marginally in favor of the uniform price

⁷ All the university students that participated in our survey attended advance finance courses. Hence, they also had a background in economics and statistics. The students in the MBA programs that participated in the survey come from many different countries.

⁸Our results are consistent with the empirical investigation of Umlauf (1993) who examined the Mexican T-bill auctions, with Feldman and Reinhart (1995) that studied the international monetary fund's auction of gold and with Tenorio (1993) that studied Zambia's weekly auctions of foreign exchange.

⁹ The experimental work by Goswami, Noe, and Robello (1996) shows that discriminatory auctions yield higher revenue than uniform auctions.

mechanism when the total revenues generated by the two methods are compared. The experiment, however, gave indications of wider participation and less concentration in the uniform price mechanism.

Taking into account that the degree of participation in the auction may not only have a direct effect on the auction results but may also have an indirect effect via its potential contribution to liquidity in the secondary market, the purpose of our study is to provide evidence, obtained from surveys, that will shed light on the preference of potential market participants. These preferences should have an impact on the tendency to participate in the auction.

Based on the answers to our survey we can test several hypotheses. We start with an elementary query regarding the preferences of participants.

H_0 : Auction participants have no preference (are indifferent) for a specific type of mechanism, be it uniform (UPA) or discriminatory (DA).

H_1 : Auction participants are not indifferent between UPA and DA.

A rejection of H_0 , leads to the next hypothesis;

H_0 : Auction participants prefer UPA over DA.

H_1 : Auction participants prefer DA over UPA.

Given the choice of an auction mechanism, how does the bidding schedule (price/quantity) look like? This is expressed by the following hypothesis:

H_0 : The bidding aggressiveness is similar for both mechanisms.

H_1 : The bidding aggressiveness is not similar for both mechanisms.

A rejection of the above hypothesis, H_0 , would lead to the next hypotheses

H_0 : Bidding is more aggressive for the UPA.

H_1 : Bidding is more aggressive for the DA

The above hypotheses are tested using the survey data.

2.2 Survey Design

2.2.1 Methodology

The responses to the surveys, which were conducted among different groups in several countries, are our source of data. Designing an effective survey is a challenging task since one needs to express in a relatively short survey a complicated realistic situation and, at the same time, to obtain honest replies. Given that, we decided to adopt the experimental design of SSZ (2006) as the base case of our survey. This enables us to check the consistency of our survey ("one shot game") with a multi- round experiment. Moreover it enables us to check the consistency of the results of two different methods, unpaid survey versus a paid lab experiment.¹⁰ In the design of the specific questions that are asked in the survey we used standard survey techniques to minimize potential biases. In addition we were constraint by IRB rules. A copy of the survey is provided in Appendix A.

In order to keep the identity of the participants confidential the survey does not ask for specific individual identification such as name, birth date, or social security number except for gender. Yet, in order to incorporate the potential impact of financial experience, in particular financial auction experience, we do ask questions about experience in the financial markets and previous experience in financial auctions.

The first part of the survey describes the objectives of the research and provides a detailed example of the two auction mechanisms. The second part consists of the questionnaire, including questions with regard to the participants' experience.

2.2.2 Survey Questions and the Main Example

In our survey (see Appendix A) the participants were asked to imagine that the market consists of 10 participants and each participant can decide in which auction mechanism to participate. As in reality, the decision of each member of the group affects the number of bidders that he or she will eventually be bidding against. The parameters of the problem are based on SSZ (2006) which is described next.

¹⁰ For an elaborated discussion on the effect of financial incentives on performance in experimental tasks see Camerer and Hogarth (1999).

In their study there are $N = 5$ bidders in each auction mechanism (5 in the uniform and 5 in the discriminatory) who compete for $Q = 26$ units of a good. The after-market value of a unit is known in advance and is equal to 20.¹¹ Prices are discrete and the “tick size” is 1. In particular, bids were submitted for quantity orders at 4 distinct prices contained in the set $\{17, 18, 19, 20\}$. Quantities are in integers and the aggregate quantity demanded by each bidder is 26. Each quantity order is an offer to purchase the specified number of units at a given price (or below in the case of the uniform-price auction). The stop-out price is determined as the highest price at which demand equals or exceeds the supply of $Q = 26$ units. Winning bids are those submitted at or above the stop-out price. All quantities demanded at prices strictly above the stop-out price are filled while orders bid at the stop-out price are rationed on a pro-rata basis.

Given this structure, SSZ (2006) describe the Nash equilibria of the one-shot auctions. While the uniform price mechanism supports multiple equilibria (at all possible prices), the discriminatory price mechanism supports only one equilibrium at the auction price of 19.

