Information and Winning: Evidence from the 3-month Canadian Treasury Auctions

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Abstract

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Keywords: Canadian Treasury Bill market, Auction, Bidding, Information.
JEL classifications: G14, G10, G15.

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Abstract

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1. Introduction

Information is an important component in auction theories. Typically, private information held by participants is revealed through their bids. Changes in their information set may affect their bidding strategies, which, in turn, determine their ability to win. This paper presents empirical evidence on the information flow and the auction winning outcomes. The data used in the study covers the 3-month Canadian treasury bill auctions held during the period of June 7, 1994 to December 18, 2001. They consist of the unofficial bidding, the official bidding and the winning outcomes. Such a data set is suitable for studying the flow of information because of the pre-bidding feature present in the Canadian treasury market. Bidders are allowed to make informal bids before the auction starts. These unofficial bids may be modified as long as the auction has not started. Intuitively, changes between the unofficial bids and the official bids reflect the informational change.

Up to now, very few analytical results have been derived from a multi-unit auction model, let alone a multi-unit auction model with a pre-bidding arrangement. Also, very few empirical studies focus on the effects of pre-bidding on auction winnings. Our study is the first attempt to document and test the relationship between information flow and auction winning outcomes with the pre-bidding information.

The objectives of the paper are two-fold. First, we investigate the role of the pre-bidding session and see whether the pre-bidding arrangement help the convergence in opinions among bidders. Second, we examine the bidding behavior of large bidders and see whether there exists a size effect in the 3-month Canadian treasury auction market. Our empirical analysis shows that the pre-bidding arrangement facilitate the convergence in opinion among bidders. It has similar predictive power on winning outcomes as that of the official bidding. In particular, the competition level during the pre-bidding session has a strong positive impact on the number of winning bidders and winning bids; more bidders posting bids during the pre-bidding session induces a larger number
of winning bidders. In addition, we also analyze the probabilities of participating and winning. The potential profitability implied by official bids has a negative effect on both probabilities. At the same time, a higher percentage winning quantity from the previous auction encourages bidders making official bids and the current competition during the official bidding session reduces the probability of winning.

To examine the size effect, we first analyze the bidding behavior of large bidders. The analysis is implemented by testing the bid synchronization hypothesis. That is, we test whether large bidders either all bid aggressively to win large shares in an auction, or whether their bids are all weak. To do so, we separate large bidders from small bidders and compute the conditional correlation of winning quantity for each large bidder with that of the remaining large bidders. The correlation is significantly positive for the six top bidders in the Canadian T-bill auction market, suggesting that when one of the large bidders wins a high proportion in an auction, others tend to win a higher than average amounts of the remaining portion of the auction. This result indicates the existence of bid synchronization in the Canadian T-bill auction market. We further examine the size effect by testing the significance of the potential profits for large bidders. Our results show that it is potentially profitable for large bidders and the potential profit is statistically significant. These results do not hold for smaller bidders.

The remaining paper is organized as follows. Section 2 provides the literature review. Section 3 describes the data and presents summary statistics. Section 4 investigates the role of the pre-bidding session on winning outcomes. Section 5 examines the size effect in the auction market. Section 6 concludes. Tables are collected in appendices.

2. Literature Review

The Canadian Treasury auctions are multi-unit, discriminatory auctions with an unofficial pre-bidding session. Up to now, there is no theoretical model describing this type of auctions. Seminal
work by Wilson (1979) introduces a general setup for an auction with divisible goods. Subsequently, Back and Zender (1993) and Wang and Zender (1995) extend the work by having bidders with constant marginal valuations but no private information. The latter paper introduces uncertainty through supply. The papers predict that bid shading increases with more bidders. Hortaçsu (2002) introduces private information using a discriminatory auction model that allows bidders to place their entire demand functions. Demands submitted by the bidders are modeled as a linear continuous function instead of being discrete. While Hortaçsu is able to solve equilibrium for two players, he can only approximate the equilibrium for more players. His setting has different predications on the relationship between bid shading and the number of players. When the bidders’ inventory positions are not important, bid shading increases when there are more bidders. However, the contrary holds when the bidders’ inventory positions are important. If there is a shortage a given security, then bidding will become more competitive, especially with more bidders. Damianov (2003) introduces a model with endogenous supply for treasury auctions, since supply may not be fixed. However, he shows that it is optimal for the seller to supply all the demands in a discriminatory auction. This is unlikely to be the case in Canadian treasury auctions as the Bank of Canada announces the size of an auction one week in advance.\footnote{For current examples, see http://bankofcanada.ca/en/cars.htm.}

These studies do not model the pre-bidding stage, nor do they predict a relationship between the number of winning bidders (or bids) and the number of official bidders (or bids). Although they provide predictions on relationship between the number of bidders and the bid shading, the predicted relationship is not unique.

