Title

How much is a Dollar Worth? Tipping versus Equilibrium Coexistence on Competing Online Auction Sites

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Abstract

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Keywords: Tipping, equilibrium coexistence, field experiments, auctions
JEL numbers: C93, D44, L86

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1 Introduction

With 95 million users listing more than 970 million items per year, eBay dominates the online auction industry (eBay, 2003). In 2001, it held 64.3 percent of the US market share by revenue (Nielsen/NetRatings, 2001). eBay dwarfs its most notable rival, Yahoo, which maintains an auction service with less than 3 percent of the market share.[1] However, Yahoo is still an active player in online auctions with hundreds of thousands of sale items and members. Both sites bring online users together to buy and sell a wide range of goods, from the unusual to the mundane, in what has been called a "vast electronic garagesale."

Online auctions sites have spread worldwide and, while relatively young, competition appears aggressive. In 2001, Yahoo overwhelmed eBay in the Japanese auction market while, in 2002, eBay's dominance forced the closure of Yahoo auctions in Europe. Yet, despite the lopsidedness of their market shares, eBay and Yahoo auctions have managed to operate simultaneously for over seven years in the US. Is the US online auction market simply in the process of "tipping" to the point where Yahoo is forced to shutter its operations? Or is this an equilibrium phenomenon where two very unequal sized players can coexist? Of course, these two questions raise a third question—does it matter whether Yahoo is a small player on the way out of the US market or a long-run small player?

To answer these questions, one needs a theory which distinguishes between equilibrium and tipping behavior in competing auction sites. Ellison, Fudenberg and Möbius (2004) offer a model where the coexistence of sites with extremely unequal market shares is an equilibrium phenomenon.[2] A key testable implication of the model is that "the law of one price" should hold across competing sites; that is, eBay and Yahoo buyers should pay approximately the same amount for identical items. There is no reason to expect "the law of one price" to hold when a market is in the process of tipping. In fact, price disparity might signal a tipping market. A second implication of the theory is that the number of buyers attracted to identical items should be approximately the same between the two sites. Thus, to examine the tipping question, we conduct a series of field experiments with collectible coins to test the price and buyer-seller ratio equalization conditions following from the theoretical model of Ellison, *et al.* Our results suggest that this is a market in the process of tipping rather than

[1] ubid.com and egghead.com had 15 and 4 percent of online auction market share in 2001, respectively. Both of these sites differ from eBay and Yahoo auction platforms. The ubid site provides business-to-buyer auction services only. The egghead site, which auctioned computers and computing accessories, was acquired by Amazon.com in December, 2001 and is currently operated as a retail site.

[2] See also Ellison and Fudenberg (2002) for a more general treatment.

an equilibrium phenomenon—we find that "the law of one price" simply does not hold. Revenue comparisons consistently indicate that buyers on eBay pay 20 to 70 percent more and attract about two additional buyers per seller than their Yahoo counterparts for identical items. Moreover, the magnitude of these differences is inconsistent with the predictions of equilibrium coexistence even after accounting for various "frictions" associated with buyers and sellers switching between the two sites. We supplement our experimental results with field data that confirm not only the presence of the revenue and buyer-seller ratio disparity but also its persistence over time.

While our empirical work examines only one specific category in a sea of online products and services, the eBay-Yahoo tipping prediction has widespread relevance. First, Yahoo's persistent presence in the online auctions may provide a check on eBay's market power; Yahoo's exit, which would effectively leave eBay to act as a monopolist, has obvious antitrust implications. Second, similar online auction "wars" are currently being fought on a global scale, as evidenced by China's recent emergence as an important battleground. Japanese, European and US experiences may be suggestive of the likely outcome in China and other developing countries. Third, online auctions are not unique in their tipping potential, and our work may closely relate to issues faced by these "two-sided markets" (see Rochet and Tirole, 2003). For instance, our result may offer some predictive insight into the future market structure of online voice communications. An early entrant in that emerging market, Skype enjoys a substantial lead in market share over its leading rival, Googletalk. Indeed, eBay's recent \$2.6+ billion acquisition of Skype may suggest that the auction giant believes that the lessons of the online auctions market may hold elsewhere. With a number of large competitors currently sharing the market, the online dating industry also has tipping potential. Will dating, like online auctions, end as "winner-takes-all", or can sites like Yahoo Personals and Match.com continue to coexist? Our paper, while not providing definitive answers to these intriguing questions, may shed valuable light on tipping markets beyond online auctions.

In addition to examining equilibrium coexistence, the field experiment data permit the empirical testing of auction style-related effects, including ending rule and reserve value effects. Indeed, by allowing the seller to change the ending rule from a fixed to a variable closing time, the Yahoo auction site offers an ideal venue for reexamining the interesting observations about the effects of ending rules first made by Roth and Ockenfels (2002). In comparing bid timing for similar items sold on eBay and Amazon auctions, which differ by closing rule, Roth and Ockenfels observed that hard-close auctions lead to considerably more late bidding in the form of “sniping” than do soft-close auctions. The theory model contained in Ockenfels and Roth (2006) rationalizes this difference in bid timing and has the further implication that expected revenues should be higher in soft-close auctions. Of course, it is difficult to test this implication using field data owing to the many differences between the two auction platforms. Ariely, Ockenfels and Roth (2005) observe higher revenues and earlier bidding under a soft-close rule compared to a hard-close rule in a series of controlled laboratory experiments. To the best of our knowledge, we are the first to study the effects of ending rules using field experiments. Somewhat surprisingly, at least compared to our prior beliefs, we find that the choice of ending rule on the Yahoo site has no effect on bid timing, number of bidders or auction revenues.

The theory model describes conditions for coexistence in an ideal environment where there are no switching costs, where reliability of the seller is not in question, and where the two sites are of identical quality—of course, none of this is likely to be exactly true in practice. Can these departures from the theory model explain the differences in revenues and numbers of bidders we observe while preserving equilibrium coexistence? We consider the implications of adding each of these more realistic features to the basic model and come to the conclusion that the answer is no. We also conduct an additional study using field data which replicates the results of the field experiment. Taken together, our view is that the evidence supports the conclusion that US online auction platform competition is a market in the process of tipping.

The remainder of this section highlights some additional related work, both theoretical and empirical. Section 2 describes a version of the Ellison *et al.* model that we use to derive testable predictions. Section 3 outlines the experimental design, motivated by the testable model predictions, while the fourth section describes key results of the statistical analysis as well as alternative explanations. Our conclusions appear in Section 5.