In our setting, the experimental design which allocates 5 bidders to each mechanism, can be thought of as a special case where either all the 10 participants choose to be indifferent between the two auction mechanisms or 50% of them choose to participate in a uniform price mechanism and the other 50% choose the discriminatory price mechanism. It should be noted that the equilibria described in the case where 10 players are divided into two groups of 5 each is not necessarily the equilibria obtained in other possible division of the 10 players. If, for example, only one participant decided to choose the uniform price mechanism, while the rest (9) decided to choose discriminatory price mechanism, then the only equilibrium in the uniform price mechanism is 17.

In our survey the participants are presented with two identical firms which try to issue debt via an auction. The only difference between the two firms is the auction mechanism; one firm is using a uniform method and the other is using a discriminatory method. It is important to note that while the participants in our survey choose between

¹¹ Though a known after- auction price was employed by SSZ (2006), there is a legitimate concern about this design decision. One motivation was to avoid the potential problem of bankruptcy of the bidders which in our survey we can not control for. Another consideration was that given a mostly liquid treasury bond market, the reissuance of the same bonds happens in a market with continuously observed known prices.

two firms, we could have replaced the word “firm” with the word “country”. Since we wanted the participants to be unbiased by the common practice of their own home country we chose a firm as the auctioning party.

We asked the participants if they have any preference, and which one, or whether they are indifferent. Given their choice, they were asked to submit a schedule of bids. We also asked them which mechanism they think most of the other participants will choose (including those who are indifferent). Although we did not ask questions about the identity of the participants, we did ask each of them about their previous exposure to financial auctions, years of experience in the financial industry and their gender. We did not reward the participants with monetary prizes and the participation in the survey was strictly voluntary.

2.2.3 Survey Sample

We conducted the survey during 2004 and 2005 in 6 different countries getting a varying rate of response.¹² Our final sample consists of 220 participants. (USA (43.2%), Israel (22.7%), Switzerland (8.2%), Luxembourg (12.3%), Norway (7.7%) and South Africa (5.9%). The participants (see Table 1) consisted of bankers from South Africa that attended a risk management course, financial professionals from one of the leading financial institutions in Israel, advanced business undergraduates from the USA, advanced MBA students from the USA, Israel, Luxemburg and Switzerland, Executive MBA students, mostly finance professionals, from Israel and Norway.¹³

Our paper joins the strand of literature that uses both professionals and students in experimental / survey settings. Friedman and Sunder (1994) provides a detailed discussion on the choice of subjects for economics experiments and survey experimental economics papers in different economics decision context. Our focus is financial markets and in this context, there are several experimental papers that investigate the choice of professionals versus students subjects and found that the behavior of professional decision makers does not qualitatively differ from that exhibit by the student subject

¹² We excluded from the sample few cases of participants that did not answer the question of the mechanism choice, or did not submit bids or in rare cases where they have submitted bids for more than 26 units.

¹³ Many of the students in the classes in Switzerland and Luxembourg are citizen of other countries such as Germany, France, Belgium and Holland.

group. Example includes: DeJong, Forsythe and Uecker (1988), Dyer, Kagel and Levin (1989), Plott (1988) and Smith Suchanek and Williams.

The participants in our sample have on average 2.33 years of experience in the financial markets (the maximum is 25 and the minimum is zero). 11.4% of them indicated that they had previous experience with financial assets auctions. Given the strand of literature that argues that gender may have an effect on different aspects of the decision making process, we also control for gender. We had 21.8% female subjects in our sample.

3. Analysis of the Results

The first main result is that about 91% of the participants are **not** indifferent to the pricing rule of the auction mechanism and most of those that have a preference for a specific price mechanism (65.5 percent) have chosen to participate in a uniform price mechanism. This is true across countries (in the sample) and across types of education (Executive MBA versus MBA versus Undergraduates). (See Table 1 for detailed results). In other words, the majority of the participants in each country and in each education group chose the **uniform** price mechanism.

Given these results, the next question is, to what extent did experience, gender and country (U.S. or other) affect bidders' choices. To investigate this question we estimated the following logit (probit) equations on the sample of participants who had a specific preference ("not indifferent") and answered all the essential questions (n=194):^{14 15},

$$UPM = \alpha + \beta_1 YE + \beta_2 \text{Dummy}(AE) \quad (1)$$

$$UPM = \alpha + \beta_1 YE + \beta_2 \text{Dummy}(AE) + \beta_3 \text{Dummy}(G) + \text{Dummy}(US) \quad (2)$$

Where:

¹⁴ We also conducted a multinomial logit test that included the group that was indifferent. The results were essentially the same.

¹⁵ In five cases the participants did not indicate the years of experience and those were not included in the analysis.

UPM (Uniform Price Mechanism) is a dummy variable that gets the value 1 if the participant chooses the uniform price mechanism and 0 if the participant chooses the discriminatory price mechanism.

