E-procurement:
Multiattribute Auctions and Negotiations

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1. Introduction

Procurement is the purchase of goods and services. It involves planning and formulation of the required specifications, search and selection of suppliers, agreement on specifications with one or more suppliers leading to a purchase, and warranty, repairs and other post-sale activities. Buyers need to use one or more of the market exchange (trade) mechanisms in order to make a purchase. This note introduces the key concepts pertaining to procurement.

1.1 Marketplaces

Markets are unique places where firms and people who have similar interests meet and interact. Sellers have similar goods to offer and they obtain information about their competitors, customers, as well as of potential suppliers of goods they may need. Buyers look for similar goods and they obtain information about other buyers and their interests. Suppliers offer goods buyers' seek as well as other goods they may need. All these interactions are not solely of economic nature, markets are also social institutions. The results of market interactions include the establishment of business relationships and setting up and changing supply chains and business networks.

Price negotiation (i.e., haggling or bargaining) is the primary form of buyer-seller interactions used on many traditional markets. It is, however, not the only way to buy and sell; professionalization of commercial activities and the setting up of permanent stores diminished the role of the traditional haggling over price. In some situations such haggling may even be frowned upon. Although, negotiation continues to be an important way to make deals, other ways gained popularity and they may provide better results.

Modern manufacturing with its standardized goods along with the appearance of small and large stores and institutions acting as a middleman between producers and buyers were instrumental to the establishment of another form of exchange, i.e., the posted price also known as *catalog*. Today posted price is most widely used for daily purchases (e.g., groceries) and for purchases of commodities and standard supplies (e.g., furniture and office supplies). While both posted price and negotiation remain in use, information and communication technologies (ICTs) popularized the third form of interaction, that is, *auction*.

1.2 Valuations

The main purpose of markets, from the viewpoint of neo-classical economics, is the valuation of goods. Their supply is compared with the demand allowing for the determination of price at which the goods are sold. Participants who buy the goods value them higher or at their price. Those who sell them obtain value (money) that exceeds or is equal to the total costs they incurred.

Buyers' individual valuations may be higher than the market price. If these evaluations do not affect the overall demand, then the buyer achieves a surplus; he purchases a good for less than he would be willing to pay. Similarly, a seller may get a surplus if he sells goods for less than the total costs (which may include certain profit level). When the market is in equilibrium and the total amount of the buyers' and sellers' surplus reaches its maximum, then the market is efficient.

Individual valuations are subjective; they depend on a particular situation and preferences of the participant. In theory it does not make any difference regarding price as no one would pay more than the market price irrespectively of the person's valuation of the good. Similarly, no one would sell for less than the market price even though by doing this he would obtain profit greater than some other sellers. In reality, because markets have frictions and buyers and sellers are not automatons, the individualization of valuations and their differences regarding price introduces an opportunity that some buyers and sellers may utilize. That is, one may try extracting additional value through a one to one negotiation.

1.3 Market transactions

Markets provide the framework within which people can interact and engage in buying and selling. The purpose of these transactions is to increase the welfare of both buyers and sellers.

In addition to buying and selling, people use markets in order to assess or value products and services. Arguably, the valuation process is as important as the actual exchange because it enable to discover information about the others' valuation and compare it with own valuation. The comparison of valuations may be used in making decisions regarding production, consumption and savings. Individual valuations provide information to market participants which they can use to determine the changes of their welfare caused by market transactions.

Valuations can be determined using: (1) money (leading to the price discovery); (2) similar or different goods; or (3) an abstract measure such as utility. The usefulness of money and other goods or services is that they can be easily compared and exchanged. These measures may be used as standards (i.e., every good can be valued in dollars, euro, yuan, etc.). They also aggregate all different attribute values of a good into a single comparable value of money. This is both strength and a drawback: strength because every market participant can easily compare different goods and a weakness because the value is the same for every person irrespectively of the individuals' willingness and ability to buy and the differences in their taste and preferences.

