Field Experiments on the Effects of Reserve Prices in Auctions: More Magic on the Internet

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Abstract

This paper presents experimental evidence on the effects of minimum bids in first-price, sealed-bid auctions. The auction experiments manipulated the minimum bids in a preexisting market on the Internet for collectible trading cards from the game *Magic: the Gathering*. They yielded data on a number of economic outcomes, including the number of participating bidders, the probability of sale, the levels of individual bids, and the auctioneer's revenues. The benchmark theoretical model tested here is the classic auction model described by Riley and Samuelson (1981), with symmetric, risk-neutral bidders with independent private values. The data verify a number of the predictions of the theory. A particularly interesting result shows that many bidders behave strategically, anticipating the effects of the reserve price on others' bids.

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1 Introduction

There has been considerable theoretical work on the effects of minimum bids (or reserve prices) in auctions, but the empirical literature on auctions has so far failed to test any of this theory. This paper represents a first attempt to fill this gap. I report experimental tests of the theory of reserve prices in first-price, sealed-bid auctions, using a methodological innovation: the ability to run "field experiments" in a preexisting market. The experimental data verify the basic predictions of the theoretical model developed by Vickrey (1961) and extended by Riley and Samuelson (1981). In particular, the bidders exhibit sophisticated strategic reactions to changes in reserve prices, as predicted by the theory. In addition, I present empirical results on the relationship between the mean revenues and the minimum-bid level.

Empirical studies of auctions can be divided into two distinct groups: laboratory experiments and field-data studies. Dozens of laboratory experiments have tested different predictions of auction theory; for a comprehensive review, see Kagel (1995). Empirical work using field data, such as that from government auctions for offshore oil rights, has been more limited in its ability to test theory, because of data restrictions. Hendricks and Paarsch (1995) provide an excellent summary of this literature. The present study's methodology is a hybrid between that of the laboratory and that of traditional field research; hence the term "field experiment." In Lucking-Reiley (1999), I used a similar methodology to test predicted equivalences between auction formats.

To my knowledge, this is the first empirical study, from either the laboratory or the field, to measure the effects of minimum bid levels.[1] I find confirmation of several basic predictions of auc-

[1] Earlier papers by McAfee, Quan, and Vincent (1995) and by Paarsch (1997) concern themselves with reserve prices, and both contain empirical work (one on real estate auctions, and the other on timber auctions). These papers both make normative predictions, using data on empirical auction outcomes in order to predict optimal reserve prices for the auctioneer. By contrast, my paper investigates a positive question: do reserve prices result in the effects predicted by theory?

tion theory: increasing the reserve price decreases the number of bids received and the probability of selling the good, and increases auction revenue for goods which are actually sold. Perhaps most interesting is the result that that bidders react strategically to the existence of reserve prices, just as predicted by Bayesian Nash equilibrium theory.

The paper is organized as follows. Section 2 reviews the empirically testable implications of the theory of reserve prices in auctions, based mainly on Riley and Samuelson (1981). Section 3 describes the history and institutional details of the marketplace where these field experiments took place. Section 4 describes in detail the two experimental designs used in this study, along with a demographic description of the experimental subjects. Section 5 describes the results of the experiments, and the paper concludes with a brief summary and suggestions for future research.

2 Theoretical Background

There is a large theoretical literature on reserve prices in auctions (see Wilson (1992) and McAfee and McMillan (1987a)), but little of it focuses on empirically testable predictions. In this section, I review the testable implications of the earliest and simplest model of auctions, due to Vickrey (1961), which assumes independent private values (IPV)[2] and an exogenous number of bidders.[3] I do this because of the simplicity of the model, for which the implications of reserve prices were first considered in detail by Riley and Samuelson (1981). Although more general models are available, I focus on this classic model as a first step in the empirical investigation of the effects of re-

[2] Many recent theories of auctions have focused on the more general affiliated-values model proposed by Milgrom and Weber (1982), where individuals' values for the good may be privately uncertain, with signals of uncertain value that are correlated among bidders. For a theory of reserve prices in an auction with affiliated values, see Levin and Smith (1996).

[3] Samuelson (1985), Levin and Smith (1996), and McAfee, Quan, and Vincent (1995) present models of auctioneers' reserve prices in auctions with an endogenous number of bidders. In such models, bidding is costly, and therefore bidders must decide whether or not to participate. Lucking-Reiley (1999b) uses experimental data to examine the assumptions of such models.

serve prices, to examine the basic model's predictive power. Future studies may be able to determine under what circumstances, if any, more complicated models manage to perform better than the simple one.

In the model of Riley and Samuelson (1981), the effects of reserve prices are relatively straightforward. Setting an optimal reserve price allows the auctioneer to use his bargaining power to extract a bit of additional profit from the highest bidder, above and beyond the profits which would result merely from competition between bidders. In effect, a minimum bid represents a take-it-or-leave-it offer from the auctioneer to the highest bidder.[4]

If N bidders' valuations are drawn independently from a distribution function with CDF $F(v)$, and if the auctioneer holds a first-price, sealed-bid auction with reserve price r, then the Bayesian Nash equilibrium to the bidding game involves each bidder submitting a bid according to the following bid function:

$$b(v;r) = \begin{cases} v - \frac{1}{F(v)^{N-1}}\int_r^v F(u)^{N-1}du & v \geq r \\ 0, & v < r \end{cases} \tag{1}$$

We can also consider the impact of the reserve price r on the auctioneer's revenue.[5] The expected revenue $R(r)$ to the auctioneer is equal to the expected value of the bid of the bidder with

[4] In some auctions, instead of announcing a minimum bid from the beginning, the auctioneer may instead use an implicit, or secret, reserve price. In such cases, the highest bidder still wins the item only if he exceeds the amount of the reserve, though he does not know in advance what this reserve price is.

[5] I focus on revenues instead of auctioneer *profits*, which are identical to revenues only in the case where the auctioneer has zero salvage value for the goods. Although profits are more meaningful to an auctioneer, I focus instead on revenues because of their easy measurability. Computing expected profits would require me to estimate my own salvage value for the goods, which is hard to do in an objective manner.

the highest valuation for the good. Riley and Samuelson (1981) derived the following expression for this quantity:

$$R(r) = \int_r^\infty b(v;r) \; N \; F(v)^{N-1} f(v) dv = N \int_r^\infty [vF'(v) + F(v) - 1] F(v)^{N-1} dv \qquad (2)$$

For example, suppose that bidders' valuations are distributed according to a uniform distribution on [0,1]. Then the bid function is:

$$b(v;r) = \begin{cases} \frac{N-1}{N} v + \frac{r^N}{N v^{N-1}}, & v \geq r \\ 0, & v < r \end{cases} \qquad (3)$$

Figure 1 illustrates this function for the cases N=2 and N=5. In each case, two lines are displayed: one for an absolute auction (that is, r=0), and one for an auction with reserve price r=0.5. With zero reserve, the bid function is linear with slope equal to $(N-1)/N$, increasing in the number of bidders. With reserve price r>0, a bidder submits no bid unless his value v exceeds r, in which case he bids on a nonlinear curve whose slope is again increasing in the number of bidders. Furthermore, this curve lies above the zero-reserve bid function for all valuations $v \geq r$.

The auctioneer's expected revenue, from equation 2, is given by:

$$R(r) = \frac{N-1}{N+1} + \left(1 - \frac{2N}{N+1} r\right) r^N \qquad (4)$$

Figure 2 illustrates the expected revenue function $R(r)$ for the cases N=2 and N=5.[6] Each curve increases to a maximum at r=0.5, and then falls off rapidly. The optimal reserve price r=0.5 is independent of the number of bidders.[7] Each curve begins flat at r=0, as $R'(0) = 0$ for all N,[8] and

[6] For the case N=5, the expected revenue varies only slightly in r. To illustrate the optimum, the figure includes a close-up of the N=5 curve over a very small segment of the vertical axis.

remains flat longer when the number of bidders is larger. (The N=2 curve begins to increase much earlier than does the N=5 curve, which is peaked only locally around r=0.5.) Furthermore, the gains to setting an optimal reserve price become very small as N increases. As the reserve price increases from zero to its optimal value, auction revenue increases by 25 percent when N=2, but only by 0.78 percent when N=5. Intuitively, as N increases beyond 2, competition between bidders creates high rent extraction for the auctioneer, which begins to swamp the revenue effect of the reserve price.

As a second example, I consider bidder valuations drawn independently from an exponential distribution with parameter β=1. This example is interesting because, unlike the uniform distribution, the exponential distribution has no upper bound on valuations. Figure 3 displays the bid functions for both N=2 and N=5, for the cases r=0 and r=1. Figure 4 displays the revenue curve $R(r)$ for both N=2 and N=5. The exponential example is similar to the uniform example in several respects. Again, the presence of a positive reserve price screens out bidders whose valuations lie below the reserve price, but strictly increases the bids of bidders whose valuations lie above the reserve price. The expected-revenue curve increases to its maximum at r=1, an optimal reserve in-

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[7] The fact that the optimal reserve level is independent of the number of bidders turns out to be a general result of the IPV model, for any value distribution $F(v)$, as proven by Riley and Samuelson (1981). The result follows directly from differentiating equation 2 with respect to r, using Leibniz' rule:

$$\frac{dR}{dr} = N \quad F(r)^{N-1}[1 - F(r) - r \quad f(r)] \quad .$$

Setting this expression equal to zero yields an expression for the optimal reserve price that is independent of the number of bidders. This may or may not be a global optimum, depending on the distribution of values $F(v)$. The revenue curve has a unique optimum if and only if the equation $vF'(v) + F(v) - 1 = 0$ has only one root. This is satisfied for any distribution with a monotone hazard rate, which is a condition often assumed for convenience by theorists.

[8] This result is not unique to the assumption of a uniform distribution of bidder valuations. Although I have not seen it proved previously, it is a general result of the independent-private-values model. The only assumption required is that there must not be a mass point at zero in the probability distribution of valuations: $F(0)$=0. Taking the equation in footnote 8 and evaulating it at r=0, one obtains:

$$\frac{dR}{dr} = N \quad F(0)^{N-1}[1 - F(0)] \, .$$

Therefore, $\frac{dR}{dr} \geq 0$ at r=0, and so long as $F(0)$ is not equal to zero or one, the inequality is strict.

dependent of the number of bidders, and falls off more rapidly to the right of the maximum. The curve begins flat at r=0. Finally, the gains to setting an optimal reserve price fall off rapidly with larger N, from 33.6 percent at N=2 to 1.9 percent at N=5.

There are also a few differences between the two examples. First, the decline in expected evenue beyond the optimal reserve price is more gradual in the case of the exponential distribution, which has an infinite support and therefore some nonzero probability of sale no matter how large the reserve price. By contrast, with the uniform distribution the expected revenue must go to zero at r=1, because there is zero probability that any bidder will value the good at $v \geq 1$. Second, the gains to be had with an optimal reserve price are more substantial (in percentage terms) under the exponential distribution, and do not dissipate quite so quickly with increased N.

Having illustrated the model with some examples, I now summarize its general predictions about the effects of a reserve price. The most basic predictions are that increasing the reserve price should (1) reduce the number of bidders who submit bids, by screening out those bidders with low valuations, (2) reduce the probability of the good's being sold, and (3) increase the revenue earned on a good, conditional on its being sold. A fourth, more subtle prediction depends on the presence of strategic behavior by bidders: that $b(v;r+\Delta r) > b(v;r)$ for all $v>r+\Delta r$, or that an increase in the reserve price will cause a strict increase in the bid for a given bidder. We see this in figures 1 and 3, where the dotted line (positive reserve price) is strictly above the solid line (zero reserve price) for all valuations above the reserve. Intuitively, in Bayesian Nash equilibrium a bidder realizes that an increase in the reserve price will increase the bids of the other bidders who choose to remain in the auction, and therefore will increase his own optimal bid level as well. Fifth, the auctioneer's revenue curve should be flat at r=0,[9] and either flat or positively sloped for all reserve prices r less

[9] Footnote 8 shows that this is true unless there is a mass point of bidders with zero valuation, which seems unlikely. A person who values the good at zero, should probably not be considered one of the N potential bidders.

than the optimal reserve price.[10] Finally, the examples show that we might expect the revenue curve to be more steeply sloped to the right of the optimal reserve than it is to the left of the optimal reserve, as expected revenues fall off sharply with the reduced probability of sale.

3 Institutional Background

My experiments involve auctions of collectible cards from the game *Magic: the Gathering*, a game whose retail success is a story in itself.[11] This product grossed hundreds of millions of retail dollars and boasted over a million players worldwide within three years of its introduction in 1993. The game features well over a thousand distinct types of cards, each of which plays a slightly different role, sold in random assortments at a variety of retail stores.