YE is years of experience that the participant has in the financial industry.

Dummy (AE) is a dummy variable that gets the value 1 if the participant has experience with financial assets auctions.

Dummy (G) is a dummy variable that equals 1 if the participant is a female and 0 if he is a male

Dummy (US) is a dummy variable that equals 1 if the survey was done in the US and 0 elsewhere.

The results obtained from estimating the above logit (probit) equations are as follows: From equation (1) we find that the preference for the uniform price mechanism is positively correlated with years of experience in the financial markets but it is barely significant ($p=0.08$ for the logit and 0.07 for the probit). However, exposure to auctions of financial assets has a non significant negative correlation with the auction choice. The pseudo R- square is rather low (0.017 for the logit and 0.018 for the probit) indicating that we are explaining a very small part of the variation in the auction choice. The basic result and the explanatory power of the model do not change when we add a dummy for gender or a dummy for the US location as control variables (equation 2).¹⁶ These two control variables were both insignificant.

We next divided the sample of participants into three groups according to their reported years of experience in the financial markets: The first group reported no experience in financial markets ($n= 104$), the second group is the group that reported experience of up to (including) 2 years ($n= 32$) and the last group is the group that reported experience of more than 2 years ($n= 78$). Figure 1 shows the preference of the participants for each of the three groups. Though all three groups show a preference for the uniform mechanism, the relatively strongest support for this mechanism is provided by the participants who reported to have experience of over two years in the financial markets.¹⁷

¹⁶ The P value of the chi-square test for the model is also insignificant.

¹⁷ It is interesting to note that the preference for the uniform mechanism among those that have work experience of about two years is only slightly more than for the discriminatory mechanism.

Moreover, we find that not only do most bidders prefer the uniform price mechanism, they are also willing to bid more aggressively under the uniform price mechanism. The weighted average, (by quantity demanded), of the price submitted by bidders that chose the uniform price mechanism is 18.72 while the weighted average of the price submitted by bidders that chose the discriminatory price mechanism is 18.59. This result is statistically significant at the 10% level and is consistent with the finding of SSZ (2006).

To test whether the difference between the weighted average price that was bid in the two auctions is statistically significant, while controlling for relevant variables, we use the following Tobit regression¹⁸

$$AP = \alpha + \beta_1 YE + \beta_2 \text{Dummy}(AE) + \beta_3 \text{Dummy}(G) + \beta_4 \text{Dummy}(UPM) + \beta_5 \text{Dummy}(DPM)$$

Where:

AP is the weighted average of the price submitted by bidders calculated as:

$$AP = \frac{\sum_{i=17,18,19,20} i * Qi}{\sum_{i=17,18,19,20} Qi} \quad \text{Where } Qi \text{ represent the quantity demanded at that price.}$$

Dummy (UPM) is a dummy variable that receives the value 1 if the participant chose the uniform price mechanism and 0 if the participant chose the discriminatory price mechanism or was indifferent. Dummy (DPM) is a dummy variable that receives the value 1 if the participant chose the discriminatory price mechanism and 0 if the participant chose the uniform price mechanism or was indifferent. YE is the amount of experience in round years that the participant had in the financial industry. Dummy (AE) is a dummy variable that receives the value of 1 if the participant had experience with financial assets auctions. Dummy (G) is a dummy variable that equals 1 if the participant was a female and 0 if he was a male. Dummy (US) is a dummy variable that equals 1 if the survey was done in the US and 0 elsewhere.

¹⁸ We use Tobit since the bidding prices in the survey are limited to the range between 17 and 20

The only significant variable at the 10% level ($P=0.07$) is UPM and its coefficient is positive, which gives additional support to the hypothesis that those choosing to participate in the uniform price mechanism bid more aggressively on average

In order to investigate which mechanism will yield higher revenue to the auctioneer given the participants' choices, we randomly assigned the 220 participants answers to twenty two groups of 10 each. In each group we divided the participants answers according to their mechanism choice; either discriminatory or uniform¹⁹. We calculated the auction price for the two mechanisms for each of the 22 groups. On average, the uniform price mechanism leads to significantly higher revenue than the discriminatory price mechanism ($t=2.95$ paired test). Consistent with SSZ (2006) we also find that there is higher variation in the obtained revenue under the uniform price mechanism than under the discriminatory price mechanism. Table 7 shows the revenues for each of the 22 groups. In most groups the uniform bids resulted in much higher revenues (14 out of 22 groups). In 13 cases the uniform bidders actually yielded the highest possible revenue of 520. The highest revenue for the discriminatory bidders was only 514 .