2. Commerce value chain

Any activity, to be performed, requires expending some resources. An exchange of goods is such an activity and the resources needed to undertake it may be quite large (e.g., shipment of flowers from Honduras to Europe by airplane, or transportation of oil by pipelines and ships).

Transaction costs cover all expenses which the buyer and seller involved in a transaction incur in the process of buying and selling. They are the costs of doing business and they include time, effort, and money. For an organization to function overtime the total cost associated with transactions should be smaller than the total value the transaction brings to this organization.

The activities which are required to realize a transaction are known as commerce value chain. The

value established during the commercial activity needs to be added to the product value before it reaches the market. This value is also known as "market friction" as it is the costs of engaging in and completing business transactions.

Typical activities which buyers and sellers undertake to do business are illustrated in Figure 1. The total costs of activities included in this value chain are *transaction costs*.
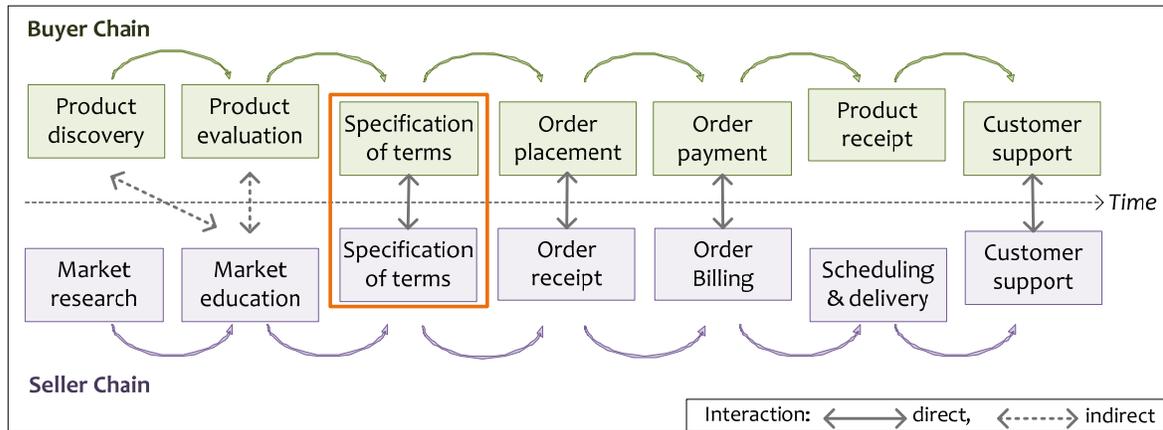

Figure 1. Buyer and seller's value chains

Transaction costs often arise before the exchange is initiated. For the buyer, they include product discovery and evaluation and they may be done without the sellers' knowledge and involvement. Sellers know about these activities and therefore they need to learn about buyer's requirements and also educate them about the products and their qualities. Also, locating potential trading partners, checking their reliability, comparing them, contacting and selecting one to do business requires time and effort.

A transaction is initiated by the buyer who engages in the specification of terms describing price, characteristics of the product (e.g., configuration, volume and color), product delivery, upgrades, warranties and service. The interactions between the buyer and seller are successful when they agree on the terms.

Transaction may not take place if the seller does not provide certain assurances and services. Because the purchase depends on them, they are also included in the commerce value chain and associated transaction costs. These additional terms require that the participants engage in post-settlement activities (Figure 1).

3. Exchange mechanisms

Contemporary markets are governed, both directly and indirectly, by many different rules.). One particular set of rules directly specifies the ways the transactions can take place. This set of rules is known as exchange mechanisms.

There are three main types of exchange mechanisms used in economic transactions: (1) posted price (catalogues); (2) auctions; and (3) negotiations. The basic structure of each mechanism is schematically illustrated in Figure 2. I assume that a the figure illustrates situation with three sellers and five buyers but the discussion remains the same if the roles are switched and three buyers want to purchase goods supplied by five sellers.

