

AUCTIONS ON THE INTERNET: WHAT'S BEING AUCTIONED, AND HOW?*

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This paper is an economist's guide to auctions on the Internet. It traces the development of online auctions since 1993, and presents data from a comprehensive study of 142 different Internet auction sites. The results describe the transaction volumes, the types of auction mechanisms used, the types of goods auctioned, and the business models employed at the various sites. These new electronic-commerce institutions raise interesting questions for the economic theory of auctions, such as predicting the types of goods to be sold at auction, examining the incentive effects of varying auctioneer fee structures, and identifying the optimal auction formats for online sellers.

I. INTRODUCTION

AUCTIONS ON THE INTERNET represent a fascinating new exchange mechanism. Every day in 1999, hundreds of thousands of goods were auctioned online, from Star Wars action figures to laboratory ventilation hoods. Internet auctions already represent billions of dollars in transactions, and have been growing at a rate of more than 10% per month. Having captured the attention of the public and the popular press,¹ they also represent a rich subject of study for economists interested in the variety of different exchange mechanisms used in practice.

This paper presents a tour of the online-auction industry, paying particular attention to features of interest to economists. What is the volume of trade? What types of auction formats are used? What types of goods are sold? What fee structures do online auctioneers charge? With

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¹For example, a *BusinessWeek* cover story on May 31, 1999, noted that some 63 million US adults recognized the brand name of eBay, the largest of the online auction sites.

online auctions still in their infancy, this paper presents a snapshot of this industry as it existed in the autumn of 1998, presenting data on 142 different auction sites in business at that time.

The remainder of this paper is organized as follows. Section II gives a brief history of the development of auctions on the Internet. Section III estimates how many goods are being auctioned online, and Section IV discusses what types of goods. Section V describes the business models utilized by the auction sites, while Section VI describes the fees they charge. Sections VII–XI describe the basic types of auction mechanisms used online: dynamic versus sealed-bid auctions, multi-unit auction formats, time duration, and other parameters of the auction rules. Sections XII and XIII discuss methods that participants in online auctions have found to ‘cheat’ or game the system, though these methods seem to be infrequently used. Section XIV presents updated data, from the summer of 1999, on the competition between three large auction sites, including comparison of the proportion of auctions which result in an actual transaction. Section XV concludes.

II. HISTORY OF INTERNET AUCTIONS

Many people mistakenly equate the World Wide Web with the Internet, but Internet auctions took place even before the Web was widely available. Even before the late-1993 release of NCSA Mosaic, the first Web browser for personal computers, there were already a number of auctions taking place on text-based Internet newsgroups and email discussion lists. See Lucking-Reiley [1999] for more details about auctions via newsgroups.

The earliest Web-based commercial auctions began in 1995, including Onsale (May) and eBay (September).² These ascending-bid auctions were the first to take advantage of the technologies offered by the Web, including the use of automated bids entered through electronic forms, and search engines and clickable categories to allow bidders to locate their items of interest. As with the newsgroup auctions, these Web auctions lasted between several days and several weeks each, with conveniently asynchronous bidding. By contrast, traditional ascending-bid auctions require all participants to gather in the same room at the same time.

Onsale started primarily as a retail merchant of refurbished computers and electronics, but using the auction format to differentiate itself from other online retailers. Its CEO, Jerry Kaplan, felt that auctions would

²It is hard to know for sure what was the very first Web-based auction site, because a number of auctions appeared and disappeared rather quickly. For example, I once visited the Web site of a Magic-card-oriented auction called ‘Zatar’s auction’ that started in April 1995 but appears to have faded away. Onsale and eBay are the earliest examples I know of auctions that eventually achieved significant sales.

make shopping 'fun and entertaining' for their customers.³ After experiencing considerably less growth than did auction-listing site eBay, Onsale undertook a change in strategy. In October 1997, Onsale added Onsale Exchange, an auction-listing service very similar to that of eBay,⁴ which Onsale eventually transferred to Yahoo! in 1998. Also in 1998, Onsale announced that it would begin to offer a fixed-price selling format for electronics at wholesale prices (Onsale atCost), and in July 1999 it merged with Egghead, another online retailer offering both auctions and fixed prices.

By contrast, eBay started out by encouraging individuals to list their own auctions online. From the beginning, most of the items on eBay have been collectibles,⁵ but their listings include a wide diversity of other types of items as well (see Section IV below). Sellers on eBay may choose a number of different parameters for each auction: number of days it will run, minimum bid level, and an optional secret reserve price. The site has grown very rapidly, at a rate of approximately 12% per month in 1998–99.⁶ During the month of July 1999, eBay hosted just under 10 million auctions, with \$190 million in transactions taking place. A number of auction sites have entered this market with similar business models during the intervening several years, but none has come close to the size of eBay.⁷ An interesting question is whether well-funded, recent entrants to this market will be able to take any significant market share from eBay (see Section XV below).

III. SIZE DISTRIBUTION OF AUCTION SITES

In our survey, my research assistants and I set out to estimate both the size of the online auction market as a whole and the volume of transactions at each individual site.⁸ This task is much easier to accomplish for online auctions than it is for almost any other type of business, since online auctions by nature display considerable information about both prices and quantities. On the other hand, estimating transaction volume remains a

³ Emert [1997]. See also Beam [1999] for more details on Onsale and its history.

⁴ Lewis [1995].

⁵ Indeed, eBay founder Pierre Omidyar was first motivated to start eBay by a girlfriend interested in buying and selling Pez dispensers with other collectors. [Roth, 1999].

⁶ From November 1 1998, to July 1, 1999, eBay's transaction volume grew from \$70 million to \$190 million per month, a growth rate of 13% per month. From early June to early August, 1999, eBay's listings grew from 2.1 million to 2.6 million listings on the site, a growth rate of 11% per month.

⁷ In a personal conversation in January 2000, eBay Vice President Jeff Skoll indicated that eBay's market share in the auction-listing market has remained relatively constant at approximately 90%. His figure is consistent with the independent revenue estimates I obtained in this research project.

⁸ Once source we drew on in constructing a list of candidate auction sites was Beam and Segev [1998], who conducted their own survey of online auctions.

TABLE I
ESTIMATED SIZE DISTRIBUTION OF AUCTION SITES

Monthly volume (\$)	Number of sites
Under 10,000	83
10,001 to 100,000	27
100,001 to 1,000,000	21
Over 1,000,000	7

Note: sizes estimated as of November 1998. See Appendix I, available on the *JIE* Web site, for details about the estimation procedure.

TABLE II
THE LARGEST ONLINE AUCTION SITES IN AUGUST 1998

Site	Monthly revenue (\$)
eBay	70,000,000
First Auction	5,000,000
Onsale	5,000,000
uBid	2,000,000
Going-Going-Sold	1,800,000
AuctionVine	1,500,000
Encore Auction	1,300,000

considerably harder task than classifying the auction formats used or the types of goods sold. Some auction sites give summary counts of the number of auctions taking place at any point in time, but none estimates the total number of dollars changing hands in transactions. See Appendix I, available on the *JIE* editorial Web site, for details of the estimation procedure used in this survey, including a discussion of the uncertainty in the estimates. Appendix II, also on the *JIE* Web site, lists the URLs for all the auctions surveyed.

