



Martin Bichler

**The Future of e-Markets**

Multidimensional Market Mechanisms

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A new phenomenon has emerged in electronic markets. Due to the low transaction costs and the high volatility in these markets many net market makers are using auction mechanisms to buy and sell goods. Recent market studies predict that by 2002 a quarter of all transactions will use dynamic pricing concepts. The design and customization of these market mechanisms involves a number of disciplines including economics, computer science and operations research.

This multi disciplinary book summarizes the introductory economics needed to understand electronic markets and surveys the literature on negotiation and auction theory. It is the first book to combine both the relevant economic and computer science aspects of electronic markets, and the first to describe the variety of new multidimensional auction mechanisms. It uses a number of real world case studies including the trading of financial derivatives.

MARTIN BICHLER is an Associate Professor in Information Systems at the Vienna University of Economics and Business Administration. He is currently visiting scientist at the IBM TJ Watson Research Center in New York. Dr Bichler is Associate Editor of the Electronic Commerce Research Journal, and has served as organizer and program committee member in numerous conferences in Electronic Commerce and Information Systems. His research focuses on electronic commerce infrastructures and advanced market mechanisms.



# **The Future of eMarkets**

## **Multi-Dimensional Market Mechanisms**

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Martin Bichler



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# Preface

Electronic markets are breaking new ground in old industries by providing them with a wealth of supply chain information via the Internet. The way that net market makers match buyers and sellers is key to the success of a marketplace and the design of electronic marketplaces has become a million-dollar business. This is a challenging field for both the business and the academic community.

This book introduces a framework of negotiation protocols for electronic markets. In particular, I will focus on multi-dimensional auction mechanisms which allow automated negotiation on multiple attributes and/or multiple units of a product. The findings and analyses should be useful to an audience of scholars as well as practitioners involved in the business of electronic market design. Through this book a reader should be able to understand the multitude of technical and economic issues involved in the design of electronic marketplaces. In contrast to purely economic treatments of this topic, the book combines aspects of both economics and computer science. The book provides a detailed description of the various negotiation protocols, which will be a valuable resource for systems engineers and designers. It also covers the relevant theoretical concepts in this multi-disciplinary field and should, therefore, be of interest to the wider academic community.

It is often difficult to write a book about a fast-moving subject. Describing the past is relatively easy. Predicting the future with reasonable accuracy is possible if the discussion is based on a good understanding of the fundamentals. I have tried to make the description of technical issues as robust as possible without tying it too closely to a particular product or development. Articles in magazines and newspapers can give an up-to-date picture of events. All web addresses (URL) cited in the text have been checked as at May 2000, but may have changed afterwards.

The book grew out of my research at the Vienna University of Economics and Business Administration and at the University of

California at Berkeley. Most of the technical expositions of electronic brokerage described in chapter 2 result from my work on the OFFER project in Berkeley. At that time I became fascinated by auction design and developed the first ideas about multi-attribute auctions. The laboratory experiments as well as the simulation studies described in chapters 6 and 7 were conducted in Vienna. The article upon which parts of chapter 6 are based was published in the *Decision Support Systems* journal. Some of the material from chapters 3 and 7 was published in the *Journal of End User Computing* and *Wirtschaftsinformatik*, respectively. I hope that having read this book you will share my fascination with this exciting research topic.

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Vienna, June 2000  
*Martin Bichler*



# 1 Electronic Commerce and Electronic Marketplaces

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New information technologies like the Internet are allowing a much closer integration of adjacent steps in a value chain. This is affecting firm and market structures and the coordination mechanisms used.

*(Davenport, 1993)*

Information systems and their application play a major role in today's business. In addition to the introduction of new technologies which help to streamline processes within companies, electronic commerce has become the most recent trend. Electronic commerce has been described as "commercial transactions occurring over open networks, such as the Internet" (OECD, 1997). These new information technologies provide new opportunities and mechanisms to cooperate or to compete, taking advantage of computer power, the communication possibilities of the network, and the fact that millions of people and businesses are simultaneously online.