Finally, we wanted to find out what the participants thought about the choice that other participants will make. About 20% of our sample did not answer this question. Hence the relevant sample decreased to 175. Out of them 10.3% predicted that most participants will be indifferent, 66.3 % predicted that most participants will choose the uniform price mechanism and 23.4% predicted that most participants will choose the discriminatory price mechanism. Overall, the predictions of our participants were in line with the actual responses. Most of them thought that the majority will choose the uniform price mechanism and most of them did. It is interesting to note that 76.6% of the participants thought that most participants will choose the same mechanism that they have chosen. It is an interesting observation because it may not be optimal to participate in the mechanism that most players will choose.

While focusing on the bidders' choice one may ask how our survey results fit into the paradigm of a general equilibrium. In a world with open financial markets and (relatively) free access to a variety of different auctions of close substitutes will there not

¹⁹ Participants who were indifferent between the two mechanisms were randomly assigned.

be some kind of an irrelevance result that applies to any country? Under this paradigm, if bidders are only concerned with paying the lowest price they will look for the best value across auctions taking into account their ability to extract rents from the seller and the anticipated participation in each auction. Our results together with the previous literature suggest that although revenues play a major role in bidders decisions, it seems that they have other considerations as well. The uniform price mechanism is associated with "fairness" and with a lower level of collusion. Indeed the bidders in our sample prefer the uniform and also prefer to bid more aggressively in the uniform price mechanism. They also prefer the uniform price mechanism even though they admit that they think that most bidders will prefer the uniform price mechanism. We believe that an interesting future research topic will be to investigate further what are the potential factors that may affect issuers' preferences with respect to auction mechanisms in addition to maximizing revenue.

4. Summary and Conclusions

In issuing financial assets governments and corporations face a major decision; what is the optimal offering process to sell their debt or equity? Most governments and some corporations use an auction mechanism. There are basically two common types of auctions for financial assets: the uniform one and the discriminatory one. The existing theoretical and empirical work is ambivalent about the method that issuers should choose.

An important consideration of issuers in selecting the auction mechanism in a global competitive market should be the preferences of potential bidders. In this paper, for the first time in the academic literature, we provide survey evidence on the preference that potential bidders may have with regard to these two auction mechanisms. We surveyed over 200 business educated people and financial professionals in order to learn about their preferences between the two auction mechanisms. The overwhelming majority of our participants are not indifferent with respect to the auction mechanism and the majority preferred to participate in a uniform price auction. The only variable that we found to be positively related to the auction type choice is the years of experience in financial markets.

In our study we document that a large majority of the bidders preferred a uniform auction²⁰ while Brenner Galai and Sade (2007) survey of countries which use auctions to issue debt shows that most of these countries use the discriminatory auctions, despite the arguments advanced by Friedman (1960) and others²¹, claiming that a UPA will generate more revenue. Though the evidence from the experiment done by the U.S. treasury in 1992²², following the Salomon Brothers scandal²³, was not significant with regard to the revenue generation, it did show that the uniform auction attracts a wider range of participants which may be an important factor in establishing liquidity in the secondary market. Following the experiment the U.S. treasury has moved to UPA in all their bond issues. Our survey provides evidence that is consistent with the US experiment and suggests that those countries that seek wider participation in their auction procedures should consider using the uniform price mechanism.

²⁰ Though it has been shown that in the indivisible good UPA the bidder will end up paying more than the average bidder in the DA one, the bidder may prefer the UPA since it is a less risky strategy and more defensible.

²¹ See the survey by Das and Sundaram (1996) and the references to papers which make the same point.

²² See Malvey, Archibald and Flynn (1995) and Malvey and Archibald (1998).

²³ For an analysis of the Solomon squeeze see Jagadeesh (1993)

Bibliography

Ausubel, L., and P. Cramton, 2002, "Demand Reduction and Inefficiency in Multi-Unit Auctions," University of Maryland working paper.

Back, K., and J.F. Zender, 1993, "Auctions of Divisible Goods: On the Rationale for the Treasury Experiment," *Review of Financial Studies*, 6, 733-764.

Back K and J.F. Zender, 2001, "Auctions of Divisible Goods With Endogenous Supply", *Economics Letters*, 73, 29-34

Bikchandani, S., and C. Huang, 1993, "Auctions with Resale Markets: An Explanatory Model of Treasury Bill Markets", *Review of Financial Studies*, 6, 311-339.

Brenner M., Galai D. and O. Sade, 2007, Auctioning Sovereign Bonds: A Global Cross-Section Investigation of the Price Mechanism, Working Paper, NYU

Bulow, J I. and P. D. Klemperer. 1996, "Auctions vs Negotiations," *American Economic Review*, 86 pp. 180-94

Camerer C.F, and R.M Hogarth, 1999, "The Effect of Financial Incentives in Experiments: A Review and Capital-Labor-Production Framework" *Journal of Risk and Uncertainty*, 19: 1-3, 7-42

Cammack, E., 1991, Evidence on Bidding Strategies and the Information in Treasury Bill Auctions", *Journal of Political Economy*, 99(1), February, 100-130

Cox C. James, Smith L. Vernon and Walker M. James, 1985, "Expected Revenue in Discriminative and Uniform Price Sealed Bid Auction", *Research in Experimental Economics a Research annual*, Editor Smith L. Vernon, volume 3, JAI Press INC, 183-232.