Table 1 shows the estimated size distribution of the 142 auction sites in this survey. This measurement is of the gross value of total transactions concluded, in dollars per month.⁹

The table shows that 58% of the auction sites were relatively small, each resulting in less than \$10,000 in sales per month. Some of these sites served small niche markets (such as the Antebellum Covers auction of century-old autographs and letters), while many others had ambitious plans for becoming large generalist auctioneers. Sites such as ABC Live Auction and Virtual Nostalgia Auction Gallery boasted impressive lists of categories of items (see Section IV), but with few items up for auction and even fewer items actually receiving bids.

⁹This totals the number of dollars which change hands between buyers and sellers. If an auction failed to result in a transaction, it has zero contribution to the total.

A number of sites had more substantial trading volume: 15% of sites in the survey had sales of more than \$100,000 per month, and 5% had sales larger than a million dollars per month. These seven largest sites are displayed in Table II. Overall, the total volume of trade through Web-based auctions, as of autumn 1999, appears to have been almost \$100 million per month.

IV. TYPES OF GOODS SOLD

The variety of goods sold at auction on the Internet is quite impressive, including spreadsheet software, darkroom print washers, car stereos, autographed baseballs, used paperback books, sold-out concert tickets, deer-shaped toothpick holders, sofas, clarinets, and characters in the Ultima Online virtual gaming world. To facilitate browsing, auction sites often classify their auction listings into categories ('collectibles,' 'arts and entertainment,' 'sports') and even sub-sub-categories ('Nintendo game software,' 'vintage Fiestaware'). Since different sites use different classification systems, we created our own set of categories to group the types of goods sold at each site. Our list of categories can be found in Table III, with measurements of the number of different sites featuring auctions in each category and the number of different sites specializing in only a single category.

The largest category by far was that of collectibles: more than 60% of all the sites in the survey included auctions for collectibles. Therefore, we also developed subcategories for the most important groups of collectibles: antiques, celebrity memorabilia, stamps, coins, toys, and trading cards. Even the 60% figure may not capture the category's true importance, because more auctions appear to occur in collectibles than in other categories. Since eBay conducted at least 75% of all online-auction transactions in this survey, we took a closer look at transactions by category on that site. We estimate that at eBay, collectibles accounted for at least 85% of listings and 75% of revenues (or \$52 million per month).¹⁰ The largest individual subcategories of collectibles at eBay were toys¹¹ (one third of all collectibles listings) and trading cards (one tenth).

Online auctions do quite a bit to improve the matching of buyers to sellers. Before the advent of online auctions, buyers were most likely to

¹⁰ Checking in November 1998, we found 121,000 of 142,000 daily closings to be for collectibles. The eBay site did not have one top-level category including all the types of 'collectibles' in our categorization scheme; our figure pools together several eBay categories. Our rough estimates of the average prices in this category tended to be lower than for items in other categories (particularly computers & electronics), which accounts for the estimated share of revenues being lower than the estimated share of listings.

¹¹ A large fraction of the 'toys' category consisted of Beanie Babies, one of the hottest collecting crazes in 1998.

have found such collectibles through chance encounters at garage sales or in a few highly specialized dealer shops. Most of the collectibles traded at eBay and other sites are relatively inexpensive, with median prices well below \$100 and almost no items above \$1000.¹² High-priced collectibles (valuable art and antiques) have remained the purview of brick-and-mortar auction houses such as Sotheby's and Christie's, but that may change in the near future. In April 1999 eBay purchased upscale auction house Butterfield & Butterfield, and in June 1999 Amazon announced a joint venture with Sotheby's, with both business moves apparently aimed at producing online auctions of goods worth \$500 and up.¹³

As can be seen in Table III, a large number of sites in our survey (97 of 142) specialized in a single category of goods. Antique Country specialized in collectibles, Quixell in electronics, Galaxy Gold in jewelry, and so on. Some sites were more specialized than Table III's categories can reveal: Basketball Bonanza in basketball trading cards and memorabilia, Going-Going-Sold in used laboratory equipment, Golfclub Exchange in golf clubs, and Cyberhorse in horses and equine equipment.

Forty-six of the sites followed a broad strategy, featuring goods in multiple categories. Modern technological tools make this feasible, as users may either perform a text search for an item of interest or use a clickable menu of categories, subcategories, and sub-subcategories to arrive at items of interest. Of the seven largest auction sites identified in Table I, five have multiple categories of goods. eBay features well-developed menus of subcategories in collectibles, electronics, jewelry, and other miscellaneous types of goods. Onsale, uBid, and Encore Auctions all had the bulk of their auctions in computers and electronics, particularly refurbished items, but featured other categories (sports, travel) as well. First Auction, sponsored by the Internet Shopping Network, has featured a substantial amount of jewelry and home furnishings (the latter being unusual among Internet auctions), with numerous other categories as well.

As Internet technology lowers the cost of running an auction relative to using other pricing mechanisms (posted-offer retailing, bilateral negotiations, etc.), we might expect to see new types of goods be auctioned.¹⁴

¹² Indeed, many items at eBay sell for under \$10 (paperback books, cheap ceramics, etc.) Such very inexpensive items would have been extremely unlikely to be sold via auction before the advent of online bidding.

¹³ For details, see Junnarkar [1999a], and Farmer and Girard [1999]. An interesting empirical question is how the revenues at these new Internet auctions will compare to those in traditional auctions by the same auction houses.

¹⁴ Carlton [1991] noted that it was quite costly to organize a market that clears by price. He identified several costs involved, including expensive real estate, extensive record-keeping, and 'undoubtedly the greatest cost is the time cost of all the people involved.' With auctions now being automated on the Internet, the cost of a price-clearing market seems to have decreased considerably.

TABLE III
TYPES OF ITEMS SOLD AT AUCTION

Category	Sites featuring that category	Sites specializing in that category
Collectibles	90 ^a	56 ^b
Antiques	40	10
Celebrity memorabilia	16	7
Stamps	11	5
Coins	17	2
Toys	17	0
Trading cards	14	0
Electronics and computers	48	9
Jewelry	17	1
Computer software	16	0
Used equipment	15	7
Sporting goods	13	4
Travel Services	7	5
Real Estate	4	2
Wine	3	2

^a This figure includes all of the sites listed as featuring the various subcategories of collectibles—and there is plenty of overlap, with some sites featuring both memorabilia and toys, for example. It also includes several other sites featuring types of collectibles (postcards, phone cards) not large enough to warrant their own subcategories.

^b This figure includes all of the sites specializing in a single subcategory of collectibles (the ten specializing in antiques, the five specializing in stamps), in addition to sites featuring several of the subcategories of collectibles, but no other top-level categories of goods.

Most goods auctioned online tend to be used (action figures, unwanted software, refurbished laser printers) rather than newly manufactured.¹⁵ The items also tend to be small and relatively easy to ship, as most of these transactions take place through parcel delivery. Economic theory (e.g., Wang [1993]) has compared auctions to other pricing mechanisms in terms of strategic behavior and equilibrium price distributions, but to my knowledge, the literature has not yet examined the question of *what types of goods* sellers would prefer to auction (rather than setting posted prices).