On the empirical front, Cammack (1991) documents evidence of imperfect information in the U.S. 3-month treasury bill discriminatory auctions.\footnote{Besides Cammack’s study on the U.S. discriminatory treasury auction, the effect of bid shading is also evidenced in Gordy (1999) for the Portuguese discriminatory treasury auctions, Nyborg, Rydqvist, and Sundaresan (2001) for the Finnish discriminatory treasury auctions, Hortaçsu (2002) for the Turkish discriminatory treasury auctions, Goldreich (2003) for the U.S. uniform treasury auctions, and Lu and Yang (2004) for the Canadian discriminatory treasury auctions.} In contrast to ours, her study focuses on the
relationship between information and prices. She uses two measures to determine how information changes: the diversity of opinion and the difference between the expected and the unexpected number of bidders. She describes how the secondary market prices are affected in opposite directions by the dispersion of opinion and the number of bidders. The prices are higher when the dispersion of opinion is higher than expected or when the number of bidders is lower than expected. Cammack’s results suggest that bid prices are likely to be lower as bidders shade their bids because of the winner’s curse. In common value auctions where the value of the good being sold is unknown to bidders, winning implies that the winner may have over-estimated the value of the good. This effect is called the “winner’s curse” which causes bidders to lower, or shade, their bids.\footnote{A similar effect can also be found in affiliated private value auction. In strictly private value auctions, bidders know their valuations. In affiliated private value auctions, their valuations may contain a common component. See Pinske and Tan (2000) for more details.} More bidders and uncertainty are likely to increase bid shading due to this effect.

Hamao and Jegadeesh (1998) empirically examine the profitability of an auction and the bidding synchronization in the Japanese discriminatory treasury auction market. They find that average bidders’ profits are not significantly different from zero, in contrast to our results and Lu and Yang’s finding for the Canadian auction markets. In addition, their results indicate a synchronization among Japanese bidders, not among the U.S. bidders.

3. Data

The Canadian treasury auction allows each bidder to submit sealed bids for multiple units. Each competitive bid consists of a yield and a quantity while a non-competitive bid includes only a quantity.\footnote{The yield of a non-competitive bid is determined at the end of each auction. The maximum quantity for a non-competitive bid is relatively small and about $ 3 million Canadian dollars.} The bidders are allowed to revise their bids prior to the commencement of the auction. Once the auction closes, each winner is awarded its bid amount and pays its bid prices. We have data for all the unofficial bids, the official bids, and the winning bids. However, we only have the
shielded identity of the submitter, not the actual bidder. Because our study on the role of the pre-bidding session is based on aggregated data for each auction, individual identification is not important, and we assume that the bidder and submitter are the same. In addition, because we focus on competitive bidding, we exclude all bids made by the Bank of Canada and other non-competitive bids. We also deleted 23 auctions because of missing observations or unreasonable bid yields such as 99%. In the end, we are left with 260 auctions with all competitive bids for 3-month T-bill covering the period of June 7, 1994 to December 12, 2001.

3.1. Constructing the Data Set

We classify the data into three stages: the unofficial bidding stage before each auction starts, the official bidding and the outcome revelation (i.e., winning bids). To distinguish from variables related to the official bids, we include the term “ex ante” for the same variables associated with the unofficial bids and “win” to the winning bids. We define bids as the number of official bids and bidders as the number of bidders making official bids. These two variables allow us to determine how information changes. The quantity variable is the total competitive bid quantity made by bidders in each auction and is measured in millions of Canadian dollars. The QW yield variable is the quantity-weighted bid yield for each auction. We also calculate the lowest yield and the highest yield for each auction. All the yields are measure in percentages.

Based on these variables, we construct informational measures. Similar to Hamao and Jegadeesh (1998), we define two measures: Potential Profit and Range. Potential Profit is the difference between each auction’s quantity-weighted average bid yield and the end-of-day market yield.\(^5\) It

\(^5\)Hamao and Jegadeesh (1998) define an auction profit variable as the difference between changes in the auction prices and the changes in three control bonds. The changes in the auction prices are calculated as the percentage difference between the value-weighted auction prices and the end-of-day market prices. While this measure alone may be used as a proxy for profit, they point out that it may not be able to capture unexpected changes in interest rates. The changes in prices of the control bonds are the average percentage differences between each date. Our profit variable is similar to the discount variable used by Nyborg, Rydqvist and Sundaresan (2000) as well as in Lu and Yang (2004). In these papers, discount is treated as the difference between the quantity-weighted average bids and the end-of-day market prices.
measures the precision of the bidders’ valuations by comparing the bid yield against the market yield. *Range* is the difference between the highest and the lowest bid yields in each auction. It measures the asymmetry of information among bidders. If information is similar, then *Range* should be small.\(^6\)

The degree of competition for each auction is measured by the *Herfindahl-Hirshman Index* (*HHI*). This index is calculated as the sum of the squares of the market share for each bid quantity. In percentage, the index is between 0 and 10,000. A high HHI means that only a few bidders account for most of the bid quantities and suggests a low level of competition for the auction.\(^7\)

We include a second competition variable *Cover Ratio*, defined by Hamao and Jegadeesh (1998). This *Cover Ratio* is the ratio between the total bid quantity and the total auction amount for each auction, and it indirectly measures the competition of an auction since a lower ratio suggests a bigger chance of winning.

### 3.2. Detailed Statistical Review

Table 1 presents the summary statistics for the variables defined above. On average, there are about 17.60 bidders submitting 87.83 bids during the pre-bidding session, 17.19 bidders tendering 57.35 official bids, 10.90 bidders winning 21.02 bids. Roughly speaking, an average bidder makes 4.99 unofficial bids and 3.33 official bids, and ends up winning 1.92 bids.

The number of bidders or bids is declining monotonically as we move along with the auction process.\(^8\) For bidders making initial bids, almost every bidder stays in the auction but 35% of the unofficial bids are withdrawn. As well, 63% of all official bidders (or 37% of all official bids) win the

\(^6\)Instead of the highest bid yield, Hamao and Jegadeesh (1998) use the auction’s quantity-weighted average bid yield. In replicating their tests, we also use their definition and obtain similar results.