Das, S. R., and Sundaram R. K. 1996, "Auction Theory: A Survey with Applications to Treasury Markets", *Financial Markets, Institutions and Instruments*, V.5, N.5, pp. 1-36

DeJong, D., R. Forsythe and W. Uecker, 1988, A Note on the Use of Businessmen as Subject in Sealed Offer Markets, *Journal of Economics Behavior and Organization*, 9 87-100

Dyer, D., J. Kagel, and D. Levin, 1989, A Comparison of Naive and Experienced Bidders in Common Value Offer Auctions: A Laboratory Analysis, *Economic Journal*, 99, 108-115

Engelbrecht-Wiggans R, List A. J, and David H. Reiley, 2006, "Demand Reduction in Multi-unit Auctions with Varying Numbers of Bidders: Theory and Field Experiments.", *International Economic Review* 47 (1), 203-231..

Feldman, R. A and V. R. Reinhart, 1995, "Flexible Estimation of Demand Schedules and Revenue under Different Auction Formats", IMF- Working Paper No. 95/116.

Friedman D and S Sunder, 1994, "Experimental Methods: A Primer for Economists", Cambridge University Press.

Friedman, M., 1960, A Program for Monetary Stability, Fordham University Press, New York.

Goldreich D, (2007) "Underpricing in Discriminatory and Uniform-Price Treasury Auctions," *Journal of Financial and Quantitative Analysis*, 42 (2), 443-466.

Goswami, G., T. Noe, and M. Rebello, 1996, "Collusion in Uniform-Price Auctions: Experimental Evidence and Implications for Treasury Auctions," *Review of Financial Studies*, 9, 757-785.

Ivanova-Stenzel Radosveta and Salmon C. Timothy, 2004, "Bidder Preferences Among Auction Institutions", *Economic Inquiry*, 42, 2, 223-236

Jagadeesh N, 1993 "Treasury Auction Bids and the Salomon Squeeze" *The Journal of Finance*, Vol. 48, No. 4. 1403-1419

Kagel, H. J., 1995, "Auctions: A Survey of Experimental Research", The Handbook of Experimental Economics edited by Kagel H. John and Roth E. Alvin, 501-585.

Keloharju, M., K. Nyborg, and K. Rydqvist, 2005, "Strategic Behavior and Underpricing in Uniform-Price Auctions: Evidence from Finnish Treasury Auctions," *Journal of Finance* 60, (4), 1865-1902.

Levin, D. and Smith, J.L.,1994, "Equilibrium in Auctions with Entry" *American Economic Review*, 84, 585-99.

Malvey, P. F., C. M. Archibald, and S. T. Flynn, 1995, "Uniform-Price Auctions: Evaluation of the Treasury Experience", Office of Market Finance, U.S. Treasury

Malvey, P. F., and C. M. Archibald, 1998, "Uniform-Price Auctions: Update of the Treasury Experience", Office of Market Finance, U.S. Treasury

McAfee R. P, 1993, "Mechanism Design by Competing Sellers", *Econometrica*, 61(6) 1281-1312

Miller J. Gary and Plott R. Charles, 1985, "Revenue Generating Properties of Sealed-Bid Auctions; An Experiment Analysis of One-Price and Discriminative Process", *Research in Experimental Economics a Research annual*, Editor Smith L. Vernon, volume 3, JAI Press INC, 159-182.

Nyborg, K., and Sundaresan, S., 1996, "Discriminatory versus Uniform Treasury Auctions: Evidence from When-Issued Transactions," *Journal of Financial Economics*, Vol. 42,

Plott, C, 1988, *Research on Pricing a Gas Transportation Network*, Office of Economic Policy Technical Report No 88-2. Federal Energy Regulatory Commission, Washington DC.

Rocholl J., 2004, *Discriminatory Auctions in which the Seller has Discretion*, working paper.

Sade O., Schnitzlein C. and J. F. Zender, 2006, "Competition and Cooperation in Divisible Good Auctions: An Experimental Examination" *Review of Financial Studies* 19(1), 195-235

Salavirta E and K. Taipalus ,2003, *Money and Capital Markets, Finish Financial Markets 2002*, Heikki Koskenkylä (ed), Bank of Finland Studies A:105, 37- 65

Smith V., G Suchanek and A. Williams, 1988, Bubbles, Crashes, and Endogenous Expectations in Experimental Spot Markets, *Econometrica*, 56, 1119-1151

Smith L. V., 1967, "Experimental Studies of Discrimination Versus Competition in Sealed-Bid Auction Markets, *Journal of Business*, 40, 56-84.

