The Impact of Uniform *vs* Discriminatory Pricing Rule on Revenue, Participation and Incentive to Collude in Government Securities Auctions

Samita Sareen
Department of Economics
Duke University

October 30, 2004

1 Introduction

Amongst both central bankers and academics, the debate on appropriate auction formats to sell government securities has focussed on the pricing rule that will minnimize the expected debt issuance cost of a central bank. The two pricing rules that have been assigned a central role in this debate have been the uniform-price and the discriminatory-price pricing rule. In a uniform-price auction each bidder pays a "uniform" price: the highest yield submitted that results in the entire auction being covered;[1] in a discriminatory-price auction "you pay what you bid".

Extending the intuition of results on auctions of a single and indivisible unit, a case has been made for uniform price auctions. Specifically, the revenue superiority of the English auction vis-a-vis the Dutch auction in single-unit auctions has been extended to the uniform-price auction vis-a-vis the discriminatory price auction for multiple units, respectively. Recently Ausbel and Cramton (1998) have argued that the analogy between the English *vs* Dutch and uniform-price *vs* discriminatory-price may not be appropriate due to "demand reduction" in multi-unit auctions. In multi-unit settings, a bidder will bid her "true" value on the first unit in a uniform-price auction. Any bid beyond her bid on the first unit can be the "pivotal" bid in that it will determine the "uniform" price at which all the units being auctioned will be sold. Hence, except for the bid on the first unit, there is an incentive on part of the bidder to shade her bid implying lower revenue for the seller in a uniform-price auction.

While revenue is one of the objectives of an issuer when designing a government debt issuance mechanism, there has been a disproportionate emphasis on revenue. This paper compares the uniform price auction and discriminatory

[1] Bids above the highest submitted yield are rejected.

price auction in terms of the expected revenue of the issuer, participation in primary issuance, and the ability to collude by bidders in government securities auctions.

Why might central banks care about participation when deciding whether to use either of the two auctions? It is well recognized that a small number of participants in primary issuance has the likelihood of reducing competition for the remaining incumbents, in turn leading to less aggressive bidding and hence higher financing cost of government debt. In addition, smaller number of bidders would make collusive behaviour more likely in the primary issuance process. Finally, in countries with the primary dealer model, primary market coverage obligations will be costlier for incumbent bidders if there are few rather than many incumbent bidders.[2]

Central banks care about collusion since collusion usually implies that government securities are issued at a higher cost. In addition, if the expertise acquired by the colluding bidders from their "incumbency" deters entry, collusion will have an impact on participation as well.[3]

2 Expected Revenue of the Issuer

In this section I shall examine the debate surrounding the revenue ranking of the discriminatory and the uniform price auctions, and the empirical evidence that is currently available on this debate.

Given that the issuer essentially price discriminates perfectly under the discrimiantory price auction, one would expect the expected revenue of the issuer to be higher under the discriminatory compared with the uniform price auction. But starting with Friedman (1959, 1981, 1991),[4] and Chari and Weber (1992),[5] several people have made a case for the uniform price auction. The argument that the uniform price auction is revenue superior to the discriminatory-price auction is based on viewing the two auctions as as the multi-unit extensions of the second-price and first-price auctions, respectively.[6] The revenue superiority of the second-price auction over the first-price auction follows from the *linkage*

[2] In a primary dealer model, the issuer imposes participation obligations on some dealers and awards them rents in the form of *advanatages* in return.

[3] Porter (2004) argues that in the OCS drainage auctions, asymmetries in information or payoff acted as barriers to entry allowing the cartel to retain its above normal profits.

[4] Friedman argues that since the discrimiantory auction penalizes mistakes for an incorrect guess about the market clearing price, it favours secondary market distribution activity of the large dealers and banks compared with small investors. Since dealers implicitly price this function, this means a net transfer of surplus from invesots to dealers rather than the issuer.

[5] Chari and Weber argue that incentives to gather information are larger in discriminatory auctions than with uniform auctions since the most aggressive bidder will pay more in the discriminatory compared with the uniform price auction. Since this information gathering is costly, uniform price auctions should lead to higher expected revenue.