Though only a few years old, electronic commerce (e-commerce) has the potential to radically alter business-to-business, business-to-consumer as well as consumer-to-consumer transactions. For instance, electronic communication between businesses and suppliers via Electronic Data Interchange (EDI) has recently been enhanced by web-based front-ends for the placement of customer orders. Inter-organizational systems, efficient consumer response, and supply chain management are only a few of the challenges that future businesses will have to meet.

The current success of electronic commerce and the creation of billions in market capitalization and revenue is based on fundamental work done in the past in various disciplines. Computer networks, cryptography, databases, and distributed object technology form a mix of technologies and standards for the development of electronic commerce applications (Bichler, 2000b). In particular, the success of the Internet and Internet protocols as an "inter-lingua" between heterogeneous information systems has fueled the enormous growth rates. Network externalities are one way to

explain the fact that millions of users worldwide have agreed upon a single network standard, since the utility for every Internet user is increasing, more people are using the Internet.

While computer and engineering sciences have laid the foundation for electronic commerce, electronic commerce technologies are no longer simple efficiency tools that automate various types of transactions. By equipping economic agents with the tools to search, negotiate, and transact online and in real time, various electronic commerce applications promise an unprecedented opportunity to rethink fundamental assumptions about the economic efficacy of markets and open a whole range of new research questions. In particular, electronic commerce techniques are transforming the marketplace by changing firms' business models, and by enabling the implementation of new market institutions.

### 1.1 Market-Based Coordination

In recent years a particularly influential phenomenon has emerged with regard to electronic markets. Markets play a central role in the economy and facilitate the exchange of information, goods, services, and payments. They create value for buyers, sellers, and for society at large. Markets have three main functions: matching buyers to sellers; facilitating the exchange of information, goods, services, and payments associated with a market transaction; and providing an institutional infrastructure, such as a legal and regulatory framework which enables the efficient functioning of the market (Bakos, 1998). Internet-based electronic marketplaces leverage information technology to perform these functions with increased effectiveness and reduced transaction costs, resulting in more efficient, "friction-free" markets.

#### 1.1.1 Markets vs. Hierarchies

Markets *clear* by matching demand and supply. Sellers are provided with information about demand which allows them to employ capital, technology, and labor, and develop products with attributes that match the needs of buyers. Buyers, on the other hand, select their purchases from the available product offerings after considering factors such as price and product attributes.

A key function of markets is discovering prices and conditions of a deal at which demand and supply clear and trade occurs. Markets are primarily an *information exchange* designed to lower the transaction costs for a deal. Markets can employ a number of mechanisms to match supply and demand. For instance, financial markets use one or more of the several

types of auctions to determine prices, such as the “call market” auction at the New York Stock Exchange (NYSE). Other markets, such as the traditional automobile dealership, employ bilateral negotiation between buyers and sellers until a price is agreed upon. In still other markets, such as the typical department store, merchants make firm offers which customers can either take or leave.

This matching establishes a contract between buyer and seller. After a deal is agreed upon, the product being sold must be transported to the buyer, and payment must be transferred. Logistics and settlement require a certain level of trust which protects buyers and sellers. Trust is often provided through the electronic market provider or a third party who issues a letter of credit or a rating of participants. The general institutional infrastructure specifies laws, rules and regulations that govern market transactions. Regulations such as contract law, dispute resolution, and intellectual property protection are typically the province of governments.

Institutional economics has classified different *governance structures*, i.e. ways to organize and conduct economic transactions (Williamson, 1975). These governance structures refer to different types of institutional arrangements within and between firms. One of these coordination forms is the market. “Hierarchies” are seen as an alternative to markets for coordinating the flow of materials and services through adjacent steps in the value chain. The decision between market or hierarchy can be rephrased in management terms as decision between make (=hierarchy) or buy (= procurement on the market) (Werthner and Klein, 1999, p. 143). Many economists have analyzed the advantages of hierarchical and market methods of coordinating economic activity in terms of various kinds of transaction costs (Coase, 1937; Williamson, 1981, 1975).