\(^7\)For comparison purpose, the Department of Justice and the Federal Trade Commission Horizontal Merger Guidelines in Canada deems an HHI greater than 1800 to be highly concentrated. If a merger raises the HHI by 100, it will likely to be scrutinized. See Church and Ware (2000) for more details.

\(^8\)Bidders are suggested to submit more bids in advance and withdraw their bids before the official process. Otherwise, their bidding behavior should be symmetric. Depending on the information, the bidders do not need to reduce the number of their bids, instead, they could introduce more bids.
auction. In other words, most bidders are willing to stay in the official auctions and then, greatly reduce the number of their bids. This observation suggests that more information is revealed as time approaches the official auction and bidders use the updated information to revise and/or refine their bids.

The average of the auction total quantities and the average of the auction quantity-weighted yields also follow similar non-linear declining patterns. Total auction quantity goes from Cdn$11493.86 millions (ex ante) to Cdn$6933.47 millions (official) to Cdn$2891.17 millions while quantity-weighted yields declines from 4.9667% (ex ante) to 4.9616% (official) to 4.9390% (winning). However, the declines in these two variables are different. Official total quantities accounts for only 40% of the unofficial quantities. In turn, only 42% of the official total quantities are won. The official quantity-weighted yield is only 0.51 basis points lower than unofficial one while the winning quantity-weighted yield is 2.26 basis points lower than the official counterpart and 2.77 basis points lower than the unofficial bidding, suggesting that the unofficial average bid yield is a very good predictor of the official average winning yield.

As for the average range, it goes from 0.5364% (unofficial) to 0.1394% (official) to 0.0299% (winning); a decline of 74% and 79% respectively. The quick reduction in range value indicates a quick convergence in opinions regarding the auction T-bill value. Similarly, the average potential profit declines from 3.37% before auction to 2.86% during the auction, a 15% decline, to 0.69% after the auction, a 79% drop.

It is important to note that the difference between Potential Profit and Range. We know that Range uses information within the auction by comparing the highest yield to the lowest while Potential Profit compares the auction yields with the market yields. Although these two measures decline throughout the auction process, the declining speed is not the same. The changes in Range are slight as the declines go from 74% to 79%. Meanwhile, Potential Profit exhibits more dramatic
changes, i.e., 15% to 79%, suggesting a greater sensitivity of bidders to the market information.

As expected, bidders are more concentrated as the auction progresses. HHI for the official bids is 375.65, which is only 31% of HHI for the winning bids of 1226.42. HHI before the auction starts is 246.30, which is 20% of the winning HHI. Cover Ratio declines overtime, as expected.

4. Empirical Results on Pre-Bidding and Winning Outcomes

Given the sequential nature of the auction, we start our analysis by using characteristics from one stage in the auction to predict the outcomes in subsequent stages. The outcomes are depicted by three variables: the number of bidders, the number of bids, and the HHI. For each variable, we forecast its outcome via Ordinary Least Square (OLS) regressions by using the characteristics from previous stages. The explanatory variables are the number of bidders, the number of bids, HHI, Range and Potential Profit. Specifically, for each variable, we run two regressions using unofficial data to predict the official and winning values, plus a third regression using official data to predict the winning values. The empirical results are summarized in Table 2.

4.1. Bidders

The three regressions to study the effects on bidders are as follows:

\[
\# \text{ of Bidders, } \text{win}_t = \alpha_1 + \alpha_2 \# \text{ of Bidders, ex ante}_t + \alpha_3 \# \text{ of Bids, ex ante}_t + \alpha_4 \text{HHI, ex ante}_t + \alpha_5 \text{Potential profit, ex ante}_t + \alpha_6 \text{Range, ex ante}_t + \epsilon_t,
\]

\[
\# \text{ of Bidders, win}_t = \alpha_1 + \alpha_2 \# \text{ of Bidders}_t + \alpha_3 \# \text{ of Bids}_t + \alpha_4 \text{HHI}_t + \alpha_5 \text{Potential profit}_t + \alpha_6 \text{Range}_t + \epsilon_t,
\]

\[
\# \text{ of Bidders}_t = \alpha_1 + \alpha_2 \# \text{ of Bidders, ex ante}_t + \alpha_3 \# \text{ of Bids, ex ante}_t + \alpha_4 \text{HHI, ex ante}_t + \alpha_5 \text{Potential profit, ex ante}_t + \alpha_6 \text{Range, ex ante}_t + \epsilon_t,
\]

Panel A of Table 2 presents the results for the above regressions. The fit for each regression is good as the R-squares are 0.3878, 0.4942 to 0.9725 respectively. The last regression has a very

\footnote{For brevity, we only present the empirical results on competition measured by the HHI index. Similar results are obtained for competition measured by Cover Ratio.}
high R-square because the number of bidders between the pre-bidding and official bidding stages are highly correlated.

Most of the explanatory variables are significant at the 1% level in all three regressions. The unofficial Range is not significant in the regressions. Since the bidders can still change their bids, some ex ante bids have relatively high bid yields (or low price) and make the unofficial range a bad predictor. This is consistent with the large standard deviations for all types of yields.

The number of unofficial bids and the unofficial Potential Profit are not significant in predicting the official number of bidders. The first result likely reflects how bidders are posting unofficial bids in anticipation of making changes just before the auction closes. The second result simply indicates that most bidders stay in the official session regardless of the potential profit.