[6] In both the first-price and second-price (or Vickrey) auctions the winner is the bidder with the highest bid. While the winner pays his bid in the first-price auction, he pays the highest rejected bid in the second-price (or Vickrey) auction.

principle (Milgrom and Weber, 1982). When bidders' valuations are *correlated* a bidder's bid will depend not only his perception of the resale price of the government debt instrument but also on the perception of other bidder's price estimates. In this scenario an auction format that gives a bidder information about what other bidders are doing will lead to more aggressive bidding and hence higher expected revenue for the seller. A second-price auction gives more information to a bidder about what others are doing by linking the price a bidder will have to pay to the highest rejected bid.[7] A bidder has an incentive to bid what he perceives the truth is since the price he will pay is the second-highest bid.

This was the prevailing wisdom till Ausbel and Cramton (1998) argued that the revenue superiority of the uniform-price auction is due to the imperfect analogy drawn between single-unit and multi-unit auctions in which bidders desire multiple units of the good. According to them the "truth-telling attribute" of a second-price single-unit auction does not extend to the uniform-price auction due to the phenomenon of *demand reduction*. In a uniform-price auction a bidder knows that there is a positive probability that one of her later bids will be a "pivotal" bid: the bid that decides the cut-off or "uniform" price. Since she will pay this cut-off price for all the previous units on which she bid, there is an incentive on her part to shade her later bids. Bid shading is present in the discriminatory-price auction as well. In the uniform-price auction there is *differential* bid shading; that is, as the quantity she bids on increases, the amount by which she shades the bid increases as well. This phenomenon of bid shading that is increasing in quantity is called *demand reduction*.[8] Unlike a uniform-price auction, a bid for an additional unit in a discriminatory-price auction has no effect on the price paid for the earlier units: you-pay-what-you-bid. Hence differential bid shading will not be observed in discriminatory-price auctions.

The empirical verdict on this issue is mixed. Two approaches have been taken to compare expected revenues. The first approach compares expost revenue in countries that have experimented with both uniform and discriminatory price auctions.[9] The argument here is that under both uniform and discriminatory price auctions, bidders will shade their bids relative to their assesment of the true value of the security to minimize the winners curse. But as I have explained above, the tendency to do so would be much less in the uniform price compared with the discrimiantory price auction, leading to higher expected revenue under the former than the latter. Several paper have tested for this effect

[7] In case the valuation of the bidders for the auctioned object were not correlated this phenomenon would not arise. Under additional assumptions, the celebrated *revenue equivalence theorm* is obtained which says that the expected revenue of the seller is invariant across the English, Dutch, first-price and second-price (or Vickrey) auctions.

[8] The demand curve that is submitted by a bidder lies below the true valuation curve. Since she reports her true value for the first unit, the two curves coincide on the price axis at this true value.

[9] Cammack (1991), Spindtz and Stoltz (1992), Bikhchandani, Edsparr and Huang (1993), Simon (1994 a,b), Malvey and Archibald (1995, 1998), Nyborg and Sunderasan (1996), Umlauf (1993).

by comparing the markup between the two auction forms, with the markup being the difference between the yield that clears the market or the auction yield and the true value of the security. The markup is generally taken to be a measure of the winner's curse with a higher markup imlying lower expected revenue. It is still an open question as to what should be used as a proxy for the true price of the security. A good proxy is really a price that impounds all information available about the auctioned security. For example, if bidders release all information about the security they have by trading in the when-issued market and this is aggregated perfectly, then the when-issued price prior to the auction deadline should be a good candidate. The expost realization of the markup between the two auctions can be used to test which auction had less bid shading and consequently generated higher expected revenue. The basic difference between the studies is the WI yield that is used as a measure of the true value of the security. But Nyborg and Sunderasan have documented the lack of trading before the auction deadline. Their key point is that it is not really appropriate to talk about a true price when the market is not liquid. They find that while the volatility in the WI market has an increasing time trend during the course of the auction day, it increases dramatically after the auction deadline till the time of release of results under discriminatory auction. For uniform auctions this was reversed with volatility decreasing during the course of the auction day till the time of release of results and then stays unchanged. Given that information about the security is impounded in the when-issued prices at different points of time during the day, using the same when-issued price under the two auction forms is questionable.