There are three types of activities indicated by the lines: (1) the dashed line depicts a single action of activating a mechanism; (2) the dotted line depicts scanning or observation of prices; and (3) the continuous line depicts repetitive actions of the participants.
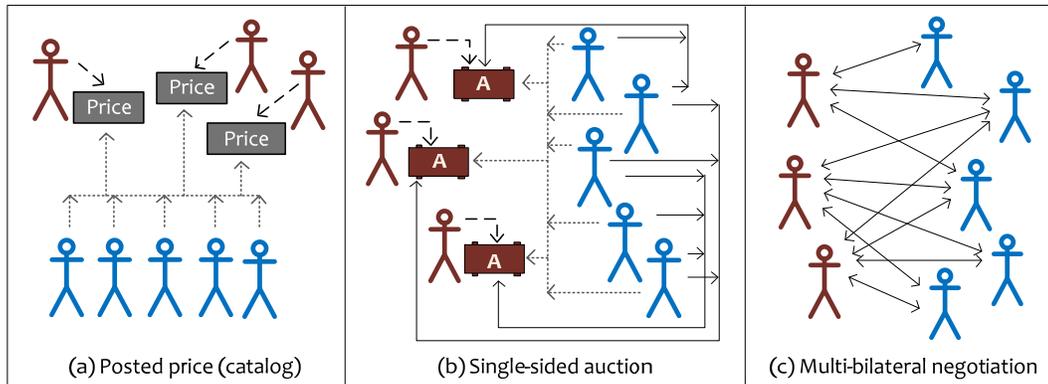
Figure 2. Three types of exchange mechanisms

Figure 21-3(a) shows three sellers who post the price of the goods they want to sell. Five buyers observe the prices and make their purchasing decisions. The sellers may change price for different reasons, including the number of transactions and visits to the physical or virtual store. However, a seller cannot post more than one price for a good at any given time. If she wants to give a volume or some other discount, then she needs to post this discount as well.

In an auction, shown in Figure 21-3(b), the sellers activate the mechanism and then, similarly to posted price, they remain passive. In an auction, however, it is the buyer who determines the price rather than the seller.

The important difference between an auction and in posted price is price determination. The price is posted by the seller, so he determines it no individual buyer can affect its value. In auction buyers compete and decide on the price. The buyer who is willing to pay the most gets the product. Thus, catalog is a passive mechanism and auction—an active mechanism.

Another difference is that in catalogs and auctions one side activates the mechanism (this side is often called owner or initiator) and, following this act, this side does not participate in the process. The persons representing the other side use the activated mechanism. In contrast, in negotiations, both sides actively participate in the transaction process. Unless noted otherwise, the owner is assumed to be the seller.

4. Procurement

A supply chain is an organized system of independent organizations which exchange information, products and services. The range of exchanges is from natural resources and raw materials to components, to finished products. Supply chains link value chains of individual organizations (Figure 1) forming a network through which information, goods and services flow.

Organizations belonging to a supply chain engage in its management which involves planning and coordination of procurement and logistics. Procurement is the acquisition of goods and services, while logistics is the organization and management of their flow from the point of origin (seller) to the point of destination (buyers).

About 70% of corporate revenue is spent on purchasing; savings of 5% translate into very significant amounts of money for companies of any size.

4.1 Auctions

4.1.1 Sealed bid auctions

Traditionally, single-round sealed bid auctions have been used in procurement. Suppliers are given

requests for quotations (RFQs) and asked to submit a bid (quotation) by a given deadline. At the deadline, the bids are opened and the best bid is selected.

4.1.2 Reverse auctions

Reverse auctions were introduced in procurement in mid-1990s and within a few years they gained popularity. Large corporations and government departments began using them because of the promises of cutting costs and making the procurement process more impartial and transparent than face-to-face negotiations.

Reverse auctions establish a competitive setting which may result in the discovery of a true market price. Field studies reported savings of between 6 and 37% on indirect materials and between 2 and 22% on direct materials. Firms reported savings of 15% to 20%; (e.g., GE ran their first reverse auction in late 1999; in 2000 they saved 16% which amounts to more $500 million).