Related Literature

The question of when markets will tip dates back to the seminal paper of Schelling (1972). More recent theoretical studies examining competing markets include, among others, Baye and Morgan (2001), Caillaud and Jullien (2003), Ellison and Fudenberg (2002 and 2003), Gehrig (1998), McAfee (1993), Peters and Severinov (1997), Rochet and Tirole (2003), Schwartz and Ungo (2003), and van Raalte and Webers (1998). While there is a burgeoning literature on field experiments using auctions (cf. Hossain and Morgan, 2006; Jin and Kato, forthcoming; Katkar and Lucking-Reiley, 2000; List and Lucking-Reiley, 2000 and 2002; Lucking-Reiley, 1999 and 2000; as well as Reiley, forthcoming and 2005), to the best of our knowledge, we are the first to examine the question of tipping versus equilibrium coexistence of competing auction sites using field experiments.

2 Theory

In this section, we sketch the model of Ellison *et al.* (2004) and develop the main testable implications associated with equilibrium coexistence. The key economic intuition underlying equilibrium coexistence is the observation that there are two competing effects which determine the site on which buyers and sellers will choose to locate. The first effect, which Ellison *et al.* refer to as the "scale effect," describes the idea that larger markets of buyers and sellers on a single site lead to higher surplus for all participants and thereby lead to concentration on a single site. The countervailing "market impact effect" favors site multiplicity since competition from others on the same side of the market decreases the surplus of a given participant. That is, both buyers and sellers prefer to locate on a site where they compete with fewer other agents of the same type. Ellison *et al.* offer conditions under which these two effects are offsetting. They show that competing auction sites can have very unequal market shares yet coexist in equilibrium.

To see how these competing effects lead to empirically testable predictions for behavior on rival auction sites such as eBay and Yahoo, consider the following version of the Ellison, *et al.* model. Two auction sites compete in a market consisting of B buyers and S sellers. Each seller wishes to sell one unit of some homogeneous product. Each buyer has unit demand for the good and a willingness to pay equal to v, where v is drawn from a uniform distribution on the unit interval. The objects are allocated via auctions on two competing online auction sites $a \in \{e, y\}$, where e is a mnemonic for eBay and y is a mnemonic for Yahoo.

In the extensive form of the game, the buyers and sellers simultaneously choose the auction site a on which they will either buy or sell. All agents are assumed to "single-home"—they restrict their buying or selling activities to only one of the two sites. Let (B_a, S_a) denote the number of buyers and sellers choosing to participate on site a. After participants have chosen their preferred platform, buyers learn their valuations and uniform price auctions are conducted to allocate the goods on each site.

Given an allocation of buyers and sellers, the payoff to a seller is the price received for the item.

When B_a buyers and S_a sellers participate on site a and $B_a > S_a + 1$ (i.e. there is no excess supply for the homogeneous product), then the expected price of the item is simply the expected value of the $S_a + 1st$ highest of B_a draws from a uniform distribution. It is straightforward to show the expected price on site a is

$$\bar{p}\left(S_a, B_a\right) = \frac{B_a - S_a}{B_a + 1}$$

Thus, the payoff to a seller on this site is

$$u_s\left(S_a, B_a\right) = \bar{p}\left(S_a, B_a\right)$$

The payoff to a buyer is equal to her expected surplus—the difference between her willingness to pay and the expected price paid times the probability of receiving an item. Conditional on receiving an item, a buyer's expected willingness to pay is simply $E\left[v|v > v^{S_a+1:B_a}\right]$, where $v^{S_a+1:B_a}$ is the realized price from the uniform price auction on site a. Adopting the notation of Ellison *et al.,* this expectation is

$$\begin{aligned} w\left(S_a, B_a\right) &= E\left[v|v > v^{S_a+1:B_a}\right] \\ &= \int_0^1 \left(\int_x^1 v \frac{1}{1-x} dv\right) f^{S_a+1:B_a}\left(x\right) dx \\ &= \int_0^1 \left(\frac{1+x}{2}\right) f^{S_a+1:B_a}\left(x\right) dx \end{aligned}$$

Note that $f^{S_a+1:B_a}\left(x\right)$ is a Beta density with parameters $r = B_a - S_a$ and $s = S_a + 1$. Further, the expectation of a random variable x under these parameters is $\frac{B_a - S_a}{B_a + 1}$; hence,

$$w\left(S_a, B_a\right) = \frac{1}{2}\left(\frac{2B_a - S_a + 1}{B_a + 1}\right)$$

Finally, the buyer's probability of receiving an object is equal to the seller-buyer ratio on the site since buyers are *ex ante* identical. Thus, the probability a buyer receives an object is simply S_a/B_a and hence, a buyer's expected payoff is

$$\begin{aligned}
u_b(S_a, B_a) &= (w(S_a, B_a) - \bar{p}(S_a, B_a)) \Pr\left(v > v^{S_a+1:B_a}\right) \\
&= (w(S_a, B_a) - \bar{p}(S_a, B_a)) \frac{S_a}{B_a} \\
&= \frac{1}{2} \frac{S_a(S_a+1)}{B_a(B_a+1)}
\end{aligned}$$

Ellison *et al.* define the notion of a "quasi-equilibrium." A quasi-equilibrium satisfies the usual equilibrium notion that, given a distribution of buyers and sellers $((B_e, S_e), (B_y, S_y))$, neither buyers nor sellers have any incentive to deviate. However, it differs from the usual equilibrium notion in that it ignores the integer constraint on the distribution of buyers and sellers across the sites. In large markets, such as those on eBay and Yahoo, ignoring integer constraints is of little consequence.

Merely from the fact that sellers have no incentive to deviate, we derive a key testable implication of equilibrium coexistence—prices across the two sites must be approximately equal. Specifically, in their Proposition 1, Ellison *et al.* show that the following inequalities hold in any quasi-equilibrium:

$$\begin{aligned}
u_s(S_y, B_y) - u_s(S_y+1, B_y) &\geq u_s(S_y, B_y) - u_s(S_e, B_e) \\
u_s(S_e, B_e) - u_s(S_e+1, B_e) &\geq u_s(S_e, B_e) - u_s(S_y, B_y)
\end{aligned}$$

Substituting for $u_s(S_a, B_a)$, the conditions become

$$\begin{aligned}
\bar{p}(S_y, B_y) - \bar{p}(S_y+1, B_y) &\geq \bar{p}(S_y, B_y) - \bar{p}(S_e, B_e) \\
\bar{p}(S_e, B_e) - \bar{p}(S_e+1, B_e) &\geq \bar{p}(S_e, B_e) - \bar{p}(S_y, B_y)
\end{aligned}$$

Notice that the left-hand side of the above inequalities is simply the change in price when one additional seller participates on a given site. As an empirical matter, the addition of a single seller in a relatively thick market on either site is likely to have little effect on price. This implies:

Hypothesis 1 (Price Equalization) If eBay and Yahoo are coexisting in equilibrium, then the average prices on the two sites for the same item should be approximately equal. Formally, the difference between the prices for the same item on the two sites is no more than the price difference on either site when one additional seller lists an item.