USA is one of the few countries that has experiemented with both types of pricing rules. A fairly detailed analysis of it's experiments is available in Malvey and Archibald (1995, 1998). The USA switched to uniform-price auctions for the 2-year and 5-year notes in September 1992. Malvey and Archibald compare the auctions for 2-year and 5-year notes for the discriminatory-price auction period, and the uniform-price auction period. For the 1995 study, the two periods are from January 1990 to August 1992, and September 1992 to December 1994, respectively. For the 1998 study, the period January 1995 to July 1998 have been added to the study. I shall refer to the periods from September 1992 to December 1994, and January 1995 to July 1998, as the first and second uniform-price auction period, respectively. The period from September 1992 to July 1998 will be referred to as the entire uniform-price auction period.

Both the 1995 and the 1998 reach similar conclusions. First, they compare the difference between the auction yield and the contemporanous WI yield, called the yield spread, under the two pricing rules. The auction yield under the discriminatory auction is the quantity weighted average yield, and the under the uniform price auction the stop out or the marginal yield. A postive difference in the yield spread between the discriminatory and uniform price auction indicates that the Fed is extracting a smaller surplus from the bidders under the uniform price auction, and hence they are revenue inferior to discriminatory auctions.

The record a postive difference, but it is not statistically significant.[10] This they argue is an artifice of the manner in which the auction yield is computed under the two pricing rules. Since quantity weighted average is used for the discriminatory auctions and the actual marginal yield for the uniform auction, this is akin to comparing an average of order statistics with the realization of a single order statistic: the highest order statistic from the distribution of yields. Hence, the variance of the yield spread under the uniform price auction is larger than that under the discriminatory price auction, corrupting the validity of the test. This leads them to conduct an alternative but indirect test to compare revenues under the two formats. The test if the yield spread for a specific auction format differs from zero rather than comparing the yield sperads of the two pricing rules. They find that the yield spread of the discriminatory price auction for the 2-year and 5-year bonds is postive and significantly different from zero. But when the same bonds are sold through the uniform price auction, the yield spread is not significantly different from zero. Finally, bonds that were always sold through discriminatory auctions have a yield spread that is positive and significantly different from zero. This leads them to conclude that there is some evidence that ex post, the Fed could issue bonds at a lower cost with uniform price auctions rather than discriminatory price auction. Nyborg and Sunderasan reach similar results using when-issued prices at the auction deadline, at the time of the release of auction results, and the end of the trading day.[11] ADD Goldreich.

A problem that makes it difficult to interpret their results is that the experiments conducted by the New York Fed were not really randomized experiments. In addition, factors other than the pricing rule could well influence the results of an auction, and there is no control for these factors. Also, I have noted earlier that Nyborg and Sunderasan (1994) document the lack of active trading around the time of the auction using transaction level data from one of the large interdealer brokers who operates on the medium end of the yield curve. This raises doubts about the study by Malvey and Archibald as they use contemporaneous yields to obtain the markups.

A second novel approach to comparing the expected revenue of the issuer under the two pricing rules has been adopted by Hortacsu (2003).[12] In the period he is studying the Turkish treasury has used discriminatory price auctions. The distribution of marginal valuation of the bidders is recovered from a structural private-values model of divisible good auctions. Assuming that the estimated

[10] The yield spread for the 2-year bond is reduced from 0.41 bp to 0.22 bp and that of the 5-year bond from 0.33 to 0.20 for the 5-year bond

[11] They find large variations in the markup under uniform price auctions irrespective of the when-issused price used; hence the null hypothesis of zero markups is not rejected. For discrimnatory auctions they find that marups are positive and statistically significant. ADD their dispersion and volatlity results even though they have less to do with revenue and more to do with strategic behvaiour. The latter also gives some sense of whether it is meaningful to use a specific price.

[12] Following Hortacsu, several other papers estimate structural models for treasury auctions and obtain the distribution of primitives of the bidders.

distribution of marginal valuations is the "distribution", he obtains the revenue of the issuer under this "best case" uniform price auction: a uniform price auction in which bidders reveal their true marginal valuation or the bids are the estimated marginal valuations. He finds that in ex-post terms, the issuer's revenue under the discriminatory auction, which is the realized revenue in his sample is greater than the revenue under the best case uniform price auction. But when he does an ex-ante comparison, that is compares the expected revenue of the seller under the discriminatory price auction and the "best case" uniform price auction, he is unable to reject the revenue equivalence result between the two. Hence, even structural estimates give only a mixed verdict on this issue.

