



# Application of the Online Reverse Auction Theory in the Software Outsourcing Procurement

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**Abstract.** When choosing software outsourcing suppliers, the enterprises need to comprehensively consider the price attributes, business attributes, technical attributes and other factors, so as to form a winner determination problem. This paper proposes to design an online reverse auction model of two phase, and use the comprehensive scoring method to determine the winning bidder. For the indicators that are difficult to quantify the business attributes and technical attributes, the expert scoring method is adopted to quantify them numerically, and the linear additive score function is used to determine the highest score as the software outsourcing supplier, thus solving the problem of winner determination in the application of the online reverse auction theory.

**Keywords:** winner determination problem · online reverse auction · software outsourcing · multiple rounds of procurement

## 1 Introduction

Procurement is a key link in the operation of a company, which determines the cost and quality of goods and relates to the benefits of the company. Compared with the traditional offline procurement, online reverse auction, as a new commercial procurement method, facilitates the communication and negotiation between buyers and sellers, shortens the procurement time, saves the transaction costs of buyers and sellers, and increases the transparency of the transaction process, which has shown great prospects for business development.

The online reverse auction is an electronic procurement method initiated and led by the buyer, and multiple sellers participate in the bidding [1]. The theory shows that enterprises purchasing products and services in this way can not only greatly reduce procurement costs, but also improve procurement efficiency [2]. However, when reverse auction is used in enterprise procurement activities, especially in software outsourcing procurement activities, it is obvious that the winning rule of forward auction cannot be copied, and only the price is taken as the only factor to select the winner. For example, in the software outsourcing procurement, it is necessary to comprehensively consider the supplier's service price, the business qualification of the supplier, and the superiority of

the technical solutions provided. Choosing a supplier based on the price alone is far from enough. So the multi-attribute features lead to a key question of—winner determination problem. Namely how to select the relatively optimal service provider through multiple attribute evaluation.

About the problem for the winner determination, the main research idea is to score with the scoring function. Ray et al. [3, 4] used the quasi-linear scoring function to study the winner determination in the inconsistency between the actual delivery of the winning bidder and the promised quotation. Based on the weighted sum scoring function, Pham et al. [5] points out that the additive utility function is the most commonly used scoring function. Zhang Xingzhou and Zhang Xuejuan [6], they analyzed the problem of winner determination in large-scale equipment procurement of engineering or manufacturing industry, establishes the value function of multi-attribute procurement and auction according to the equipment procurement practice. Jing Huirong [7], designed a multi-attribute reverse auction mechanism based on fuzzy evaluation is designed, which can maximize the expected income when the supplier bid meets the incentive compatibility conditions.

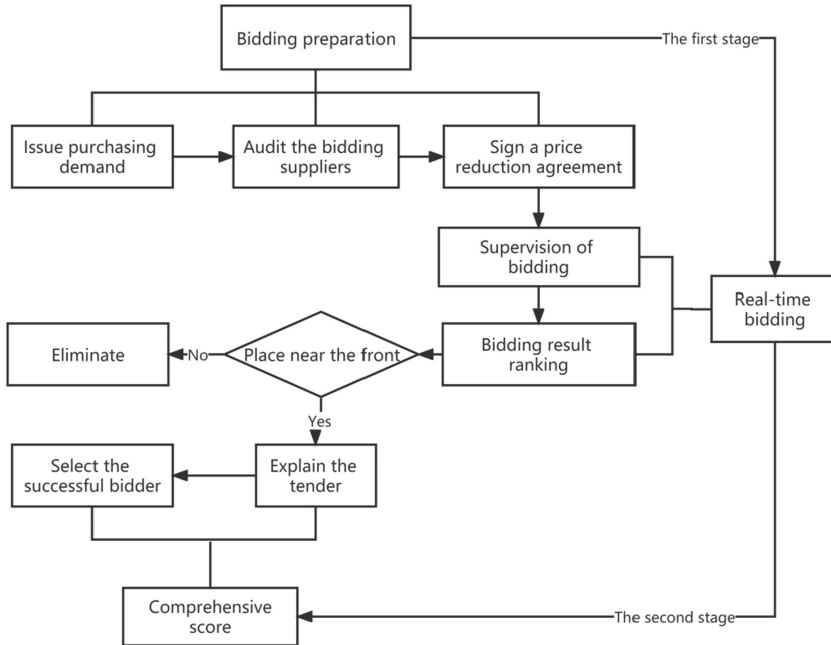
Based on the above literature, we find that, on the one hand, most of the online reverse auction theory still stays in the theoretical research level. For the winner determination problem, the literature mostly focuses on normalizing the non-price attribute and the price attribute index, which is difficult to apply in practice. On the other hand, about the software outsourcing service procurement activities, the purchaser must have to evaluate the supplier's technical plan and determine whether it is applicable to the business needs of the enterprise, and this step is inevitable. For enterprises in the actual procurement activities want the suppliers continue to hold down prices, and also need comprehensive consideration the double requirements of power suppliers. Hence the article designed an online reverse auction model of two phase, the first stage uses the reverse auction way to make full price competition between suppliers, the second stage, we use expert scoring method to numeralize the supplier's business attributes and technical attributes for the winners in the first stage by price, and then use the comprehensive scoring method to determine the winning bidder, implementation the overall improvement of purchasing performance. Furthermore, we give a adjustable scoring functions and examples.