Auctions seem most likely to be used for goods in limited supply where the demand is unknown to the seller, because an auction reveals to the seller the unknown market-clearing price. For example, in the future we may see much more auctioning of services: movie tickets, hotel reservations, plumbing services, etc. One obstacle to auctions of services is that

¹⁵The goods at First Auction (and several other merchant sites like it) are an exception to this rule. Auctions would seem to provide relatively little social benefit in the case of newly manufactured items, because the supply of such items is not fixed, so the retailer can adjust prices or quantities in response to observed demand. By contrast, used and rare items are in relatively fixed supply, so auctions can be valuable in determining the correct price and allocation in the face of uncertain demand. This informal argument suggests that auctions at eBay may provide considerably more social welfare than those at First Auction.

many services (movies, plumbing) are essentially local, while most auction sites are currently national or international in scope.¹⁶ But as Internet usage becomes more ubiquitous, perhaps thicker local markets will begin to support auctions for local services. For example, in mid-1999 the national career service Monster.com introduced an auction facility to supplement its resume-listing service, so that job-hunters can have potential employers bid for their services, though it remains to be seen whether this type of auction will become popular.

V. BUSINESS MODELS: MERCHANT AND LISTING-AGENT SITES

The two primary business models for Internet auctions are those of merchant sites and listing-agent sites. A merchant site, such as Onsale, chooses which merchandise to offer for sale—it acts as a retailer who happens to conduct its transactions through auction. A listing site, such as eBay, acts as an agent for other sellers, allowing them to register their items and running the auctions on their behalf. Listing sites usually avoid getting involved in the actual exchange of goods; all the details of payment and shipping are worked out by the buyer and seller on their own. Some auction sites, such as Up4Sale, combine both types of business: auctioning their own merchandise while also allowing others to list independent auctions on the same site. The ownership distinction is not always clear, as some ‘merchant’ sites actually sell goods owned by others, through a consignment system. Also, some ‘agent’ sites have the listing process take place offline, by contrast with eBay’s Web-based listing system. We maintained a consistent definition of a ‘listing’ site as one where independent sellers list their own auctions, and a ‘merchant’ site as one where no independent seller is identified.

Our survey of 142 Internet auctions found 96 listing sites, 25 merchant sites, 11 combination agent/merchant sites, and 10 sites where the available information did not enable us to make a clear categorization. The largest merchant sites include Onsale, First Auction, uBid, and Encore Auction, all relatively general in that they featured several different categories of items. We also found some smaller, more specialized merchant sites, such as SportsAuction and Hollywood Auction, each with only a single category of goods. The largest listing-agent sites include eBay,

¹⁶ CityAuction is a notable exception. This site was designed to allow sellers to list auctions as being restricted to particular local areas, in order to facilitate auctions for large or otherwise difficult-to-ship items. However, in our survey we found that almost all sellers on the site were choosing to auction easily shippable items in geographically unrestricted (national) auctions. Recently (summer 1999), eBay has also begun to develop local auctions, beginning with a Los-Angeles-specific auction area.

AuctionVine, Going-Going-Sold, and Auction Universe.¹⁷ Some agent sites, such as AuctionVine and Going-Going-Sold, allowed only qualified dealers to put items up for auction. These tended to specialize in single categories of goods. By contrast, eBay, Auction Universe, and a number of similar listing-agent sites have developed user-friendly interfaces to enable any potential seller to add an auction listing to the site.¹⁸ Their offerings tended to be broader, with the diversity of product offerings fueled by the imaginations of individual sellers.

VI. AUCTIONEERS' FEES

While merchant sites derive their income directly from the sale of their items, agent sites derive their operating revenues from fees charged to buyers and sellers. These fees tend to be considerably lower for Internet auctions than for traditional auction houses. Sotheby's in the late 1990s, for example, charged a buyer's premium of 15% over the final bid price, and a standard (though negotiable) seller's commission of 20% of the bid price.¹⁹ By contrast with this total fee of more than 30% of the final bid price, the total fees at online agent sites like eBay have been only about 5–7% of the final bid price. Traditional auctions offer more services than Internet auctions, such as appraisal services and well-appointed viewing areas, but the difference in fees remains notable.²⁰

At eBay in 1999, there is no buyer's premium; all fees are paid by the seller. There are two components to the seller's fees. First is an insertion fee for the auction listing, ranging from \$0.25 to \$2.00, depending on the size of the minimum bid or reserve price. Second is a percentage of the amount of the final bid price, with the marginal rate declining from 5% to 1.25% as the size of the sale increases. Some additional fees are charged for optional promotional services, such as a boldface listing for the auction

¹⁷ Auction Universe was not quite large enough to make it into Table II, but at an estimated \$600,000 per month, it is still one of the largest sites in the sample. This site, operated by a consortium of newspaper publishers, is an online extension of the newspapers' traditional classified ads. Auction listings placed by customers at one newspaper can be shared in the Auction Universe listing service to provide a national pool of bidders, appearing on the Web sites of the participating newspapers as well as at the independent Auction Universe Web site. The site offers a broad variety of categories of goods.

¹⁸ While some sites have developed their own proprietary software, others have purchased their auction software from a surprisingly large number of auction software providers. See Appendix II for details on the market for auction software.

¹⁹ See Hildesley [1997]. These figures hold at least for items under \$50,000. Percentage commissions tend to decline with the auction price—for example, buyer's premiums were only 10% for items over \$50,000.

²⁰ At this writing, Sotheby's and Christie's faced an antitrust probe from the US Department of Justice, and class action lawsuits have asserted that these two auction houses conspired to 'fix, raise, stabilize and maintain at artificially high levels the commissions and premiums they charged.' See Leab [2000] and Peers and Davis [2000].

(\$2), a featured location within a category (\$14.95), or a featured location on the eBay site overall (\$99.95).

Most of the general-purpose listing-agent sites have charged similar fees to those of eBay; there is some variation, but few charged more than 5% in commissions. A few sites, in an effort to build up their business, charged no fees at all; examples include AuctionX and Up4Sale.²¹ Agent sites specializing in traditionally auctioned types of goods, such as antiques and wines, tended to charge considerably higher fees, often matching those of traditional auction houses. For example, AuctionVine and Antique Canada charged commissions of 15%, while CyberHorse and Going-Going-Sold charged 10%.²²

Competition might drive these commissions down as the market continues to evolve. Given that the auction is no more costly to run for a \$100 item than for a \$10 item, it is noteworthy that the fees are increasing in the price of the good. This is in contrast, for instance, to the flat fee per trade that has become the norm in financial brokerage services. One would not expect this type of price discrimination to be possible under perfect competition. On the other hand, percentage commissions have long been the norm at traditional auction houses.

In all, 62 of the 107 listing-agent sites charged a seller's commission as a percentage of the final selling price. Of these 62 sites, 28 had commissions of 5% or less, 18 had commissions ranging from 7% to 20%, and the remaining 18 did not give information on the size of the commission. In addition, 23 different sites charged a flat listing fee to the seller. Buyer's premiums, common at traditional auction houses, are much less prevalent on the Internet: only 18 of 142 surveyed firms used a buyer's premium. Six of these were merchant sites, while the other twelve were listing-agent sites. The buyer's premiums were generally in the range of 10% to 15% of the purchase price, with two exceptions (5% and 8%, respectively). Only eight of the sites in the survey charged both a buyer's premium and a seller's commission.²³ Section XV below explores the possible incentive effects of fee structures on sellers' behavior.