Empirical support for demand reduction is provided by Nyborg, Rydqvist and Sunderasan (2002) in which they show that bidder will "reduce" demand more with increased uncertainity.[13] Anecdotal evidence aslo suggests that demand reduction was observed in the U.S. after it switched to the uniform-price auction? In conversation with traders in the US secondary market, traders reported that they observed bidders putting in a bid at a large price and then another one at a small price; it was almost as if there were *no* bids in the *middle*. Does this imply that the Treasury's revenue increased with the switch? There is no firm evidence here. One trader remarked that they are seeing higher prices; but he also reneged on his statement when he was told that the high prices could be due to a higher value for government debt instruments in an era of surpluses in the U.S.

The remark "bidders adapt" made by one of the traders summarizes the revenue debate; it seems unlikely that there will be a revenue-swing with the switch between auction formats.

3 Participation

The issue then is whether a **switch from discriminatory-price auctions to uniform-price auctions would induce increased participation by smaller PDs and non-PDs?** The analysis below suggests that **participation by smaller PDs and non-PDs is likely to increase with a switch from discriminatory-price to uniform-price auctions. However this increase may not persist in the longer-term as primary market participants learn and adapt their bidding to the strategic effects of the uniform-price auction environment.**

The analysis in this section is subject to important caveats.

First, there are neither theoretical, nor empirical papers in the literature which attempt the kind of comparison being done in this paper. This is unlike revenue comparisons of the two pricing rules where a huge literature, both theoretical and empirical, exists. The only existing literature that compares

[13] Assuming that prices are essentially fixed as primary dealers have binding constraints, they show that quantity demanded decreases with and increase in uncertainity.

participation under the two different pricing rule regimes are empirical comparisons for the USA by Malvey and Archibald (1995, 1998), when the US treasury switched pricing rules from discriminatory-price to uniform-price for auctioning the 2-year and 5-year notes. However, these papers admit that the results on comparisons for the two pricing rule regimes are affected by factors exogenous to the pricing rule as well, and these factors have not been controlled for in the comparisons that have been made.

Second, as I have summarized in the last section, the impact on revenue of the switch to uniform price rule is ambiguous. To the extent that bidding is more aggressive if participation increases with uniform-price auctions, uniform-price auctions may be revenue superior to discriminatory-price auctions if participation and revenue are modelled jointly rather than assuming participation is exogenous.

DISCUSS single-unit private value results for endogenous entry and revenue ranking. What can be said about these results in a cv setting?

3.1 Defining Participation

How should participation be defined in treasury auctions. As the three definitions given below indicate, there is no straightforward answer. I shall argue that the third definition seems most compelling.

First, participation could refer to the *number* of bidders eligible to participate in government securities auctions. It seems unlikely that the number of government securities distributors and customers eligible to participate in the auctions will increase with a switch to uniform-price auctions. The number of bidders is determined by issues related to contestability and sustainability that are eventually determined by the regulatory and institutional features of these markets.[14] The pricing rule has a limited role to play in these issues as bidders are likely to "price" into their demand functions the effect of a switch to a uniform-price auction, by submitting different tenders under the discriminatory-price and uniform-price auctions.

A second definition for participation is the cover-ratio, which is the ratio of the total bid amount to the issue amount. Large cover-ratios may be meaningless if they are accompanied by large tails.[15] The seller wants to ensure that that the auction is not only covered, but that the bidding is aggressive as well. This seems to suggest that a definition for participation should be based on a yield relative to the *cutoff* yield. The third definition of participation takes these considerations into account.

[14] Contestability refers to the absence of entry constraints in the primary market. Sustainability refers to normal profits to primary market participants on average over business cycles.

[15] The tail of an auction is the difference between the average yield of all accepted bids and the *cutoff* yield.

The third definition of participation is the probability of an eligible bidder winning a nonzero amount in the auction, with an increase in this probability implying an increase in participation by this bidder. This definition is compelling for *at least* three reasons. First, this probability and hence participation will increase for a bidder only if his bidding is aggressive relative to other bidders. Hence, this concept takes into account bids relative to the *cutoff* yield. Second, a relatively straightforward measure of this probability is available for empirical work. The probability of an eligible bidder winning a nonzero amount in an auction can be measured by the share of this bidder in auction winnings, where the latter is referred to as the *concentration of awards* for this bidder. Third, this concept of participation can be used directly to address the question posed in this paper. A corollary, though imperfect, of an increase in participation of smaller PDs and non-PDs, with a change from discriminatory-price auctions to uniform-price auctions, is that it should lead to a decrease in the *concentration of awards* to PDs, and an increase in the *concentration of awards* to smaller PDs and non-PDs.