We derive a second key testable implication of equilibrium coexistence from the fact that buyers have no incentive to deviate—the number of buyers per seller must be approximately equal across the two sites . In Proposition 1, Ellison *et al.* derive the following quasi-equilibrium conditions for buyers:

$$\begin{aligned} u_b(S_y, B_y) - u_b(S_y, B_y+1) &\geq u_b(S_y, B_y) - u_b(S_e, B_e) \\ u_b(S_e, B_e) - u_b(S_e, B_e+1) &\geq u_b(S_e, B_e) - u_b(S_y, B_y) \end{aligned}$$

Substituting for $u_b(S_a, B_a)$, the conditions become

$$\begin{aligned} \frac{1}{2}\frac{S_y+1}{B_y+1}\frac{S_y}{B_y} - \frac{1}{2}\frac{S_y+1}{B_y+1}\frac{S_y}{B_y+2} &\geq \frac{1}{2}\frac{S_y+1}{B_y+1}\frac{S_y}{B_y} - \frac{1}{2}\frac{S_e+1}{B_e+1}\frac{S_e}{B_e} \\ \frac{1}{2}\frac{S_e+1}{B_e+1}\frac{S_e}{B_e} - \frac{1}{2}\frac{S_e+1}{B_e+1}\frac{S_e}{B_e+2} &\geq \frac{1}{2}\frac{S_e+1}{B_e+1}\frac{S_e}{B_e} - \frac{1}{2}\frac{S_y+1}{B_y+1}\frac{S_y}{B_y} \end{aligned}$$

When markets are large, the seller-buyer ratio on site a, γ_a, satisfies $\gamma_a \equiv \frac{S_a}{B_a} \approx \frac{S_a+k}{B_a+l}$ for all finite k and l. Therefore, under large market assumptions, the above inequalities reduce to

$$\begin{aligned} 0 &\geq (\gamma_y)^2 - (\gamma_e)^2 \\ 0 &\geq (\gamma_e)^2 - (\gamma_y)^2 \end{aligned}$$

and hence, for large markets, the number of buyers per seller must be approximately equal across the two sites.

Outside the limit case, define $\hat{\gamma}_a \equiv \frac{S_a+1}{B_a+1}$. Notice that the expression for $\hat{\gamma}_a$ converges to the seller-buyer ratio when markets are large. Temporarily assume that $\hat{\gamma}_e < \hat{\gamma}_y$. Then, the quasi-equilibrium conditions imply

$$\begin{aligned} (\hat{\gamma}_e)^2 &> \hat{\gamma}_y \frac{S_y}{B_y+2} \\ (\hat{\gamma}_y)^2 &> \hat{\gamma}_e \frac{S_e}{B_e+2} \end{aligned}$$

Further, from the definition of $\hat{\gamma}_a$, one obtains the inequalities

$$\begin{aligned}(\hat{\gamma}_y)^2 &> \hat{\gamma}_y \frac{S_y}{B_y+2} \\ (\hat{\gamma}_e)^2 &> \hat{\gamma}_e \frac{S_e}{B_e+2}\end{aligned}$$

Combining these inequalities yields a bound on the difference between $\hat{\gamma}_e$ and $\hat{\gamma}_y$:

$$\frac{S_y}{B_y+2} < \hat{\gamma}_e < \hat{\gamma}_y$$

Similarly, if one assume that $\hat{\gamma}_e > \hat{\gamma}_y$ then we obtain the bound

$$\frac{S_e}{B_e+2} < \hat{\gamma}_y < \hat{\gamma}_e$$

This implies that, in any quasi-equilibrium, the difference in seller-buyer ratios across the sites is small, amounting to no more than the change to $\hat{\gamma}_a$ with one additional buyer and one fewer seller on the site. As we showed above, for all practical purposes, the effect of such a change is negligible in large markets. This implies:

Hypothesis 2 (Buyer-Seller Ratio Equalization) If eBay and Yahoo are coexisting in equilibrium, then the average number of buyers per seller on each site should be approximately equal.

In the remainder of the paper, we describe the experimental design and the data set collected through a series of field experiments, and use the data to test our two hypotheses empirically.

3 Experimental Design

The presence, size and services of eBay and Yahoo Auctions provide us with the opportunity to test directly the hypotheses described above. It is reasonable to argue that eBay is familiar to most internet-users, and the brand name "Yahoo" is certainly well-known.[3] While small relative to eBay, trade on Yahoo Auctions is not insignificant. To illustrate, searches of the "Morgan Dollars (1878-1921)" product category on eBay and Yahoo, performed November 5, 2004, revealed 12,559 and 1,209

[3] The main Yahoo website is the most trafficked Internet site worldwide. (Yahoo, 2004)

items for sale, respectively. One-tenth the size of eBay, the coin market on Yahoo is still thick and active.[4]

Online auctions provide accessible and user-friendly means for individuals and firms to buy and sell a wide variety of items, from common goods to collectibles. Lists of sale items can be searched by keywords, broad categories and price-ranges. Internet visitors may search without logging in, while bidders and sellers must register a username and password for future identification. Sellers may post product descriptions, digital images and other information on the product page. Sellers on eBay and Yahoo pay fees for listings and selected options.[5] Neither site charges bidders for market participation. Registered bidders may submit single bids, or use a proxy-bidding feature. With a proxy-bid, buyers submit their maximum willingness-to-pay value and, as price increases, bids are automatically submitted on their behalf up to their indicated maximum. Once the maximum value is reached, they can drop from the auction or adjust their maximum willingness-to-pay.

Both eBay and Yahoo use a second-price auction mechanism with sequential bidding and a private maximum bid. Participants submit a bid indicating their willingness to pay for the item, and the auction is won by the bidder who submits the highest bid. Current price is set at the second-highest bidder's maximum bid plus some small increment, and is updated as new high bids are received.[6] When a nontrivial opening bid is specified, the first bidder's standing price is the seller-specified opening value. The next bidder to bid higher than the first bidder's maximum bid faces the standing price of the first bidder's maximum bid. The auction continues similarly until time elapses, or the ending criterion is reached. All eBay auctions have a fixed ending time. Yahoo auctions allow sellers to also choose the auction ending rule. The hard-close ending rule specifies an exact time at which

[4] Many items available on eBay are not listed on Yahoo. Moreover, the Yahoo-eBay listing ratio for collectible coins does not hold across all common item categories; on March 12, 2005, Yahoo-eBay ratios were approximately 1:3, 1:6 and 1:20 for antique books, antique firearms and collectible beanie babies, respectively. Note that the quality of many collectibles is not systematically established as it is with graded coins, making direct product and price comparisons between the sites difficult. While suggesting that relative market thickness is not consistent across product categories, these overall differences between the sites do not detract from the remarkable results outlined below.