²¹ Up4Sale, with its slogan 'Free Auctions Forever', indicated that it intends to make a profit only by charging sellers for 'premium services', mainly featured listings which make their auctions stand out from the crowd.

²² These sites sometimes offered more services in return for the fees (for example, AuctionVine offered advertising services for wine consignors). None of these sites charged any buyer's premium, so their overall charges are still less than half the norm at Sotheby's or Christie's.

²³ A related question is whether the seller's net revenues are equal depending on whether the nominal incidence of the fee is on the buyer or on the seller. Marks [1999] investigates this question empirically with data from the Chicago wine-auction market.

VII. AUCTION FORMATS

In our survey of different sites, we found examples of different basic auction formats discussed in the auction-theory literature: English, Dutch, sealed-bid, and double auctions. Of the 142 sites, 121 used English ascending-price auctions, 21 used sealed bids,²⁴ three used Dutch descending-price rules, and four were continuous-trading double auctions. Six of the sites had more than one auction format available; this is why the sum adds to more than 142. For example, the Auction Nation site gave sellers a choice between running an ascending-bid auction or a 'silent' (or sealed-bid) auction where the high bid is not made public until the closing time.²⁵ The English auction format was even more dominant than it first appears in the raw statistics. Of the seven sites with a dollar volume of at least \$1,000,000 per month (see Table II), all used an English format.²⁶

VII(i). *English Auctions*

Ascending-bid auctions are what people traditionally think of when they hear the word 'auction,' so it is not surprising that they are by far the most prevalent online auction format on the Internet. Online sites include a number of features to make participation easy for bidders. Once a bidder finds the item she's interested in, she can view the current high bid and decide whether to raise it by filling out a Web-based bid form. After submitting her bid, she will see an automatic update of the auction status, confirming whether or not she successfully became the current high bidder. She can return to the site at any time before the close of the auction to check on her bidding status. Most sites provide automated 'outbid notification' email messages to let a bidder know instantly when she is no longer the high bidder in an auction.

In a traditional English auction with bidders present in a single room,

²⁴ We have chosen to include in the 'sealed-bid auction' category some auctions which were problematic to categorize. Four of these auctions were primarily traditional English auctions with a bidding floor, but these auctions also encouraged absentee participation by Internet bidders. In each case, a Web-based bidding form allowed Internet bidders to submit their bids in advance, which would be executed on their behalf at the live auction. Thus, the experience for the Internet bidders was that of a sealed-bid auction, even though the participants on the bidding floor experienced an ascending-bid auction. Of the four auctions in this category, two appear to use a first-price rule for Internet bidders (pay your bid), while the other two used a second-price rule (pay one increment over the highest bid on the floor). The use of a second-price rule for absentee bids at a 'live' English auction has been common at traditional auction houses as well; see Lucking-Reiley [2000] for examples from the stamp auction market.

²⁵ A quick scan of the listings at Auction Nation indicated that most, if not all, sellers chose the English ascending format.

²⁶ One of the seven, Encore Auction, listed a 'non-published' or sealed-bid auction as an alternative to the English auctions on its site, but I never saw Encore actually run such an auction for its merchandise.

the auctioneer closes the auction using a 'going . . . going . . . gone!' procedure. A live auctioneer never specifies a closing time for his auction, because such auctions always end in a matter of seconds or minutes, but Internet auctioneers typically set a closing time in advance. For example, at eBay sellers often run auctions ending 7 days after they begin, measured to the exact minute. The fixed end time poses an incentive problem: if the auction closes at a fixed time, then an early bid serves no benefit to the bidder, but only reveals information to her rivals. Indeed, many Internet auction bidders have engaged in 'sniping,' or waiting until the final minute of the auction to submit a bid (see Section XIII). In a simple ascending-bid auction with a fixed end time, submitting an early bid is dominated by the strategy of submitting the same bid just before the auction ends, because it deprives rivals of the ability to see one's bid amount and raise it. If all bidders were to follow a strategy of bidding only at the last minute, the game would become equivalent to a first-price, sealed-bid auction. This destroys the English auction's attractive feature that bidders have a dominant strategy to bid up to their maximum willingness to pay, and makes bidders face a much more complicated bidding decision. To restore the English auction mechanism's desirable properties, two alternative solutions have been developed by Internet auctioneers.

The first alternative is to offer a short 'extension period' to the auction. The most common extension period is five minutes long, meaning that if there is any bidding activity in the last five minutes of the auction, then the auction's closing time will be extended by an additional five minutes.²⁷ This process may iterate if bidding continues, effectively adding a 'going, going, gone!' activity rule to the auction, and giving bidders the opportunity to react to would-be 'snipers.' We found this solution used at a number of sites, including Onsale, Paulus Swaen (antique maps), and Surplus Auction (computer software). A disadvantage of this solution is that it obligates any serious bidder to return to the auction at its closing time and stay until the auction is over. This removes the convenience of asynchronous bidding, which in principle gives Internet bidders the flexibility to enter their bids at any time. Asynchronous-bidding convenience can be improved by lengthening the extension period,²⁸ but a longer extension period also decreases the convenience of having the auction end in a timely fashion.

An alternative solution is for the auction site to implement a 'proxy bidding' mechanism. eBay explained its proxy bidding system as follows: 'Everyone has a little magical **elf** (aka proxy) to bid for them . . . all you need to do is tell your elf the most you want to spend for that item and

²⁷ One site, Lightning Auction, used a much shorter extension period, only one minute long.

²⁸ We saw extension periods up to one hour in length in our survey of Web-based auctions. In addition, newsgroup-based auctions for Magic cards still frequently have an activity rule requiring up to five days with no bid raises before the auction can close.

he'll sit there and outbid other elves for you, until his limit is reached.' We found proxy bidding at 65 of the 142 sites, and the idea has grown in popularity: Onsale, for example, added a proxy-bidding feature called 'Bid Maker' in 1998, after several years without one. Proxy bidding makes the fixed-length English auction resemble the Vickrey second-price sealed-bid auction, reducing incentives for 'sniping',²⁹ and restoring the dominant strategy of bidding one's maximum willingness to pay.³⁰

VII(ii). *Sealed-bid Auctions*

The two types of sealed-bid auctions most studied in auction theory can both be found on the Internet. In a first-price sealed-bid auction, the winning bidder pays his bid amount. In a second-price sealed-bid auction, the winning bidder pays one increment over the second-highest bid received. We found seven of the former and five of the latter. The remaining eight sealed-bid auctions in our sample of twenty could not be classified with certainty, but are most likely also first-price auctions.³¹ The first-price auctions included Timeshare Resale International's auction of vacation timeshares, as well as several listing sites giving sellers the (seldom-used) option of running a sealed-bid instead of an English auction. Second-price auctions included Antebellum Covers (manuscripts and ephemera), Sandafayre (stamps), and Nauck's Vintage Records.