Well before the popularity of the World Wide Web and of auction sites such as eBay,[12] an online marketplace had already developed for *Magic* cards. Initially, *Magic* players developed the Internet newsgroup <rec.games.deckmaster> to discuss game play and strategies. Buy, sell, and trade offers for individual cards soon appeared there, with individuals agreeing to terms of trade via email, and cards delivered via postal mail. Messages devoted to economic trades soon overwhelmed the discussion, so within a few months a second newsgroup was dedicated exclusively to the trading of these cards. In the spring of 1995, the marketplace newsgroup had nearly 6,000 messages posted each week, making it the highest-volume newsgroup on the entire Internet.[13]

Some individuals posted lists of cards they were willing to trade, along with "wish lists" of cards they would be willing to accept in return, and solicited responses by private electronic mail.

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[10] This assumes that the distribution of values is such that the expected-revenue function has a unique local maximum, a condition often assumed for convenience by auction theorists.

[11] This retail success has since been eclipsed by a newer product from the same manufacturer, Wizards of the Coast. Readers with children will likely recognize the Pokémon trading-card game, introduced in early 1999.

[12] See Lucking-Reiley (2000) for a survey of various online-auction Web sites.

[13] Source: *Top 40 Newsgroups in Order by Traffic Volume*, April 1995.

Others post fixed prices at which they are willing to sell cards for cash. Many sellers conducted auctions of their unwanted cards, using a variety of different auction mechanisms. Most auctions were English ascending-bid auctions, but Dutch and first-price auctions could also be found. Some auctioneers specified nonzero minimum bids, while others did not.

This marketplace represented a real-world laboratory for the testing of auction theory. Laboratory experiments, which to date have provided the majority of data on bidders' behavior in auctions, have occasionally been criticized on the grounds that subjects' behavior in an artificial laboratory environment may not be exactly the same as their behavior would be in the “real world.” The *Magic* card market provided the opportunity to run controlled experimental auctions in the field rather than in the laboratory.[14] Since in any given week there were dozens of auctioneers holding *Magic* auctions on the Internet, an experimenter could be a “small player” who did not significantly perturb the overall market.[15]

One of the strengths of this study is its subject pool. The bidders in these experiments had diverse demographic backgrounds,[16] but shared an intense interest in the auctioned items, making them representative subjects for a test of auction theory. Indeed, the trading of *Magic* cards has become just as enthralling an activity for some people as the actual playing of the game, in part because enjoyment of the game depends critically on the composition of one’s deck. A player will

[14] Of course, this also meant giving up some of the useful controls of the laboratory environment. For example, I could not observe the bidders’ valuations or ensure common knowledge of the number of bidders or the distribution of values. In a field experiment, one cannot verify many of the underlying assumptions of a theory; instead one checks whether the predictions of the theory hold true in a messy, real-world environment.

[15] This technique of running field experiments can also have a financial advantage over traditional laboratory techniques. Since real people actually demand the goods being auctioned in the experiments, the experimenter need not pay the traditional monetary inducement to get subjects to participate. A typical laboratory experiment might cost $2000 in payments to 40 or 50 subjects. By contrast, the within-card experiments described below involved purchasing cards for about $1600 and selling them for about $2000, realizing a $400 gross profit. (Profits on the between-card experiments are difficult to calculate, because they involved selling only portions of larger sets of cards I purchased.)

[16] For more detailed demographic information about the bidders, see my doctoral dissertation (Reiley (1996), available on request). The bidders, from all over the United States and several foreign countries, included college students, professional engineers, government employees, and military personnel.

typically own several different decks, each of which has been designed for specific game strategies. Many *Magic* enthusiasts also collect the cards as one might collect baseball cards, so a particular card might fine-tune one player's deck, or complete part of another player's collection. Scarcity is one major determinant of transaction prices for cards, as some cards have been designated "rare" (versus merely "uncommon" or "common"), and some cards were printed in limited editions. This research project used only limited-edition cards.

One trader wrote an automated computer program to search the marketplace newsgroup for each instance of each card name (with some tolerance for misspellings) and gather data on the prices posted next to each card name in the newsgroup messages. It was designed to compute trimmed means, standard deviations, quantiles, and so on, automatically placing these data on the Internet for interested parties to read. The Cloister price list, as it became known, was recomputed each week, with each week's list archived for public use. Each card's price on the list represents the trimmed mean of hundreds (or thousands) of individual observations. Such observations may have come from auctions in progress (perhaps with low opening prices), from consummated trades, or from advertised prices too high to actually result in trades. Despite the variability of the underlying observations, a number of people found the trimmed-mean Cloister prices to be a reliable measure of card value: I frequently observed traders using the Cloister list as their standard price reference.[17] I make considerable use of these Cloister prices in this paper.

[17] It is commonly believed that the existence of potential resale value (as is the case with *Magic* cards) automatically implies that bidder valuations have a common-value component, rather than having independent private values (IPV). However, recent theoretical work by Haile (1999) formally demonstrates that this need not be the case. Furthermore, many of the bidders in Magic card auctions are primarily interested in the cards for their own use, rather than for resale value. Some individuals will have intense intrinsic desires for specific cards, wanting them for a specific deck strategy or a particular collection. Cards are available for sale at a variety of sources (friends, card stores, Internet auctions, etc.), with considerable price dispersion across sellers. Because people have different access to information on card prices, and different values for the amount of time it takes to search for a bargain, we might realistically expect the effective valuation for the good, a "valuation net of search cost," to vary from bidder to bidder. For these reasons, the IPV model seems a plausible approximation to the truth.

4 Experimental Procedure

Two distinct experimental designs are used in this paper. The first examines the effects of a binary variable: whether or not minimum bids were used. By auctioning the same cards twice, once with and once without minimum bids, the design exploits within-card variation to find the effects of the treatment variable on bidding behavior. The second design investigates the effects of a continuous variable: the reserve price level (expressed as a fraction of the Cloister reference price). The across-card variation provides information that can be used to test predictions about the shape of the revenue curve $R(r)$ as a function of the reserve price level.

4.1 Within-Card Experiments

The first part of the data collection consisted of two pairs of auctions. Each of the four auctions was a sealed-bid, first-price auction of several dozen individual *Magic* cards. This simultaneous auction of many different goods at once, although not common in other economic environments,[18] was the norm for *Magic* card auctions on the Internet. Running auctions in this simultaneous-auction format thus made the experiment as realistic and natural as possible for the bidders, who saw many other similar auctions in the Internet marketplace for cards.

Each auction lasted one week, from the time the auction was announced to the deadline by which all bids had to be received. I announced each auction to potential bidders via two channels. First, I posted three announcements to the appropriate Internet newsgroup. For each auction, I posted a total of three newsgroup messages spaced evenly over the course of the week of the auction. Second, I solicited some bidders directly via email messages to their personal electronic mail-

[18] Although simultaneous auctions are not traditional for familiar auctions, such as those of art, estate goods, or tulip bulbs, such formats have been used for timber and offshore oil auctions. The advent of computerized bidding appear to be making the simultaneous auction format even more common. In addition to the card auctions (and auctions for other goods) taking place on the Internet, a simultaneous-auction format was used for the recent FCC auctions of spectrum rights. See McMillan (1994) for details.

boxes. My mailing list for direct solicitation was comprised of people who had already demonstrated their interest in participating in auctions for *Magic* cards by participation in previous ones.

The paired-auction experiment proceeded as follows. First, I held a zero-minimum-bid auction for 86 different cards (one of each card in the Antiquities expansion set). The subject line of the announcement read "Reiley's Auction #4: ANTIQUITIES, 5 Cent Minimum, Free Shipping!" so that potential bidders might be attracted by the unusually low (essentially zero) minimum bid per card.[19] After the one-week deadline for submitting bids had passed, I identified the highest bid on each card. To each bidder who had won one or more cards, I emailed a bill for the total amount owed.[20] After receiving a winner's payment via check or money order, I mailed them their cards.[21]

I also emailed a list of the winning bids to each bidder who had participated in the auction, whether or not they had won cards, as an attempt to maintain my reputation as a credible auctioneer. I did not give the bidders any explicit information about the number of people who had participated in the auction, or about the number of people who had received email invitations to participate.[22]

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[19] A 5-cent minimum is effectively no minimum, since the auction rules required all bids to be in integer multiples of a nickel.

[20] Although the standard practice in this marketplace is for auctioneers and other card sellers to charge buyers for postage and/or handling, I did not do so. I wanted bidders to bid independently, as much as possible, on each of the cards in which they were interested. Someone seriously interested in one card might decide to bid higher on a second card in the same auction than they would if the cards were auctioned independently, in order to spread out the postage costs per card by purchasing more than one card simultaneously from the same source. In addition, some of the cards I auctioned had rather low values, and I wanted to avoid having the card values be swamped by the cost of shipping. For example, if a bidder won a single card for 20 cents and then had to pay a fixed 50-cent shipping charge on top of that, the amount of useful information which could be derived from her bid would be rather suspect. Therefore, in the interests of keeping bid data as clean as possible, I decided to pay postage costs myself, and announced in advance that first-class shipping was included in the amount of each bid.

[21] A small number of winning bidders failed to pay for the cards they had won. In all, I received payment for 90 percent of the cards sold, constituting 89 percent of the reported revenue in the within-card auctions. Almost all of the "deadbeat" bidders were those who won only a single card, and who explained that they had originally hoped to win more cards, and didn't feel it was worth it to complete the transaction. I discouraged such behavior, but was unable to eliminate it. Out of 170 winning bidders in the eight auctions, only eight individuals won multiple cards but failed to pay for them. Since none of the unpaid cards seemed to have outlandishly high winning bid amounts, I have adopted the belief that all bids were made in good faith, and have therefore not excluded any observations from the analysis.

[22] See Reiley (1996) for more details on the demographics of the bidders and the numbers of cards won by each bidder in the auctions.

After one additional week of buffer time after the end of the first auction, I ran the second auction in the paired experiment, this time with reasonably high minimum bid levels on each of the same 86 cards as before. The minimum bid levels were determined by consulting the standard (trimmed-mean) Cloister price list of *Magic* cards cited in section 3 of this paper, and setting the minimum bid level for each card equal to 90 percent of that card's price-list value.

This contrast in minimum bid levels (zero versus 90 percent of the Cloister price list) was the key difference between the two auctions.[23] By keeping other conditions identical between the two auctions, I attempted to isolate the effects of minimum bids on potential bidders' behavior. One condition that could not be kept identical, unfortunately, was the time period during which the auction took place. Because the two auctions took place two weeks apart, there were potential differences between them that might have affected bidder behavior. First, the demands for the cards (or the supplies by other auctioneers) might have changed systematically over time, which is a realistic possibility in such a fast-changing market as this one.[24] Second, the results of the first auction may have affected the demand for the cards sold in the second auction.[25]

To control for such potential variations in conditions over time, I simultaneously ran the same experiment in reverse order, using a different sample of cards. This second pair of auctions each featured the 78 cards in the Arabian Nights expansion set, with minimum bids present in the first

[23] Both auctions lasted exactly seven days. The same 86 cards were up for bid in each auction. Each auction announcement was posted exactly three times to the marketplace newsgroup, and was emailed to the same list of potential bidders (except for bidders who asked to have their names removed, and did not bid in either auction). Even the subject line of the announcements and mailings was identical, except that in the second auction, the words "5 Cent Minimum" were removed.

[24] For example, certain cards from the Arabian Nights expansion set increased in value by a factor of ten during their first year out of print. It turns out that market prices for cards were actually rather stable during the month in which this experiment was conducted, but I did not know *ex ante* what was going to happen to card prices.

[25] For example, suppose that Jane Bidder is very anxious to obtain a Guardian Beast card for her deck, so that her valuation of the card is much higher than that of any of the other bidders in the experiment. She then wins the card in the first auction, and then has zero demand for that same card in the second auction, since she only really wants one copy. If this is generally the case for most cards, that the highest-value bidders in the sample are screened out in the first auction, then we might expect to see systematically lower revenues in the second auction.

auction but absent in the second. Just as before, minimum bids were set at 90 percent of the market price level from the Cloister price list. The first auction in this pair began three days after the start of the first auction in the previous pair, so that the auctions in the two experiments overlapped in time but were offset by three days. I used a larger mailing list for my email announcement in this pair of auctions (232 people) than I had for the previous pair of auctions (50 people), with the first mailing list being a subset of the second mailing list.[26] Also, the Arabian Nights cards in the second pair (median reserve price $8.36) were more valuable than the Antiquities cards used in the first pair (median reserve price $4.41). Otherwise, all other conditions were identical between the two pairs of auctions. A sample auction announcement is displayed in the Appendix.

Table 1 reports summary statistics for each of the four auctions in the within-card experiments.[27] For ease of reference, I introduce two-letter mnemonics for each auction. The first letter represents the card set: A for Antiquities, B for Arabian Nights. The second letter is A for an absolute auction (reserve prices equal to zero), and R for an auction with positive reserve prices. In the table, the auctions are displayed in two pairs: first Auctions AA and AR, for the 86 Antiquities cards, and then Auctions BA and BR, for the 78 Arabian Nights cards.[28] Auctions AA and BA were "absolute auctions" (no minimum bids), while Auctions AR and BR had sizable minimums .