The price of a product can be seen as a combination of three elements: production costs, coordination costs, and profit margin. *Production costs* include the physical or other primary processes necessary to create and distribute the goods or services being produced. *Coordination costs* take into account the costs of gathering information, negotiating contracts, and protecting against the risks of “opportunistic” bargaining. Finally, the profit margin is what the producer earns. Williamson (1981) was the first to classify transactions into those that support coordination between multiple buyers and sellers (i.e. market transactions) and those supporting coordination within the company, as well as industry value chains (i.e. hierarchy transactions) (Wigand and Benjamin, 1993).

Various factors affect the relative desirability of markets and hierarchies. One of these factors is *coordination cost*, which seems likely to decrease through the use of information technology. Two other factors are *asset specificity* and *complexity of product description* (Malone, Yates and

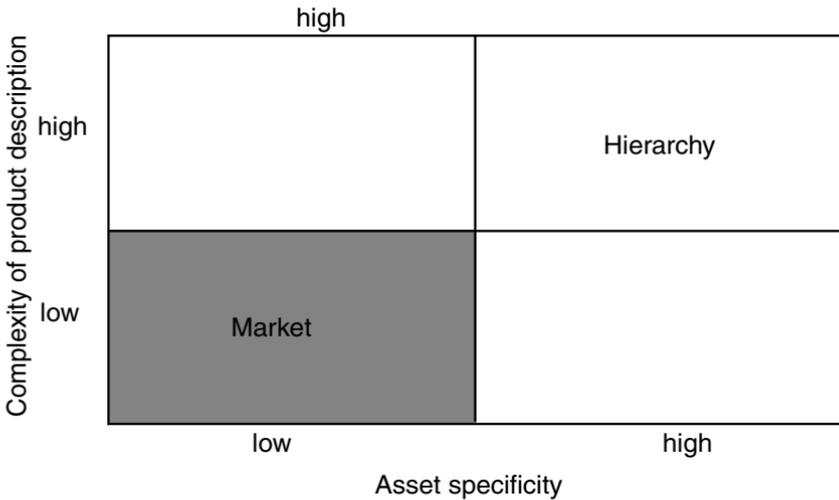


Figure 1.1 Product attributes and forms of coordination.

Benjamin, 1987). The input used by a company is highly asset-specific if it cannot readily be used by other firms because of site specificity, physical asset specificity, or human asset specificity. The term “complexity of product descriptions” refers to the amount of information needed to specify the attributes of a product in enough detail to allow potential buyers to make a selection. Stocks and commodities have simple descriptions, while those of automobiles or insurance companies are much more complex.

Highly specific assets are more likely to be acquired through hierarchical coordination than through market coordination because they often involve a long process of development and adjustment which allows the supplier to meet the needs of the procurer. Moreover, there are fewer alternative suppliers or buyers for a highly specific product. A highly complex product description often leads to hierarchical coordination, for reasons centring on the cost of communication about a product. Figure 1.1 shows that items that are both highly asset-specific and highly complex in product description are more likely to be obtained through a hierarchical relationship.

The shortcomings of market relations to provide sufficient incentives for relationship-specific investments and safeguards against opportunism and quality faults of the participants provide the background for the rise of a third coordination form, namely “inter-organizational networks” (Werthner and Klein, 1999). Networks try to combine the best of both worlds.