## 2 Materials and Methods

### 2.1 Purchasing Process

Strecker and Seifert [8], their study proved the superiority of the reverse English Auction in the allocation efficiency and the surplus of the bidder. In the process of the bid assessment, the procurement specialists and business specialists of enterprises will comprehensively score the price attributes, business attributes and technical attributes to select the winning bidder [9]. The goal of procurement is to reduce the purchase price and ensure the quality of service through online reverse auctions [10].

In the article, on the basis of fully investigating the use of auction theory in enterprises, we are committed to the application of online reverse auction theory in enterprise software outsourcing procurement. We design a two-stage procurement model, so as to



**Fig. 1.** The Procurement Process

solve the actual procurement activities for the efficiency of price negotiation, as well as the requirements for comprehensive evaluation of suppliers.

In the first stage, the reverse auction theory is used to select the Reverse English Auction method and set bidding rules to stimulate suppliers to compete in the single price factor.

In the second stage, we invited enterprise procurement experts to give points to the shortlisted suppliers for the second stage about the multiple attributes, comprehensively consider the overall performance of suppliers under multiple indicators, and select the best supplier. The procurement process is shown in Fig. 1.

## 2.2 Bidding Rules

- Reverse English Auction (sealed): In the event, suppliers will not be informed of the number or identity of other suppliers, only know the ranking of their own quotation in order of price from lowest to highest. Suppliers bid in the form of successive price reductions. If different suppliers bid the same, the supplier who bid first gets the better ranking.
- Starting price: the final valid quotation submitted by the supplier before the event, such as RFQ, RFI, etc.

- **Minimum spread:** The minimum difference between a supplier's new offer and its current best offer.
- **Bid limit:** This option is the range set to avoid typing errors. The system will reject bids from suppliers that exceed a predetermined bid limit of 50% in a single bid.
- **Delay interval:** When the supplier bids at the end of the event. The delay interval ensures that the supplier has sufficient time to handle the competitor bid before the end of the event.

### 2.3 Score Function

The arithmetic and number-weighted evaluation method is adopted for the comprehensive evaluation. Three first-level evaluation factors,  $p$  is price attribute,  $q$  is business attribute, and  $v$  is technical attribute. Among them, the price attribute can be numerized, but the quotation difference between suppliers is large, so the appropriate price evaluation function is selected, otherwise it is easy to offset the weight of the non-price attribute. For business attribute and technical attribute, because service outsourcing involves the need to review the suppliers and their bidding technical scheme, the expert evaluation method is adopted to score the suppliers. So as to achieve quantification, which not only reduces the difficulty of numerical value, but also saves time. For price attributes, the lowest bid price is selected as the benchmark price score to encourage fierce price competition among the suppliers and set the coefficient  $F_k$  to be a adjustment coefficient. The score function is the below formula (1).

$$E_i = E_p + E_q + E_v = 100 \times w_p - \left( \frac{P_i - P_{\min}}{P_{\min}} \right) \times 100 \times F_k + \sum_{t=1}^m q_t \times w_q \times 100 + \sum_{r=1}^n v_r \times w_v \times 100 \quad (1)$$

In formula (1),  $E_i$  is the bid score of the supplier  $i$ ,  $E_p$  is the score for the price section,  $E_q$  is the business attribute score,  $E_v$  is the technical attribute score;  $w_p$ ,  $w_q$ ,  $w_v$  are the weight of price, business, technology respectively, and  $w_p + w_q + w_v = 1$ ;  $q_t$  is the score of each secondary evaluation index under business attribute;  $v_r$  is the score of each secondary evaluation index under technical attribute; 100 means that each primary attribute takes a percentage system.  $P_{\min}$  is the benchmark price of target evaluation (the lowest price in the bidding);  $P_i$  is the bid price of the supplier  $i$ ;  $F_k$  is the adjustment coefficient that the purchaser can adjust the value for the bid price according to the actual situation.