Tenorio, R., 1993, "Revenue-Equivalence and Bidding Behavior in a Multi-Unit Auction Market: An Empirical Analysis" *Review of Economics and Statistics* vol.75 pp.302-314.

Umlauf, S., 1993, "An Empirical Study of the Mexican Treasury Bill Auction," *Journal of Financial Economics*, 33, 313-340.

Wilson, R., 1979, "Auctions of Shares," *Quarterly Journal of Economics*, 93, 675-698.

Table 1
Bidders Choices between the Auction Methods

The table summarizes the answers obtained by participants in a survey conducted during 2004 and 2005. Participants specify the location, academic institution, type of education or type of occupation of the participants. Month and year specifies the time that the survey was conducted. Number indicates the qualified answers from this sub group. % uniform indicates the percentage of the qualified answers that choose uniform as their preferred mechanism. % discriminatory indicates the percentage of the qualified answers that choose discriminatory as their preferred mechanism % indifferent indicates the percentage of the qualified answers that indicate indifference between the two proposed price mechanisms.

Participants	Month and Year	Number	% Uniform	% Discriminatory	% Indifferent
<i>Executive MBA and Executive Courses</i>					
Israel-Hebrew U- Executives MBA-Finance	June 2004 And April 2005	18	55.56%	38.89%	5.56%
South Africa-Bankers	June 2004	13	46.15%	30.77%	23.08%
Norway – Executive MBA at BI	May 2005	17	76.47%	17.65%	5.88%
<i>MBA</i>					
Luxemburg - School of Finance	February 2004 and January 2005	27	70.37%	25.93%	3.70%
Switzerland - Lausanne-MBA finance	May 2004	18	50.00%	33.33%	16.67%
Israel – Hebrew U – Advanced MBA - Finance	November 2004	10	40.00%	60.00%	0.00%
NYU- -MBA 2-3 year part time MBA	December 2004	24	66.67%	20.83%	12.5%

NYU- full time 2 nd year MBA	December 2004	40	62.50%	32.50%	5.00%
NYU- 2 nd year MBA- investment banking, Business & law School	December 2004	19	52.63%	31.58%	15.79%
<i>Advanced Undergraduate</i>					
NYU-Business Undergraduate- – Seniors	December 2004	12	41.67%	33.33%	25.00%
<i>Professionals</i>					
Financial Professionals from a leading financial institution in Israel	January 2005	22	63.64%	36.36%	0.00%
<i>TOTAL</i>		<i>220</i>	<i>90.91%</i>		<i>9.09%</i>
<i>TOTAL</i>		<i>220</i>	<i>59.55%</i>	<i>31.36%</i>	<i>9.09%</i>

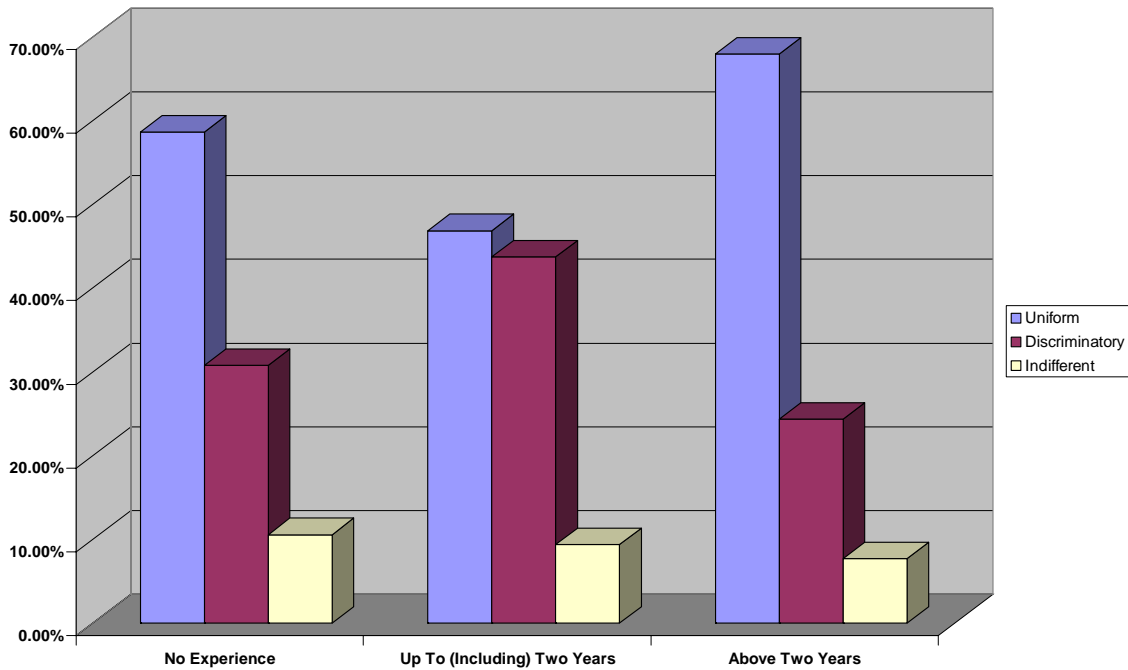
Table 2**Revenues for each random group for both groups of bidders**