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[26] I added a large number of names to my mailing list between the A pair of auctions and the B pair of auctions when a new list of names became available to me; it was important to me (for both financial and experimental reasons) to maintain a large number of participating bidders. Many of the additions to my list turned out not be interested in my auctions; they were subsequently dropped from the list (see footnote 29). The number of invited bidders was not a variable of primary interest in this study.

[27] These auctions were part of a series of auctions run for a larger research program, so participating bidders saw me run several other auctions (not part of the research presented here) during this same time period. This had two advantages. First, it helped avoid drawing bidders' attention to the point of my research. (For example, during this time period I also ran an English auction, a second-price auction, and another first-price auction, with different sets of cards.) I feared that if they knew I was looking for the effects of reserve prices, it might distort their behavior (for example, they might consciously try to bid consistently from one auction to another). Second, it had the effect of making bidders unsure what I would do next. In particular, I didn't want bidders to expect that I would always auction the same card twice, for it might distort their behavior if they knew they would have a second chance to bid on the same card.

[28] A few of the auction items I denote as "cards" were actually groups of cards: either a sealed pack of out-of-print cards, or a set of common cards bundled together.

The table includes descriptive statistics on the number of participating bidders, the number of bids received, and the total payments received from winning bidders. Note two key points. First, "real money" was involved in the auction transactions. Of the 73 different bills I sent to winning bidders over the course of the experiment, the median payment amount for each auction was between $10 and $24. A few individual payments exceeded $100. Second, in each auction there are multiple winning bidders. The number of winning bidders in each auction ranges from 6 to 27, and the fraction of bidders who win at least one card is between 40 percent and 86 percent. In each auction, the median number of cards won by each winner is between 2 and 3.5, while the maximum number of cards won by a single bidder ranges from 12 to 26. Except in Auction AR, no winner won more than 29 percent of the cards sold in any single auction. (In Auction AR, participation was very low: only 7 people submitted bids, 6 of whom won at least one card, and 39 of the cards went unsold.) The biggest spender in any of the auctions won cards totalling $316.50 of the total revenue of $774.75 in Auction BA, generating 41 percent of the revenue despite winning no more than 15 percent of the cards - evidently, she was particularly interested in high-value cards. Thus, it is not the case that one person is the highest bidder on all cards in an auction, suggesting that a given bidder's valuations for different cards are at least somewhat independent. This provides some justification for the statistical results below in which each individual card bid is assumed to be an independent observation.

4.2 Between-Card Experiments

A second set of experiments was designed to examine the effects of changes in the *level* of the reserve price, rather than merely changes in the *existence* of reserve prices. Four first-price, sealed-bid auctions took place, each with a one-week timeframe for the submission of bids. Each was a simultaneous auction of 99 different items, this time with no overlap of items between auctions, and each card had a posted reserve price. Just as before, each auction was announced via three posts to the relevant newsgroup, as well as via email to a list of bidders.[29]

I set the reserve price for each card as a particular fraction of the current Cloister price of that card. In each of the first two auctions, nine cards were auctioned at a minimum bid of 10 percent of the Cloister price, nine at 20 percent, nine at 30 percent, and so on, up to a maximum of 110 percent of the Cloister price. After noticing interesting results in these two auctions both at relatively low and at relatively high reserve price levels, I decided to increase the number of such observations in these regions in the two subsequent auctions. Therefore, the third and fourth auctions auctioned equal numbers of cards at reserve levels of 10, 20, 30, 40, 50, 100, 110, 120, 130, 140, and 150 percent of the Cloister price.[30]

This variation in reserve price levels was designed to investigate how both bidder behavior and expected auction revenue would react to changes in the reserve price, and to calculate the revenue-maximizing reserve price level. Normalizing by the Cloister price, since this is a standard reference price computed in the same way for all *Magic* cards, makes cross-card comparisons feasible. Besides the exceptions noted above, all experimental protocols and bidder instructions were kept identical to those in the auctions with reserve prices described in section 4.1.

Summary statistics for the between-card auctions are given in Table 4. Reserve prices ranged from 10 percent to 150 percent of each individual card's Cloister value; the average reserve price level varied slightly from auction to auction, from 60 percent to 85 percent. Each auction had doz-

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[29] For this series of auctions, the bidder pool was larger than before. As described in footnote 26, I added new bidders to my mailing list over the course of the research program (by contrast, within any single experiment I tried to hold the potential bidder pool constant). Auction R1's announcement was emailed to 531 individuals. Because some people specifically requested to be removed from my mailing list, the total dropped to 489 individuals by the time Auction R4 began.

[30] In my haste to run these follow-up auctions, I made some errors in computing the minimum bid levels, so these numbers were not quite equal in practice. Some cards were mistakenly assigned reserve levels of 60 percent and 90 percent in these auctions, but this does not compromise the integrity of the data.

ens of bidders and hundreds of bids on individual cards. The number of people receiving email invitations to participate declined with each successive auction, but only due to recipients asking to be removed from my mailing list, so the changes in the mailing list should not have affected the number of interested participants. The data from the between-card auctions are not directly comparable to that those the within-card auctions, because the size and composition of the pool of participating bidders changed considerably during the intervening six months. Very few bidders overlapped between the two experiments; most of the bidders in the between-card experiment were new recruits. Table 4 also displays some aggregate statistics on revenue, including the total Cloister value of all the cards in each auction and the total revenue earned on cards sold. The four auctions generated revenues reasonably close to the total Cloister value of the cards, with only 13 percent of the cards going unsold.

5 Results

In the first subsection below, I consider two of the most basic predictions of the theory: whether the number or bids and the probability of sale both decline with the reserve price. In the second subsection, I examine whether a reserve price increases revenues conditional on a sale, and then consider the effects on unconditional expected revenues. Finally, I test the prediction that bidders ought to react strategically to reserve prices,anticipating the effects on their rivals bids.

5.1 Number of bids and probability of sale

In the theoretical model, higher reserve prices ought to reduce both the number of bidders and the probability of selling the item, because they screen out low-value bidders. These predictions are very basic, because they do not require bidders to act strategically; they require only that bidders participate at low reserve prices but stop participating at higher reserve prices. Note that while we would expect these predictions to be satisfied in most economic models of bidding, it is also possible to imagine the predictions being violated. For example, some bidders might choose not to bid in auctions where the reserve prices are too low, if they assume that none of the items were valuable enough to be worth bothering with. Data have not previously been available to test even these most basic predictions about reserve prices, so this is an important place to begin.

In the within-card experiment, the number of bids declined measurably with the imposition of reserve prices, as shown in Table 1. In experiment A, the imposition of nonzero minimum bids reduced the number of participating bidders from 19 to 7, and the number of individual card bids from 565 to 71. Similarly, the imposition of minimum bids in experiment B lowered the number of participating bidders from 62 to 42, and the number of submitted bids from 1583 to 238. In both cases, the qualitative results support the theory.

The probability of sale also decreased when reserve prices were imposed. As shown in Table 1, all cards were sold in the auctions without minimum bids (Auctions AA and BA). When nonzero reserve prices were imposed (Auctions AR and BR), the number of cards sold declined from 86 to 47, and from 78 to 74, respectively. The thin bidder pool in experiment A coincided with a relatively high number of unsold cards when minimum bids were imposed, in Auction AR. Thus, reserve prices decreased the probability of sale, as predicted by the theory, and this effect was greater when the number of potential bidders was small.

The between-card auctions allow me to measure how these auction outcomes vary with different levels of the reserve price. In assigning reserve prices to each of the cards up for auction, I chose some to be at 10 percent of Cloister value, some at 20 percent, and so on up to 150 percent of Cloister value. One may think of the cards as having been assigned to one of fifteen discrete "bins," each of which represents a different reserve level.[31] There are at least 16 observations in each bin, so it is possible to estimate the number of bidders and the probability of sale as a nonparametric function of the reserve price *r*, by regressing the auction outcome variable on a set of bin dummies (denoted by RESBIN1 through RESBIN15). In the absence of other regressors, this would be equivalent to computing the mean of the dependent variable in each of the fifteen bins. These regressions also include as control variables the Cloister value of each card (CLOISTER) and a set of dummy variables (R1, R2, R3, R4)[32] for the four auctions.[33] The results of the regressions are reported in Table 5. The dependent variables are NUMBIDS, the number of bids received on a given card, and SOLD, an indicator variable for whether the auction resulted in a sale or not.

The results for NUMBIDS confirm that the number of bids is a monotonically decreasing function of the reserve price level, particularly for reserve prices between 10 percent and 70 percent of Cloister value. The coefficients decline from 9.8 at a reserve price of 10 percent down to 1.0 at a reserve price of 70 percent.[34] At higher reserve-price levels, all bin coefficients have point estimates less than 1.0 and are insignificantly different from each other at the 5-percent level of significance. The slope of n(r) is negative, as predicted.[35]

The empirical probability of sale similarly is a decreasing function of the reserve-price level. The results of a least-squares linear-probability model, with SOLD as the dependent variable, are reported in Table 5.[36] The table shows that the base probability of sale is indeed decreasing in the reserve price, from 0.95 for the 10 percent reserve bin to 0.49 for the 140 percent reserve bin. The

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[31] When rounding was necessary in order to satisfy my requirement that all minimum bids be in even multiples of 5 cents, I always chose to round down to the nearest nickel. Thus, in practice the 10-percent bin contains cards whose reserve prices were less than or equal to 10 percent of Cloister value, the 20-percent bin contains cards whose reserve prices were between 10 percent and 20 percent of Cloister value, and so on.

[32] Auction dummy R4 is the omitted category in the regression results.

[33] The Cloister value is relevant if, for example, the $10 cards attract more bidder interest than the fifty-cent cards. The auction dummies are potentially relevant because of the simultaneous auction of sets of cards; for example, an auction with ten $10 cards might attract more bidders than an auction with only six $10 cards, so that the same fifty-cent card might attract more bidders if it were included in the former auction than in the latter.

[34] When CLOISTER is evaluated at its mean value, this indicates that in the base auction R4, there are an average of 10.7 bidders at reserve levels of 10 percent, and 2.1 bidders at reserve levels of 70 percent.

decline in the coefficient point estimates is not monotonic in the reserve price, but the standard errors are large enough that one cannot reject for any pairwise comparison of bins (except one[37]) the hypothesis that the larger reserve price bin has a coefficient less than or equal to the coefficient for the bin at the smaller reserve price. The coefficients on the first four bins *are* pairwise significantly greater than the coefficients on the last four bins, indicating a decline in the probability of sale as the reserve price increases.[38]

5.2 Auction revenue conditional on sale

Next, I consider the theory's prediction that reserve prices increase revenue on those goods that are actually sold,[39] beginning with the within-card experiments. Table 1 contains a row labeled "Revenue from twice-sold cards," which reports the total revenue earned on the set of cards sold in both auctions. In both experiments, the cards sold under reserve prices earned more than their matches did in the absence of reserve prices. In card set A the aggregate difference was $44.85, while in card set B it was $25.55. Examining the percentage difference between a card's revenue

[35] The Cloister value of the card also has a positive and significant coefficient, indicating that more bidder interest is generated by more expensive cards. This makes sense for a market in which the transaction cost of purchasing a $10 card is a negligibly small fraction of the card value, but where the 32-cent cost of mailing a check for a 50-cent card may discourage bidder interest. The coefficients on the auction dummies indicate that that Auctions R1 and R2 had significantly more participation than did Auctions R3 and R4. This may reflect the fact that the average reserve prices in the first two auctions were lower than in the latter two auctions. That is, bidders appear to have been more likely to bid in on a particular card set if there were more potential bargains available.

In another specification, not reported here, I added a set of interaction terms that allowed the coefficient on Cloister value to be different for each reserve-price bin level. The results were qualitatively the same as in the specification reported in Table 5, with the additional result that the Cloister value significantly influences the number of bidders only when the reserve price level is low. The interaction coefficients were positive and statistically significant (at the 5-percent level) only for RESBIN1 through RESBIN6, but insignificantly different from zero for RESBIN7 through RESBIN15. Thus, a valuable card at a low reserve price attracted more bids than does a cheap card at a low reserve price, but the same was not necessarily true at high reserve prices.

[36] In addition to the linear-probability model, I also tried a probit specification. The probit had the disadvantage that I was unable to identify a full set bin-dummy coefficients, because some of the bins contained no unsold cards and therefore their indicator variables were perfectly correlated with SOLD. Instead of including a full set of dummy variables, I included the normalized reserve-price level as a single regressor. The results were qualitatively the same as in the linear-probability model, as the reserve-price level had a coefficient significantly less than zero at the 5-percent level.

