COMPARISON OF BIDDING STRATEGY FOR
SEALED BIDS AND ENGLISH REVERSE AUCTIONS

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ABSTRACT

In this paper a methodology to prove the bidding strategy of sellers for two selected tender methods, a sealed bid and an English reverse auction, is designed. The bidding strategies are based on an assumption of rational behaviour of the sellers in each of tender method. The sellers in the sealed bid submit the best bid they can. The sellers in the English reverse auction submit an initial bid for the auction, which is higher than their best bid. For the verification an original methodology of statistical testing is designed. It is based on the comparison of coefficients of variation between the two tender methods. In the paper the basic principle, process and practical application of each tender method are also described.

KEY WORDS

Purchase. Negotiation. Supplier selection., Sealed envelopes. English reverse auctions.

JEL CLASSIFICATION

D440, M190, M210

INTRODUCTION

The process of purchasing of product begins with finding out a need of a concrete product, the product specification and the conditions of purchase. It continues with looking for potential sellers, negotiation and decision about the supplier selection, purchasing itself and its evaluation (Kotler and Keller, 2007). To negotiate the right price it is necessary to select the appropriate negotiation method with the evaluation criterion to compare the seller bids and choose a supplier (Kotler, Wong, Saunders and Armstrong, 2007).

The aim of this paper is to design a new methodology to verify the bidding strategies for two selected tender methods. To achieve this aim it is necessary to compare selected tender methods and on the base of this comparison to define the bidding strategies of the sellers. As selected tender methods the sealed bid and the English reverse auction were chosen. Their

selection is based on the widespread use in practice (Fiala, 2012). For the result clarity only tenders with more than 3 sellers evaluated by total submitted price will be compared.

Individual chapters define the characteristics of mentioned tender methods, the comparison and description of the bidding strategy of the sellers. Based on these chapters the methodology for verifying the bidding strategy is designed.

1 THEORETICAL BACKROUND

In this chapter two selected methods commonly used in purchasing tenders are characterized. Basic characteristics of the different methods, the process of submitting bids by the seller and comparison of bought methods are described.

1.1 Sealed bid

Sealed bid is a method characterized by the possibility to offer only one bid (Fiala, 2012). The entire bidding process is secret (Schneider, 2014). Individual sellers have no information about the number of all invited sellers, the number of sellers taking part or theirs bids. The purchase with the sealed bid method contains usually one phase. After the bid opening the purchaser evaluates and selects the best seller, the supplier.

High emphasis is on keeping the bidding secret. Bidding secret is an essential element without which this method has no effect. Thanks to the bidding secret the sellers get equal access to information and there is no discrimination (Maschler, Solan and Zamir, 2013).

The bidding begins with an invitation of the sellers to participate in the tender. Interested sellers subsequently receive the tender specification from the purchaser. The tender specification generally contains a description of purchased products, purchase conditions and the evaluation procedure. Purchaser tries to limit the amount of bidding information that is shown to the sellers, because this has big influence on the strategy of sellers. After acceptance of the tender specification the sellers submit their bids. Sellers can submit only one bid, but while keeping all the assumptions of the bidding secret, the sellers can change their bids until the bidding end. Valid bid is always the last submitted bid within the set time interval (Milgrom, 2004).

The aim of the sellers is to maximize their profit by selling the product at the highest possible price. Sellers decide about the amount of their bids according to market information, which is due the bidding secret incomplete (Binmore, 2014). To win the tender, the sellers have to offer a lower price than his competitors, yet high enough to ensure the profitability of

the transaction. If the sellers know the common market price, which is the assumption for a rational seller, it is highly probable that the submitted bid is in the range of sellers breakeven (price without any profit or loss) and the common market price (Hirshleifer, Glazer and Hirshleifer, 2005).

1.2 English reverse auction

A tender process that gives its sellers an opportunity to change the submitted bid in response to published actual information about the tender is called an auction (Schneider, 2014). English auction is a selection procedure, where the submitted bids can only increase. English auction is used to sell a product. An English reverse auction is then designed to purchase a product. The submitted bids can only decrease.

