ABSTRACT

Reverse auctions, also called procurement auctions, have been an important tool in procurement process for many decades now, in both public and private sectors. Multi-attribute reverse auctions are an advanced form of this procurement tool where a buyer chooses the seller based on the assessment of non-price attributes like quality, time for delivery, maintenance requirements, distance, and other relevant factors along with the price. As the number of decision variables increases, complexity increases, making the process difficult for both the buyer and sellers. For the buyer, the decision support issues include winner determination, preference elicitation, determination of weights for attributes, choosing an appropriate auction model, and designing scoring functions. For sellers, issues are the determination of optimal bid to maximize his/her expected payoff, consideration of strong and weak attributes with respect to buyer's bid evaluation method, and so on. With this backdrop, we have framed three objectives with respect to multi-attribute reverse auctions: i) Developing a mechanism for designing optimal scoring, function and winner determination ii) Winner determination strategy for quality sensitive buyers iii) Winner determination mechanism with decision support for bidders. The scope of the thesis is limited to winner determination in sole sourcing, single-unit procurement auction scenario using a fully revealed scoring rule.

In the first objective, we propose a two-stage reverse auction mechanism. The first stage is dedicated to price discovery, determining the cost functions of the sellers, and derivation of an optimal quasilinear scoring function for evaluating the bids. The second stage is for executing the auction and winner determination. We prove that the proposed model induces truthful bidding and is the dominant strategy for the participating sellers, through mathematical as well as simulation analysis. We also demonstrate the proposed auction mechanism with the help of a case study. While the proposed mechanism ensures truthful bidding, there is no guarantee for the buyers to get products with a better quality attribute, even when he is willing to pay more. This observation leads to the second objective, wherein we focus on determining the most suitable scoring function for winner determination when the buyer is quality-sensitive. We consider quasilinear, independent non-linear, and interdependent non-linear scoring functions for bid evaluation and compare the outcomes under different levels of competition through a large number of simulation experiments, observe the bid distribution pattern, and statistically compare them. We find that interdependent non-linear scoring rules are the best choice for quality-sensitive buyers,

specifically when the competition is high. While in the first and second objectives, the nature of the scoring function has to be decided by the buyer prior to the auction process; it requires a certain degree of experience to select the function with the right parameters. To deal with such situation, in the third objective we adopt an integrated DEA-BWM model for bid evaluation and winner determination. This model is transparent and does not require any intervention from the buyer once the preferences for various attributes, including price, are announced to the sellers. This model is simpler for the buyer as she does not have to worry about determining precise weights for each attribute. For the seller, we propose a bid determination model, which helps him to formulate bids to beat the highest score in the most optimal way taking care of his profit as well as reservation quality values. We conduct simulation experiments to demonstrate that the proposed bid determination model not only results in increased profit and winning probability for the bidder but also gives higher utility to the buyer.

Keywords: Multi-attribute auctions, winner determination, scoring auctions, quasilinear functions, non-linear functions, decision support, data envelopment analysis, simulation.