3.2 Uniform Price Auctions Could Increase Participation

The *key* underlying assumption for uniform price auctions to increase participation of smaller PDs and non-PDs is that there exists two groups of bidders whose ability to "discover the price" in the Government of Canada debt market varies markedly. Specifically, one group can predict the *cutoff* yield in the primary market and the resale price in the secondary market, more accurately *ex ante* than the other group. The former group will be referred to as informed bidders, and the latter as uninformed bidders. In the current context, informed bidders are the PDs, and uninformed bidders the smaller PDs and the non-PDs. The most likely reason for the informed bidders being able to better predict the *cutoff* and resale yields more accurately is that they have a relatively non-noisy signal of order flow information.[16]

It is well-known that in discriminatory-price government securities auctions with unknown *ex ante* mark-ups,[17] winning is bad news for a bidder as winning implies that he has been too optimistic about the *cutoff* yield compared to other bidders. This is the "winner's curse". Both informed and uninformed bidders will shade their bids to take account of this curse. However, informed bidders will shade their bids less than the uninformed bidders as the former are able to predict the *cutoff* yield more accurately *ex ante* than the uninformed bidders. The result is that the informed bidders will bid more aggressively than the uninformed bidders. This will be reflected in greater participation by informed bidders, or larger *concentration of awards* to informed bidders compared to the scenario where this differential bid-shading does not occur. I next turn to this scenario.

[16] This could be either because they have a larger customer base, or a technical edge in resources devoted to sophisticated financial analysis, or both.

[17] Mark-up is the difference between the *cutoff* yield and the yield at which the security is resold. Both are unknown prior to the auction.

Now suppose that instead of a discriminatory price auction, government securities are sold through a uniform-price auction. The winner's curse still exists. However, it does not affect bidding under a uniform-price auction in that bidders do not need to shade their bids to alleviate the curse, as all bidders pay the same price, *viz* the lowest accepted yield. The absence of differential bid-shading under the uniform-price rule leads to a reduction in the *concentration of awards* to, or participation of informed bidders, and an increase in the *concentration of awards* to, or participation of uninformed bidders, under the uniform-price auction relative to the discriminatory-price auction. In effect, since the issuer does not price discriminate under the uniform price auction, the winner's curse effect is lowered compared to discriminatory price auction.

This argument is supported by two empirical studies for USA by Malvey and Archibald (1995, 1998). The USA switched to uniform-price auctions for the 2-year and 5-year notes in September 1992. Malvey and Archibald compare the auctions for 2-year and 5-year notes for the discriminatory-price auction period, and the uniform-price auction period. For the 1995 study, the two periods are from January 1990 to August 1992, and September 1992 to December 1994, respectively. For the 1998 study, the period January 1995 to July 1998 have been added to the study. I shall refer to the periods from September 1992 to December 1994, and January 1995 to July 1998, as the first and second uniform-price auction period, respectively. The period from September 1992 to July 1998 will be referred to as the entire uniform-price auction period.

The following empirical results support the argument that uniform-price auctions induced participation by the relatively uninformed bidders. First, the *concentration of awards* to the top five and top ten PDs for their own account have declined by 10% for 2-year notes, and by 17% for 5-year notes, between the discriminatory-price auction period and the first uniform-price auction period. Second, the *concentration of awards* to the top five, ten and all large customers increased from about 17% to 25% for both 2-year and 5-year notes between the discriminatory-price auction period and the first uniform-price auction period. Third, there was no significant change in *concentration of awards* to the PD community as a whole. Combined with the first result, this implies that the *concentration of awards* to the PDs other than the top ten, increased between the discriminatory-price auction period and the first uniform-price auction period. Finally, no change in the *concentration of awards* to either the top five or ten PDs or customers was observed in the auctions for 3-year and 10-year notes in the entire sample. For both securities no change was made to the pricing rule in the period under consideration.