[37] The exception is bin 15, which despite having extremely high reserve prices of 150 percent of Cloister value, had a large number of sold cards (12 of 18). See the end of section 5.3 for a discussion of this anomaly.

in the reserve auction and its revenue in the absolute auction, I find its mean to be statistically significantly greater than zero for the set of twice-sold cards (t=5.4 for card set A, t=3.3 for card set B).

Additional evidence comes from the between-card experiments. Table 7 displays the results of a nonparametric (binned) regression again confirming the hypothesis that the revenue conditional on sale is an increasing function of the reserve price.[40] The dependent variable is REV2CLO, the auction revenue normalized by the Cloister value of that card; the sample is restricted to those 345 cards (out of a total of 396) whose auctions resulted in sale. The point estimates do not always increase monotonically, but the standard errors are large enough that for any pair of bins, one cannot reject the hypothesis that the bin with the larger reserve price has a larger revenue coefficient than the bin with the smaller reserve price. By contrast, one can reject each of the pairwise hypotheses that the coefficient on any one of the four largest reserve bins is less than or equal to the coefficient on any of the four smallest reserve bins. This verifies that, as predicted, a higher reserve price trades off a decreased number of bids and decreased probability of sale in exchange for higher revenues conditional on sale.

5.3 Unconditional expected auction revenue

Now I consider the effects of reserve prices on overall auction revenue, unconditional on sale. This is a topic of considerable empirical importance for auctioneers. In within-card experiment A (Antiquities cards), the minimum bids had a negative effect on revenue (see Table 1). Auction rev-

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[38] The control variables produced results qualitatively the same as in the NUMBIDS specification, though the relative standard errors are larger in the SOLD specification. CLOISTER again had a positive, statistically significant coefficient. The point estimates indicated auctions R1 and R2 yielding higher probabilities of sale than R3 and R4, but this time the difference was not statistically significant at the 5-percent level.

[39] This is another basic prediction that might be expected in other bidding models besides Nash equilibrium, but it is by no means a tautology. For example, a zero-reserve auction for a card might generate $10 in revenue, while an auction with a $5 reserve for the same card might generate only $8.

[40] The regressors are the same as those in the previous subsection. Besides the reserve-price bin dummies, the only other statistically significant regression coefficient is that for the dummy variable for Auction R1, which has a positive coefficient.

enue per card was \$3.40 without minimum bids, but only \$2.73 with minimum bids, and the difference is highly significant (t=-5.27). However, in experiment B (the Arabian Nights cards), minimum bids had a slight positive effect, causing revenue per card to rise from \$9.93 to \$10.05, which is not statistically significant (t=1.03). The inconsistency between the two experiments may be due to the ordering of the auctions. In each experiment, the revenue was higher in the first auction in the pair, suggesting that demand for the second copy of any given card may be lower than demand for the first copy. Also, more bidders were invited to experiment B than experiment A, so the result is also consistent with the theoretical prediction that reserve prices should have less of an effect on auction revenues as the number of participating bidders increases. (The difference is negative and significant with fewer invited bidders, but positive and insignificant when more invited bidders.)

The evidence overall indicates that reserve prices in the within-card experiments had some tendency to reduce auction revenues.[41] What could have caused this effect? One possible explanation is that I might have set the reserve prices suboptimally high. Since the parameters (such as the distribution of valuations) required to compute the optimal reserve price for each card were unknown to me, this is certainly possible.[42] Theoretically, when reserve prices are set too high they screen out even the highest-valuation bidder in an auction, so imposing too-high reserve prices could decrease revenue by causing many cards to go unsold. This could account for the lower experimental revenue raised in the presence of reserve prices. On the other hand, I tried to choose my reserve

[41] The two t-statistics reported in the previous paragraph are independent standard-normal random variables, so their sum is a normal random variable with mean zero and variance 2. Therefore, to test the joint null hypothesis that revenues are equal across auction formats, an appropriate standard-normal test statistic is the sum of the two t-statistics divided by the square root of 2. That aggregate test statistic is t=-2.99 in this case, indicating that reserve prices had a statistically significantly negative effect on revenues.

[42] After spending months observing this market environment and after running auctions myself, it is hard for me to imagine how an auctioneer in a real-word environment could ever have enough information to choose precisely the optimal reserve price.

prices to be similar in level to those used by other auctioneers in this market, which casts some doubt on the explanation that my reserve prices were too high.[43]

The between-card experiments allow me to trace out the entire shape of the expected-revenue curve, rather than merely sampling it in two places. I regress the normalized revenue per card, REV2CLO, on the reserve-price bin dummies and the control variables used previously. The results are reported in Table 7. The major features of the results are that the expected revenue starts at approximately 80 percent of Cloister value for low (20 to 50 percent) reserve price levels, increases to approximately 100 percent of Cloister value for intermediate (80 to 110 percent) reserve price levels, and then declines back down to approximately 90 percent of Cloister value for very high (120 to 140 percent) reserve price levels. The additional control variables (Cloister value, auction dummies) all turn out to be statistically insignificant.[44] The empirical expected revenue curve, $R(r)$, as given by the reserve-price-bin regression coefficients, is plotted in Figure 8, with error bars representing the standard errors of the coefficients. The mean normalized revenue per card is statistically significantly higher in the middle of the curve, for cards with reserves of 80 to 110 percent (118 observations), than for cards at the left of the curve, with reserves of 10 to 50 percent (166 observations, t=3.13), and not quite significantly higher than for cards at reserves of 120 to 150 percent, at the right of the curve (72 observations, t=1.80).

How does this curve compare with the revenue curve predicted by the theory? It is difficult to test the general theory here, because the shape of the revenue curve depends on the shape of the value distribution $F(v)$, which is unobserved in the experiment.[45] For example, a multimodal distribution $F(v)$ can lead to a revenue curve with more than one local optimum. Since auction theo-

[43] Some auctioneers chose to run absolute auctions, with zero minimum bid, but those auctions with nonzero minimum bids tended to be around 90 percent of Cloister value on average.

[44] An additional specification, not reported here, also included a set of interaction terms between the reserve-bin dummies and the Cloister price, but none of these coefficients proved to be statistically significant, nor did they affect the other qualitative results of the regression.

rists sometimes assume a monotone hazard rate condition on F(*v*) for convenience, we can check that assumption by asking whether revenue curve is nondecreasing for all reserve prices less than the optimal one (just as in the examples plotted in Figures 2 and 4). The data suggest that this prediction may be violated, as the point estimates of expected revenue actually *decline* from reserve prices of 10 percent to reserve prices of 40 percent. However, this decline is not statistically significant; one cannot reject the hypothesis that the revenue curve is flat over the first four bins (F=1.02). Still, the downward slope indicated by the point estimates is intriguing; additional data would be useful. Perhaps very low reserve prices might attract more participation (relative to moderate reserve prices) even by high-value bidders, which would translate into increased revenues.[46]

Note that at a reserve level of 150 percent of Cloister price, the mean revenues are very high: a normalized revenue value of 1.17, compared with a value of 0.81 at a reserve price of 140 percent. (At a reserve price of 150 percent, only 6 of 18 cards went unsold, compared with 9 of 16 cards at 140 percent.) This would indicate that the revenue curve R(r) has two local maxima, and that the optimal reserve price is actually at 150 percent or more of the Cloister value. However, this difference is not statistically significant at the 5-percent level. Post-experiment interviews revealed that

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[45] A laboratory experiment would obviously result in a cleaner test, because it could control the distribution of bidder values. The point of this field experiment is not to do a formal test, but to explore the empirical revenue curve for an unknown real-world distribution of values. Though different cards might well have very different value distributions, this empirical exercise is to look for the optimal reserve price as a fraction of book value, on average for these cards.

[46] In Riley and Samuelson, the number of potential bidders is fixed at some exogenous number *N*, and the reserve price reduces the number of actual bidders only by screening out the low-valuation bidders who wouldn't have contributed much to auction revenue anyway. But perhaps minimum bids also have some probability of eliminating even high-valuation bidders, at the time of the bidder's entry decision (the decision of whether or not to prepare a bid at all). This idea can be found in more recent models with endogenous entry of bidders, such as those of Engelbrecht-Wiggans (1987, 1992) and McAfee and McMillan (1987b). In such a model, eliminating minimum bids altogether could conceivably be a profit-maximizing strategy for the auctioneer (particularly if his outside option value for the good is low). A no-minimum strategy would, of course, open up the possibility for losses on some goods, but if an auction is advertised as having zero minimum bids, then it may induce more bidders to participate. Thus, although a few items may end up being sold at very low prices, they mmight serve as "loss leaders," similar to the goods advertised at deep discounts by supermarkets, enabling the auctioneer to collect higher revenues overall. Though I have no definitive empirical evidence, I see it as an interesting possibility for future research.

at least one bidder used the minimum bid levels as approximate signals of the cards' value; this could explain why cards continued to sell even at such high reserve prices. It would be interesting to know whether some bidders consistently behave in this manner, in violation the standard theory of rational bidding.

5.4 Strategic bidding behavior

The most interesting results of this paper concern the levels of individual bids. Recall that in the theoretical model, $\frac{\partial b}{\partial r} > 0$ for a bidder with v>r. This implies that if a bidder's valuation is high enough to induce him to participate in both auctions for the same card, he will (for strategic reasons) bid strictly higher in the auction with the higher reserve price. This prediction is borne out in the bid data reported in Figures 5 and 6, which show the distributions of the bid amounts received in the four within-card auction treatments. One can see that imposing reserve prices does not raise bid levels merely *to* the level of the reserve, but rather *above* the level of the reserve, just as predicted. Imposing reserve prices at the 90 percent level consistently increases the number of bids placed at levels of 100, 110, 120, and even 130 percent of Cloister value.

A more quantitative look at these data appears in Table 3. A total of 2,457 individual bids were placed on the cards in the four auctions. Of these, 2,148 occurred in the no-minimum auctions; 309 occurred in the auctions with reserve prices. Although the total number of bids was lower in the presence of reserve prices, the number of bids exceeding 90 percent of Cloister value was *greater* in the presence of reserve prices. Reserve prices appear to have caused some bidders to increase their bids above the amounts they would have chosen in an absolute auction. The total number of bids equal to the reserve price increased from 7 to 69 when reserve prices were added, and the number strictly greater than the reserve price increased from 162 to 240. This increase in the number of bids strictly greater than the reserve price strongly supports the theory's prediction that $\frac{\partial b}{\partial r} > 0$ for bidders whose valuation is greater than the reserve. To see this, consider a bidder who values a card at more than 90 percent of its Cloister price, but who in an absolute auction decides that his optimal bid is less than 90 percent of Cloister value. In the change from an absolute auction to an auction with minimum bids, a naive bidder might choose to raise his bid exactly to the level of the reserve price. A rational bidder, however, will take into account the strategic consideration that there is some probability that other bidders might also raise their bids in the presence of reserve prices, and will thus raise his bid to a level strictly greater than the reserve price. The data indicate that the strategic considerations identified by the theory are relevant to real-world bidding behavior.

On the other hand, the increase in the number of bids exactly equal to the reserve price (from 7 in the absolute auctions to 69 in the reserve auctions) seems inconsistent with the theory. The bid function (1) implies that only a bidder with valuation $v=r$ should bid exactly the reserve price, which is an event of probability zero if the distribution of valuations is continuous. The discreteness of acceptable bids is one possible explanation for the increase in the number of bids at the reserve level. Since the auctions required bids to be even multiples of $0.05, a bidder who wished to bid one penny over the minimum, for example, would have been forced instead to bid exactly at the minimum. However, this explanation is unlikely to be the whole story, because most of the reserve-price bids were large compared to the bid increment of $0.05. Only 25 of the 69 bids were for amounts less than $2.50, so the vast majority of reserve-price bids were at least 50 times the amount of the bid increment. The median reserve-price bid was $6.60, with several bids at large odd amounts such $16.45, $39.95 , and $40.10. This likely indicates that some bidders behaved naively regarding reserve prices. Of the 46 unique[47] bidders in auctions AR and BR, 18 submitted

[47] Three bidders bid in both auctions AR and BR.

at least one bid equal to the reserve.[48] Despite the violations by some bidders, most of the bidders tended to bid strictly above the reserve price in the reserve auctions.

I also compare the pairs of bids of those bidders who bid on both copies of the same card Four bidders submitted a total of 22 such pairs of bids in experiment A, and 17 bidders submitted 88 such pairs of bids on cards in experiment B. The data are displayed in Figure 7, where the right tail clearly contains much more mass than the left tail of the distribution. The mean difference between reserve-auction bids and absolute-auction bids, as a fraction of the posted reserve price, was a statistically significant 14.88% (t=4.58).[49] Of the 110 observations where the same bidder bid on the same card in both auctions, 70 of them had higher bids in the presence of reserve prices,[50] 35 were lower under reserve prices, and 5 were exactly the same in the two auctions.[51] The bids that were lower in the presence of reserve prices are a bit difficult to explain. Some may be accounted for by random bidding errors or random changes in bidders' valuations, but a few bidders systematically bid perversely: 3 of the 21 bidders accounted for 21 of the 35 aberrant observations.