[5] Throughout the experiments, Yahoo fees were two-part; listing fees were based on the starting price of the sale item, ranging from $0.05 for low-value items to $0.75 for prices over $50, and the final value fee was 2 percent of the final value up to $25 and 1 percent of the remaining closing price. Reserve fees were $0.40 or $0.75 depending on chosen value.

eBay fees were higher than Yahoo's fees. eBay listing fees ranged from $0.30 to $4.80, and the final value fee was 5.75 percent of the initial $25 and 2.75 percent of the remaining value up to $1,000. Reserve fees were $1 or $2 depending on the chosen reserve. eBay also charged for displaying more than one photo ($0.15 each), highlights, borders and other display options.

To compare site fees, consider listing a coin with three photos, no reserve and a $50 starting price that sells for $100. Yahoo fees would amount to $2, while eBay would collect $6.08 from the sale.

[6] On both sites, increments depend on current price, ranging from less than $1 for items valued below $100 to $100 for items valued over $5000.

the auction will end. The soft-close ending rule allows for the automatic extension of the auction by five minutes if a bid is placed close to the auction end. On the Yahoo item description screen, a small ending rule indicator appears under the Auction Information Notes (see Figure 1 for the Yahoo screenshot).[7]

3.1 The Field Experiments

The online experiments conducted on eBay and Yahoo were designed to address the two hypotheses outlined in Section 2. The experiments took place between August, 2003 and November, 2004. Eight types of coins from the Morgan and Peace Dollar series, described in Table 1, were purchased from a coin dealer in Southern California. Prior to purchase, the coins were professionally graded and sealed by the Numismatic Guaranty Corporation of America. Each encapsulated coin was marked with the coin's date, denomination, grade, and identification number. Table 1 lists the prices that we paid the coin dealer, as well as the "book value" of the coin as posted by the Professional Coin Grading Service (PCGS) on August 1, 2004. The book value is an estimate of the retail price of each coin, compiled from various sources including dealer advertisements in trade papers, dealer fixed price lists, significant auctions, and activity at major coin shows. Notice that the book value of each of our coins is higher than our purchase price.

The choice of coins for these experiments was strategic; the coins are popular, yet not particularly rare, collectibles. That is, the market is thick enough to limit the effect of these auctions on market prices. Furthermore, the relative common nature of the auctions was unlikely to reveal these auctions as field experiments.[8] Coin experts may have more insight into valuations than non-experts, but not to the extent that casual buyers cannot establish their own valuations for the objects.

We created the online auctions by first logging into the sites with a user identification name and password. Selecting the option to "Sell", we entered the sellers' interface to create the item description pages.[9] All coins were sold with nearly identical descriptions, varying only by coin age and rating, with three detailed digital photographs of the encapsulated coin.[10] All auctions were seven days in

[7] For the hard-close ending rule, the text states: "This auction does not get automatically extended." For the soft-close rule, the text states: "Auction may get automatically extended."

[8] This mitigates any behavior changes that could arise as a consequence of bidders' awareness of the experimental aspect of the auctions.

[9] Sellers' accounts on eBay and Yahoo, through which payments are exchanged, had already been established.

[10] The text below the photographs was: "The coin shown is the exact coin you will receive. Sealed in NGC slab. Free shipping and handling with USPS first class. Picture cannot capture all details, please go with grading. Payments can be made via paydirect, paypal, cash and money order only."

length. Both eBay and Yahoo auction websites allow sellers to choose the opening bid value as well as a secret reserve price for an item. No secret reserve price was selected. Instead, opening bid values were modified to test high-reserve effects. Shipping and handling charges (totaling approximately $1.30 for US addresses) were free to buyers in all auctions.

For the field experiments, we divided the coins into "batches", each comprised of the eight different Morgan and Peace silver dollars identified in Table 1. In total, we conducted eighty-eight auctions (or, equivalently, 11 batches) for this study. All the coins in a given batch were auctioned using the same site, ending rule, and reserve. Thus, our treatments consist of varying the identity of the site, the ending rule, and the reserve price. This paired design allows for comparison both between sites holding reserve price and ending rule constant, and within sites varying reserve price and ending rule. Figure 2 offers a graphical depiction of the complete experimental design, which we summarize below:

Baseline. In our baseline comparison, we test the predictions of Hypotheses 1 and 2 in the simplest possible fashion. That is, we auctioned two batches of coins on Yahoo and three batches on eBay specifying a hard close and zero reserve on both sites.[11]

High Reserve. While treatments were held constant within each batch of coins, we conducted auctions with zero and positive reserve values to examine Hypotheses 1 and 2 in the presence of a significant reserve price. Starting prices in positive-reserve auctions were equal to 70 percent of the purchase price of the coins from the dealer. Two batches of coins where auctioned on Yahoo and two batches on eBay under this high-reserve treatment.[12]

Ending Rule. Ockenfels and Roth (2006) suggest that ending rule may affect auction revenue. Yahoo offers sellers the choice between a hard and soft close, while eBay offers only a hard close. Thus, in principle, differences across the sites could be attributable to our use of the possibly "inferior" hard close on Yahoo in the baseline treatment. To investigate this possibility, we conducted fours batches of zero-reserve auctions on Yahoo—two batches were auctioned using the hard close and two using the soft-close ending rule. We also sold two batches of auctions on Yahoo with a 70 percent reserve price—one using the hard close and the other using the soft-close ending rule.

Both Yahoo and eBay sites maintain reputation ratings for registered users. Reputation values reflect users' reviews from previous transactions; positive feedback increases a user's rating by one

[11] Technically, the no-reserve treatment used a reserve of $1, a trivial price relative to the actual value of the coins.

[12] Note that for the Yahoo auctions, one batch was auctioned with a hard close and one with a soft close. As we shall see, the ending rule robustly has no effect on auction revenues. Thus, we pool these two batches to compare them to eBay under the same reserve.

point, while negative feedback reduces the rating by one point. Since previous studies have identified reputation effects on sales (Resnick and Zeckhauser, 2002), the seller's name and reputation rating was identical for all items auctioned on each site. Seller reputation values were reasonably high on both sites at 87 and 245 for Yahoo and eBay, respectively. The data set was constructed from information gathered from auction bidding history files. Both Yahoo and eBay sites allow users to view summaries of auction activities, including bids, bidders' usernames and, on eBay only, all bidders' reputation ratings. Yahoo lists only winning bidders' reputation ratings.