3.3 Uniform Price Auctions Could Decrease Participation

The repeated nature of government securities auctions makes them dynamic games. That is, participants learn from previous auctions, and translate this learning into their bidding in future auctions. In the current context, over the course of several auctions, informed bidders learn that uniformed bidders are

free-riding on their informational advantage with respect to the "price discovery" process in the auctions. Informed bidders can discourage the uniformed bidders from "free-riding" by concentrating their bid distribution at yields ahead of the market. Note that these aggressive bids do not correspond to order flow information; rather they reflect strategic bidding by the relatively informed bidders to discourage the uninformed bidders. This strategic bidding by the informed bidders will be referred to as the ***strategic*** effect. The impact of the ***strategic*** effect is that the *cutoff* yield in the presence of the ***strategic*** effect is lower than the *cutoff* yield in the absence of the ***strategic*** effect. The uninformed bidders learn about this effect over the course of several auctions. Realizing that on an average they are paying higher prices on account of this effect, the uninformed bidders adapt their bidding by reducing their participation at auctions and buying government securities directly from the informed bidders. The result is that there is a reduction in participation or the *concentration of awards* to uninformed bidders, and an increase in participation or the *concentration of awards* to informed bidders, compared with the scenario where the ***strategic*** effect is absent.

Empirical results that support this argument are found in Malvey and Archibald (1998), but not in Malvey and Archibald (1995), reflecting that government securities auctions are dynamic games with participants adapting their bidding by learning from previous auctions. The following empirical results in Malvey and Archibald (1998) support the argument that uniform price auctions may not increase participation of the relatively uninformed bidders in the longer run. First, though the *concentration of awards* to the top 5 and 10 PDs is higher throughout the entire uniform-price auction period compared to the discriminatory-price auction period, the *concentration of awards* drifted upwards in the second uniform-price period compared with the first uniform-price period. Second, the *concentration of awards* to the top five and ten customers under the uniform-price format are not statistically different from the discriminatory-price format if the entire uniform-price auction period is considered. This suggests that some large customers may have returned to buying new supply from dealers rather than bidding in the auctions through dealers in the second uniform-price auction period. Third, bid distributions are less dispersed in the second uniform-price auction period compared with the first uniform-price auction period. This suggests a learning pattern on the part of the auction participants.

The discussion above suggests that participation by smaller PDs and non-PDs is likely to increase with a switch from discriminatory-price auctions to uniform-price auctions. This follows from uniform-price auctions not penalizing relatively uninformed bidders compared to discriminatory-price auctions, as all bidders who win pay an identical price. However, this increased participation may only be a first-order effect of a switch in the pricing rule from discriminatory-price to uniform-price. That is, increased participation may not persist over a longer time-period. Smaller PDs and non-PDs realizing that the larger PDs are bidding ahead of the market to discourage them from "free-riding" on the more accurate order-flow information of the larger PDs, are likely

to curtail their participation in auctions over a longer time-period. This time-period will depend on the time primary market participants take to learn from previous auctions and adapt their bidding in future auctions.

4 Market Manipulation

A well-known market manipulation practice described in Section 2 is a market *squeeze*. The Salomon Brothers scandal is used to illustrate this practice. In May 1991, Salomon Brothers violated their auction limit for 2-year T-notes by submitting fake bids on behalf of customers. They managed to purchase a large amount of the 2-year T-notes in the auction through this practice. Having cornered the 2-year T-notes market they squeezed the shorts in the secondary market; bidders who had written forward contracts in the when-issued market prior to the auction could acquire 2-year T-notes at very high prices. The fear of a market squeeze reduces the volume of trade in the when-issued and secondary markets and raises the cost of price discovery.

Which pricing rule will discourage market squeezes? Activity in the when-issued market is the result of bidders wanting to acquire information about what other bidders know about the price at which the auction will clear. In a uniform-price auction bidders have a smaller incentive to acquire information about what other bidders are doing because they will all pay the same "uniform" price in the auction. This implies that uniform-price auctions are more likely to reduce the size of the when-issued market. Anecdotal evidence suggest that this may be the case. Traders in the U.S. fixed income markets have commented they "talk" to each other less frequently in the uniform-price era.

A more subtle form of market manipulation is forming an implicit cartel or colluding implicitly by submitting demand curves that are steeper. Back and Zender (1993) Wang and Zender (1996) and Vishwanathan and Wang (1998) show that uniform-price auctions encourage implicit collusion by bidders in the form of bidders submitting steep demand curves;[18] it is the steepness of the demand schedules that binds the bidders into a self-enforcing collusive arrangements.[19] The result is that the seller awards the auction at too low a price. An example illustrates these points.