In addition to price reduction of purchased goods, other benefits include shortening of the procurement process (from days or weeks to a few hours), increased buyer reach, the creation of new markets, and information transparency and price visibility.
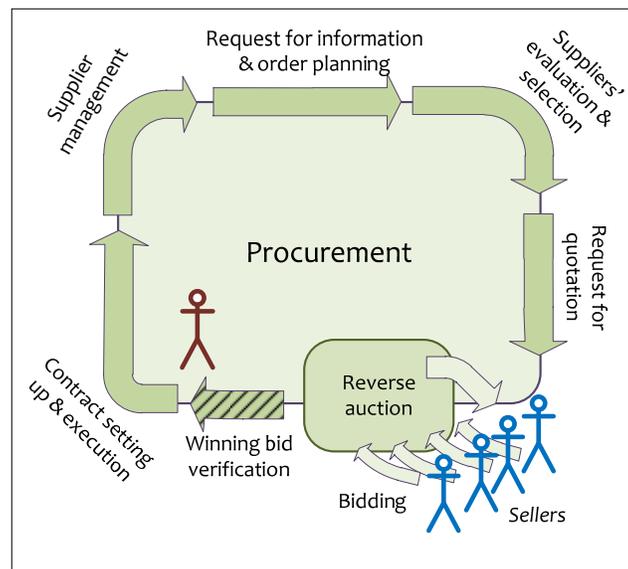
Figure 3. Reverse auctions in procurement process

Very positive perspectives on the use of reverse auctions in procurement have been accompanied by strong criticisms. Some studies have shown that savings are greatly overstated, supplier relationships are damaged, and distrust among incumbent suppliers is created. Some organizations and business associations consider reverse auctions antithetical to business values, compromising quality. For example, Cypress Semiconductor Corp. announced in May 2009 that the company policy is not to participate in reverse auctions, and the Surety Association of Canada and the Canadian Construction Association strongly discourage their use.

Some of these criticisms are unfounded, reflect lack of familiarity and limited experience, and conflicting reports. Others, however, note the limitations of reverse auctions, which are suitable for transactional buyer-seller relationship focused on obtaining best price, medium-to-short term contract, and requiring little collaboration. They are useful in purchasing when there are several or more qualified suppliers of goods which can be clearly specified and are of low-to-medium complexity.

The procurement process with the use of reverse auction is shown in Figure 3. The sellers bid until the deadline is reached or no seller is willing to offer lower price than the one offered in the last bid.

At that time, the auction ends and the buyer verifies the bid and works with the winner on contract preparation.

4.1.3 Multiattribute reverse auctions

Reverse auctions are single-attribute, sellers bid only on price. However, over 90% of purchasing managers based their decisions on both price and non-price variables (e.g., durability, warranty, service, lead-time, and trust). Therefore, there is a need to develop multi-attribute auctions that can be used in e-procurement. The first step in this direction is the design of an auction procedure. Such auctions can be experimentally studied. The most recent survey of experimental auction research does not include any multi-attribute auction experiment

The consideration of attributes other than price, describing the item and/or the bidders, introduces a level of complexity that is difficult to address for many real-life situations. Therefore, many organizations tend to modify the pure single-attribute auctions. The modifications include:

Pre-selection of bidders so that only bidders who are known to meet the additional criteria are included;

1. Giving incumbents an advantage because their qualifications are known; and
2. The use of disclaimers such as "the lowest bid may not be awarded the contract".

The results of such auction modifications are mixed because of collusion and selection of inferior offers. In some situations the process becomes an auction in name only, as is the case with an auction in which neither the winner nor any other bidder is awarded the contract.