The invitation process for the English reverse auction is similar to the sealed bids. English reverse auction usually contents two phases (Fiala, 2012). In the first phase the sellers submit an initial bid. This initial bid determines the maximum sellers price for the product and his starting bid in the second phase, the auction. In the auction the purchaser allows the sellers to see some information of the tender to motivate them to decrease the bids. This information can have a form of ranking of the sellers, the best bid of each item or the best total bid (Schneider, 2014). To limit the bid changes the purchaser uses following instruments: the minimum step of bid change (in absolute or relative values) and the inability to match the bids and the time interval for bid change. The last submitted bid of each seller in the defined time interval is always valid, regardless of whether it was submitted in the first or second phase (Maschler, Solan and Zamir, 2013).

The first phase runs generally in days or weeks to provide sufficient space for sellers to submit the initial bid. Because it is not necessary to keep the bidding secret (like in the sealed bid), the buyer has no extra costs. An effect of this method is delivered by the auction. The purchaser has to guarantee all tender rules and to provide a space to participate in real time for all the sellers (Kaplan and Zrník, 2007). The sellers who are interested to get the additional information published during the auction have to participate in it.

The sellers acquainted with this tender method know that their bid can be changed during the auction. They also know the limitations caused by their initial bid. That is why the sellers are motivated to submit a higher initial bid than the one they would submit in case there would be no correction option during the auction (Milgrom, 2004). Higher initial bid gives the

sellers a comparative advantage in the auction. They use this overview of the situation and their position to decrease their bids if it is needed to win.

1.3 Comparison of sealed bid and English reverse auction and definition of their bidding strategies

Particular tender methods have a number of unique characteristics. In the table 1 there are selected the ones with significant effect on the bidding strategy of the sellers in a tender. These are the bidding secret, show of added information to the sellers, real time competition and reaction on competition (Binmore, 2014). The fundamental difference between the chosen methods is caused by the amount of information that sellers get.

Table 1: Comparison of sealed bid and English reverse auction

	Sealed bid	English reverse auction
Number of phases	One	Two
Bidding secret	Yes	No
Show of added information	No	Yes
Real time competition	No	Yes
Reaction on added information possible	No	Yes

Source: Martin Heinisch, Personal collection

The bidding decision of the sellers in sealed bid is not based on any additional information or another competitors. This makes it possible to assume that the sellers participating on the tender have the real interest to sale. For a seller that is not interested in sale the participation has no added value. Sellers participating in the tender tend to behave rationally (Binmore, 2014). Because of no additional information it is assumed the submitted bids will be close the own breakeven point. A higher bid can cause not winning the contract. A lower bid below the breakeven point is unprofitable for the sellers in short and long term and that is why also not logic. The bidding strategy of rational sellers for sealed bid is to submit the best possible bid with which the seller thinks he is able to win.

English reverse auction gives the sellers an option to rework the submitted bid on the base of the added information. This situation affects the bidding strategy of sellers. The added information that is published to each supplier with submitted bid motivates to participate also the sellers that have no interest to win the tender but would like to get some information about the market situation. Therefore the sellers are not motivated to submit their best initial bid in the first phase. They will wait to do so until the auction phase. The bidding strategy of

rational sellers for English reverse auction is to overvalue the initial bid. After display of additional information in the auction the real interested sellers start to decrease their bids.

2 OBJECTIVE AND METHODOLOGY

This chapter contains the introduction to the problematic of verification of the bidding strategy, the methods used for the verification and the design of the methodology to verify the bidding strategy of sellers in sealed bid and English reveres auction.

2.1 Verification of the bidding strategy

The bidding strategy of sellers is for each of the tender method different. The bidding strategy from the section 1.3 says that the sealed bid is more effective than the English reverse auction because the sellers in sealed bid submit their best bid, while the sellers in English reverse auction wait with their best bid for the auction. It is possible that a seller with an overvalued bid wins the auction. It can occur in a situation when no other seller challenges the winning seller.

To verify these bidding strategies for a sealed bid tender and an English reverse auction a comparison between both tenders has to happen. The best way is the direct comparison of the bids of two equal tenders with the same content and the sellers in the same market situation. These conditions are possible to reproduce in a simulation but the real praxis is different. Each day a lot of products in different currencies on different markets with different sellers are tendered. To use this data an indirect methodology for verification of the bidding strategies based on assumptions of the consequences of the bidding strategies will be designed. The methods that will be used for the design of the methodology are specified below.

2.2 Coefficient of variation

The coefficient of variation indicates the relative degree of variability in a data set. This is a percentage of the average deviation from the arithmetic mean value of the group according to the formula (Neubauer, Sedlačík and Kříž, 2012):

$$v = \frac{\sigma_x}{\bar{x}}, \tag{1}$$

where

v - coefficient of variation,

σ_x - standard deviation of the data set,

$\bar{x}$ - arithmetic mean of the data set.