Focusing on the first two regressions, we see that about 50% of the official bidders are likely to win in the auction as the coefficients for bidders are 0.615 and 0.488 respectively. The coefficient for the number of bids is negative at -0.042 and -0.049 respectively, indicating that 25 more bids result in one fewer winner. Although the effect is small, it suggests that competition is coming through bids, not bidders. The coefficient for HHI is -0.014 and -0.012, implying that an increase of HHI by about 80 would result in approximately one fewer winner. The effect of Potential Profit is negative with a coefficient of -8.925 and -27.730 respectively. The larger negative effect comes from the official bidding stage. This result seems counter-intuitive. One possible explanation may be as follows: when high potential profits are present during the pre-bidding session of an auction, many small bidders feel that large bidders would do anything to win the auctions, which would significantly reduce their chance of winning, unless they bid aggressively with a higher yield. In this case, they may not make any profit. After realizing this, many small bidders simply drop out of the official bidding and in turn the number of winning bidders are reduced.\footnote{This result also motivates us to study the size effect for large bidders and small bidders regarding potential profitability in Section 5.} Range is significant
only when using the official data as predicting variables.

To summarize, these three regressions indicate that (1) when there are more bidders participating in the official bidding or when there is more competition during the official bidding, there would be more winners; (2) when the profit potential is high, the auction would be concentrated on a few winners; (3) when the information is less refined (i.e., big range), more official bidders are likely to win the auction.

4.2. Bids

This subsection studies the relationship between the number of winning bids and the features of the official bidding and the unofficial bidding. We run the following three regressions:

\[
\text{# of Bids, win}_t = \alpha_1 + \alpha_2 \text{# of Bidders, ex ante}_t + \alpha_3 \text{# of Bids, ex ante}_t + \alpha_4 \text{HHI, ex ante}_t + \alpha_5 \text{Potential profit, ex ante}_t + \alpha_6 \text{Range, ex ante}_t + \epsilon_t,
\]

\[
\text{# of Bids, win}_t = \alpha_1 + \alpha_2 \text{# of Bidders}_t + \alpha_3 \text{# of Bids}_t + \alpha_4 \text{HHI}_t + \alpha_5 \text{Potential profit}_t + \alpha_6 \text{Range}_t + \epsilon_t,
\]

\[
\text{# of Bids}_t = \alpha_1 + \alpha_2 \text{# of Bidders, ex ante}_t + \alpha_3 \text{# of Bids, ex ante}_t + \alpha_4 \text{HHI, ex ante}_t + \alpha_5 \text{Potential profit, ex ante}_t + \alpha_6 \text{Range, ex ante}_t + \epsilon_t,
\]

The results are shown in Panel B of Table 2. The fit of the regression varies as the R-square ranges from 0.2223 to 0.7189. Similar to the previous set of regressions, the unofficial range has very little predicting power. All other coefficients are significant. The coefficient is 0.374 for unofficial bidders and -0.070 for unofficial bids in the first regression while the coefficient for official bidders and bids is -0.447 and 0.171 respectively in the second regression. These results indicate that, during the unofficial stage, more bidders produce more winners but more of their bids result in less winning bids. The opposite holds for the official stage.

One possible reason for these results may be in the informational advantage for some of the bidders. The “informed” bidders make fewer precise bids that are likely to win while the “uninformed” bidders simply make more bids that are likely to lose. Furthermore, the “informed” bidders are likely to keep more of their bids than the “uninformed” bidders. More unofficial bidders imply
more “informed” bidders, who then make more winning bids. However, the “uninformed” bidders are likely to lose and so, more unofficial bids result in fewer winning bids. In the official stage, only the “informed” bidders are likely to win. Since almost all auction participants stay in the official round, more official bidders tend to result in fewer winning bids. Yet, if there are more official bids, there will be more “informed” bids and hence it is more likely to win.

Similarly, the last regression using unofficial data to predict the official outcomes also support an intuitive outcome: more unofficial bidders and unofficial bids result in more official bids. The coefficients for Range: -0.038 using the unofficial data and 45.883 using the official data. This means that less refined information in the unofficial stage is most likely from “uninformed” bidders and results in fewer winning bids. In the official bidding stage, the bids are likely made by “informed” bidders and the official range has a positive effect on the number of winning bids.

In all three regressions, the coefficients for $HHI$ (-0.046, -0.032, -0.018) and Potential Profit (-19.910, -70.978, -11.081) are all negative. As expected, more competition causes more official and winning bids. On the other hand, when there are less potential profits, the incentive in participating in the auction is lower.

4.3. Competition in the Auction

Panel C in Table 2 presents the effects of explanatory variables on competition in the winning and official bidding stages. We run the following three regressions:

$$Winning\ HHI_t = \alpha_1 + \alpha_2 \# \ of \ Bidders, ex \ ante_t + \alpha_3 \# \ of \ Bids, ex \ ante_t + \alpha_4 HHI, ex \ ante_t + \alpha_5 Potential\ profit, ex \ ante_t + \alpha_6 Range, ex \ ante_t + \epsilon_t,$$

$$Winning\ HHI_t = \alpha_1 + \alpha_2 \# \ of \ Bidders_t + \alpha_3 \# \ of \ Bids_t + \alpha_4 HHI_t + \alpha_5 Potential\ profit_t + \alpha_6 Range_t + \epsilon_t,$$

$$HHI_t = \alpha_1 + \alpha_2 \# \ of \ Bidders, ex \ ante_t + \alpha_3 \# \ of \ Bids, ex \ ante_t + \alpha_4 HHI, ex \ ante_t + \alpha_5 Potential\ profit, ex \ ante_t + \alpha_6 Range, ex \ ante_t + \epsilon_t,$$

For the first two regressions, the R-squares are 0.4665 and 0.7448. All explanatory variables are significant, except for the number of bidders. When there are more bids, the winning HHI is higher.
as indicated by the positive coefficient of the variable. This result suggests that more bids do not imply more competition unless the bids are coming from equally informed bidders.