The strategic network has been defined as a long-term, purposeful arrangement among formally independent but related for-profit organizations that primarily allow those firms which are part of it to gain or sustain a competitive advantage over competitors outside the network. Although a strategic network is a polycentric system it is, unlike regional networks, strategically led by one or several hub organizations. (Sydow, 1992)

### 1.1.2 *The Impact of Information Technology*

Based on the coordination forms introduced in the previous subsection, electronic forms of governance have been established. In a seminal paper, Malone, Yates and Benjamin (1987) described the concept of electronic hierarchies and electronic markets. Electronic hierarchies facilitate a technically enabled, close relationship between companies in a value chain. EDI links between suppliers and retailers in the food industry are an example of hierarchical relationships. These technically enabled relationships often lead to a high level of dependence in asymmetrical power relations. Electronic markets have been defined as institutions in which entire business transactions among multiple buyers and sellers are executed electronically. Online Auctions such as Onsale <<http://www.onsale.com>> are an example of electronic markets (see section 5.7 for a broader overview). From an economics perspective, electronic markets have fundamental differences from traditional markets:

- *Transparency*: Electronic markets can be completely transparent owing to marginal search costs (Picot, Bortenlänger and Heiner, 1995). “Market transparency” is defined as the ability of market participants to observe the information in the trading process. Information can be related to current or past prices, offers, volume, and the identities and motivations of market participants. This information in electronic markets is available through advanced search and comparison services.
- *Size*: An important characteristic of electronic markets is that they are in principle not limited to regional borders, enabling the easy matching of partners from all over the world. This significantly increases the number of potential trade partners compared to traditional markets. It must also be considered, however, that partners may be located in another country with a different culture, other trade customs, etc. which may heighten the complexity of the interaction.
- *Cost*: The transaction costs for advertising, searching for trade partners and subsequent coordination are generally low owing to a high degree of automation and the cheap connectivity to the Internet (Wigand and Benjamin, 1993). In the early days of electronic commerce (in particular with value added networks and EDI during the 1980s) switching costs

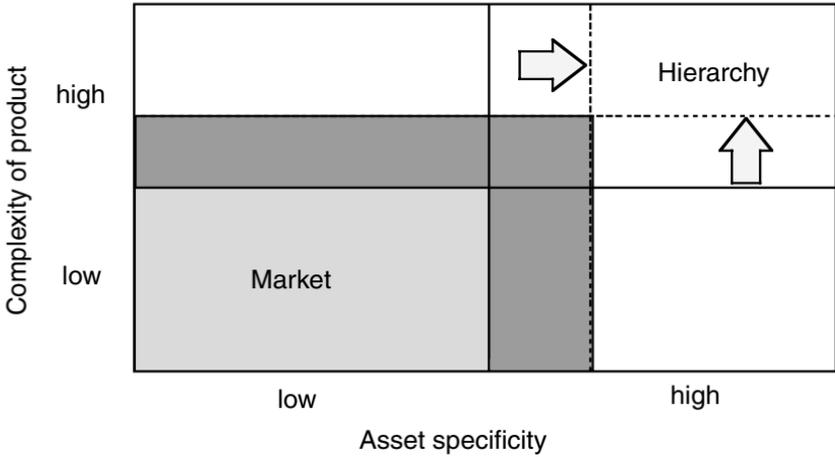


Figure 1.2 Move to electronic markets.

Source: Malone, Yates and Benjamin (1987).

for consumers were rather high owing to significant setup costs for electronic transactions. The costs have decreased as the Internet and its related standards homogenize the access channels.

Although the effects of information technology make both markets and hierarchies more efficient, Malone, Yates and Benjamin (1987) predicted an overall shift towards market coordination (see figure 1.2). The primary disadvantage of markets is the cost of conducting the market transactions themselves, which are generally higher in markets than in hierarchies. An overall reduction of coordination cost reduces the importance of the coordination cost dimension and, thus, leads to markets becoming more desirable. Moreover, low-cost computation favors electronic markets by simplifying complex product descriptions and asset specificity. For example, flexible manufacturing technology allows rapid changeover of production from one product to another. Besides, electronic marketplaces can be accessed by geographically separated buyers and sellers all over the world.