With decreasing coefficient of variation the homogeneity of the data set increases. Because the coefficient of variation is a dimensionless value it is suitable for comparing the variability between data sets represented by different values.

2.3 Outliers cleansing

Outliers file are identified by rule 1.5IQR (Moore, 2010), which is used to compile a boxplot. Outliers are located in the interval:

$$(-\infty; x_{25} - 1.5IQR) \text{ and } (x_{75} + 1.5IQR; \infty), \qquad (2)$$

where

x_{25} - lower quartile,

x_{75} - upper quartile,

IQR - interquartile range of the upper and lower quartiles.

The remaining value belonging to the interval from $(-\infty; x_{25} - 1.5IQR)$ to $(x_{75} + 1.5IQR; \infty)$ are data used in further statistical testing. By removing the outliers the information capability of statistical test increases.

2.4 Shapiro-Wilk normality test

Shapiro-Wilk test verifies that the probability of distribution comes from a normal Gaussian distribution. The test is based on the ratio of two estimated variances.

Test criterion W is the ratio of the square unbiased estimation of standard deviation of the data set and the estimation of its variance (Sen and Srivastava, 1997). It is a ratio of two estimates variances (Marques de Sá, 2007)

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n} (x_i - \bar{x})^2}, \qquad (3)$$

where

W - test criterion of the Shapiro-Wilk test,

a_i - weight derived from the mean and variance matrix of order statistics simple random sampling,

x_i - i-th value of the data set,

$x_{(i)}$ - i-th ordinal value of an ordered set of values,

$\bar{x}$ - arithmetic mean of the data set.

Test criterion of the Shapiro-Wilk test significantly close to 1 indicates the acceptance of the null hypothesis. The value of 1 corresponds to an identical probability distribution of normal Gaussian distribution. Verification of the result is possible with Q-Q plot (quantile-quantile plot). In case of normal Gaussian distribution the regression line corresponds with the theoretical division.

For testing the null hypothesis of equal probability distribution of the data set with normal distribution the Shapiro-Wilk test for normality at a significance level of 5% will be used.

2.5 Mann-Whitney test

Mann-Whitney test tests the conformity of a probability distribution for two independent data sets. It is a nonparametric test. The data sets may not reflect the normal Gaussian probability distribution (Black, 2009).

Ascending sorted values of both data sets creates so-called mixed selection. Each value of this mixed selection will receive a rank in which it occurs. In case of identical values, each of them receives the arithmetic average of the rankings. The rank of assigned values for each of the two original data sets is summed (Marques de Sá, 2007). The result are values R_1 and R_2, for which applies:

$$R_1 + R_2 = \frac{(n_1 + n_2)(n_1 + n_2 + 1)}{2}, \tag{4}$$

where

R_1 and R_2 - sum of the ranks of each data set,

n_1 and n_2 - number of values of each data set.

Test statistics U_1 and U_2 for each data set is calculated according to the formula (Roger, 2007):

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \tag{5}$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2, \text{ where} \tag{6}$$

U_1 and U_2 - test statistics of each data set,

n_1 and n_2 - number of values of each data set,

R_1 and R_2 - sum of the ranks of each data set.

Test criterion $U_{\min(U_1;U_2)}$, which is compared with the table values for Mann-Whitney test, is to lower value of test statistics U_1 and U_2. The table value for Mann-Whitney test is taught

by the level of significance 5%, number of the values in first data set n_1 and number of the values in second data set n_2.

The null hypothesis about conformity of the probability distribution of the two data sets is accepted when the value of the test criterion $U_{\min(U_1;U_2)}$ is higher than the table value for Mann-Whitney test. Vice versa, when the value of the test criterion $U_{\min(U_1;U_2)}$ is lower than the table value for Mann-Whitney test, the null hypothesis is rejected.

2.6 Design of the methodology for the verification of the bidding strategies

The methodology is based on the rational strategy of sellers by submitting bids in sealed bid and English reverse auction.

Rational sellers submit their best bid in the sealed bid, because they can not react on additional information and improve theirs bids. That is why is it possible to assume, the submitted bids will tend to be not too different from each other.

Rational sellers submit theirs initial bids in the English reverse auction overvalued. Because the bid decision is individual, the overvaluation is also individual. This makes it possible to assume that the initial bids in the first phases will significantly differ from each other.