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[48] Only seven bidders had all their bids exactly equal to the reserve: one with nineteen bids, one with six bids, and five bidders with one bid each. The other eleven bidders had only some of their bids at the reserve: 13 of 31 bids, 11 of 30 bids, 8 of 9 bids, 2 of 8 bids, 1 of 4 bids, and so on. For those bidders who submitted both types of bids, the reserve bids were for lower amounts (mean \$4.72, standard error \$0.92, 40 bids) than the above-reserve bids (mean \$8.58, standard error \$1.14, 64 bids) to be for lower amounts while the above-reserve bids tended to be for higher amounts, indicating that bid-increment rounding probably affected these bids.

Only nine of the bidders submitted more than half of their bids above the reserve (and six of these submitted only a single bid observation). These nine bidders appear indeed to have been behaving naively. It is possible that they were used to bidding in English auctions rather than sealed-bid auctions, and therefore bid at the minimum bid amount because they expected to have the opportunity to raise their rivals' bids later.

[49] This t-statistic assumes independence of all 110 observations. A much more conservative approach is to assume that each bidder generates only one independent observation. Taking each bidder's mean difference to be the unit of observation and equally weighting each bidder, I find that the overall mean difference falls to 7.2%, and the t-statistic falls to only 1.22, no longer statistically significant at the 5% level. However, this approach ignores a considerable amount of statistical information. The reader is left to decide which test seems more appropriate.

[50] Of the 70 increases described above, it turns out that 28 increased up to the level of the reserve price, while 42 increased to a level strictly greater than the reserve price. The 42 bids provide additional evidence in favor of strategic bidding behavior, while the 28 may be due to minimum bid increments or due to naive bidding.

[51] By making the (questionable) assumption that all 110 observations are independent, I can reject the null hypothesis the bid difference is equally likely to be positive as negative (z=2.97).

Thus, most individual bidders in the within-card auctions behaved consistently with the theoretical prediction, bidding higher in the presence of a reserve price.

Table 6 reports relevant data from the between-card experiments. Each row denotes a reserve price bin (0.1 through 1.5 times Cloister value); the number of cards per bin ranges from 16 to 39. Each column denotes a reference bid level; the cells of the table report the average number, per card, of bids greater or equal to this reference level. For example, the first cell of the table shows that for cards with a reserve price level of 0.1 (that is, 10 percent of Cloister value), there were an average of 11.4 bids received per card auctioned. The cell immediately to the right excludes bids which were less than 20 percent of Cloister value; here the average number of bids falls to 9.7, implying that just under 2 of 11 bids on average for these cards fell between 10 percent and 20 percent of Cloister value. The next cell on the right shows that the number of bids per card falls to 6.8 if bids less than 30 percent of Cloister value are excluded, and so on. Cells on the diagonal of the table show the total number of bids greater than or equal to the reserve price, while cells to the right of the diagonal show the number of bids greater than or equal to even higher levels.

Within any given column of Table 6, the number of bids received turns out to be an increasing function of the reserve price employed in the auction. For example, in the “bids >=0.4” column, we see that the number of bids received at levels greater than or equal to 40 percent of Cloister price increases as the reserve price increases. There are 4.4 such bids received per card auctioned at a reserve price of 0.1, 4.8 bids per card at a reserve price of 0.2, 6.2 bids per card at a reserve price of 0.3, and 9.1 bids per card at a reserve price of 0.4. This is consistent with the sort of strategic behavior predicted by the theory: the reserve price can cause bidders to raise their bids even when the reserve is not binding. For example, raising the reserve price from 0.2 to 0.3 increases not only the number of bids submitted at prices of 0.3, but also the number of bids at prices of 0.4 (in this case, from 4.8 bids to 6.2 bids on average). This phenomenon is generally true down each of the columns of the table, although the effect appears only in the last several rows of each column. For example, increasing the reserve price from 0.2 to 0.3 has very little effect on the number of bids submitted at levels of 1.5 or more, just as changes in the reserve price have very little effect on the rightmost sections of the theoretical bid functions in Figures 1 and 3.

These differences in the empirical bid distribution appear to be statistically significant for the most part, though it is not clear what the single best summary statistic should be. For example, in comparing auctions with a reserve price of 0.1 to auctions with a reserve price of 1.0, the number of bids greater than or equal to 1.1 increases from 0.333 to 1.179 bids per card, which is a statistically significant difference (t = 3.318). For each different column of the table, one can similarly compare the first row to the next-to-last row, and find that the point estimate of the difference is always positive (that is, the number of bids greater than or equal to X is always higher with a high reserve price, of just under X, than it is for a low reserve price, of 0.1). These differences are individually statistically significant for each of columns 0.5 through 1.2, with t-statistics ranging from 2.73 to 4.48. In columns 0.3 and 0.4, the differences are statisically insignificant (t=0.68 and 1.63, respectively), because small reserve prices have relatively small effects on the magnitudes of large bids.[52] In columns 1.3 and 1.4, the differences are again individually insignificant (t=1.49 and 1.36), because very few bids can be generated at levels of 1.3 or 1.4 times Cloister price or more, no matter how high the reserve.[53] Thus, every column of the table indicates point estimates consistent with the type of strategic bidding behavior predicted by the theory, with statistically signif-

[52] This is predicted by the theory. See, for example, equation 3.

[53] Furthermore, the experimental design generated fewer observations for reserve prices greater than 1.1, which also increases the standard errors of these estimates of the mean number of bids. Note, however, that the difference in column 1.5 turns out to be statistically significant (t=2.19), indicating significantly higher numbers of bids of at least 1.5 times Cloister price when r=1.4 than when r=0.1.

icant differences for the vast majority of columns (particularly those where the theory would predict the observed differences to be greatest).[54]

Just as in the within-card experiments, the between-card experiments also generated a substantial amount of bidding exactly equal to the reserve price. Of a total of 2217 bids submitted in the four auctions, 563 were exactly equal to the posted reserve price; these bids were submitted by 50 of the 119 unique participating bidders. Twenty of the bidders had more than half of their submitted bids equal to the reserve price. In these auctions, there were more low card values than in the within-card experiments: 358 of the 563 reserve-price bids were for amounts less than $2.50, indicating that some of this reserve-price bidding may have been due to rounding to the nearest bid increment. Overall, the evidence from the experiments suggests that while some bidders react naively to reserve prices, the majority of bidders behave strategically, as predicted.

6 Conclusion

This study presents the results of controlled experimental auctions performed in a field environment. By auctioning real goods in a preexisting, natural auction market, I have combined the experimental methods of the laboratory with the real-world environment of traditional IO field studies. Not every variable could be observed (for example, I could not assign "valuations" for each good to each bidder, as a laboratory experimentalist might), but I did hold constant all of the relevant variables in the environment except for the treatment variable, which in this case was the

[54] An aggregate test of all thirteen point estimates being jointly equal to zero would have much higher power than any of the individual tests. Such a test would almost certainly reject the null, given that each of the point estimates had the same sign. Unfortunately, I do not know how to compute a valid aggregate test statistic. If each of the thirteen t-statistics were an independent standard-normal random variable (see footnote 41), an aggregate standard-normal test statistic would equal the average of the thirteen t-statistics multiplied by the square root of thirteen, which in this case would yield an enormous value of t=10.16. However, this procedure is not strictly valid, because these t-statistics are not in fact independent (while the rows of Table 6 are independent of each other, the columns within a row are not, and each individual test involves subtracting an observation in the first row).

existence and level of reserve prices. By giving up the ability to observe and manipulate some of variables that laboratory experimenters can control, I gained a very realistic environment, akin to the field data traditionally used by empirical economists. The transactions which took place in this experiment were unquestionably real economic transactions.

The first result of this paper is that auction theory accurately predicts a number of important features of the data. Holding all else constant, implementing reserve prices (1) reduces the number of bidders, (2) increases the frequency with which goods go unsold, and (3) increases the revenues received on the goods conditional on their having been sold. Second, the empirical shape of the expected revenue curve is roughly consistent with examples from the theory. Some intriguing potential anomalies appear both at low reserve prices and at high reserve prices, but neither is statistically significant in this data set. Finally, perhaps the most subtle and interesting result is that bidders appear to behave strategically in the presence of reserve prices, just as predicted by the theory. Though a few bidders appear to react naively to reserve prices, most high-value bidders apparently raise their bids to be strictly above the reserve, as if they correctly anticipates that rival bidders will also raise their bids in the presence of posted minimums.

This paper suggests some interesting lines of research. First, it would be useful to reproduce these experiments in a laboratory setting, where bidder valuations can be observed and controlled. Second, it would be useful to experiment with the number of invited bidders as a treatment variable. Riley and Samuelson (1981) predict that the optimal reserve price is independent of the number of potential bidders N, while Samuelson (1985) and Levin and Smith (1996) predict that the optimal reserve declines with N.[55] By manipulating the number of invited bidders as a treatment variable, an experiment could investigate this and other questions about the different effects of reserve prices in thick versus thin markets.

I am optimistic that the field-experiment methodology described in this paper will be useful in other areas of research. The general concept is that rather than relying solely on field data, which typically do not have the variation needed to test the economic theories of interest, economists can run their own businesses with the intent of collecting data on the effects of different decisions (such as the decision to employ reserve prices in auctions). Field experiments can complement both field data and laboratory experiments, and with the development of electronic markets for goods and services, some types of field experiments can generate detailed data at relatively low cost.

[55] The results of the present paper provide some weak evidence against all three of these theories. In the within-card experiment, it appeared that 90% of Cloister value was higher than optimal, particularly for the experiment (A) with the lower number of invited bidders. By contrast, the between-card experiments, with a large number of invited bidders, had an empirically optimal reserve in the range of 80% to 110% of Cloister price. One possible interpretation is that the optimal reserve price is increasing in the number of bidders. However, these results are merely suggestive, and not at all conclusive (for example, the experiments took place at very different points in time). A new experiment could be designed to provide a much cleaner test of this hypothesis.

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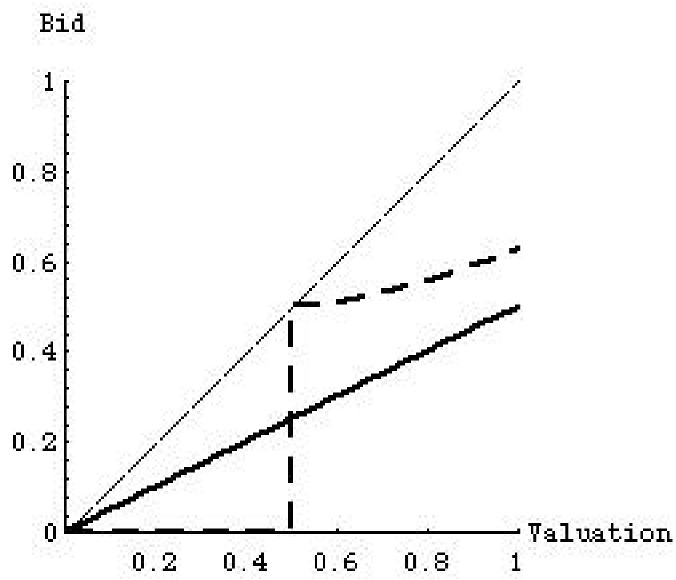
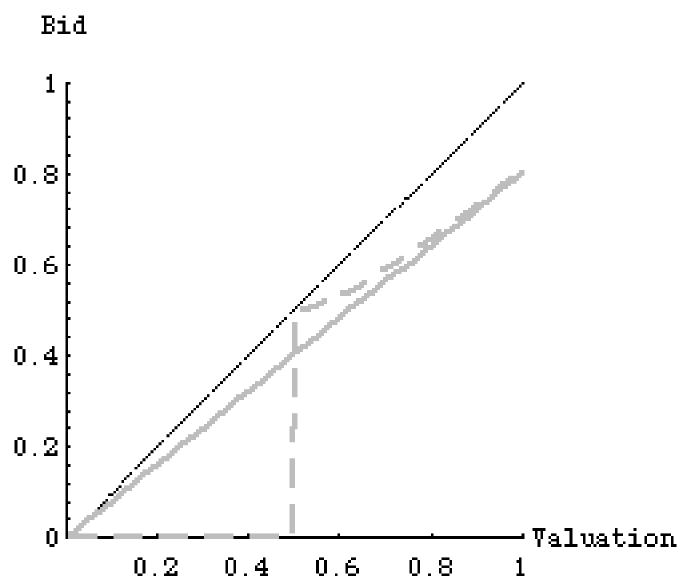
Figure 1: Bid functions for the uniform distribution:

For the case N=2:



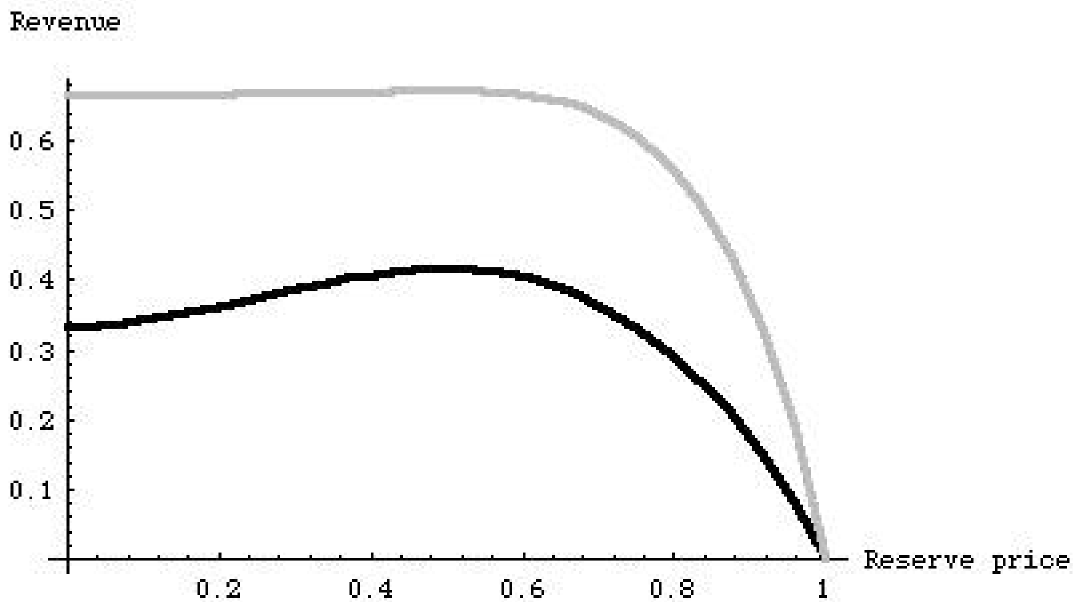
For the case N=5:



The solid lines represent the r=0 case, while the broken lines represent r=0.5.

Figure 2: Revenue curve for the uniform distribution.

The N=2 case is a black curve, while the N=5 case is a gray one:



Vertical close-up of the optimum for N=5:

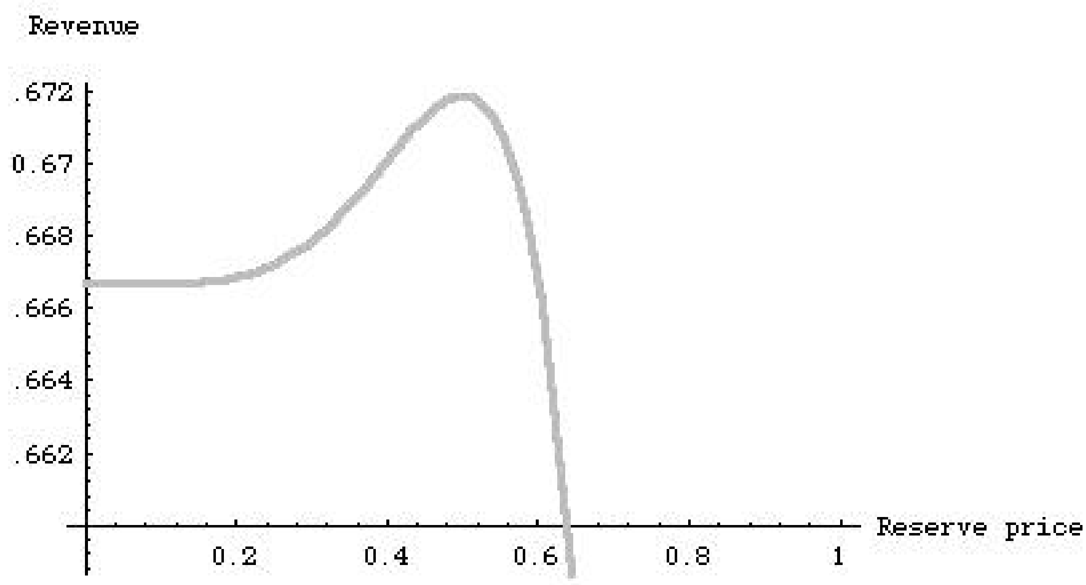
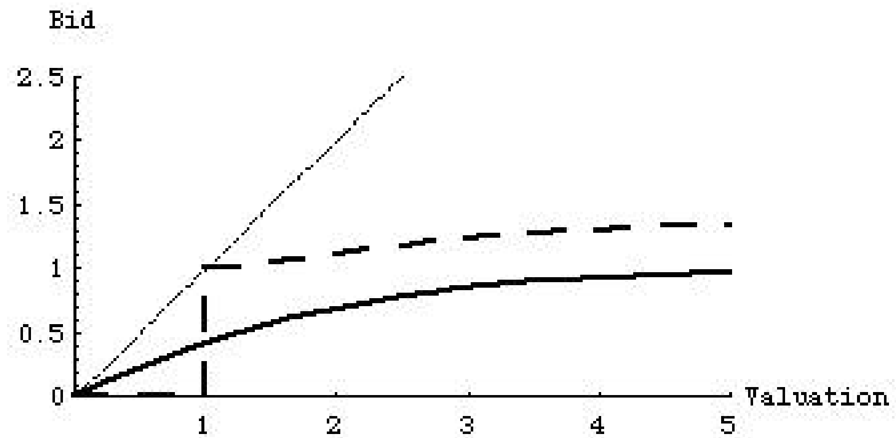
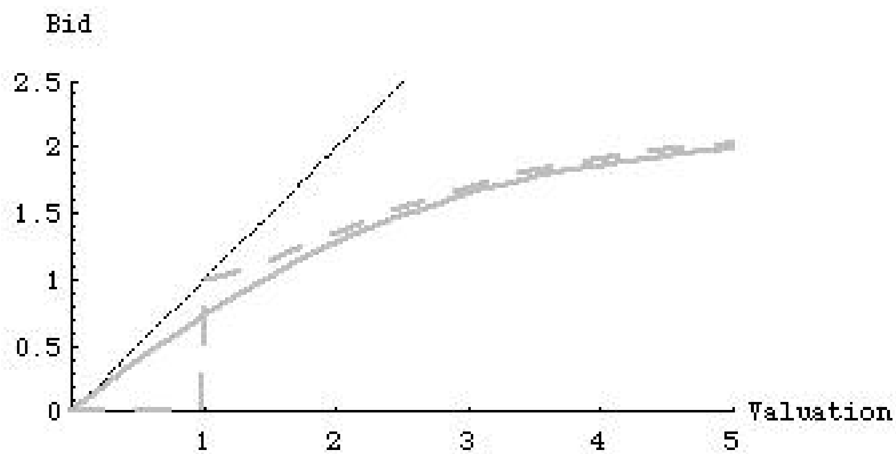


Figure 3: Bid functions for the exponential distribution.

For the case N=2:



For the case N=5:



The solid lines represent the r=0 case, while the broken lines represent r=1.

Figure 4: Revenue curves for the exponential distribution.

The N=2 case is a black curve, while the N=5 case is a gray one:

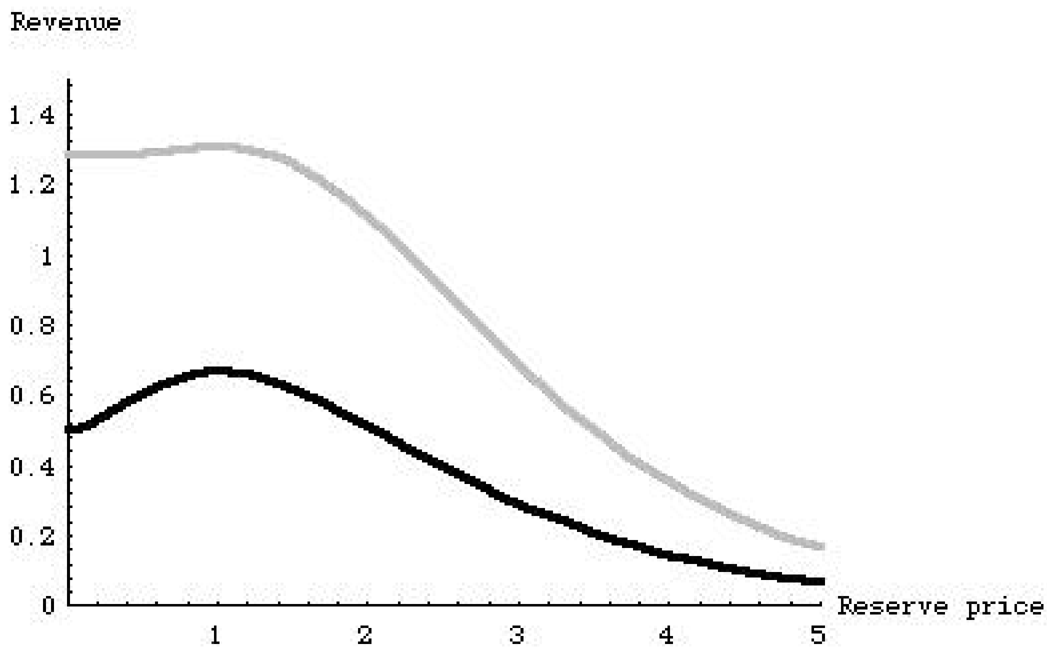


Figure 5: Distribution of bids in Antiquities auctions.

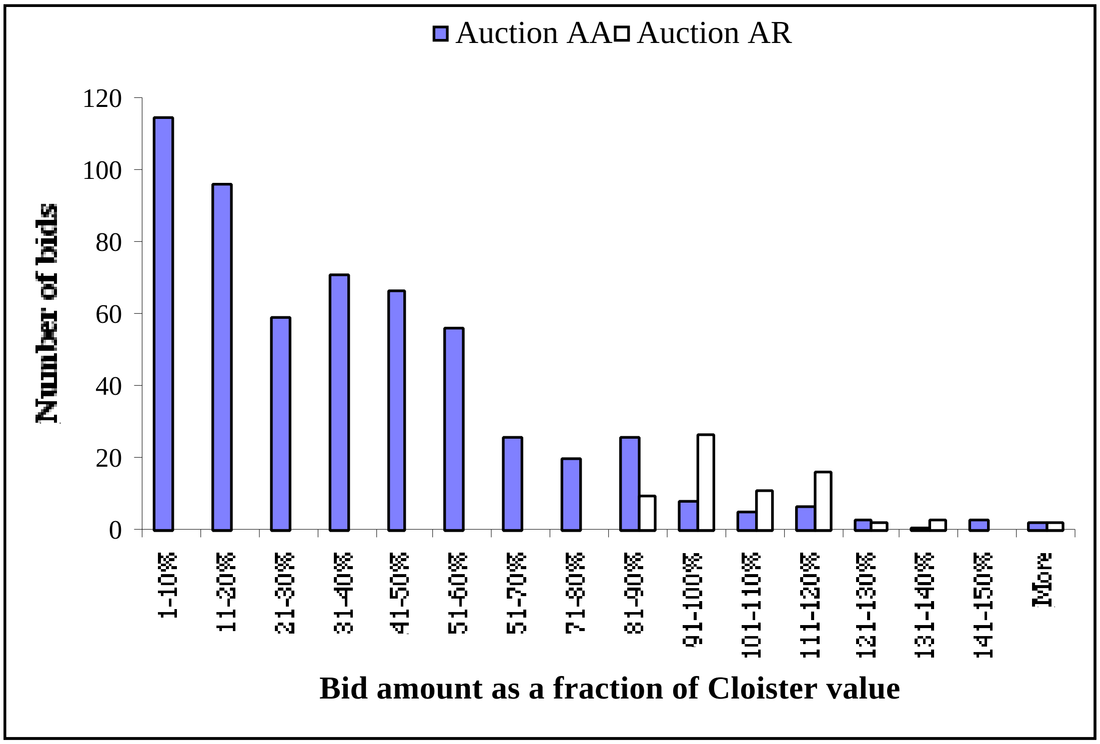


Figure 6: Distribution of bids in Arabian Nights auctions.