This “move to the market” hypothesis has been questioned by Clemons and Reddi (1994) who instead propose a “move to the middle” hypothesis. This means, on the one hand, a move away from the hierarchical vertically integrated organization to a higher degree of outsourcing, and, on the other hand, a move away from “faceless” market relations towards a situation where the firm relies on a few cooperative partners. These arguments are also based on transaction cost theorizing. The first part of the reasoning is

similar to the “move to the market” hypothesis of Malone, Yates and Benjamin (1987). The second part is based on the assumption that long-term relationships provide higher incentives to invest in IT and in the requisite organizational adaptations and learning processes. Long-term relationships also provide some protection against the risk of opportunistic behavior and especially the loss of critical resources (Werthner and Klein, 1999, p. 177). These new forms of coordination combine the competitive power of markets and the integration benefits of hierarchies, and are often called “inter-organizational networks.”

The past few years have shown the enormous success of electronic marketplaces on the Internet and illustrate the shift from hierarchies to markets. Bakos (1991) originally hypothesized that, owing to increased competition and less overhead, prices in an electronic market would be lower than in traditional markets. Crowston (1997) and Lee (1998), among others, have empirically tested this reduced-price hypothesis in several situations, but these tests have not led to unequivocal results since prices actually went up in an electronic market in some cases. Choudhury, Hartzel and Konsynski (1998) also showed mixed consequences of the usage of electronic markets and suggested that the scope of the electronic market (i.e. which phases of the transaction are supported) is an important variable that has been overlooked thus far.

## 1.2 Fixed vs. Dynamic Pricing

The previous section described the general reasons for the emergence of new electronic marketplaces on the Internet. An electronic market system can reduce customers’ costs for obtaining information about the prices and product offerings of alternative suppliers as well as these suppliers’ costs for communicating information about their prices and product characteristics to additional customers. This has implications for the efficiency of an economy in terms of the search costs experienced by buyers and their ability to locate appropriate sellers (Bakos, 1991).

Electronic catalogs were the first step in this direction (Bichler and Hansen, 1997). Over the past few years, companies have put their product catalogs on the web, in order to make them universally available. Most electronic catalogs comprise fixed offers in the form of static list prices. Jango and Bargainfinder (see section 2.2) provide simple catalog aggregation services on the Internet. If the search costs for price information are zero, consumers can be expected to have perfect price information. This typically leads to price wars. Bargainfinder <<http://bf.cstar.ac.com/bf>> was one of the first experiments with this new kind of competition. Suddenly strong brands became commoditized. Standardized products such as CDs, gas,

phone carriers, and even credit card companies had to find new ways of pricing their products. Many economists see product or price differentiation as a solution (Varian, 1996a).

Impeding price comparisons basically means reintroducing search costs. Typically, this can be done by charging different prices to different consumers for the same transaction. Price differentiation achieves this by exploiting differences in consumer valuations (see section 3.2). This discrimination strategy requires detailed consumer information and independent billing. Airlines are an oft-cited example. Currently, it is easy to search for convenient flights but finding the least expensive rate is cumbersome because the number of different tariffs is huge. Complicated pricing schemes for airline tickets defy comparison shopping. Airlines introduced this discriminated price structure (frequent-flyer programs, early reservation discounts, weekend tariffs, etc.) to deliberately reduce market transparency after a phase of open price competition (Picot, Bortenlänger and Roehrl, 1997).

By differentiating products, suppliers can decrease the substitutability of their products and services and customize offers to the requirements of specific consumers or market segments. The more successful a company is at differentiating its products from others, the more monopoly power it has – that is, the less elastic the demand curve for the product is. In such markets (often referred to as “monopolistic competition”), it is possible for providers to extract consumer surplus even among consumers who have perfect price information. Often, suppliers use mechanisms such as personalization, targeted promotions, and loyalty programs in order to distinguish their products from those of their competitors and establish customer relationships. Another very popular strategy in this context is *bundling*, i.e. packages of related goods (such as software suites) offered for sale together.