VII(iii). *Dutch Auctions*

We found three examples of Dutch auctions,³² in which the price starts at some relatively high level and continues until the first bid determines the winner. However, we were never able to observe an actual transaction on any of these sites. Intermodal Exchange presented rules for a slow (days per auction) Dutch auction of large cargo containers, but no auctions were in progress when we visited. At the other end of the spectrum, Klik-Klok

²⁹ The incentive to bid early is increased by the fact that the first bid received usually has priority in the case of a tie.

³⁰ This discussion implicitly assumes a private-values model of auction bidding, so that bidders know with certainty their own values for the items. Other models of auction bidding, such as Milgrom and Weber's [1982] affiliated-values model, do not involve strict equivalence between English and second-price sealed-bid auctions.

³¹ During the initial survey in the autumn of 1998, we mistakenly assumed that any sealed-bid auctions would use a first-price rule, so we neglected to record the price rule carefully. Upon reexamination in the summer of 1999, eight of the sealed-bid auctions from our sample were no longer operating.

³² Many other sites misleadingly indicate that they run Dutch auctions. In these cases, 'Dutch' turns out to be common usage for the use of a uniform-price rule in a multi-unit auction, rather than the economist's usage to mean a declining-price auction. Typically, a 'Dutch' auction on the Web will be an English ascending-price auction where each winning bidder pays the amount of the lowest accepted bid. See Section VIII(i) below.

Auctions and Bid.com both featured three-minute Dutch auctions for various consumer goods running simultaneously in several categories (food, jewelry, collectibles, electronics, furniture, etc.), twenty-four hours a day. Upon entering one of these auctions, one could see a description of the good, a listing of the total quantity available (usually 5–10 units), a clock displaying the time remaining in the auction, and the current price, lowered every five to ten seconds. Over a three-minute period, the price would decline by a total of approximately 15 to 20 percent, which did not appear to be low enough to stimulate bidding. The merchandise resembled that offered on home-shopping television, with the same items repeatedly cycled through the auction schedule every few hours. One would not expect bidders to feel much urgency in bidding, when the same items are likely to come up for auction again soon.

After the conclusion of our survey, I discovered what is essentially a Dutch auction of overstocked items at the Land's End Web site. The feature, called 'On the Counter,' begins with a listing of items every Saturday with 'initial offer prices' around 30–60% below retail; these prices fall by 25% on Monday, 50% on Wednesday, and 75% on Friday (relative to the initial offer price). The store does not post the quantity available for each item, but merely indicates when each item has been sold out. Unlike the other Dutch auctions in the survey, this auction actually appeared to be resulting in transactions. This type of slow Dutch auction has some precedent in brick-and-mortar retailing, but can be implemented much more easily and automatically with Internet technology. For example, the price might decline continuously over the course of a week, with continuous updates as to the number of remaining items. Open questions for economists include whether the clock speed and the size of the 'tick amount' have any impact on the outcome of the auction.³³

VII(iv). *Double Auctions*

We also found four examples of double auctions, which allow continuous updating of sellers' offers as well as buyers' bids. Three of the four sites specialized in a single type of good: FastParts in electronic components, LabX in laboratory equipment, and Dallas Gold and Silver Exchange (DGSE) in jewelry.³⁴ The fourth, BidNAsk,

³³ In Lucking-Reiley [1999], I report the experimental results of slow Dutch auctions (approximately a 5% decline per day) run via email for cards from the game Magic: the Gathering. Interestingly, the Dutch auctions tended to raise greater revenues than did sealed-bid auctions.

³⁴ Traditional double auctions take place with buyers and sellers trading multiple units of standardized commodities, but both LabX and DGSE were curiously dominated by listings of unique items. This made their auctions similar to single-sided English auction listing sites like eBay, except that sellers had the formal ability to lower their minimum acceptable bids over time.

pursued a strategy allowing users to set up a new 'trading floor' for any type of good whatsoever. Of the four sites, three seemed to have very low trading volumes. Only FastParts seemed to have significant trading volume, with hundreds of listings of both 'parts for sale' and 'parts wanted to buy.' The continuous-trading nature of the site made it difficult to estimate total transaction volume directly. However, a July 1999 telephone call to FastParts revealed that their auction site had 13 employees, approximately 1000 registered buyers and sellers, and trading volume somewhere between one and ten million dollars annually.

VIII. MULTI-UNIT AUCTIONS

Auctions of multiple units of a good have received increasing attention in the theoretical economics literature on auctions (see, for example, Ausubel and Cramton [1996]).³⁵ Internet technology increases the feasibility of ascending-bid multi-unit auctions by conveniently organizing the bid data. For example, in an English auction for 10 units, the computer can give automatic status updates which conveniently show the 10 highest bids and the bid amount required to displace one of them.³⁶ Of the 120 English auction sites we surveyed, at least 41 included multi-unit capabilities.

VIII(i). *Multi-Unit Pricing Rules in Ascending-Bid Auctions*

There are two different pricing rules used in multi-unit ascending-bid auctions. First there is the discriminatory or pay-your-bid rule, where each winning bidder pays the amount of her own bid. Second is the uniform-price rule, where each winning bidder pays the amount of the lowest accepted bid. The discriminatory rule tends to be used at the

³⁵ I focus here on multi-unit auctions of homogeneous units, but the Internet also presents possibilities for bidding on combinations of non-homogeneous items. Winebid is an example of an auction that encourages such 'package bidding.' This site frequently organizes its auctioned wines into groups which might be more valuable to some bidders if they were together in combination. For example, individual lot numbers 103a, 103b, and 103c might represent the 1992, 1993, and 1994 vintages of a Merlot from a particular winery in California. In addition to allowing bidding on those individual bottles, the auction also encourages interested bidders to submit bids on lot number 103, a 'vertical collection' of the three different vintages from that winery. Ascending bids proceed separately on the individual items and on the full package. At the close of the auction, the highest bid total determines whether the wines are sold as a package, or sold individually, at the amounts of the high bids.

³⁶ By contrast, traditional English auctions have typically sold only one unit at a time. For example, when multiple cases of the same wine are available, each case will be auctioned off sequentially by the auctioneer. See Ashenfelter [1989] for details.

merchant sites (Onsale, uBid, Encore Auction), while the uniform-price rule is fairly standard for multi-unit auctions at the listing sites.^{37,38}

One might expect these two formats to produce roughly equivalent results, if each bidder in the discriminatory auction follows the sensible strategy of always bidding just enough to stay among the winning bids. (For example, if the ten current winning bids consist of four bids of \$90 and six bids of \$100, the minimum increment is \$10, and I am willing to pay up to \$150, I would submit a bit of \$100 to displace the current high bidder for the time being.) Ignoring the discreteness of bid increments, one would expect such a strategy to result in all participants paying the amount submitted by the lowest accepted bidder—regardless of whether the format were uniform-price or pay-your bid.

However, online multi-unit discriminatory auctions frequently exhibit winning bids with a spread of more than one minimum increment. Easley and Tenorio [1999] have collected data on bidding behavior at Onsale and uBid, showing that jump bids are quite prevalent in such auctions.³⁹ A pay-your-bid auction for ten identical video-capture devices had winning bids ranging from \$42 to \$57, with a minimum increment of only \$5. Similar spreads can be found in uniform-price auctions; for example, a recent eBay auction for six identical Beanie Babies had winning bids ranging from \$100 to \$115, with a minimum increment of only \$2.50, though of course in this case each winner paid only \$100. Given the observed jump bids, one might conclude that the pay-your-bid auction would generate higher revenues on average. This assumes that bidders would use the same bidding strategies in either format, but it is not clear, either on theoretical or empirical grounds, whether such an assumption should hold.⁴⁰ A comparison of these two multi-unit ascending-bid auction formats has yet to be addressed in the economics literature.