At the InterNeg Research Centre we have developed a unique multiattribute auction procedure and implemented it in the Imaras system. The procedure is based on automatically generated limit sets, these are sets which the sellers get and which they have to obey if they want to submit their bids. Sets are generated for every round of the auction. An example of sets generated for three rounds is given in Figure 4.
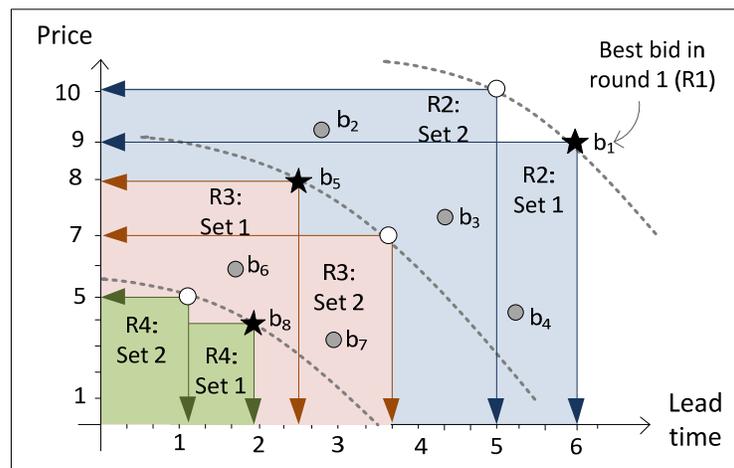
Figure 4. Limit sets in multiattribute reverse

The limits for each round are determined based on the best bid in the previous round and additional parameters set up by the buyer (e.g., the number of limit sets calculated for each round). This means that there may be more than one set of limits in each round.

Three sets per each round are shown in Figure 4; they are indicated by rectangles bounded by rows; every bid in the rectangle is admissible.

Best bids for the buyer are indicated by stars; best bid (b_1) in round 1 (R1) is used to generate Set 1.

Another set is generated using an alternative that is as good for the buyer as bid b_1. In round 2 (R2), the sellers are informed that their bids have to belong either to Set 1 or Set 2. That is, they are given the following limits:

Set 1: Price ≤ 9 and Lead time ≤ 6; and *Set 2*: Price ≤ 10 and Lead time ≤ 5.

In round 2, the sellers made four bids (b_2, b_3, b_4 and b_5), bid b_5 is the best and it is used to generate the first limit set for round 3. The second limit set is generated by an alternative that is as good for the buyer as b_5.

Figure 5. Reverse auctions in a procurement process

We implemented this procedure in Imaras using our Invite platform.[1] A bid construction and submission screen is shown in Figure 5. The limit sets are included in the table surrounded by dotted green line. The numbers in dark red represent limits; one row in the table corresponds to one limit set. In this auction, there are 3 limit set. The seller makes a bid by selecting values that meet limits of one of these sets.

4.2 Negotiations

A negotiation is a significantly more flexible exchange mechanism than auctions. It allows the parties to use different strategies and tactics; they may cooperate or compete while an auction is naturally competitive. The negotiators may present arguments and counter arguments; they may add issues (attributes) to the table or remove them.

An important aspect of negotiations is education and justification. The negotiator tries to educate her counterpart about her (organization she represents) needs and requirements. She also provides justification so that her counterpart may better understand the requirements and accept (which is the negotiator's expectation). Her counterpart does the same and through this exchange of information both sides learn about each other.

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[1] A video demonstrating the Imbins system is available at: http://invite.concordia.ca/imaras/demo_a.cfm

4.2.1 Bilateral and multi-bilateral negotiations

Commercial negotiations are typically bilateral or multi-bilateral. In bilateral negotiations we assume that neither the buyer nor seller is seeking other sellers or buyers, respectively. Such negotiation may take place after the seller has selected the best buyer or when there is an ongoing relationship between the two sides and they need to jointly determine some details regarding the trade.