U and D are the revenues for the Uniform and Discriminatory respectively. U-D represents the difference in revenue obtained under the uniform price mechanism to the revenue obtained under the discriminatory price mechanism. Avg Represent the average of each of the variables.

Market	U	D	U-D
1	520	508	12
2	520	481	39
3	494	507	-13
4	520	494	26
5	520	495	25
6	520	494	26
7	520	478	42
8	520	496	24
9	520	495	25
10	520	494	26
11	494	497	-3
12	494	496	-2
13	520	494	26
14	494	494	0
15	520	500	20
16	494	513	-19
17	520	504	16
18	494	514	-20
19	494	495	-1
20	494	499	-5
21	520	505	15
22	494	495	-1
AVG	509.36	497.64	11.73

Figure 1
Mechanism Choice and Experience in Financial Markets

Figure 1 describes the distribution of choices of the participants among the pricing mechanism as a function of their years of work experience in the financial markets. “No Experience” represents the group of participant with no work experience in the financial markets. “Up to (including) Two Years” represents the group of participants that have positive work experience in financial markets that is less than (including) two years. “Above Two Years” represents the group of participants with above two years of work experience in financial markets.



Appendix A – Survey Submitted to Individuals

Professor Dan Galai and Dr. Orly Sade from the Finance Department at the School of Business Administration, Hebrew University of Jerusalem and Professor Menachem Brenner from the Finance department at New York University Stern School of Business are conducting academic research in an attempt to better understand auction design mechanism. For the purpose of this research we would like you to answer a few questions. Everything contained in these instructions and everything you hear in this session is an accurate representation of this research. Be sure to ask any questions that you may have during the instruction period, and ask for assistance, if needed, at any time. All subjects receive the same instructions. (no minors are allowed to participate).

Your identity will be confidential with regard to the participation in this study. The survey does not ask for specific individual identification. The survey responses will be combined, and results will be presented only in aggregated form. Participation in this study is strictly voluntary. Omitting answers to specific questions is at the participant's discretion.

This Survey includes:

1. Case description
2. Examples
3. Survey

1. Case Description:

Two identical firms decided to issue bonds and to sell them via auctions. Each of the firms is going to sell 26 units. The economic value of each of the bonds in the secondary market is known with certainty and is equal to 20. The minimum price that can be submitted in the auction is 17. Bids can be made only in integers. Each participant can participate only in one of the auctions. The only difference between the two firms is the auction mechanism that is used: Firm “A” uses uniform price auction while firm “B” uses discriminatory (pay your bid) price auction. Each participant can bid for 26 units at most.

Firm “A”

This firm is going to issue bonds and sell them via “Uniform Price Auction”

The Auction Method:

There will be **26** units available for sale. You can submit bids for up to 26 units. Your resale value for each unit is **20**. (This means that after the auction your profit will be 20 for each unit that you hold, less what you paid for each unit). Prior to the auction, you are required to submit a schedule of bids. This schedule indicates the number of units you are willing to buy (including zero units) at each possible price level. The possible price levels will be 17, 18, 19, and 20. The sum of all of your bids may not exceed 26 units.

Once all participants have submitted their bids, the auctioneer will calculate the highest price at which all 26 bonds can be sold and will allocate units to players that submit bids that are equal to or higher than this price (if needed, the units will be allocated proportionally to the units demanded at the clearing price). **The price paid for each bond will be equal to the clearing price. The market-clearing price will be the highest price at which the total demand for bonds summed across all bidders is equal to 26.** If the total demand will be smaller than 26 at any of the suggested prices, the maximum total demand will be sold. A numerical example that illustrates this type of auction will be presented.

Firm “B”

This firm is going to issue bonds and sell them via “Discriminatory (Pay Your Bid) Price Auction”

The Auction Method:

There will be **26** units available for sale. You can submit bids for up to 26 units. Your resale value for each unit is **20**. (This means that after the auction your profit will be 20 francs for each unit that you hold, less what you paid for each unit). Prior to the auction, you are required to submit a schedule of bids. This schedule indicates the number of units you are willing to buy (including zero units) at each possible price level. The possible price levels will be 17, 18, 19, and 20. The sum of all of your bids may not exceed 26 units.