VIII(ii). *OpenIPO: A Sealed-bid Multi-Unit Auction*

Though all the multi-unit auctions in the survey were ascending-bid auctions, February 1999 saw the introduction of an interesting online

³⁷ Some listing sites, such as Auction Port and Boxlot, give the seller a choice between the two price rules.

³⁸ The uniform-price rule appears to be considered a substitute for the proxy-bidding system available on single-unit auctions, since a winning bidder in either case generally has her price determined by the bids of lower bidders. In fact, eBay does not enable proxy bidding in its multi-unit auctions. An important difference from proxy bidding is that the highest bid amounts are public, rather than secret, in an ongoing uniform-price auction at eBay. Revelation of these bids could cause problems, such as increased opportunities for shills.

³⁹ They propose the time cost of bid submission as an explanation for this behavior.

⁴⁰ For example, both theoretical and experimental results indicate that bidders bid higher in a second-price sealed-bid auction than in a pay-your-bid sealed bid auction. See Vickrey [1961] and Kagel [1995].

sealed-bid multi-unit auction. OpenIPO, founded by investment banker William Hambrecht, aims to improve the efficiency of initial public offerings of corporate stock through the use of online auctions. Investment banks face a difficult problem in setting the opening price for a new issue of stock, and they prefer to err on the side of setting the price too low. The investment bank typically rations the underpriced shares to its best institutional clients, who get a windfall gain as their shares rise to the fair market price on the first day of trading.⁴¹ OpenIPO claims that this is bad both for individual investors (who can't get in on the opening price) and for the companies (who raise less capital than they could if the price were set correctly). In order to solve this problem, OpenIPO proposes to auction shares, with individual investors able to participate in a sealed-bid online auction. In its first IPO, OpenIPO sold a million shares of stock in Ravenswood Winery at an auction price of \$10.50 per share.

OpenIPO uses a uniform-price rule, charging the amount of the lowest accepted per-share bid to each of the winning bidders. Their information page describes the auction as follows: 'The OpenIPO auction is actually a modified version of an auction developed by William Vickrey. In 1996, he won the Nobel Prize in Economics for his work on designing auctions that bring new efficiencies to the marketplace.' Ironically, some recent work by auction theorists emphasizes that the uniform-price auction is, in fact, inefficient, and not the correct demand-revealing generalization of the Vickrey second-price auction (Engelbrecht-Wiggans and Kahn [1998], Ausubel and Cramton [1996]).^{42,43}

IX. TIME DURATION OF AUCTIONS

Of the 142 sites in our survey, 86 allowed us to estimate the average duration of their auctions. Most listing sites give sellers the opportunity to choose their own auction length. At eBay, for example, sellers can choose a length of 3, 5, 7, or 10 days for their auctions. The mean length of

⁴¹ For a more detailed description, including quantitative evidence, of the underpricing of IPOs, see Ritter [1998].

⁴² The correct generalization would in general cause bidders to pay different prices on different units they won, and different prices from other winning bidders. Kagel and Levin [2000] and List and Lucking-Reiley [2000] provide experimental evidence demonstrating that bidders do indeed strategically underreveal demand in the uniform-price auction relative to the multi-unit Vickrey auction.

⁴³ On the other hand, it is possible that OpenIPO may care more about other aspects of the auction than about efficiency and demand revelation. For example, OpenIPO claims to want to 'level the playing field' for individual investors. They indicate that in their auction, 'shares are allocated in a completely even-handed way. Your allocation is based on what you are willing to pay rather than on the size of your brokerage account.' The efficient multi-unit Vickrey auction would generally give discounts to high-demand bidders to give them incentive to reveal their high demand, and OpenIPO might well wish to avoid such an outcome in favor of an auction with a uniform price.

auctions at the different sites in this survey was 9.3 days, with a modal length of 7 days (occurring at 36 of 86 sites).⁴⁴ The shortest auctions, measured in minutes, took place at merchant sites, and were few in number relative to the regular several-day auctions at the same sites; they include Onsale's 60-minute 'express auctions' and First Auction's 3-minute 'flash auctions.' The longest auctions in the survey, with lengths up to 90 days, were auctions for government surplus items at the WW Sales site.

X. MINIMUM BIDS AND RESERVE PRICES

Internet auctions usually specify a minimum acceptable bid amount, below which no bids will be accepted. On listing-agent sites, the individual seller chooses this as a parameter in the auction listing. In addition, many auctions also feature a secret 'reserve price,' specified in advance but not revealed to the bidders until after the auction. If the highest bid does not exceed the amount of the reserve price, then the good will not be sold.

Of the 142 sites reviewed in our study, practically all of them used non-zero minimum bid levels, and 55 also allowed the use of reserve prices. Typically (in at least 44 of 55 cases), an auction in progress on the Web site indicated to bidders when it had a secret reserve price in use. On eBay and the majority of other English auction sites, the message changed from 'the reserve price has not yet been met' to 'the reserve price has been met' at the appropriate point in the bidding. A minority of English-auction sites gave no information at all, so that a winning bidder learns about the presence of a reserve price only after the auction is over.

An interesting question concerns the effect the reserve price has on the auction. The conventional wisdom among some sellers appears to be that a \$0 minimum bid plus a \$50 reserve price would be more profitable to the seller than a \$50 minimum bid with no reserve price. As Auction Universe indicated in its seller instructions, 'A Reserve Auction is an auction format that allows a seller to enter a low starting price in the hopes of generating interest and bids on their item.' That is, starting bidding at a falsely low minimum bid might generate interest and build bidding momentum, sending the bidding up past a high, but secret, reserve price.

A possible theoretical explanation for this behavior involves a 'winner's-curse' model of privately uncertain, affiliated bidder values. A low-minimum, high-reserve auction would give a bidder more opportunity to observe the bidding of others than would a high-minimum-bid auction, so the 'linkage principle' of Milgrom and Weber [1982] indicates that more aggressive bidding would be rational in the low-minimum, high-reserve

⁴⁴ These are rather rough estimates. For example, if a site had auctions lasting from one to five days, we used an unweighted estimate of three days as an estimate for that site.

auction.⁴⁵ On the other hand, it is not clear whether the types of goods being sold in Internet auctions really involve bidders being uncertain of their own values. A used laser printer presumably has a known value to the bidder. Some collectibles might be speculative investments with uncertain future value, but others involve privately known values to bidders who wish urgently to complete their collections.⁴⁶ If values are privately certain, then the winner's-curse argument does not hold.