The auctions were posted online on Tuesday, Wednesday or Thursday evenings. Yahoo and eBay's planning feature allows sellers to schedule auction starts in advance, allowing all auctions in a batch to be posted at approximately the same time. The field experiments were monitored only through the seller's portal to ensure that pageview counts were not affected. Upon auction completion, the item information page and the bidding history page were saved electronically to preserve the results. All items were shipped promptly to the winners.

Unlike field data retrieved from online auctions where results are potentially confounded by unobserved heterogeneities and where the auction "rules" (such as ending time, duration, and opening bid) are endogenous, our field experiments ensure the consistency of product quality and online descriptions, shipping fees, seller's name and reputation value, and auction length. The matched-pair design allows for direct comparison between the treatment groups, exploiting the homogeneity of the auctioned item pairs and directly addressing the testable hypotheses outlined above. The following section highlights the important results of the statistical analysis.

4 Results

4.1 Descriptive Statistics

Pooling auctions by site, Table 2 presents descriptive statistics for the experiments. As the table indicates, the average revenues and numbers of bidders were higher on eBay compared to Yahoo under all treatments. Consistent with auction theory, the presence of a reserve price raises revenues and reduces the average number of bidders on both sites. A typical bidder made between 1 and 2 bids for a given coin over the course of the auction, with a slightly higher incidence of multiple bidding on eBay compared to Yahoo. Winning bidders tended to be quite experienced with average feedback scores of approximately 263 on eBay and 232 on Yahoo. Unlike many auctions on eBay, the winning bidder in this market was less likely to be a "sniper" (a user who submits bids in the closing seconds of the auction); the last bid by the winning bidder was entered an average of 296 minutes (almost five hours) before the close of the auction on eBay and 1050 minutes (17.5 hours) before the close on Yahoo. On average, we received 9.38 bids for coins sold on eBay and 7.88 bids for coins sold on Yahoo.

4.2 Equilibrium Coexistence

We begin our empirical analysis by examining the equilibrium coexistence hypotheses for Yahoo and eBay. Our field experiments provide us with a rich data set consisting of observed bid values and times, bidder names and feedback levels, as well as other auction attributes from the 88 auctions. Note that five Yahoo auctions finished without a sale and were subsequently dropped from the data.[13]

Table 3 summarizes the revenues and the number of unique bidders per auction for the two sites, aggregated by coin type.[14] Hypotheses 1 and 2 suggest that both revenues and numbers of bidders per auction should be approximately equal across the two sites. Turning first to revenues, note that average Yahoo revenues are lower than average eBay revenues for each of the different coins. Moreover, the Yahoo-eBay price spread appears to be quite large, ranging from approximately 20 to 70 percent depending on coin type. Averaging across all auctions, eBay buyers paid 35 percent more than Yahoo buyers for identical items.

Table 3 also displays the number of unique bidders per auction for the two sites, aggregated by coin type. Note that the average number of unique bidders per auction is lower on Yahoo than on eBay for each of the different coins. The difference in the number of bidders per auction also appears to be quite large, ranging from approximately 35 to 120 percent more bidders per auction on eBay as compared to Yahoo. Averaging across all auctions, there were almost 60 percent more bidders per auction on eBay than on Yahoo for auctions of identical items.

Of course, Table 3 is merely suggestive of significant differences in the revenues and the number of bidders per auction across the two sites. Next, we test Hypotheses 1 and 2 formally using econometric

[13] Failure to sell is not simply a case of censoring of revenue. While an unsuccessful seller loses the fees paid to the site, he may attempt to sell the item again in a subsequent auction. That is, revenue from a failed posting is not zero; it is simply delayed and eroded by additional fees.

[14] We construct the bidder count variable by observing the number of unique bidder identification names participating in an auction. To the extent that the same physical bidder places multiple bids under different user IDs, we would be overcounting the number of bidders. However, given the high average "experience level" of our bidders (measured by feedback ratings which averages 232.1 on Yahoo and 242.5 on eBay), this does not seem to be a serious issue.

techniques. Let $revenue_{air}$ denote the revenue obtained from an auction held at site a for coin i under treatment r. Similarly, let $bidders_{air}$ be likewise defined as the number of bidders participating in a particular auction.

Hypothesis 1: Price Equalization

Hypothesis 1 suggests the following econometric specification:

$$revenue_{air} = \beta_0 + \beta_1 site_{air} + \gamma X_{ir} + \varepsilon_{air}, \tag{1}$$

where $site_{air}$ is a dummy variable which equals 1 when the auction occurs on eBay and zero when the auction occurs on Yahoo. The variable X_{ir} represents a matrix of controls associated with an auction for coin i under treatment r. Our matrix of controls may include the following variables, depending on the specification:

Book Value - We use the PCGS book values to control for variation in retail demand for the coins.

Dealer Price - We use the price we paid for each of the coins to reflect the fact that revenue will reflect, at least partially, the costs of acquisition.

Reserve - We use a dummy variable, set equal to one under the high reserve treatment, to reflect the theoretical possibility that reserve price affects revenue (see, for instance, Myerson (1981)).

Ending Rule - We use an ending rule dummy variable, set equal to one when an auction ends at a fixed time (i.e. hard close), to reflect the possibility that ending rule affects revenue (see Ockenfels and Roth (2006)).

Item Dummies - In versions of specification (1), we include dummy variables for each of the coins auctioned. The inclusion of these dummies allows for unobserved heterogeneity by coin type apart from book value and costs. For instance, if the popularity of a coin changed between the time of our purchase and subsequent sale, an item dummy variable for that coin would capture this variation.

Finally, the expression ε_{air} represents a standard error term. To control for heteroskedasticity, robust standard errors are reported.[15]

In Appendix A, we report the results of specifications where, instead of using item dummies, we postulate that the error term contains a coin-specific random effect. We perform Hausman tests to examine the appropriateness of our random effects specification and fail to reject the null hypothesis

[15] White's general test for heteroskedasticity was conducted. The null hypothesis of constant variance is rejected in all cases.

for all models—the use of the random effects specification appears justified. As Appendix A shows, our results are substantially unaffected by the inclusion of random effects.

The theory described in Section 2 suggests that revenues should be approximately equal between the sites. That is, Hypothesis 1 predicts that the site coefficient is zero ($\beta_1 = 0$) under specification (1).