However, product and price differentiation are difficult in many markets where there is uncertainty about the price of a good or service and there is little knowledge about market participants. This uncertainty may stem from unknown or volatile supply and demand (e.g. bandwidth, electricity), or from the fact that the item being traded is unique (e.g. power plants). Nowadays, many companies are moving beyond *fixed pricing* and online order taking to create entirely new electronic marketplaces. These companies are setting up exchanges for trading things such as phone minutes, gas supplies, and electronic components, a field that is expected to grow enormously over the next few years. Like stock exchanges, these electronic markets must set up mechanisms for negotiating the terms of a contract and for making sure that both buyers and sellers are satisfied. By ensuring that prices match current market conditions, these *dynamic pricing mechanisms* create an optimal outcome for both the buyer and the seller that is otherwise unobtainable.

In general, negotiation is a broad concept and can be defined as “a process by which a joint decision is made by two or more parties. The parties first verbalize contradictory demands and then move towards agreement by a process of concession making or search for new alternatives” (Sierra, Faratin and Jennings, 1997). Dynamic pricing mechanisms such as auctions support contract negotiations in a market. In physical markets, the high transaction costs associated with dynamic pricing mechanisms have limited their application to specific sectors such as finance, commodities, and art. On the Internet, companies such as Onsale <<http://www.onsale.com>> or EBay <<http://www.ebay.com>> successfully run live auctions where people outbid one another for computer gear, electronics components and sports equipment. EBay facilitates a consumer-to-consumer exchange, whereas Onsale buys surplus or distressed goods from companies at fire-sale prices and resells them to end customers.

However, up until now, most electronic commerce has involved fixed price transactions. For stable markets or for day-to-day, low-involvement purchases where the stakes are small, the predictability and low transaction costs associated with fixed pricing are more compelling for the consumer. Two trends in electronic commerce are causing a shift from fixed to dynamic pricing for both business-to-consumer and business-to-business electronic commerce. First, price uncertainty and volatility have risen and the Internet has increased the number of customers, competitors, and the amount and timeliness of information. Businesses are finding that using a single fixed price in these volatile Internet markets is often ineffective and inefficient. Second, the Internet has reduced the transaction costs associated with dynamic pricing by eliminating the need for people to be physically present in time and space to participate in a market. The conclusion is that more negotiations can be expected to take place in electronic markets than in traditional markets (Stroebel, 2000). Certainly, fixed pricing will never disappear, but the Internet is changing the balance in favor of dynamic pricing.

This shift from fixed pricing to dynamic pricing (figure 1.3) is expected to be most evident in the business-to-business electronic commerce. Forrester Research predicts that business-to-business Internet auctions will grow to US \$52.6 billion by 2002, while analyst Vernon Keenan (1998) forecasts that in the same period dynamically priced business-to-business transactions will rise to US \$88 billion, representing 27 percent of the value of all business-to-business electronic commerce transactions.

Nowadays, many other new and interesting market mechanisms can be found on the Internet. Some deploy conventional auction procedures in innovative ways, others invent entirely new matching procedures for products which are either very difficult to describe or which have high trust and security requirements.

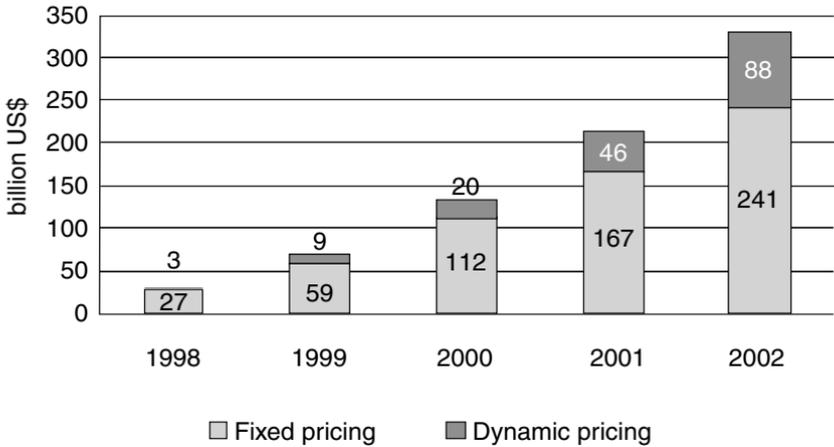


Figure 1.3 Fixed vs. dynamic pricing.  
*Source:* Keenan (1998).