Once all participants have submitted their schedule of bids, the auctioneer will calculate the highest price at which all 26 bonds can be sold, and will allocate units to players that submit bids that are equal to or higher than this price (if needed, the units will be allocated proportionally to the units demanded at the clearing price). **The price you pay for each unit you receive, is equal to the price that you bid for that particular unit.** This means that it is possible that you will pay different prices for the bonds you buy, and it is possible that different bidders will receive bonds at different prices. If the total demand will be smaller than 26 at any of the suggested prices, the maximum total demand will be sold. A numerical example that illustrates this type of auction will be presented.

You will randomly be assigned to a group that contains 10 participants, you will not know in advance who are the members of your group. You must choose your preferred auction mechanism. Then, you will participate in the chosen mechanism and submit your bids accordingly. At the time that you submit your bids you will not know how many of your group members decided to play the type of auction as you have decided upon.

The number of units allocated to you and the price per unit will be determined based on the results of the auction mechanism of your choice and the bids submitted for that mechanism by members of your group.

The profits are calculated as: number of bonds purchased * 20 – total purchase cost

2. Examples

The following examples are for illustration purposes only. They are not intended to be suggested as “best” strategies and simply demonstrate the implications of a possible set of actions.

In the examples, for simplicity, we assume that 5 participants decided to choose the Uniform Price Auction and 5 participants decided to choose the Discriminatory Price Auction.

2.1 Results for the Uniform Price auction

Uniform Price Auction Example
(Numbers in the table are units)

Price	Participants					Demand	Aggregate Demand	Supply
	A	B	C	D	E			
20	11	0	5	0	0	16	16	26
19	5	0	3	2	0	10	26	26
18	5	0	8	6	18	37	63	26
17	5	26	10	18	8	67	130	26

The demand at each price is the sum of the demands of bidders A, B, C, D, and E. For example the demand at price 20 is equal to $11+0+5+0+0 = 16$. The aggregate demand is equal to the total demand at that price and all higher prices. For example the aggregate demand at the price of 19 is 26: (Demand at 20) + (Demand at 19) = 26 units. The clearing price is the highest price at which the cumulative demand equals the supply. In this case, the cumulative demand equals the supply at price equal 19.

The allocations in units and profits of the participants i as follows:

Price	Participants				
	A	B	C	D	E
Allocation	16	0	8	2	0
Profit	$16*(20-19)=16$	0	$8*(20-19)=8$	$2*(20-19)=2$	0

Since the resale value of the bond for each player is 20, each player makes a positive profit for each unit that he/she buys at a price below 20. The equilibrium price is 19 hence each player will profit one for each unit allocated.

2.1 Results for the Discriminatory Price auction

Discriminatory Price Auction Example (Numbers in the table are units)

Price	Participants					Demand	Aggregate Demand	Supply
	A	B	C	D	E			
20	1	0	0	0	0	1	1	26
19	20	0	3	2	0	25	26	26
18	0	0	13	6	18	37	63	26
17	5	26	10	18	8	67	130	26

The demand at each price is the sum of the demands of bidders A, B, C, D, and E. For example the demand at price 20 is equal to $1+0+0+0+0 = 1$. The aggregate demand is equal to the total demand at that price and all higher prices. For example the aggregate demand at the price of 19 is 26: (Demand at 20) + (Demand at 19) = 26 units. The clearing price is the highest price at which the cumulative demand equals the supply. In this case, the cumulative demand equals the supply at price equal 19.

The allocations and profits of the participants are as follows:

	Participants				
Price	A	B	C	D	E
Allocation	21	0	3	2	0
Profit	$1*0+20*1=20$	0	$1*3=3$	$2*1=2$	0

Since the resale value of the bond for each player is 20, each player makes a positive profit for each unit that he/she buys at a price below 20. Player A receives one unit that he demanded at price 20 and pays 20 for it, and receives 20 units at price 19, and hence his profit is 20.

Questionnaire

1. I choose to participate in the auction of firm: (circle the appropriate answer)
 - a. "A" Uniform Price Mechanism
 - b. "B" Discriminatory Price Mechanism
 - c. I am totally indifferent between participating in each of the two mechanisms
 - d. I prefer not to participate in any of the suggested mechanism.

If your answer is either a or b please continue to question number 3 if your answer is c please continue to question 2 and if your answer is d please continue to question 4.

2. Please randomly select between the mechanisms. Your random selection is _____

Now continue to question 3

3. My bids are:

Price	Quantity Demanded
20	
19	
18	
17	

4. I believe that most of the participant will choose: A / B / indifferent

5. Gender:

- a. Female
- b. Male

6. Did you ever participate in financial assets' auction?

- a. Yes
- b. No

7. Years of work experience in financial markets_____