No matter how much revenue is pouring in, a firm is not likely to prosper if its spending is undisciplined. Firms typically spend half their revenue or more on goods and services procured from external suppliers. It has become critical for companies to manage their procurement processes intelligently to maintain a competitive edge in today’s business environment. This paper studies procurement mechanism design for a buyer who obtains an input from an upstream supplier. The buyer can be either a manufacturer or retailer, and the input can be either a component or product. Both the buyer and the supplier can hold inventories to improve service performance. The buyer’s cost consists of two parts: the procurement price paid to the supplier, and the operating cost, the latter including stock holding cost and goodwill loss for backlogged orders. It is clear that the buyer’s operating cost depends on the delivery performance of the supplier, which is determined by the supplier’s stocking policy. The more responsive the supplier is, the lower the operating cost the buyer has to incur. The buyer’s objective is to find a procurement mechanism that minimizes the total cost, i.e., procurement cost plus operating cost. The supplier incurs a linear production cost, which is private information. The buyer only has an unbiased estimation of the production cost.

This is a typical multi-attribute procurement problem. The setting described above reflects the situation faced by many buyers that depend on their suppliers for the delivery of components or products. It is well known that a supplier’s delivery or service lead time should factor prominently in the procurement decision (Cavinato 1994 and Laseter 1998). For example, Sun Microsystems considers procurement cost and delivery performance as the two most important factors when choosing suppliers (Farlow, Schmidt, and Tsay 1996). The advent of information technology has led to a boom in online markets (Geoffrion and Krishnan 2003a, 2003b and
Pinker, Seidmann, and Vakrat 2003). In most B2B industrial exchanges (e.g., FreeMarkets), the buyers post requirements such as product specifications and delivery speed and ask suppliers to bid on the contracts. The increasing use of online auctions has raised new research questions. One of the biggest challenges in designing a procurement auction is bringing into consideration the multiple factors that affect buyer-supplier relationship (Elmaghraby 2004). Although one may name a dozen factors when making procurement decisions, the focus of this paper is to take procurement price and delivery performance as the two primary considerations and study the buyer’s procurement strategies accordingly.

Given the importance of the supplier’s delivery performance, there has been surprisingly little research on how the buyer should design the procurement process so that the objective, through an effective balance of procurement price and delivery performance, is optimized. The key to the above problem is the supplier’s private cost information. The supplier’s cost has a direct impact on the price the buyer needs to pay, and moreover, it indirectly influences the supplier’s inventory holding cost, which in turn may affect the buyer’s operating policy.

Two scenarios are considered in this paper. In the first, there is only one potential supplier with whom the buyer can do business. The situation might be due to quality, technology, and long-term relationship considerations. In this case, the buyer needs to design a contract that minimizes total cost, under the constraint that the supplier is assured participation. In the second scenario, there is a pool of suppliers, and the buyer can choose any one as the source of the input. With two or more suppliers, the buyer can use auctions to single out the most favorable supplier. In fact, procurement auctions are ubiquitous in the real world, especially in online B2B markets, where the auction is the most common format for making transactions.

For both scenarios, we derive the optimal procurement mechanism for the buyer. In the optimal mechanism, the supplier is asked to reveal its cost structure and, based on the announced information, the supplier provides certain delivery performance and is paid. With two or more suppliers, the winner is determined by an auction. Not surprisingly, the optimal mechanisms are quite complex: they involve nonlinear transfer payment and non-intuitive formats. Although they are less appealing from a practical point of view, the optimal mechanisms serve as a benchmark to evaluate other, simpler mechanisms.