Hypothesis 2: Buyer-Seller Ratio Equalization

Hypothesis 2 suggests the following econometric specification:

$$bidders_{air} = \beta_0 + \beta_1 site_{air} + \gamma X_{ir} + \varepsilon_{air}, \tag{2}$$

where the right-hand side variables are defined identically to equation (1) . Hypothesis 2 of the theory model also predicts that the site coefficient is zero ($\beta_1 = 0$) in this specification. Of course, equations (1) and (2) assume that any shift in the price level associated with using a given site is constant for all coins. Given the wide variation in the coin prices, one might worry that such a specification is overly restrictive. Accordingly, we also examine equivalent specifications of equations (1) and (2) where the dependent variable is $\ln(revenue_{air})$ and $\ln(bidders_{air})$, respectively. For these cases, the site coefficient, β_1, represents the percentage change in revenue or number of bidders per auction. Once again, the theory model predicts that $\beta_1 = 0$.

Baseline

Table 4 displays the results of the regression specifications under the baseline treatment—auctions with a low reserve price and a hard close. Model 1 presents the coefficients associated with equation (1) with book value and dealer price controls. Model 2 presents results with coin dummies in lieu of cost and book value controls. Model 3 presents the log specification of Model 2. Models 4 to 6 are the analogous specifications for equation (2).

As Table 4 indicates, eBay auctions yield significantly higher revenues than the equivalent auctions conducted on the Yahoo site. Not only can we reject the hypothesis that $\beta_1 = 0$ at the 1 percent significance level, but the economic magnitude of the coefficient estimates is substantial. For instance, Model 3 of the table indicates that conducting an auction on eBay rather than Yahoo increases seller revenues by 26.8 percent. Similarly, for regressions examining the number of bidders, we can reject the hypothesis that $\beta_1 = 0$ at the 5 percent significance level in all instances. Again, the economic magnitude of the coefficients is considerable—an eBay auction attracts more than two additional bidders when compared to an equivalent Yahoo auction.

Table 4 also suggests that item cost is an important predictor of revenue. Indeed, the coefficient in Model 1 of Table 4 implies that a \$1 increase in the dealer price is associated with a 99 cent increase in the sale price. In contrast, book value has little explanatory power. Not only are the book value coefficients not statistically significantly different from zero, but the economic magnitudes are quite small. Interestingly, neither item cost nor book value appear to have much effect on the number of bidders attracted to an auction. As Model 4 of Table 4 shows, the economic magnitude of these coefficients is small and neither rise to statistical significance at conventional levels.

High Reserve

How does the presence of a reserve price affect revenues? One possible cause of the significant differences between the revenues and numbers of bidders per auction on eBay and Yahoo is that the reserve price is non-optimally set, and that this seller "mistake" has a greater effect on Yahoo than on eBay. To address this potential explanation, we pool the results of the hard-close auctions across the two sites and include a dummy variable to indicate positive reserve values. The results of these analyses are displayed in Table 5. First, notice that the inclusion of auctions with a positive reserve price has little impact on the magnitude or significance of the site-related coefficients. Once again, we can reject the hypothesis implied by the theory that $\beta_1 = 0$ at the 1 percent significance level—coefficient estimates suggest that running auctions on eBay leads to 29.3 percent higher revenues and attracts 2.124 more bidders than the equivalent Yahoo auction.

Table 5 also reveals that the presence of a reserve price plays a significant role in auction outcomes. In Models 1 to 3, we can reject the null hypothesis that the coefficient associated with the positive reserve is equal to zero at the 5 percent significance level; coefficient estimates suggest that a positive reserve price increases revenues by approximately 7 percent. The effect of a positive reserve price on the number of bidders is consistent with theoretical predictions and statistically significantly different from zero at the 1 percent significance level. Coefficients estimates for the number of bidders specification indicate that positive reserve prices successfully screen certain bidders—a 70-percent reserve price attracts approximately 2.8 fewer bidders than a low reserve price.

The inclusion of a 70-percent reserve price in Table 5 does not alter our earlier conclusions about the differences in revenues and numbers of bidders across sites. In fact, the coefficient estimates of the revenue difference across sites vary little from those in Table 4. Moreover, the hypothesis of the coexistence theory—that $\beta_1 = 0$—is rejected at the 1 percent significance level in all of the models.

Ending Rule

Failing to explain the large revenue and bidder count disparity with the reserve price treatments, we turn to the effect of the ending rule on revenues. The theoretical rationale for differences in bid timing stemming from differences in the auction ending rule, described in Ockenfels and Roth (2006), implies that revenues may be higher under a soft close than under a hard-close rule.[16] In principle, since Yahoo allows sellers to select a soft close while eBay does not, the difference in the revenues across the two sites could be attributed to the fact that the hard-close auctions run on Yahoo are "inferior" to those run by a sophisticated seller aware of the importance of the ending rule. Accordingly, we run specifications analogous to equations (1) and (2) , but confine our attention to auctions conducted on Yahoo. Table 6 displays the results of this analysis. Notice that the coefficient associated with the ending rule is not statistically significantly different from zero in any of the six models. Moreover, the economic magnitude of the coefficients is small. For instance, the coefficient estimate in Model 2 of Table 6 indicates that revenue increases by less than half of one percent when a seller selects the soft close over the hard-close rule. In short, there is little evidence that the eBay-Yahoo revenue differences are affected by the ending rule in this setting.

In addition to finding no revenue or number of bidder effects associated with the ending rule, we also investigate the effect of the ending rule on bid timing as well. Roth and Ockenfels (2002) report that late bidding occurs with much greater frequency in auctions with a hard close than in auctions with a soft close. To investigate this possibility, we examine the following specification for the Yahoo auctions:

$$bid\_time_{ir} = \beta_0 + \beta_1 endingrule_{ir} + \gamma X_{ir} + \varepsilon_{ir} \tag{3}$$

where bid_time_{ir} is the time in minutes between the instant a particular bid was placed and the time that the auction ended. The variable *endingrule* is the dummy variable described above. The matrix X_{ir} includes dummy variables for each of the coin types as well as the reserve treatment. As usual, we use robust estimation to account for heteroskedasticity in the data.

If bid timing were affected by the ending rule in a manner consistent with the theory and findings of Roth and Ockenfels, we would expect the coefficient β_1 to be negative. The null hypothesis is, of

[16] Specifically, the revenue ranking result follows from the combination of Ockenfels and Roth's (2006, page 303) theorem characterizing equilibrium behavior in hard-close auctions and the theorem characterizing bidding behavior in in soft-close auctions (page 309).

course, that ending rule has no effect. The results of the estimation of equation (3) are reported in Table 7 using two measures of the dependent variable. In Model 1, we examine the timing of last bids only. That is, if a bidder entered multiple bids in a given auction, we take only the timing of his last bid as representing his true bid timing. As Model 1 of Table 7 shows, the coefficient estimate for β_1 is in the direction consistent with Roth and Ockenfels results (bidders bid an average of 223 minutes later, all else equal); however, we cannot reject the null hypothesis that $\beta_1 = 0$ at conventional significance levels. Model 2 of Table 7 includes the timing of all bids. Again, the coefficient estimate of β_1 is not statistically significantly different from zero at conventional levels. More surprisingly, it takes on a positive sign—bidders bid an average of 118 minutes *earlier* in hard close auctions, all else equal. Taken together, the results appear rather different from the findings contained in Roth and Ockenfels (2002), Ariely, Ockenfels, and Roth (2005), and Ockenfels and Roth (2006).