A good example of the innovative use of an auction procedure is Priceline <<http://www.priceline.com>>. The company lets consumers specify what they want to buy and name their price. Priceline then forwards the bids to participating airlines (or other companies) which can anonymously choose to accept the request or not. The anonymity of the marketplace ensures that suppliers do not jeopardize the prices in their conventional sales channels. Priceline makes its money on the spread between the bid and the lower price of the product. Letsbuyit <<http://www.letsbuyit.com>> enriches the model by creating a virtual buying cartel (sometimes called “power shopping”). The company gathers a group of buyers interested in a certain product. The bundling of buyer demand allows Letsbuyit to negotiate a better deal with a supplier. All of these examples illustrate that market power has shifted to the buyer side and new electronic exchanges are focusing much more on buyers’ preferences instead of suppliers’ offerings.

### 1.3      **Advanced Auction Design for Electronic Markets**

In section 1.2 auctions were introduced as the most widely used form of dynamic pricing mechanism. In an auction a bid taker offers an object to two or more potential bidders, who send bids indicating willingness-to-pay (WTP) for the object (Milgrom and Weber, 1982). Auctions have been defined as a “market institution with an explicit set of rules determining resource allocation and prices on the basis of bids from the market participants”. (McAfee and McMillan, 1987). That is, any well defined set of

rules for determining the terms of an exchange of something for money can reasonably be characterized as an auction (Wurman, Wellman and Walsh, 2000). An auction *clears* when it commands an allocation based on the bids it has received. In the following, auctions will be considered as a particular type of negotiation. In contrast to unstructured bidding, auctions are particularly robust forms of multilateral negotiation: They work well, even in the face of mistakes or irrational behavior by the market participants. In cases where no one person knows the true value and each individual's estimate may be highly imperfect, the clearing price is still an accurate value estimate. The competitive process serves to consolidate the scattered information about bidders' valuations.

Auctions are not a new phenomenon. They were already being used in China in 700 AD to sell the belongings of deceased Buddhist monks, or even earlier in 500 BC for wife and slave auctions (McAfee and McMillan, 1987). Today, auction houses such as Sotheby's or Christie's in London auction off paintings, wine, and other fine goods. In an auction, bid takers can determine a market price for a product without having to set a possibly suboptimal price. As already mentioned, this is also a reason why auctions are a particularly successful negotiation protocol for Internet markets where they account for an enormous volume of transactions.

The English and the first-price sealed-bid auction are widespread auction formats in practice. English, first-price sealed-bid, Dutch, and Vickrey auctions are one-to-many (i.e. single-sided) auctions, between one seller and many buyers (or vice versa in a so-called *procurement or reverse auction*):

- *English auctions* allow back-and-forth offers and counter-offers. The buyer may update the bid; the seller may update the offered sale price. Finally, the highest bidder wins.
- The *first-price sealed-bid auction* is similar; however, bidders are allowed to submit only a single, private bid.
- In a *Dutch auction* the price at which an item is offered for sale starts from a high level and declines steadily until one of the buyers stops the clock and buys the good at that price.
- Finally, the *Vickrey auction* is similar to the first-price sealed-bid auction; however, the winner pays only the amount of the second-highest bid. In this case, neither the buyer nor the seller will have an incentive to lie or hide their strategies (see section 5.3 for details).

In all of these single-sided mechanisms, bidders are uniformly of the type "buyer" or uniformly of the type "seller." Double auctions admit multiple buyers and sellers at once. These mechanisms are mostly deployed in financial markets.

These standard auction formats are primarily a means of negotiating prices. The products in question are pre-specified in all their qualitative