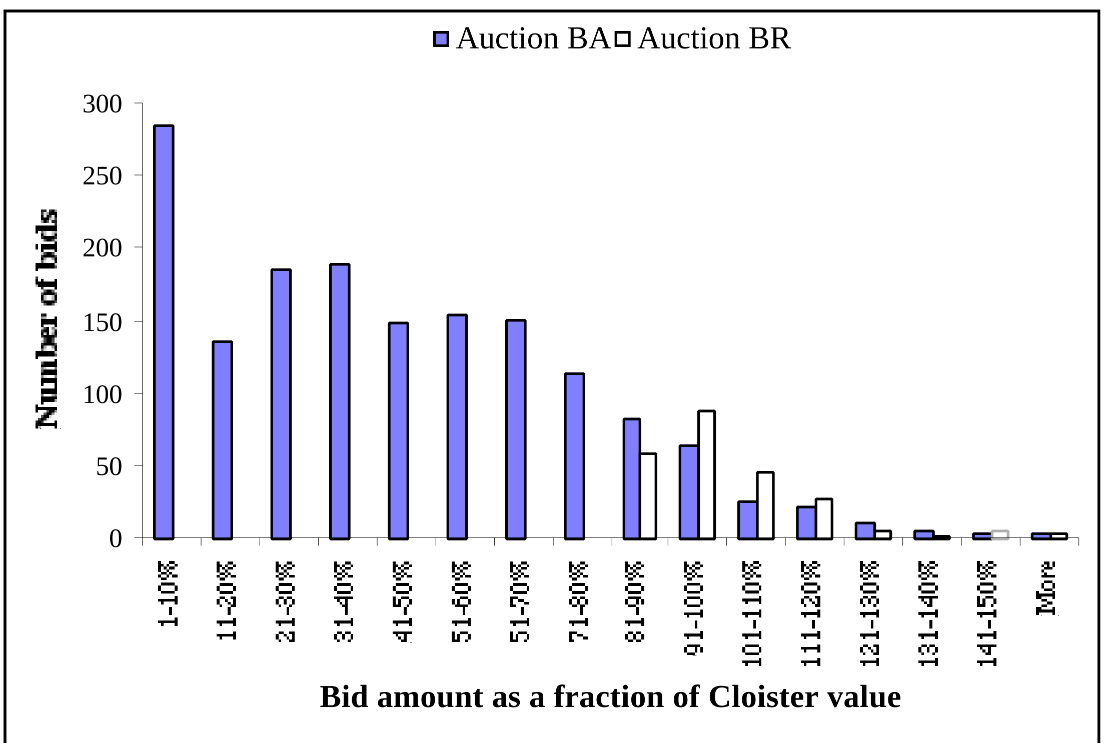


Figure 7: Distribution of changes in bids on the same cards by the same bidders.

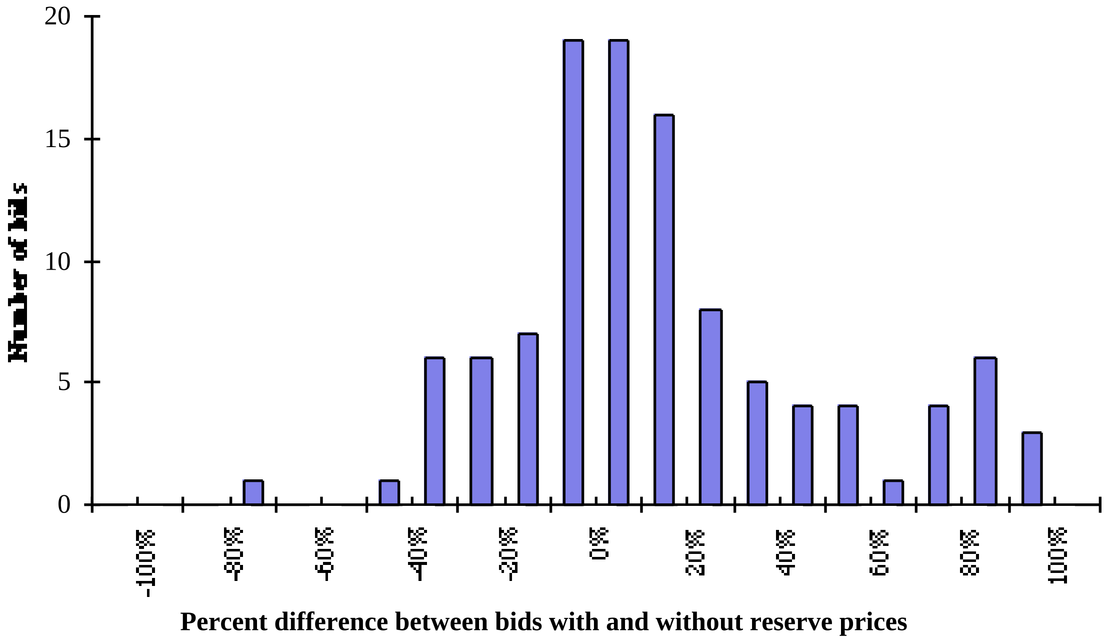


Figure 8: The empirical expected revenue curve, R(r).

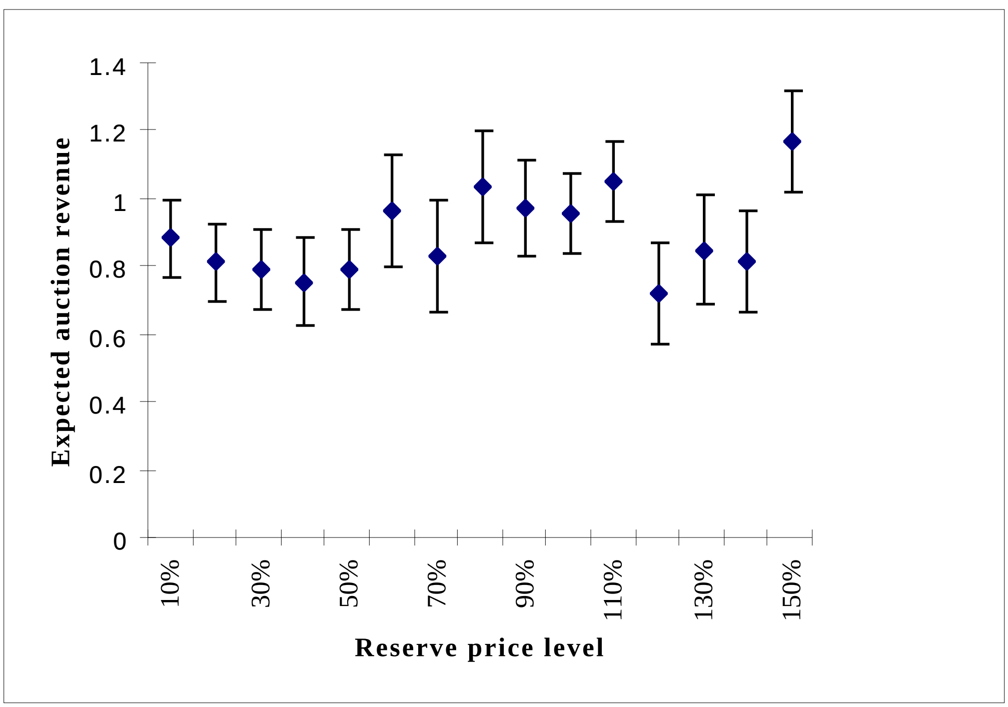


Table 1: Summary statistics for within-card experiments.

	Auction AA	Auction AR	Auction BA	Auction BR
Minimum bids?	No	Yes	No	Yes
Card set	Antiquities	Antiquities	Arabian Nights	Arabian Nights
Start date	Fri, 24 Feb	Fri, 10 Mar	Tue, 14 Mar	Tue, 28 Feb
End date	Fri, 3 Mar	Fri, 17 Mar	Tue, 21 Mar	Tue, 7 Mar
Number of items for auction	86	86	78	78
Number of items sold	86	47	78	74
Revenue from twice-sold cards	$189.90	$234.75	$758.25	$783.80
Total auction revenue	$292.40	$234.75	$774.75	$783.80
Total number of bids	565	71	1583	238
Total number of bidders	19	7	62	42
from email invitations	12	5	46	35
from newsgroup announcements	7	2	18	7
Number of email invitations sent	52	50	232	234
Number of winners	15	6	25	27
Winner/bidder ratio	78.9%	85.7%	40.3%	64.3%
Cards per winner:				
Max	25	26	12	18
as share of total	29.1%	55.3%	15.4%	24.3%
Min	1	1	1	1
Mean	5.7	7.8	3.1	2.7
Median	3	3.5	2	2
Payment per winner:				
Max	$70.00	$129.40	$316.50	$128.00
as share of total	23.9%	55.1%	40.9%	16.3%
Min	$3.00	$0.70	$1.05	$2.55
Mean	$19.49	$39.13	$30.99	$29.03
Median	$10.50	$23.68	$13.15	$13.00

Table 2: Bids received in the within-card auctions.

	Auction AA	Auction AR	Auction BA	Auction BR
Minimum bids?	No	Yes	No	Yes
Card set	Antiquities	Antiquities	Arabian Nights	Arabian Nights
Number of bidders	19	7	62	42
Number of items for auction	86	86	78	78
Number of bids per bidder:				
Mean	29.7	10.1	25.5	5.7
Median	13.0	4.0	14.0	4.0
Max	86.0	29.0	78.0	30.0
Min	1.0	1.0	1.0	1.0

Table 3: Comparison of submitted bid levels to the minimum bid levels.

Number of bids in:	Below the minimum	Equal to the minimum	Strictly above the minimum	Total
Auction AA	531	5	29	565
Auction AR	0	10	61	71
Auction BA	1448	2	133	1583
Auction BR	0	59	179	238
Total in absolute auctions	1979	7	162	2148
Total in reserve-price auctions	0	69	240	309
Grand totals	1979	76	402	2457

Table 4: Summary statistics for the between-card experiments.

	Auction R1	**Auction R2**	**Auction R3**	**Auction R4**
Card set	Artifacts	Black	White	Blue
Start date	Tue, 3 Oct	Fri, 6 Oct	Fri, 20 Oct	Mon, 23 Oct
End date	Tue, 10 Oct	Fri, 13 Oct	Fri, 27 Oct	Mon, 30 Oct
Number of items for auction	99	99	99	99
Number of items sold	98	92	77	78
Mean reserve level	60%	60%	85%	81%
Total number of bids	798	652	366	401
Total number of bidders	57	55	46	38
Number of email invitations sent	532	523	512	489
Total Cloister value	345.83	271.55	285.87	224.89
Total auction revenue	338.45	282.65	260.95	219.25
Revenue plus salvage	343.94	283.65	269.48	224.52

Table 5: Least-squares regressions of number of bids and probability of sale, regressed on reserve-price-level bins.

	Dependent variable: NUMBIDS	SOLD
RESBIN1	9.8043 (0.8411)	0.9564 (0.0585)
RESBIN2	8.0201 (0.8318)	0.9592 (0.0578)
RESBIN3	5.8973 (0.8390)	0.9032 (0.0583)
RESBIN4	6.0878 (0.9411)	0.9444 (0.0654)
RESBIN5	3.3543 (0.8433)	0.8430 (0.0586)
RESBIN6	2.8973 (1.2013)	0.8727 (0.0835)
RESBIN7	1.0484 (1.2039)	0.9247 (0.0837)
RESBIN8	-0.2924 (1.1799)	0.8602 (0.0820)
RESBIN9	-0.0082 (1.0153)	0.8647 (0.0706)
RESBIN10	-0.1592 (0.8430)	0.7599 (0.0586)
RESBIN11	0.2704 (0.8389)	0.8478 (0.0583)
RESBIN12	0.3449 (1.0775)	0.5415 (0.0749)
RESBIN13	0.4758 (1.1379)	0.5468 (0.0791)
RESBIN14	0.3371 (1.0762)	0.4880 (0.0748)
RESBIN15	0.5464 (1.0770)	0.6533 (0.0748)
R1	3.3535 (0.6898)	0.0075 (0.0035)
R2	2.1689 (0.6887)	0.0784 (0.0479)
R3	-0.1215 (0.6285)	0.0235 (0.0479)
CLOISTER	0.3867 (0.0501)	-0.0085 (0.0437)
R^2	0.4935	0.2249
Number of observations	396	396

Table 6: Number of bids received, as a function of the bid amount.
This reports the mean number of bids received per card in each reserve-price bin, with std. dev. of the mean in italics.