Multi-bilateral procurement negotiations are common when the buyer seeks the best value and is in no relationship with the seller other than the commercial one. When, for example, a person wants to buy a house or a car, he often checks a number of them and engages in discussion on sale condition with owners, agents or dealers. This means that she conducts multiple bilateral negotiations; each one with a different side (see Figure 5).
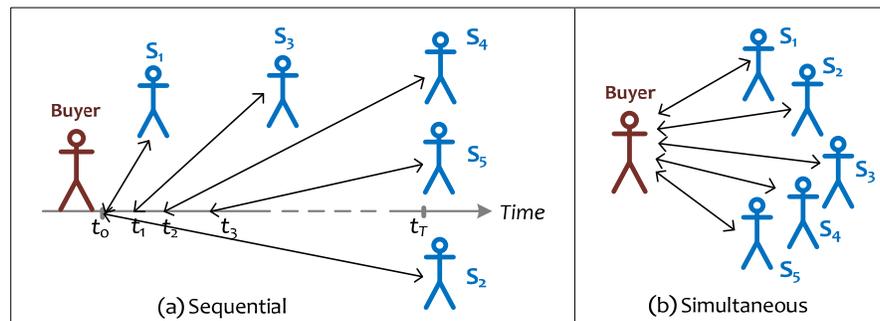

Figure 5. Multi-bilateral negotiations

In general, multi-bilateral negotiations are initiated by the "single-person" side, for example, the buyer who contacts two or more car dealers. The process may be sequential or simultaneous.

In sequential negotiations the buyer begins negotiating with one seller and tries to obtain the best possible deal from this seller. Before closing this negotiation, the buyer contacts another dealer and initiates another bilateral negotiation. At any point in time the buyer may have opened two or more bilateral negotiations; he may close some of them and open new ones.

The process of sequential multi-bilateral negotiations is illustrated in Figure 5(a). The buyer invites sellers S_1 and S_2 at time t_0. S_1 sees another opportunity to sell her goods and terminates the process. The buyer then invites S_3. He also initiates negotiations with S_4 and S_5 at time t_2 and t_3, respectively. Sometime later he terminates the negotiation with S_3. Between t_3 and t_T he could have negotiated with other sellers (indicated by dashed line). At time t_T the buyer makes his decision and selects the seller. The reverse is, however, also possible, that is, the seller may accept an offer made by the buyer terminating this and all other negotiations (unless the buyer wants to purchase several the same or similar goods from different sellers).

Sequential multi-bilateral negotiations introduce an opportunity for the buyer to negotiate a better deal than a single-bilateral one. This opportunity arises when there are many sellers who are willing to compete, but it is not costs free (frictionless). Time, communication and cognitive efforts, and possibly money requirements, are significantly greater than in a bilateral negotiation. These costs increase with every negotiation but, for the buyer, the value of the deal does not have to become greater. This creates a dilemma for the buyer (the negotiator single-side) whether the costs associated with an additional negotiation are lower than the value difference this negotiation causes.

The procurement process with the use of multi-bilateral negotiations is shown in Figure 6. The sellers make offers and the buyer may make counteroffers or request new improved offers. The buyer may make the same offer to every seller or make different offers. This imposes significantly more cognitive and time requirements on the buyer than it was the case in bidding (Figure 3). The process ends when either the buyer accepts an offer or one seller accepts the buyer's offer.
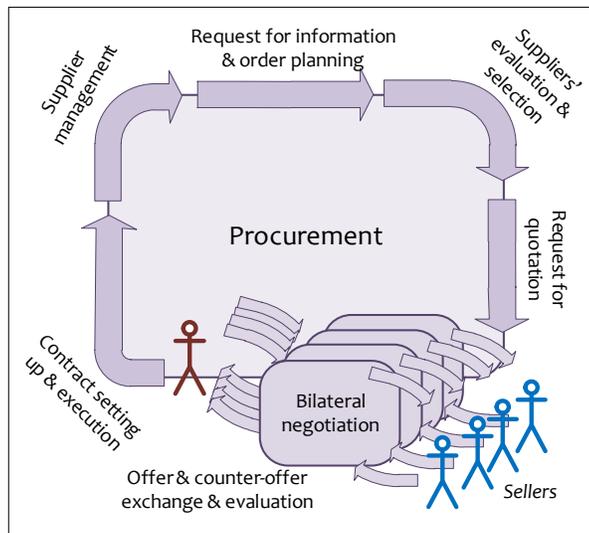
Figure 6. Negotiations in procurement process

4.2.2 Imbins negotiation system

Another system built using our Invite platform is Imbins.[2] This system allows for multi-bilateral negotiations which share some similarities with multi-attribute auctions. An offer construction and submission screen is shown in Figure 7. As we can see, in Imbins there are no limit sets; instead, of the table (see Figure 5), this space is reserved for messages that the negotiator may send to her counterpart(s).