## 3 Case Analysis

To better understand the bidding rules and scoring function above, choose a specific example to explain. S company is a multinational company with business all over the world. With the continuous promotion of enterprise digital strategy, IT service outsourcing is becoming more and more frequent. In order to standardize procurement process

and improve procurement performance, enterprises build reverse auction procurement websites themselves to carry out software service procurement activities.

In order to quickly obtain the appropriate supplier quotation, S company published the procurement demand, auction requirements and evaluation indicators on its own procurement website, and invited qualified suppliers to participate in the auction. Enterprises sign online auction agreements with participating suppliers, and inform suppliers of reverse auction process, auction rules and evaluation index system. On the basis of the system quotation provided by each supplier, a price auction is carried out. The whole procurement process is carried out in two stages. At the same time, the supervision bidding mechanism of the enterprise supervises the work in real time.

In the first stage, suppliers are constantly engaged in fierce price competition and constantly reduce their respective in the Reverse English Auction (sealed), and the suppliers are ranked according to the price from lowest to highest. Then the top two suppliers enter the second round of scoring stage. In the second round of scoring, the shortlisted suppliers will explain their service technical solutions respectively, and the procurement experts and business experts of the enterprise will score the performance of the suppliers in each attribute by a percentage system.

In the final scoring function, 50% of the price attribute, 20% of the business attribute, and 30% of the price attribute,  $F_k$  equals 0.1, that is 0.1 points are deducted from the bid price for each one percentage point above the benchmark price. And publish the bidding rules and the final scoring function before the bidding.

The initial bids of the five suppliers and the final quote after sharply bidding are shown in Table 1 within the Reverse English Auction. The quote is the price that the supplier is willing to accept the price paid by the enterprise.

According to Table 1, supplier D and supplier E are selected for the second round of bid evaluation. In the second round of bid evaluation, supplier D and supplier E explained their scheme design book and the enterprise background qualification in detail respectively, and the procurement experts and business experts of the enterprise to conduct evaluation and score. Finally, the procurement staff shall score and summarize the suppliers respectively, and decide the final winning supplier. The calibration details are shown in Table 2.

According to Table 2, for  $88.04 > 85.7$ , namely, the Supplier D is selected to sign the project contract with the enterprise. If the supplier is selected according to the traditional bidding, and the supplier will only bid once, so that there is no efficient price competition.

**Table 1.** The Supplier quotations

Supplier	Initial quotation	Final bidding quotation
A	765,620	562,364
B	742,600	683,582
C	1,085,340	732,560
D	679,400	498,620
E	718,280	454,899

**Table 2.** The calibration details

Supplier	Final price	Business points	Technical points	The final score
D	498,620	80	86	$88.04 = 100 \times 0.3 - \frac{498620-454899}{454899} \times 100 \times 0.1 + 80 \times 0.2 + 86 \times 0.5$
E	454,899	81	79	$85.7 = 100 \times 0.3 - \frac{454899-454899}{454899} \times 100 \times 0.1 + 81 \times 0.2 + 79 \times 0.5$

The final transaction price is signed according to the initial quotation, then no matter which supplier is selected, the final transaction price is much higher than 498,260. However, if the reverse auction only takes the lowest price, then the supplier's technical service ability can not be well guaranteed.

## 4 Conclusion

Combining the reverse auction theory with the traditional bidding, this paper designs a two-round procurement process, which solves the problem of determining the winner well. It not only gives full play to the price discovery characteristics of auction, but also takes into account the multi-attributes of the purchased items in the actual procurement process of enterprises, which can provide a reference for the decision-making scheme of the software outsourcing procurement activities of enterprises.

For some large enterprises, the group's annual purchase amount is large, so it can build its own procurement platform, and with the help of online reverse auction as an effective tool to achieve the improvement of procurement performance.

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