In view of the complexity of the optimal mechanisms, we are curious about the performance of mechanisms that are intuitive and easy to implement. Many of them have also been observed in practice or studied in the literature. With a single supplier, we consider a fill-rate
mechanism in which the buyer specifies a fill rate that the supplier must satisfy and pays a price so that the most inefficient supplier will participate. Another possible strategy for the buyer is to coordinate the supply chain by transferring all its operating cost to the supplier. The buyer then sets a price that guarantees the supplier’s participation. It can be shown that the fill-rate mechanism and the coordination mechanism are equivalent from the buyer’s standpoint, although the supplier is worse off in the fill-rate mechanism scenario (since it does not coordinate the supply chain). More interestingly, we find through extensive numerical experiments that the simple mechanisms perform nearly as well as the optimal mechanism.

When there are two or more suppliers, we study three auction formats in addition to the optimal mechanism. The first one is a scoring-rule auction. The suppliers bid on both procurement price and fill rate, and the supplier whose bids minimize the buyer’s total cost wins the auction. The scoring-rule auction is quite intuitive; however, it is not optimal for the buyer and the bidding involves two dimensions. A natural way to reduce the complexity of the scoring-rule auction is to utilize a single-dimensional auction. A price auction is the second auction format we study in this paper. In a price auction, the buyer specifies the fill rate and the suppliers bid on the procurement price they charge. The third auction format is a fill-rate auction, i.e., the buyer specifies the procurement price and the suppliers bid on the fill rate. For each of the three auction formats, we consider both first-bid and second-bid auctions. In a first-bid auction, the winner fulfills his own bid; while in a second-bid auction, the winner needs to fulfill only the second highest bid. Several issues are investigated and the major results include: first, the scoring-rule auction and price auction are nearly as good as the optimal mechanism; second, the scoring-rule auction outperforms the price auction by only a negligible margin in most cases, so a single-dimensional auction is preferred if simplicity is taken into account; third, a price auction generally performs much better than a fill-rate auction, which might explain the observation that a fill-rate auction is seldom used in practice; finally, if a fill-rate auction is chosen, then a first-bid auction should be preferred over a second-bid auction. These results provide managerial insights for managers who are choosing procurement mechanisms.

We are also interested in two additional contracts. In the multi-echelon inventory literature, a widely quoted concept is termed echelon inventory. Implementing an echelon inventory policy requires the supplier to see through to the downstream stage, i.e., the buyer’s inventory status should be transparent to the supplier. It is well-known that the centralized optimal
policy consists of echelon inventory policies. Does it help if the buyer shares pipeline information with the supplier and contracts on the supplier’s echelon inventory policy? The answer is no. Actually, contracting on the supplier’s echelon inventory level is suboptimal compared to contracting on the supplier’s local inventory level. Nevertheless, in most cases the difference is not significant. To evaluate the benefits of including multiple attributes in the procurement process, we consider a price-only contract in which the buyer only cares about the procurement price. Under this situation, the supplier simply makes to order, or the fill rate is zero. Numerical examples demonstrate that ignoring the fill rate attribute may result in a significant cost increase – as high as 15% relative to the optimal mechanism.

Most of the literature on supply chain management revolves around how to improve supply chain efficiency through coordination. We demonstrate that, in general, the procurement mechanisms studied in this paper do not coordinate the supply chain. In fact, the optimal mechanism induces a lower inventory level at the supplier compared to the supply chain’s optimal solution. This is due to the buyer’s incentive to reduce information rent paid to the supplier. Interestingly, however, we find in the numerical study that the supply chain inefficiency caused by information asymmetry is negligible. With either a single supplier or two competing suppliers, the percentage cost increase relative to the supply chain optimal solution is in the order of 0.01%. This is true with either the optimal mechanism or the simple mechanisms (e.g., a fill-rate contract with a single supplier and price auction with multiple suppliers).

In summary, the insight provided by this study is as follows: including the operation factors into procurement is crucial; however, the operation factors can be easily taken care of. That is, the buyer may simply specify the service level to be provided by the suppliers, and then set the payment schedule either to ensure a supplier’s participation (with one potential supplier) or by asking the suppliers to bid on price (with two or more potential suppliers).

References