Figure 7. Negotiations in procurement process

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[2] A video demonstrating the Imbins system is available at: http://invite.concordia.ca/imbins/demo_b.cfm (illustrating the buyer's activities) and at http://invite.concordia.ca/imbins/demo_s.cfm (illustrating the seller's activities).

4.3 Procurement portfolio matrix

Empirical studies of supply chain management and B2B transactions result, among others, in a portfolio of supplier relationship. This portfolio, first proposed by Kraljic (1983) postulates the following four types of buyer-supplier relationships:

1. Strategic relationship with few specialized suppliers is postulated when the required goods or services are either unique or critical for the production. This relationship takes place when switching to new suppliers is difficult and/or very costly; and
2. Leverage takes place when the required products are complex and very important for the buyer but there are many capable suppliers who can provide them;
3. Acquisition involves low costs standardized goods which do not have critical impact on production. These goods, however, are not readily available or there are not many suppliers who provide them in the required amounts; and
4. Noncritical goods are easily available from multiple sources.

The differences in the importance of goods and services for the company, their availability, and the degree of their standardization may require the use of different exchange mechanisms. An overview of the portfolio matrix and associated mechanisms is given in Figure 8.

The procurement relationships shown in Figure 8 are indicative and they do not cover all possibilities. Exchange mechanisms are suggested for each form of the relationship.

In *acquisition* of complex goods which have low priority for the firm, the preferred mechanism is posted price. The relationship between the buyer-seller should be good but not necessarily very close. If possible purchasing should be automated.

Purchasing of complex and critical goods requires *strategic* relationship between the parties and the procurement mechanism is the negotiation. Good close relationship should be maintained and the parties need to inform each other about any changes made during the production and distribution processes.

High	**Acquisition**	**Strategic**
	• **Goods:** complex, low priority; • **Suppliers:** few available; • *Mechanism: posted price, automation;* • **Relationship:** good customer, cooperation; • **Orientation:** long-, medium-term.	• **Goods:** complex, critical; • **Suppliers:** few available or very high switching costs; • *Mechanism: negotiations;* • **Relationship:** partnership, cooperation; • **Horizon:** long-term
	Noncritical	**Leverage**
	• **Goods:** simple, low priority; • **Suppliers:** many, compete for buyers; • *Mechanism: spot markets, reverse auctions, automation;* • **Relationship:** none, customer; • **Horizon:** short-term.	• **Goods:** simple, high priority; • **Suppliers:** many, compete for buyers; • *Mechanism: reverse auctions, negotiation, mix;* • **Relationship:** customer; • **Horizon:** medium-, short-term.
Low	Value/profit impact	High

(Vertical axis label: Supply risk/complexity)

Figure 8. Portfolio matrix and exchange mechanisms

Noncritical exchanges involve simple goods that have low priority for the firm and, therefore, a highly

efficient mechanism is preferable. Automation of purchasing is probably the best solution, providing that the prices are periodically reviewed. Reverse auctions may be used as long as they do not consume too many resources. This is the type of relationship where the negotiation software agents may be used.

Leverage type involves simple goods which are important for the firm. Because the goods are simple, reverse-auctions may be used, their high importance may, however, require negotiations or a mix of these two mechanisms (e.g., an auction followed by the negotiation with a few of the selected suppliers).

Time-orientation is one of the attributes of the relationships specified in the procurement portfolio matrix. It is closely associated with the buyer-supplier relationship (i.e., these two attributes are not independent) and they both affect the purchasing process.

Recent studies confirmed that business organizations follow these guidelines in implementing their procurement strategies. Auctions tend to be used when the relationship between the auction-giver and bidders is noncritical and when goods are simple and have a low-to-medium priority. Negotiations are used when the relationship is critical and goods are complex and have a critical-to-high priority.