Interestingly, the presence of a 70-percent reserve price does have a significant effect on bid timing. Regardless of how bid timing is measured, the coefficient associated with the reserve dummy is negative and significant at the 1 percent level. The coefficient estimates suggest that the presence of a positive reserve price delays bids by approximately 30 hours. A positive reserve screens out bidders submitting bids well below the market price for the particular coin whereas, in the auctions with no reserve, such bidders are often active at the beginning of an auction.

Pooled Results

Finally, we examine the effect of site on revenue and number of bidders for all treatments. The results of these "pooled" regressions are displayed in Table 8. Once again, we reject the theory model prediction that site has no effect on revenue or number of bidders at the 1 percent significance level for all models. The results indicate that eBay listings lead to a 29.6 percent increase in revenues and attract 58.3 percent more bidders than Yahoo listings. Overall, the evidence is inconsistent with the implications of the theoretical model of eBay and Yahoo coexistence.

To summarize:

1. In all specifications, the coefficient estimates suggest that auctioning a given coin on eBay yields approximately 29 percent higher revenues than auctioning the same coin on Yahoo. This is inconsistent with the equilibrium coexistence theory.

2. In all specifications, the coefficient estimates suggest that approximately two more bidders per seller bid on a given coin auctioned on eBay than bid on an identical coin auctioned on the

Yahoo site. This is also inconsistent with the equilibrium coexistence theory.

3. In all specifications, the coefficient estimates suggest that ending rule choice (hard close versus soft close) affects neither revenues nor the number of bidders in an auction for a given coin on the Yahoo site. This is different from the findings of Roth and Ockenfels (2002), Ariely, Ockenfels, and Roth (2005), and Ockenfels and Roth (2006).

4.3 Alternative Hypotheses

While the results are inconsistent with the stark model of equilibrium coexistence contained in Ellison, *et al.,* that model abstracts away from a number of factors which might possibly reconcile our results with equilibrium coexistence. We examine the following alternatives:

1. Platform Differentiation. While the theory model postulates that sites do not differ from one another in inherent quality, some have suggested that eBay's platform offers superior service compared to Yahoo and that this might account for the revenue differences.

2. Switching Costs. The theory model assumes that it is costless for buyers and sellers to switch between platforms. As a practical matter, there are frictions in moving between auction sites. Perhaps lock-in, in the form of switching costs, accounts for our results.

3. Reputational Differences. In the theory model, seller reputation was inconsequential to buyers. A large existing literature, however, suggests that reputation does matter a great deal. Perhaps sellers on eBay simply have superior reputations relative to Yahoo sellers, and this accounts for the site differences.

4. Anomalous Data. Our study focused on 88 auctions at a particular point in time. Perhaps with either a larger number of auctions or a different time period, the observed revenue differences would disappear.

Platform Differentiation The hypotheses we tested were derived under the assumption that the competing sites were homogeneous—given the same number of buyers and sellers on the two sites, a buyer (or seller) derives the same payoffs from using the eBay site as from using the Yahoo site. Of course, in reality, it may be the case that one of the sites offers certain advantages relative to the other—perhaps in the form of buyer or seller insurance or ease of use. It has been suggested that the price disparity and differences in the number of bidder across the two sites may stem from the fact that eBay is vertically differentiated compared to Yahoo from the perspective of buyers, sellers, or both.

To examine this possibility, we generalize the theory model to allow for vertical differentiation across the sites. Specifically, suppose that the expected payoffs to sellers are the same as in the original model when selling on Yahoo, but eBay buyer payoffs are now

$$w\left(S_e, B_e\right) = \frac{1}{2}\left(\frac{2B_e - S_e + 1}{B_e + 1}\right) q^S$$

where $q^S \geq 1$ represents the vertical differentiation advantage of eBay from the perspective of sellers. Similarly, suppose that the payoffs to buyers on the Yahoo site are the same as in the original model, but eBay seller payoffs are now

$$u_b\left(S_e, B_e\right) = \frac{1}{2}\frac{S_a\left(S_a + 1\right)}{B_a\left(B_a + 1\right)} q^B$$

where $q^B \geq 1$ represents the vertical differentiation advantage of eBay from the perspective of buyers.

Can platforms coexist in equilibrium when they are vertically differentiated and the number of buyers and sellers is large? Can the price differences observed in the data be rationalized through vertically differentiated platforms? The following propositions establish that the answer in both cases is no. Specifically, suppose that the eBay site is vertically differentiated from the Yahoo site. That is, $q^S \geq 1$ and $q^B \geq 1$ with strict inequality for either q^B or q^S. Proposition 1 shows that coexistence is impossible when markets are large.

Proposition 1 *As the number of buyers and sellers grows arbitrarily large, the fraction of buyers and sellers at one of the sites goes to zero.*

Proposition 1 implies that, when sites are vertically differentiated and the number of buyers and sellers grows large, only "tipping" equilibria remain. It is silent about the direction of tipping or what happens outside of the limit. Suppose that we consider the case for large, but finite, numbers of buyers and sellers, and restrict attention to equilibria in which both sites are active. Again, the addition of vertical differentiation does not help to rationalize the observed results. Specifically, for the two sites to coexist under these conditions, it must be the case that the majority of buyers and sellers locate at the *inferior* site, i.e., on Yahoo. The intuition for this seemingly counterintuitive result is that the scale effect must compensate for the vertical differentiation advantage of eBay; hence, for buyers and sellers to be approximately indifferent between the two sites, it must be that Yahoo enjoys significant scale advantages. Formally,

Proposition 2 *When there are a sufficiently large number of buyers and sellers, fewer than half of each visit the eBay site. Formally, for N sufficiently large, in any interior quasi-equilibrium, $B_e(N) < \frac{N}{2}$ and $S_e(N) < \gamma \frac{N}{2}$, where γ is the ratio of sellers to buyers.*

The proofs of both of these propositions are contained in Appendix B and use essentially the same equilibrium arguments as in the baseline model of Ellison, *et al.* The main conclusion to be drawn is that the introduction of vertical differentiation is not sufficient to rationalize the coexistence of the two sites with the results of the field experiments.