The positive and significant coefficients for the unofficial and official HHI indicate that more competition in the pre-bidding and official bidding stages results in less concentrated winner. HHI seems to be a better proxy for competition than the number of bids since this variable also incorporates the bid quantities.

The coefficients for Range are negative while those for Potential Profit are positive. As information becomes less refined (i.e., high range), the winners become less concentrated. At the same time, more potential profit results in more concentration among the winners.

In the last regression using the pre-bidding data to predict the bidding outcomes, all the coefficients are significant. Here, more bidders in the pre-bidding stage result in less concentration in the official bidding stage, but more bids result in a higher concentration. As with our earlier explanations, these results come from the heterogeneity in information among the bidders. The results for the variables HHI, Range and Potential Profit are all similar to those in the first two regressions.

4.4. Probability of Participating and Winning

In this section, we first examine the probability of a bidder to make an official bid conditional on that he has participated in the pre-bidding session. The analysis is based on the following logit model with heteroskedasticity, which is estimated through the Weighted-Least-Squares (WLS) procedure.

\[
\ln \left( \frac{P_{off, t}}{1 - P_{off, t}} \right) = \alpha_1 + \alpha_2 \# of \ Bids_{t-1} + \alpha_3 \text{Cover Ratio}_{ex \ ante_t} + \alpha_4 \text{Cover Ratio}_{t-1} \\
+ \alpha_5 \text{Potential profit, ex ante}_{t} + \alpha_6 \text{Range, ex ante}_{t} + \epsilon_t,
\]

\[
\text{with} \quad P_{off, t} = \frac{\# of Bids_{t}}{\# of Bids_{ex \ ante_t}}.
\]

The dependent variable is calculated as the natural log of the odds ratio in these models. The odds ratio is the probability of having an official bid over the probability of not having an official bid. Since we do not have these probabilities, we proxy them by using the ratio of official bids to
unofficial bids. For the 260 observations, the mean of estimated probability of having an official bid is 0.67625 with a standard deviation of 0.1237. Our explanatory variables are the number of bids from the previous auction, ex ante Cover Ratio, Cover Ratio from the previous auction, Potential Profit and Range. The reason that we use two measures from the previous auction (namely, the number of bids and the cover ratio) is because that the results from the previous auction may affect bidders’ behavior one way or the other. For example, observing a large number of winning bids from the previous auction, bidders may be encouraged to submit an official bid during this auction. Similarly, we use three measures from the pre-bidding session is because they are important elements to bidders when deciding whether to submit official bids.

Panel A of Table 3 presents the results. The R-squares is reasonably good at 0.5510. All the coefficients are significant. The coefficient for the number of bids from the previous auction is positive, implying that more bids from the previous auction increases the probability of submitting an official bid. The coefficient for the unofficial cover ratio is negative, indicating that a higher bidding quantity during the pre-bidding session reduces the probability of making an official bid. In contrast, the coefficient for the cover ratio from the previous auction is 0.293, implying that a higher official bidding quantity encourages the likelihood of participating in the auction.

As for the information variables, the coefficient for Potential Profit is positive and that for Range is negative. The probability of making an official bid increases as Potential Profit increases, and decreases as Range increases.

Now we consider the probability of winning an auction conditional on a bidder having made at least on bid. Similar to the above analysis, we use a logit model with heteroskedasticity.

\[
\ln \left( \frac{P_{\text{win}_t}}{1 - P_{\text{win}_t}} \right) = \alpha_1 + \alpha_2 \# \text{ of Bidders}_{t-1} + \alpha_3 \text{Cover Ratio, ex ante}_t + \alpha_4 \text{Cover Ratio}_{t-1}
+ \alpha_5 \text{Potential profit}_t + \alpha_6 \text{Range}_t + \epsilon_t,
\]

with \( P_{\text{win}_t} = \frac{\# \text{ of Bids}_t}{\# \text{ of Bids, ex ante}_t} \).

The dependent variable is the natural log of the ratio of the probability of winning over the the
probability of losing. The probability of winning or having a winning bidder is approximated by the number of winning bidders to the total number of official bidders. For the 260 observations, the mean of the estimated probability of having a winning bidder is 0.64048 with a standard deviation of 0.1659. Our explanatory variables are \textit{the number of winning bidders from the previous auction}, \textit{ex ante Cover Ratio}, \textit{Cover Ratio from the previous auction}, \textit{Potential Profit} and \textit{Range}. The reason that we use two measures from the previous auction (namely, \textit{the number of winning bidders and the cover ratio}) is because that the results from the previous auction may influence bidders’ behavior and hence the winning outcome for this auction. Also, we use three measures from the official bidding is because they are important elements in determining winning outcomes.