XI. BUYOUT PRICES

A few English auctions in our survey specified a 'buyout price,' allowing the buyer to buy an early end to the auction by submitting a sufficiently high bid. Examples include One Web Place (agent site for collectibles), Mackley and Company (merchant/agent site for jewelry), and LabX (agent site for lab equipment). This procedure was also common with the newsgroup auctioneers I observed in 1994 and 1995. When a 'buyout' occurs, it benefits buyer and seller by bringing the auction to a close early (a savings of perhaps days or even weeks). The buyer gets certain victory, but does not know whether she might have been able to pay less had the auction continued. The seller gets a certain high price, but gives up the possibility that bidding might have gone even higher had the auction continued. Although sellers tend to set these prices quite high, I have seen buyers meet them on several occasions. Bob Kafato, president of LabX, indicated to me that in auctions where sellers choose to set an 'Auction Stop' price (LabX's term for a 'buyout'), a bidder chooses to invoke this option in about 10% of cases. An interesting question for auction theory is to determine the optimal level of a 'buyout price' in an ascending-bid auction.

XII. STRATEGIC MANIPULATIONS: SHILLING AND BID SHIELDING

Some Internet auction users have been observed 'gaming the system' with strategic manipulations. Shilling is an attempt by the seller to drive up the price of the good, while 'bid shielding' is a technique designed to allow a bidder to get a 'steal' on an item at a low price. Both practices violate the rules on Internet auction sites, but these rules can be difficult to enforce.⁴⁷

⁴⁵ Vincent [1995] provides a formal theoretical model of reserve prices along these lines.

⁴⁶ Bajari and Hortaçsu document the interesting empirical regularity that in eBay auctions for collectible mint sets and proof sets of coins, sellers tend to use secret reserve prices more often for high-value items than for relatively low-value items.

⁴⁷ One strategy that could help eliminate strategic bid manipulations would be to require bidders to guarantee their bids with credit-card accounts, but in our survey we saw no auctioneers using this strategy.

It is unclear how frequently these manipulation strategies are used, though documented examples of both do exist.

Incidents of shilling have been reported in traditional English auctions for many years.⁴⁸ When only one bidder remains in the auction, the seller can try to drive the auction price higher by bidding against her. Most auctioneers (including eBay) do not allow sellers to submit bids on their own goods while the auction is in process, but sellers have been known to circumvent this restriction by getting others to bid on their behalf. A number of states have made shilling illegal, but such laws are difficult to enforce. Enforcement can be particularly difficult in Internet auctions, where the bidders cannot see each other: a seller might invent a false identity with a new email address, and use that identity to bid in his own auction.

Bid shielding is, in a sense, the inverse of shilling. Like shilling, bid shielding also involves artificially high bids—but by a buyer, not by the seller. The bidder puts in an early lowball bid (say \$10) on an item he's interested in, and then gets a friend (or a false identity) to put in an extremely high bid (say \$500) on the same item. The high bid acts as a 'shield' of the lowball bid, keeping anyone else from bidding in the auction. Just before the end of the auction, the bidder retracts the \$500 bid, leaving the \$10 bid as the winning bid on an item that should have gone for a higher price.⁴⁹

XIII. FRAUD

Another issue of interest to economists is the possibility of fraud in online auctions. At listing-agent sites, the standard procedure has been for the buyer to mail a check or money order to the seller, and wait for the seller to mail the goods in return. But how does the buyer know she can trust the seller? Despite many economists' instincts, there appears (qualitatively) to be very little fraud in online auctions.

In addition to the social norm of honesty, three formal mechanisms also discourage fraud. First, eBay and other auction sites encourage defrauded users to file formal complaints with state Attorneys General or the US Post Office, and the auction sites cooperate with prosecutors. A 1999 conviction in California indicates that online-auction fraud cases will be taken seriously by the courts.⁵⁰

Second, eBay pioneered a feedback and rating system, imitated by other

⁴⁸ See, for example, Cassady [1967], who quotes a 1937 law text on 'puffing', a synonym for shilling (p. 212). Engelbrecht-Wiggans and Nonnenmacher [1999] document that anti-shilling laws for the Port of New York date back to at least 1817.

⁴⁹ For documentation of one such instance, see Sullivan [1999].

⁵⁰ See Fernandez [1999].

sites, that encourages buyers and sellers to rate each other at the close of a transaction. Ratings are publicly visible: in any auction listing one sees the seller's numeric feedback rating, equal to the number of positive ratings minus the number of negative ratings. Similarly, a seller may see the feedback ratings of the bidders in her auction, and has the option to reject bids from any bidder. A single click yields access to the entire history of written comments. A feedback rating of -4 results in automatic suspension of that user's account, but such events appear to be rare. During our survey, sellers already had positive feedback ratings numbering in the thousands. Whether seller ratings affect bidders' willingness to pay for an item is an interesting empirical question.⁵¹

Third, most listing-agent sites encourage users to use third-party escrow services when they fear the possibility of fraud. The buyer sends payment to an escrow agent, who verifies receipt of payment to the seller before she ships the good. Once the buyer receives the good and confirms that it meets his expectations, the escrow agent releases the funds to the seller.⁵²

XIV. COMPETITION BETWEEN EBAY, YAHOO!, AND AMAZON

eBay appears to have a large first-mover advantage in a market with significant network effects: sellers prefer to list their goods where the most buyers visit, and buyers prefer to visit sites with large selections of goods.⁵³ But as online auctions received increasing amounts of popular attention and eBay's profitability became clear, two of the biggest consumer brands on the Internet began to compete with eBay in the listing-agent market. Yahoo! introduced its person-to-person auction listings in October 1998, and Amazon opened its own auction listings in March 1999.⁵⁴ Both

⁵¹ Lucking-Reiley *et al.* [1999] present econometric evidence from auctions of Indian head pennies, suggesting that the answer to this question is yes. Negative seller rating points decrease the price received by auctioneers. The effect of positive rating points on price is positive but statistically insignificant.

⁵² The dominant firm in the Internet-auction escrow market appears to be i-Escrow, founded in 1997. It accepts payments via credit card, check, or money order, and charges fees of between 1% and 6% of the transaction amount. I-Escrow's President Sherman Kwok indicated in July 1999 that his firm's average transaction size was approximately \$300, and that its sales volume had been growing at a rate of approximately 25% per month (Junnarkar [1999b]).

⁵³ Meta-search engines have recently developed to search the listings of eBay and other competing auction sites simultaneously. Such meta-searches, available at Web sites with names like Bidder's Edge, Auction Rover, and AuctionWatch, threaten to weaken the network-externality advantages enjoyed by eBay. eBay has claimed the ability to restrict access to its listings by aggregator sites, lobbying for legislation in Congress to make it illegal to engage in 'piracy' of specialized collections of information such as eBay listings. eBay sued Bidder's Edge in December 1999 to protect its interests, and was accused of anticompetitive practices in a countersuit by Bidder's Edge. (See Wilke [2000] and Gurley and Simpson [2000].)

⁵⁴ See Hof and Himmelstein [1999] for more details.