Example: An issuer is going to auction $10 billion worth of a one-year zero-coupon security through a uniform-price auction. There are three risk neutral bidders and no noncompetitive demand. Each bidder agrees that the price at which the security will trade in the secondary market is 5 percent; they also

[18] Vishwanathan and Wang (1998) model the interactions in the three markets, the *when-issued, primary* and *secondary* markets, through a 2-stage game that resembles the actual process in the market for government of canada debt. Back and Zender (1993) and Wang and Zender (1996) model only the primary market. They make different assumptions about the risk attitude of the bidders.

[19] An added feature that makes collusion self-reinforcing is that the same bidders are participating in subsequent auctions. Hence the deviant cartel member can be punished by the rest of the cartel in a subsequent auction.

agree to "share the spoils" equally. On the basis of a consensus, the three bidders submit three demand schedules.
Steep demand scenario. All three bidders submit two bids: one for \$3333 million at a yield of 3 percent and another for \$6666 million at a yield of 20 percent. The price at which the bids are filled or the "uniform price" is 20 percent. Each bidder gets one-third of the \$10 billion (\$3333$\frac{1}{3}$ million). Each bidders expected profit (in millions) as a member of the cartel is

$$\Pi^{steep}_{cartel} = \$3333\frac{1}{3}\,(1/1.05 - 1/1.2) = \$396.82.$$

Now suppose one of the cartel member deviates and submits a second bid at the rate of 19.99 percent instead of 20 percent. Then the deviating cartel member gets \$ 3334 million of the issue and the market clearing yield drops down to 19.99 percent. The deviating cartel member's expected profits (in millions) drop down to

$$\Pi^{steep}_{deviate} = \$3334\,(1/1.05 - 1/1.1999) = \$396.67.$$

Clearly deviation *does not* pay.
Flat demand scenario. Instead of submitting the first bid of \$3333 at a rate of 3 percent, the cartel members now submit the first bid of \$3333 at a rate of 15 percent. Each bidder is again assigned \$3333$\frac{1}{3}$; but now the rate at which bids are filled or the "uniform price" is 15 percent. The expected profit of each cartel member is

$$\Pi^{flat}_{cartel} = \$3333\frac{1}{3}\,(1/1.05 - 1/1.15) = \$276.05.$$

Now suppose a cartel member deviates and submits one bid for \$10 billion at the rate of 14.99 percent. The expected profit (in millions)of the deviating cartel member is

$$\Pi^{flat}_{deviate} = \$10000\,(1/1.05 - 1/1.1499) = \$827.40.$$

Deviation pays in the *flat demand* scenario.

A collusive arrangement of the kind discussed above cannot be sustained in a discriminatory price auction since submitting steep demand curves is costly for the bidders as the bidders end up paying for the low yield-low quantity points on their demand schedules. In the example above, if bidders submitted steep demand curves and the pricing rule was discriminatory, then each bidder would get \$3333 million at a yield of 3 percent and \$0.33 million at a yield of 20 percent. Further, Vishwanathan and Wang (1998) show that smaller the number of bidders and lower the mean noncompetitive demand, the greater is the advantage of submitting steep demand schedules. Alternatively, a large number of bidders or large mean noncompetitive demand push bidders onto the high-price, low-quantity of their demand schedules and hence makes a discriminatory-price auction favorable for the bidders. Hence in a market such as Canada which is characterized by both a small number of bidders and low mean noncompetitive demands, it is likely that a switch to uniform-price may lead to dealers manipulating the price to their advantage by submitting steeper demand schedules.

References

[1] Ausbel, L.M., Cramton, P., 1998. Demand reduction and inefficiency in multi-unit auctions. Working Paper, University of Maryland.

[2] Hortacsu, A., 2002. Mechanism choice and strategic bidding in divisible good auctions: an empirical analysis of the Turkish treasury auction market. Forthcoming *Econometrica*.

[3] Malvey, P.F., Archibald, C.M., 1995. Uniform price auctions: update of the treasury experience. Department of Treasury, USA.

[4] Malvey, P.F., Archibald, C.M., 1995. Uniform price auctions: evaluation of the treasury experience. Office of Market Finance, U.S. Treasury.