Panel B of Table 3 describes the results. The R-squares is 0.2604, which is reasonable. Unlike before, the coefficient for \textit{Range} is now insignificant. The coefficient for \textit{the lagged number of winning bidders} is positive, indicating that the probability of having a winner increases as the number of winners from the previous auction increases. The coefficient for \textit{Cover Ratio} is negative while that for \textit{the lagged Cover Ratio} is positive, implying that the probability of having a winner decreases (increases) as the bidding quantity (previous bidding quantity) increases. Lastly, the negative coefficient for \textit{Potential Profit} indicates that higher profits reduces the chance of having a winning bid. This is an intuitive and expected result.

In summary, the statistics and regression analysis indicate that the bid yield converges as the auction moves from the pre-bidding session to the official stage. The characteristics describing the pre-bidding stage have similar predictive power as those of the official bidding. In particular, the competition level during the pre-bidding session has a strong positive impact on the number of winning bidders and winning bids, and more bidders during the pre-bidding session induce a larger number of winning bidders. In addition, a higher percentage winning quantity during the previous auction encourages bidders making official bids while the current competition during the official
bidding reduces the probability of winning. A higher number of winning bidders or a higher cover ratio in the previous auction results in a higher winning probability while a higher range (or a more diverged opinion) or a higher profit potential induces a lower winning probability.

5. Size Effect

5.1. Bidding Synchronization among Large Bidders

Now we turn our attention to the size effect. Based on the regression result presented in the previous section, we hypothesize that large bidders behave differently from small bidders. To implement this test, we first investigate whether there is evidence of bidding synchronization among large bidders in the 3-month Canadian T-bill auction market. This is, we test whether a certain group of bidders either all bid aggressively to win the auction or whether their bids are all weak. To do so, we divide all bidders into three groups. This first group consists of the first top three bidders (Bidders 1, 2 and 3), the second consists of the next top three bidders (Bidders 4, 5 and 6) and the last group consists of the remaining bidders. As indicated in Table 4, on average, the top three bidders capture 22.52%, 14.18% and 10.12% of the total winning quantities while the next three top bidders account for 8.11%, 6.6% and 5.4% of the total winning quantities. In total, the top six bidders capture close to 70% of the total winning outcome.

The test of the synchronization hypothesis is developed in the following sense: consider the top three bidders with winning shares, $\alpha$, $\beta$ and $\gamma$. The remaining winning share $\eta$ is distributed among the next three bidders and all remaining bidders. Under the hypothesis that all three bidders bid independently, the fraction of the auction won by Bidder 1 should not have any relationship to how the rest of the auction is divided between Bidder 2 and Bidder 3. On the other hand, if the winnings by Bidder 1 and Bidder 2 are correlated, then a large share for Bidder 1 ($\alpha$) will be associated with the large share for Bidder 2 ($\beta$) as a proportion of $\beta + \gamma + \eta$. As in Hamao and Jegadeesh (1998), we measure the conditional correlation between the winnings of Bidder 1 and Bidder 2.
by the correlation between \( \alpha \) and \( \frac{\beta}{\beta+\gamma+\eta} \). Under the null hypothesis of uncorrelated winning, the correlation between \( \alpha \) and \( \frac{\beta}{\beta+\gamma+\eta} \) should be zero. That is, \( \text{corr}(\alpha, \frac{\beta}{\beta+\gamma+\eta}) = 0 \).

As indicated in Table 4, among the top three bidders, their bids are highly correlated as the values range from 0.3902 to 0.7048. Similarly, the bids are also highly correlated among the next three bidders as their correlation coefficients range from 0.1798 to 0.7899. All the correlation coefficients are significantly different from zero. These results suggest that when one of the top three bidders, or one of the next three bidders, wins a high proportion in an auction, the other top two bidders also gain a similar amount from the remaining portion of the auction. These tests provide support to the synchronization hypothesis among large bidders. They also lend support to our explanation to the seemingly counter-intuitive negative relationship between potential profit and the number of winning bidders presented in the previous section.

5.2. Significance of Potential Profits for Large Bidders

Now we turn our attention to the potential winning profits. Instead of aggregating the data for each auction, we examine each bid in the sample. Since a small number of the auctions have less than six bidders, we eliminate them from the data. Our sample size becomes 253 auctions and 5447 bids. We redefine range and the cover ratio using each bidder’s data in this section. For each auction, range is the difference between the bidder’s high bid yield and the bidder’s low bid yield while the cover ratio is the ratio between the bidder’s total bid quantity and the total award quantity.

We hypothesize that the size of the bidders should have an effect on potential profits. To test our hypothesis, we use t-tests and regressions. We first test whether the potential profits for all three groups are significantly different from zero. We then test whether the potential profits for each group is the same. The tests are performed for potential profits on the day of the auction and a window of a few days after the auction. The reason to study the potential profits on or after the
day of the auction is to capture the possible profits realized after the auction. Since the results for the potential profits in days after the auction are very similar, to save space, we only report the results for the potential profits on the day and 3 days after the auction in Table 5. Also we focus our discussion for potential profits on the day after the auction in Panel A.

In our sample, the top three bidders made 768 bids, so did the next three bidders. the remaining bidders made 3911 bids. The average potential profit for the top three bidders is 0.316%, the next three bidders 0.543% and the remaining bidders -0.048%. Overall, the entire bidders made 0.087%. With exception of the remaining bidders, all the values are significantly different from zero. This result suggests that large bidders can make profits, but not the small bidders, which confirms our hypothesis on the size effect. The intuition for the size effect can be explained by the difference in information quality, bidding skill and bidding strategy between large and small bidders. We further test whether potential profits are the same among different groups. The results indicate that the potential profits for the top three bidders are not significantly different from those of the next three bidders. However, the profits for these top six bidders are significantly different from the rest of the bidders. This evidence further supports the size effect hypothesis.