TABLE IV
 SIZE ESTIMATES FOR eBay, Yahoo!, AND Amazon, SUMMER 1999
 (ESTIMATED STANDARD ERRORS IN PARENTHESES^a)

	Auctions closing per day	Revenues per month (\$)
eBay	340,000	190,000,000 (18,000,000)
Yahoo!	88,000	19,000,000 (7,900,000)
Amazon	10,000	2,000,000 (620,000)

^a We computed these estimates by choosing a day in June or July to visit each site, observing the number of auctions closing that day, and taking a sample of closed auctions to estimate the average revenue per auction closing. Sample sizes were 1232 auctions at eBay, 259 auctions at Yahoo!, and 241 auctions at Amazon. (At Amazon and Yahoo!, we obtained simple random samples of goods, while at eBay we took a stratified sample over 12 different categories, computing weighted averages instead of simple averages). To compute monthly revenues from daily estimates, we multiplied by 30. Standard errors are based on sampling variation in the revenues per auction listing. We did not make a formal estimate of the sampling error in the number of auctions closing per day, because it was too difficult to obtain separate estimates on a large sample of different days. On eBay, where the past 30 days' results are relatively easy to obtain, we estimated that the standard deviation of the number of auction closings per day is approximately 25% of the mean number of closings (though this was abnormally high due to an unusual eBay system outage which prevented auctions from closing on June 10–11, 1999.)

companies boasted millions of regular users at their existing sites, and sought to leverage their user bases to create marketplaces large enough to benefit from network effects already enjoyed by eBay.⁵⁵ Amazon and Yahoo! entered the auction industry too late to be part of our original autumn 1998 survey, but this competition has generated so much attention that we performed an updated survey of these three large auction sites: eBay, Yahoo!, and Amazon.

To produce updated volume estimates for summer 1999, we sampled hundreds of auction listings at each of the three sites. The results can be found in Table IV. In terms of revenues, eBay remained 100 times as large as Amazon and 10 times as large as Yahoo!. Both of the new sites quickly grew large enough to make the list of the ten largest auction sites on the Internet, but in the meantime eBay's size more than doubled.

The two newcomers closely resembled eBay, with similar categories of goods, similar fixed-length English auction bidding rules, and similar auction-listing procedures. All three sites offered proxy bidding, but differed in their treatment of the end of the auction: Amazon featured a 10-minute extension period after the last bidding activity, Yahoo! gave the

⁵⁵ Competition between auctioneers has generated recent interest by auction theorists (see, for example, Lu and McAfee [1998]). However, the auction-theory literature has not addressed the question of network externalities in competing auction exchanges.

seller the option to choose a 5-minute extension period or a hard close time, and eBay continued to use a hard close. Another difference is that eBay generally gave the user more options for searching through the auction data, such as the option of browsing through any auction which closed in the past 30 days. A third difference was in fee structure. Amazon and eBay charged sellers both a listing fee and a percentage commission, while Yahoo! charged no fees at all (presumably a strategy designed to increase auction traffic and generate additional advertising revenue for the site).⁵⁶

This difference in fees appears to have an important effect on sellers' incentives and behavior. With fees (even small ones) for auction listings, a seller has more incentive to make sure that her auction results in an actual transaction. Indeed, a quick check revealed that most Yahoo! auctions had very high minimum bids or reserve prices, with the sellers apparently hoping for someone to come along and be willing to pay their high price. By contrast, at eBay and Amazon, sellers knew that they would incur a listing fee whether the item sold or not, so they had an incentive to set reasonably low reserve prices to increase the probability of an actual transaction. Our summer 1999 data confirm the existence of this effect: eBay had 54% of all auctions result in a sale, Amazon's fraction was 38%, while Yahoo!'s fraction was only 16%. With five-sixths of its auctions failing to receive any acceptable bids, Yahoo! had a significantly⁵⁷ lower auction transaction rate than either eBay or Amazon.

It seemed puzzling at first that Amazon's transaction rate was also lower than eBay's, but the reason may be a special 'SummerDime' promotion run by Amazon. During summer 1999, Amazon's listing fees were only \$0.10 per auction, instead of their regular rates (matching eBay's) of \$0.25 to \$2.00 per listing. So incentives may be working in the predicted direction: the higher the listing fee, the more careful sellers are to design an auction listing which actually results in a transaction.⁵⁸

⁵⁶ Yahoo! also has an automatic relisting option, so that if a seller's auction fails to have any bids, the seller can have that same auction renewed again for an additional week (or however many days the seller originally chose for the auction), and a seller can do this indefinitely. By contrast, both eBay and Amazon allow only one 'second chance' to the seller: one free relisting for an item which didn't sell (with the original listing fee having already been paid).

⁵⁷ The difference is statistically as well as economically significant. With the sample sizes obtained in this study, the *p*-values for comparisons of Yahoo! to the other two sites are both less than 10^{-6} .

⁵⁸ Additional research would help to pin down this interpretation. For example, might it be possible to establish quantitatively that minimum bids and reserve prices are higher at the sites with lower fees, for similar goods? And if Amazon returns to an eBay-style fee schedule, will its transaction rate rise to match eBay's?

XV. CONCLUSION

Auctions on the Internet represent one of the most interesting developments in electronic commerce. In this paper, I have attempted to present an economist's guide to Internet auctions, based primarily on a comprehensive survey of Internet auctions as they appeared in autumn 1998. The volume of transactions (approximately \$1 billion per) was impressive, especially for an industry with such a brief history. Equally impressive is the diversity of goods auctioned.

I have focused particular attention on the details of online auction mechanisms, trying to point out the relationships between the auction methods used on the Internet and the existing body of auction theory literature. Most Internet auctions are English ascending auctions, but there are also examples of sealed-bid and Dutch declining-price auctions online. In addition to several true Vickrey (second-price sealed-bid) auctions, many of the English auctions employ proxy-bidding systems that make them resemble Vickrey sealed-bid auctions. Quite a few sites conduct auctions for multiple identical units, and these might be able to benefit from recent developments in multi-unit auction theory. Minimum bids and reserve prices in Internet auctions provide interesting fodder for empirical research, while buyout prices represent a feature not yet tackled by auction theory. I have discussed the institutional features designed to promote trust in transactions between agents who are unknown to each other. I have also presented examples of strategies (shilling, bid shielding) used by Internet auction participants to manipulate the results of the auctions, since mechanism design may have a role to play in solving such practical problems for auctioneers.

For the most part, this survey turned up auctions oriented towards individual consumers. Since the completion of the survey, there has been a great deal of excitement about business-to-business (B2B) online auctions, with a number of announcements of new companies intending to run such auctions in markets ranging from aircraft parts to cattle embryos to advertising services.⁵⁹

Competition between auctioneers on the Internet is made particularly interesting by the possible presence of network effects: sellers tend to prefer to auction items at the site visited by the most bidders, and vice versa. To examine the most important example of competition between Internet auctioneers, I have presented detailed data on the three largest general-purpose auction sites: eBay, Yahoo!, and Amazon. In July 1999,

⁵⁹ See, for example, firms called Inventory Locator Service, Farms.com, and AdAuction.com, respectively. FreeMarkets Online was an early entrant in B2B auctions, having conducted \$1 billion in procurement auctions in 1998 for industrial and government buyers of various industrial supplies. Freemarkets' auctions take place using proprietary Internet software, however, not over the World Wide Web. See FreeMarkets Online [1999].

eBay remained ten times larger than Yahoo! and one hundred times larger than Amazon. The most interesting empirical finding indicated that sellers at the sites may respond to incentives provided by the auctioneers' fee structures: sellers appear more serious about selling where listing fees are imposed.

ACCEPTED MAY 2000

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