Reserve	Observed bids at amounts greater than or equal to a price level of:														
Price	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.3	1.4	1.5
0.1	11.436	9.667	6.769	4.410	3.231	1.949	1.256	0.923	0.590	0.436	0.333	0.282	0.256	0.256	0.231
	1.349	*1.206*	*0.893*	*0.632*	*0.529*	*0.382*	*0.246*	*0.206*	*0.136*	*0.115*	*0.106*	*0.090*	*0.088*	*0.088*	*0.078*
0.2		10.111	7.694	4.778	3.472	2.528	1.833	1.111	0.667	0.583	0.417	0.361	0.333	0.278	0.250
		1.187	*1.023*	*0.733*	*0.525*	*0.476*	*0.407*	*0.232*	*0.191*	*0.175*	*0.115*	*0.114*	*0.105*	*0.086*	*0.083*
0.3			8.314	6.200	3.343	2.200	1.514	0.943	0.686	0.543	0.286	0.257	0.114	0.086	0.086
			0.965	*0.901*	*0.545*	*0.395*	*0.308*	*0.201*	*0.191*	*0.161*	*0.120*	*0.111*	*0.055*	*0.048*	*0.048*
0.4				9.115	6.962	4.154	2.692	1.808	1.115	0.692	0.385	0.115	0.077	0.077	0.077
				1.380	*1.262*	*1.015*	*0.695*	*0.571*	*0.361*	*0.227*	*0.167*	*0.085*	*0.053*	*0.053*	*0.053*
0.5					6.118	4.882	2.706	1.529	1.059	0.794	0.500	0.441	0.324	0.265	0.206
					0.896	*0.794*	*0.471*	*0.344*	*0.257*	*0.218*	*0.195*	*0.190*	*0.162*	*0.136*	*0.125*
0.6						6.150	4.250	1.950	1.050	0.700	0.500	0.350	0.350	0.250	0.200
						1.047	*0.852*	*0.432*	*0.285*	*0.219*	*0.185*	*0.109*	*0.109*	*0.099*	*0.092*
0.7							5.438	3.313	1.750	0.625	0.375	0.250	0.188	0.188	0.125
							0.671	*0.546*	*0.470*	*0.301*	*0.180*	*0.112*	*0.101*	*0.101*	*0.085*
0.8								3.650	2.100	1.100	0.500	0.350	0.300	0.150	0.150
								0.519	*0.390*	*0.216*	*0.154*	*0.109*	*0.105*	*0.082*	*0.082*
0.9									3.440	2.400	1.000	0.400	0.320	0.160	0.120
									0.566	*0.436*	*0.271*	*0.141*	*0.111*	*0.075*	*0.066*
1.0										2.256	1.179	0.564	0.256	0.179	0.128
										0.293	*0.232*	*0.183*	*0.080*	*0.072*	*0.066*
1.1											2.606	1.485	0.485	0.424	0.212
											0.351	*0.258*	*0.180*	*0.151*	*0.084*
1.2												2.053	1.421	0.947	0.842
												0.883	*0.777*	*0.789*	*0.735*
1.3													1.800	0.900	0.600
													0.639	*0.464*	*0.373*
1.4														1.278	0.722
														0.311	*0.211*
1.5															1.375
															0.554

Table 7: Least-squares regression of normalized revenues (REV2CLO), both conditional and unconditional on sale.

Variable	Sold Cards Only	All Cards
RESBIN1	0.9433 (0.0964)	0.8852 (0.1167)
RESBIN2	0.8709 (0.0955)	0.8164 (0.1154)
RESBIN3	0.8890 (0.0977)	0.7959 (0.1165)
RESBIN4	0.8324 (0.1066)	0.7588 (0.1306)
RESBIN5	0.9552 (0.1012)	0.7950 (0.1170)
RESBIN6	1.1133 (0.1397)	0.9667 (0.1170)
RESBIN7	0.9357 (0.1372)	0.8352 (0.1671)
RESBIN8	1.2035 (0.1370)	1.0367 (0.1638)
RESBIN9	1.1365 (0.1205)	0.9729 (0.1409)
RESBIN10	1.2489 (0.1074)	0.9573 (0.1170)
RESBIN11	1.2421 (0.1025)	1.0560 (0.1164)
RESBIN12	1.3264 (0.1575)	0.7271 (0.1495)
RESBIN13	1.5364 (0.1648)	0.8530 (0.1579)
RESBIN14	1.6498 (0.1683)	0.8166 (0.1494)
RESBIN15	1.7700 (0.1463)	1.1682 (0.1495)
R1	-0.0060 (0.0057)	0.1524 (0.0957)
R2	0.0598 (0.0815)	0.0448 (0.0956)
R3	-0.0045 (0.0824)	-0.0212 (0.0826)
CLOISTER	-0.0125 (0.0799)	0.0032 (0.0872)
R^2	0.1974	0.0511
Number of observations	345	396

Appendix. A Sample Auction Announcement.

Date: Tue, 28 Feb 1995 18:19:10 -0500
To: reiley@MIT.EDU (David Reiley)
From: reiley@MIT.EDU (David Reiley)
Subject: Reiley's Auction #5: ARABIANS, Free Shipping!

Hi! As a participant in one of my previous auctions, I thought you might be interested in this NEW AUCTION opportunity.

Please read the rules of this auction carefully, as each auction I run typically has a different set of rules.

This will be a SEALED-BID, FIRST-PRICE AUCTION. Here's how it works:

I will accept all bids up until the deadline of NOON (Eastern Standard Time), next TUESDAY, March 7, 1995. All bids are "sealed" in the sense that I will not post updates or otherwise reveal information about the highest bid until the auction is over.

After the deadline for bids has passed, I will award each card to the highest bidder at the price of their bid. The exception is that if no one bid at least the posted minimum bid for some card, that card will not be sold.

Note that SHIPPING IS INCLUDED in the bid price. If you win, you mail me exactly the amount of your bid, with no extra charges. This is to encourage everyone to bid separately on each card they're interested in - no worrying about having to win multiple cards in order to make it worth your while.

Here are THE RULES:

1. Submit bids via email to <reiley@mit.edu>. Make sure that the subject line of your email contains the phrase "Auction #5". (Simply using the "reply" command on most mail and news programs should work just fine.) If your message does not contain this text in the subject line, your message will be discarded.

2. In your email message, please put each of your bids on a separate line of text.
Each bid line should be in the following format: the 3-digit identification number
of the card you're bidding on, immediately followed by a right parenthesis, and then the amount of your bid in dollars and cents (such as 1.00). For example:

```
 305) 2.00
 306) 0.65
```

Including extra information on the bid line is okay, too. Such extra information might include email quote marks (such as the greater-than symbol), the card name, condition, etc. You may include anything that makes bidding easier for you, EXCEPT that your bid amount should be the only price-formatted number which appears on that line. In other words, no other number containing a decimal point should appear on that line.

For example, the following are also perfectly valid bids:

```
 > 305) Ghosts of the Damned             U1     Blk   M  2.00
 > 306) Demonic Torment   0.65
```

Bids that do not conform to these rules will be discarded.
Here are examples of INVALID bids:

```
 >305) Ghosts of the Damned      $2                        [no decimal point]
 306 ) Demonic Torment 0.65  [space between the 6 and the right parenthesis]
```

3. All bids must be in integer multiples of a nickel ($0.05), in US currency.

5. The auction closes on Tuesday, March 7, 1995, at noon (EST). Any bids received after that time will be ignored. All cards receiving a bid of at least the posted minimum bid will be sold at that point to the highest bidder. In the case of a tie, the winner will be the person whose bid was received first.

6. The winning bidder will be notified by email, and will be asked to pay the amount of his/her bid via US check or money order.

7. This payment will include free shipping within the United States, via first class mail. The cards will be wrapped in plastic sheaths and packed in cardboard for protection. All cards will be shipped within one week after the receipt of payment.

8. While this is a real auction for real cards, you should know that I plan to use data on the bids in this auction for economic research. In no case will individual bidders be identified in this research; anonymity will be preserved. By bidding in this auction, you indicate your consent to have your bid be used in economic research. If you do not approve of this, you have the right not to participate in this auction. Should you have any questions or concerns about the use of data from this auction in academic research, please contact the chair of the COUHES committee at MIT by phone at 617-253-6787.

That's it! Enjoy the auction. Good luck, and thanks for participating!

Here is the LIST OF CARDS:

ID	Card Name	Rarity	Color	Cond	Minimum
501)	Bazaar of Baghdad	U3	Lnd	M	8.90
502)	City of Brass	U3	Lnd	M	17.85
503)	Desert	C11	Lnd	M	3.55
504)	Diamond Valley	U2	Lnd	M	26.40
505)	Elephant Graveyard	U2	Lnd	M	18.30
506)	Island of Wak-Wak	U2	Lnd	M	20.10
507)	Library of Alexandria	U3	Lnd	M	21.00
508)	Mountain	C1	Lnd	M	2.45
509)	Oasis	U4	Lnd	M	5.65
510)	Aladdin's Lamp	U2	Art	M	3.10
511)	Aladdin's Ring	U2	Art	M	3.05
512)	Bottle of Suleiman	U2	Art	M	2.75
513)	Brass Man	U3	Art	M	0.90
514)	City in a Bottle	U2	Art	M	10.60
515)	Dancing Scimitar	U2	Art	M	2.55
516)	Ebony Horse	U2	Art	M	3.05
517)	Flying Carpet	U3	Art	M	2.95
518)	Jandor's Ring	U2	Art	M	2.70
519)	Jandor's Saddlebags	U2	Art	M	2.80
520)	Jeweled Bird	U3	Art	M	5.40
521)	Pyramids	U2	Art	M	16.20
522)	Ring of Ma'ruf	U2	Art	M	21.85
523)	Sandals of Abdallah	U3	Art	M	6.30
524)	Cuombajj Witches	C4	Blk	M	2.40
525)	El-Hajjaj	U2	Blk	M	2.85
526)	Erg Raiders	C5	Blk	M	0.50
527)	Guardian Beast	U2	Blk	M	40.10
528)	Hasran Ogress	C5	Blk	M	1.25
529)	Junun Efreet	U2	Blk	M	13.50
530)	Juzam Djinn	U2	Blk	M	27.00
531)	Khabal Ghoul	U3	Blk	M	21.45
532)	Oubliette	C4	Blk	M	3.75
533)	Sorceress Queen	U3	Blk	M	5.05
534)	Stone-Throwing Devils	C4	Blk	M	2.40
535)	Dandan	C4	Blu	M	1.50
536)	Fishliver Oil	C4	Blu	M	1.55

537)	Flying Men	C5	Blu	M	2.40
538)	Giant Tortoise	C4	Blu	M	1.30
539)	Island Fish Jasconius	U2	Blu	M	3.20
540)	Merchant Ship	U3	Blu	M	6.15
541)	Old Man of the Sea	U2	Blu	M	24.65
542)	Serendib Djinn	U2	Blu	M	9.95
543)	Serendib Efreet	U2	Blu	M	3.95
544)	Sindbad	U3	Blu	M	7.30
545)	Unstable Mutation	C5	Blu	M	0.50
546)	Cyclone	U3	Gre	M	6.30
547)	Desert Twister	U3	Gre	M	1.95
548)	Drop of Honey	U2	Gre	M	17.50
549)	Erhnam Djinn	U2	Gre	M	15.70
550)	Ghazban Ogre	C4	Gre	M	1.40
551)	Ifh-Biff Efreet	U2	Gre	M	16.10
552)	Metamorphosis	C4	Gre	M	1.60
553)	Naf's Asp	C4	Gre	M	1.35
554)	Sandstorm	C5	Gre	M	1.85
555)	Singing Tree	U2	Gre	M	20.20
556)	Wyluli Wolf	C5	Gre	M	3.30
557)	Aladdin	U2	Red	M	16.45
558)	Ali Baba	U3	Red	M	9.25
559)	Ali from Cairo	U2	Red	M	39.95
560)	Bird Maiden	C4	Red	M	2.15
561)	Desert Nomads	C5	Red	M	2.00
562)	Hurr Jackal	C4	Red	M	1.80
563)	Kird Ape	C5	Red	M	0.60
564)	Magnetic Mountain	U3	Red	M	2.55
565)	Mijae Djinn	U2	Red	M	3.90
566)	Rukh Egg	C4	Red	M	5.85
567)	Ydwen Efreet	U2	Red	M	6.60
568)	Abu Ja Far	U3	Whi	M	11.10
569)	Army of Allah	C4	Whi	M	3.25
570)	Camel	C5	Whi	M	1.45
571)	Eye for an Eye	U3	Whi	M	3.20
572)	Jihad	U2	Whi	M	23.00
573)	King Suleiman	U2	Whi	M	11.85
574)	Moorish Cavalry	C5	Whi	M	2.75
575)	Piety	C4	Whi	M	1.45
576)	Repentant Blacksmith	U2	Whi	M	9.40
577)	Shahrazad	U2	Whi	M	11.95
578)	War Elephant	C4	Whi	M	3.50

END OF LIST

Key to Card Types and Conditions:

C1 = Common
C2 = Common (twice as common as C1, printed twice per common sheet)
C4 = Common (four times as common as C1, printed four times per common sheet)
C11 = Common (printed 11 times per common sheet)
U1 = Uncommon
U2 = Uncommon (twice as common as U1, printed twice per uncommon sheet)
R = Rare

Lnd = Land
Art = Artifact
Blk = Black
Blu = Blue
Gre = Green
Red = Red :)
Whi = White

M = Mint
NM = Near Mint (never played, but has tiny blemishes from handling)
E = Excellent (played a few times, has small scuff marks)

If you are unfamiliar with some of these cards, you can get information about any Magic card (spell type, power, toughness, artist's name, etc.) from the following Internet sources:

http://www.itis.com:80/deckmaster/magic/cardinfo/
ftp://marvin.macc.wisc.edu/pub/deckmaster/card.info/lists.w.spoilers/

Remember to send any bids, comments, or questions about the cards or the rules of this auction to <reiley@mit.edu>.

Thanks!