5.3. Determinants of Potential Profits for Large Bidders

Now we use regressions to determine the factors which influence the potential profits for the large six bidders. The dependent variable in the regression is Potential Profit while the explanatory variables are Range, Cover Ratio, HHI, dummies for the top three and next three groups. As in Table 5, we only present the results for the day of the auction and 3 days after in Table 6.

It is shown that the results between potential profits on the day of the auction and 3 days after are very similar. For brevity, we focus our discussions on the results using potential profits on the day of the auction. In this regression, all the coefficients are significant except for the top three dummy. The coefficient for Range is 0.498. Since this is the bidder’s range, the bidder expects more
potential profit when her information is less refined. As for competition, the coefficient for $HHI$ is close to zero. The reason may be that $HHI$ is calculated for each auction and its effect on each bid is small. The coefficient for Cover Ratio is positive and significant for the first regression. Since Cover Ratio is for each bidder, it does not really measure competition; rather it measures each bidder’s demand relative to the auction size. An interpretation of this result is that high demand implies high potential profit.

6. Conclusion

In this paper, we investigate the role of the pre-bidding session and see whether the pre-bidding arrangement help the convergence in opinions among bidders in the 3-month Canadian treasury auction markets. We also test the size effect hypothesis and see whether large bidders behave differently. Our empirical analysis shows that the pre-bidding arrangement facilitate the convergence in opinion among bidders and it has similar predictive power on winning outcomes as that of the official bidding. Specifically, the competition during the pre-bidding session has a strong positive impact on the number of winning bidders and winning bids; more bidders posting bids during the pre-bidding session induces a larger number of winning bidders. A higher percentage winning quantity from the previous auction encourages bidders making official bids and the current competition in the official bidding reduces the probability of winning. The potential profitability of the official bids has a negative effect on the probability of participating as well as the probability of winning. Also, our empirical results indicate that there exists bid synchronization among large bidders and the profit potential for large bidders is statistically significant while it is not for small bidders.

Since this paper only examines the 3-month Canadian Treasury bill auction, a natural step to take in future studies is to extend the analysis to the treasury auction markets with different maturities and it would be interesting to see whether the observations for the 3-month Canadian treasury auction market also exist.
References


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<th>Variables</th>
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<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
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<th>Mean</th>
<th>Std. Dev.</th>
<th>Min.</th>
<th>Max.</th>
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Note:
1. Range = Highest Yield - Lowest Yield;
Table 2: Effects of Pre-Bidding on Winning Outcomes

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<th>Range</th>
<th>Profit</th>
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<td>0.121</td>
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<td># of Bidders, win</td>
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<td><strong>2.544</strong></td>
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<td>0.499</td>
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<td><strong>5.571</strong></td>
<td><strong>13.362</strong></td>
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<td><strong>Panel C: Effects on Official and Winning HHI</strong></td>
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Note:
1. Sample Size is 260.
2. The asterisks *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively (two-sided test).
### Table 3: Probabilities of Participation and Winning

**Panel A: Predicting the Probability of Making Official Bidding**

\[
P_{\text{off},i} = \frac{\# \text{ of Bids}_i}{\# \text{ of Bids, ex ante}_i}
\]

\[
\ln\left( \frac{P_{\text{off},i}}{1 - P_{\text{off},i}} \right) = \alpha_1 + \alpha_2 \# \text{ of Bids}_{i-1} + \alpha_3 \text{ Cover Ratio, ex ante}_i + \alpha_4 \text{ Cover Ratio}_{i-1} + \alpha_5 \text{ Profit, ex ante}_i + \alpha_6 \text{ Range, ex ante}_i + \varepsilon_i
\]

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<tr>
<th>(\alpha_1)</th>
<th>(\alpha_2)</th>
<th>(\alpha_3)</th>
<th>(\alpha_4)</th>
<th>(\alpha_5)</th>
<th>(\alpha_6)</th>
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<td>3.3070 ***</td>
<td>1.3740 *</td>
<td>-1.9850 **</td>
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**Panel B: Predicting the Probability of Winning**

\[
P_{\text{win},i} = \frac{\# \text{ of Bidders,win}_i}{\# \text{ of Bidders}_i}
\]

\[
\ln\left( \frac{P_{\text{win},i}}{1 - P_{\text{win},i}} \right) = \alpha_1 + \alpha_2 \# \text{ of Bidders,win}_{i-1} + \alpha_3 \text{ Cover Ratio}_i + \alpha_4 \text{ Cover Ratio}_{i-1} + \alpha_5 \text{ Profit}_i + \alpha_6 \text{ Range}_i + \varepsilon_i
\]

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<thead>
<tr>
<th>(\alpha_1)</th>
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**Note:**
1. Sample Size is 260.
2. The asterisks *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively (two-sided test).
Table 4: Bidding Synchronization Test among Large Bidders

<table>
<thead>
<tr>
<th>Winning Quantity as % of Total Auction</th>
<th># 1 Bidder</th>
<th># 2 Bidder</th>
<th># 3 Bidder</th>
<th># 4 Bidder</th>
<th># 5 Bidder</th>
<th># 6 Bidder</th>
<th>Rest Bidder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>22.520%</td>
<td>14.177%</td>
<td>10.125%</td>
<td>8.112%</td>
<td>6.670%</td>
<td>5.403%</td>
<td>32.713%</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>10.907%</td>
<td>5.675%</td>
<td>3.348%</td>
<td>2.354%</td>
<td>1.905%</td>
<td>1.752%</td>
<td>16.385%</td>
</tr>
</tbody>
</table>