The dispersion of the submitted bids will be expressed by the coefficient of variation calculated for each tender. The coefficient of variation equalizes the different values, amounts and currencies of the tenders. The coefficients of variation of submitted bid in the sealed bid as one data set and the coefficients of variation of the initial bids in the English reverse auction as second data set would be the base for the statistical testing. There will be tested an assumption that the coefficients of variation of submitted bids in sealed bid are lower than the coefficients of variation in the initial bids in English reverse auction.

The statistical testing starts with exclusion of the outliers in each data set. Normality of the data sets will be tested by the Shapiro-Wilk test for normality at a significance level of 5%. With regards to the above-described process of bidding it is possible to assume that the distribution of the data set does not match the normal Gaussian distribution. After confirmation of this assumption, the final testing of the equality of the coefficients of variation will be performed by the Mann-Whitney nonparametric test at a significance level of 5%.

To accept the assumed bidding strategy, that the coefficients of variation of the submitted bids in the sealed bid are not same as the coefficients of variation of the initial bids in the English reverse auction, the null hypothesis of the Mann-Whitney test has to be rejected.

3 RESULTS AND DISCUSSION

This chapter contains a summarisation of the proposed methodology to verification of the bidding strategies and the conditions to apply this proposed methodology on real data.

3.1 Methodology for the verification of the bidding strategies

According to the designed methodology in section 2.6 the verification of the bidding strategies for the sealed bid and the English reverse auction will be performed in following steps.

1. The coefficients of variation from submitted bids in sealed bids and the coefficients of variation from initial bids of English reverse auctions will be calculated. The coefficients of variation create two data sets divided by the used tender method.
2. The data sets will be cleaned out of the outliers.
3. The normality of the data distribution will be tested by the Shapiro-Wilk test for normality at a significance level of 5%. It is assumed that the distribution of the data sets is not normal.
4. The probability distribution of the data sets will be tested by the Mann-Whitney nonparametric test at a significance level of 5%. It is assumed that the data sets have different distribution.

The designed methodology for verification of the seller bidding strategies should lead to the confirmation of these bidding strategies for sealed bid and English reverse auction.

3.2 Conditions for applying the proposed methodology

Application of the proposed methodology is limited by below described conditions of input data. The conditions secure the comparison of the submitted bids in different tender methods.

- All tenders have to be evaluated only by price. Another criteria cannot influence the evaluation of the bids.
- The sellers have to submit bids to all items of the tender. All submitted bids in a tender must be complete.

- In a tender there has to be only one winner. The best seller with the best total bid gets the order from the purchaser. No "cherry picking" of the purchased items is allowed.

- The tenders have to contain at least 3 submitted bids. Bids of two or one seller in a tender are not a representative input for the coefficient of variation.

- The purchasers must not publish any expected tender price to the sellers. The information about the expected tender price influences the bid submitting, especially the initial bids of English revere auction.

CONCLUSION

The paper proposes a methodology to prove the assumed bidding strategy of the sellers in two common methods used for purchasing tenders: a sealed bid and an English reverse auction. The sealed bid assumes submitting bids close to each other on level of the best seller´s bid. The English reverse auction assumes submitting of overvalued initial bid before the auction that will tend to be different of each other.

The designed methodology is based on an indirect comparison by the coefficient of variation of submitted bids in each of the tender method. Both data sets of coefficients of variation cleared from the outliers should be tested on normality by Shapiro-Wilk normality test at a significance level of 5%. The equality of the data sets should be than tested by the nonparametric Mann-Whitney test at a significance level of 5%.

According the theoretical assumption of bidding strategy the rejection of the null hypothesis of the Mann-Whitney test is expected. The p-value of the Mann-Whitney test should be lower than 0,05. The data sets of the coefficients of variation should not have equal distribution of the values. The coefficients of variation of the submitted bids in the sealed bid should be significantly lower than coefficients of variation of the initial bids in the English reverse auction.To apply the proposed methodology on the real data, the conditions for the input data from the tenders were proposed.The application of designed methodology for verifying the assumed bidding strategy of sellers in selected tender methods will be further researched and applied on real data. There is an expectation that the results will lead to the specification of conditions for the use of selected methods. Analysing the bidding strategy of the winners of the English reverse auction, observing bid changes in the auction round of English reverse auction, etc. are another possible research directions.

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