Test on Bid Synchronization

<table>
<thead>
<tr>
<th></th>
<th>Top 3 Bidders</th>
<th>Correlation</th>
<th>t-value</th>
<th>Next Top 3 Bidders</th>
<th>Correlation</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td># 1 Bidder</td>
<td>0.6027</td>
<td>11.9914</td>
<td>***</td>
<td># 4 Bidder</td>
<td>0.581</td>
<td>11.3323</td>
</tr>
<tr>
<td># 2 Bidder</td>
<td>0.7048</td>
<td>15.7693</td>
<td>***</td>
<td># 5 Bidder</td>
<td>0.7899</td>
<td>20.4497</td>
</tr>
<tr>
<td># 3 Bidder</td>
<td>0.3902</td>
<td>6.7276</td>
<td>***</td>
<td># 6 Bidder</td>
<td>0.1798</td>
<td>2.9018</td>
</tr>
</tbody>
</table>

Note:
1. Sample Size is 253. Seven auctions were eliminated from the previous sample of 260 to ensure all six top bidders participated in each auction.
2. The standard error of the correlation is $\sqrt{\frac{1-\rho^2}{n-1}}$ where $\rho$ is the correlation and $n$ is the number of observations.
3. The asterisks *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively (two-sided test).
Table 5: Significance of Potential Profits

Panel A: Potential Profit on Auction Day

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Top 3 Bidders</th>
<th>Next 3 Bidders</th>
<th>Rest Bidders</th>
<th>All Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>768</td>
<td>768</td>
<td>3911</td>
<td>5447</td>
</tr>
<tr>
<td>Mean</td>
<td>0.316%</td>
<td>0.543%</td>
<td>-4.800%</td>
<td>8.700%</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>3.977%</td>
<td>3.920%</td>
<td>4.234%</td>
<td>4.161%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>t - Tests</th>
<th>Top 3 Bidders</th>
<th>Next 3 Bidders</th>
<th>Rest Bidders</th>
<th>All Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₀ : Zero Profit</td>
<td>2.2002</td>
<td>** 3.8372</td>
<td>*** -0.7052</td>
<td>1.5394 *</td>
</tr>
<tr>
<td>H₀ : Equal Profit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top 3 Bidders</td>
<td>-1.1269</td>
<td></td>
<td>2.2907 **</td>
<td></td>
</tr>
<tr>
<td>Next 3 Bidders</td>
<td>3.7657 ***</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Panel B: Potential Profit Three Days after Auction

<table>
<thead>
<tr>
<th>Statistics</th>
<th>Top 3 Bidders</th>
<th>Next 3 Bidders</th>
<th>Rest Bidders</th>
<th>All Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Size</td>
<td>768</td>
<td>768</td>
<td>3911</td>
<td>5447</td>
</tr>
<tr>
<td>Mean</td>
<td>2.394%</td>
<td>2.621%</td>
<td>1.742%</td>
<td>1.958%</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>11.720%</td>
<td>11.705%</td>
<td>12.396%</td>
<td>12.211%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>t - Tests</th>
<th>Top 3 Bidders</th>
<th>Next 3 Bidders</th>
<th>Rest Bidders</th>
<th>All Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td>H₀ : Zero Profit</td>
<td>5.6604</td>
<td>*** 6.2041</td>
<td>*** 8.7859</td>
<td>*** 11.8317</td>
</tr>
<tr>
<td>H₀ : Equal Profit</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top 3 Bidders</td>
<td>-0.3799</td>
<td></td>
<td>1.3966 *</td>
<td></td>
</tr>
<tr>
<td>Next 3 Bidders</td>
<td>1.8845 **</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
1. The asterisks *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively (two-sided test).
Table 6: Determinations of Potential Profits

<table>
<thead>
<tr>
<th></th>
<th>Potential Profit on Auction Day</th>
<th>Potential Profit 3 Days after</th>
<th>Range</th>
<th>HHI</th>
<th>Cover Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>0.087%</td>
<td>1.958%</td>
<td>0.98%</td>
<td>9.89</td>
<td>0.0956</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>4.161%</td>
<td>12.211%</td>
<td>1.01%</td>
<td>5.35</td>
<td>0.0827</td>
</tr>
</tbody>
</table>

**Regression Results**

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Range</th>
<th>Cover Ratio</th>
<th>HHI (* 10^4)</th>
<th>Dummy for Top 3 Bidders</th>
<th>Dummy for Next 3 Bidders</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potential Profit on Auction Day</td>
<td>0.498</td>
<td>0.015</td>
<td>0.101</td>
<td>0.001</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>7.974</td>
<td>1.813</td>
<td>9.063</td>
<td>0.320</td>
<td>1.914</td>
</tr>
<tr>
<td>Potential Profit 3 Days after</td>
<td>0.331</td>
<td>0.012</td>
<td>0.195</td>
<td>0.001</td>
<td>0.003</td>
</tr>
<tr>
<td></td>
<td>1.796</td>
<td>0.483</td>
<td>5.887</td>
<td>0.223</td>
<td>0.689</td>
</tr>
</tbody>
</table>

Note:
1. Sample Size is 5447.
2. The asterisks *, **, and *** indicate statistical significance at the 10%, 5% and 1% levels, respectively (two-sided test).