Switching Costs Results from the field experiments suggest that, free from other motives or constraints, rational buyers should switch to Yahoo and rational sellers switch to eBay until the gains from switching approach zero. In practice, however, there may be constraints on switching and switching costs may not be small. For instance, a seller with an established reputation (feedback rating) on one site may be loath to undertake the costs of rebuilding this reputation after switching to another site. Likewise, a buyer with successful purchase experience on one site may be reluctant to "test" the reliability of sellers on an alternate site. More mundanely, a buyer already participating on one site may simply be unwilling to expend the "hassle cost" of filling out the necessary forms to participate on the other site. Since the theoretical model generating Hypotheses 1 and 2 assumed zero switching costs, it could be the case that, in the presence of significant switching costs, the revenue differences observed above are still consistent with equilibrium coexistence. In this section, we investigate whether these factors can account for the revenue differences across the two sites.

A straightforward explanation for the observed revenue differences is that significant numbers of eBay buyers and Yahoo sellers are simply unaware that the other service exists—the effective switching cost for these ignorant buyers and sellers is infinite. However, searches on several popular online search engines provides some evidence that both Yahoo and eBay are easy to "find" on the Internet; searches for keywords "auction," "internet auction" and "online auction" put Yahoo and eBay in the top five results for Google and Yahoo search services.[17] If the field experiment participants were all novice Internet users, then we could speculate that a search engine directed them to either eBay or Yahoo, and that they were unaware of other options. Yet, with average Yahoo and eBay feedback values of 232.1 and 242.5, respectively, the majority of auction participants are quite experienced users.[18] Therefore, the argument that many eBay users are ignorant in terms of service selection seems unconvincing. Moreover, while one might plausibly argue that the lesser-known status of Yahoo's auction service makes it effectively "invisible" for eBay buyers, it seems hard to imagine that Yahoo sellers are simply unaware of eBay.

Even if aware of the alternatives, high switching costs could prevent users from moving their business between eBay and Yahoo. The cost of registration alone is low; on both sites, users complete identification information forms and select a username and password. Yahoo simplifies its sign-up process by allowing individuals with Yahoo e-mail addresses to bypass the personal information page of user registration. Given the size of the revenue differences in Table 7, for an individual buyer interested in a coin in our auctions to be dissuaded from signing up at the Yahoo site, the "hassle cost" would have to exceed \$15—this seems implausibly high. Put differently, since it takes around one minute to fill out the Yahoo registration form, the opportunity cost of time for this buyer would have to exceed \$900 per hour.

While registration is not costly in terms of time or effort, some users may feel invested in terms of their reputation (feedback rating) on a site. In general, buyers' reputations matter little, since the seller can hold the item until payment is received. However, it is quite reasonable to argue that our bidders may also be sellers in the collectible coin market.[19] From a bidder's perspective, high seller reputation values may signal quality and reliability. Feedback points can be gained through both selling and purchasing activities and are not allocated based on the value of the transaction. That is, users may boost their rating through many low-value transactions; successfully completing 10 one-dollar purchases is indistinguishable from the completion of 10 one-thousand-dollar transactions. In addition, the auction services promote positive ratings by simply subtracting negative from positive feedback, despite negative ratings being rarer and more informative (Resnick and Zeckhauser, 2002).

[17] Searches were conducted on November 20, 2004.

[18] Winning bidders' user histories, listing details of all transactions from the previous 30 days, were examined on March 12, 2005 for evidence of participation on both sides of the coin market. Twenty-four of the 31 winning bidders on eBay had multiple coin-related transactions in their buying and selling histories.

[19] According to their recent user histories, ten of 31 winning bidders were actively selling collectible coins.

Casually, however, it seems plausible that if users place some value on positive feedback scores, then rebuilding reputation stocks after switching auction services could be costly.

When one considers the magnitude of the price disparity, this argument becomes much weaker. If the disparity were mere cents, then the reputation argument might seem more convincing. However, with 20 to 60 percent premiums, reputation would need to be extremely valuable to deter switching. Consider a user with a reputation value of 100 on eBay who is considering switching to Yahoo. Since Yahoo lists many items valued at or below \$1 (often with the option to buy immediately without bidding), the user could rebuild his reputation for approximately \$100. With the average eBay-Yahoo price disparity, if he purchases seven Yahoo coins, the user's savings have more than offset switching costs.[20] In fact, Brown and Morgan (forthcoming) identify a market on eBay whose sole purpose is the "manufacture" of reputation for users. Trading seemingly-valueless items such as ebooks and publicly available digital photographs for pennies in this market, a user could artificially enhance (or rebuild) her 100-point reputation for approximately \$1—a tiny fraction of the values of the coins we sold on the sites. Clearly, this assumes user preferences over reputation on a site, but not the site itself.

Reputational Differences Neither eBay nor Yahoo endorses the reliability of their sellers, yet, is it possible that eBay bidders simply do not trust Yahoo or its members? Perhaps Yahoo sellers have a reputation for failing to deliver products, or selling damaged or counterfeit goods. Are eBay bidders paying a premium to avoid default? In fact, several online reviews from individual buyers characterized Yahoo sellers as fraudulent, blaming Yahoo's perceived inaction on abuse claims (for example, see Ciao, 2005). However, searches for eBay-related complaints yield similar results.[21]

Using the data collected from our field experiments, we calculate the implied default rate needed to deter switching. Suppose an individual is indifferent between eBay and Yahoo purchases when the following expression holds with equality:

$$(1 - \lambda) U_g + \lambda U_b = U_e \tag{4}$$

where U_g is the utility associated with a successful Yahoo transaction, U_b is the utility from a Yahoo

[20] Insufficient purchases to recoup switching costs does not appear to be relevant for many participants. Only 4 of the 31 eBay winners had not recently participated in a coin-related auction. The 27 active collectors had purchased between 2 and 76 coins during the month of March 2005, alone.

[21] Google searches for "eBay rip off" (omitting the term "Yahoo") and "Yahoo auction rip off" (omitting the term "eBay") revealed 725,000 and 234,000 results, respectively (July 26, 2005).

transaction that results in total loss, U_e is the utility from a (always) successful eBay purchase, and λ, the default rate, is the probability that a Yahoo purchase will result in total loss.

Solving (4) yields

$$\lambda = \frac{U_e - U_g}{U_b - U_g}$$

where $U_b - U_g \neq 0$.

To model a consumer's expected utility from a given transactions, we follow the experimental auction literature (see Cox *et al.*, 1988) and assume that consumers have constant relative risk aversion utility functions,

$$U(w) = \frac{1}{1-\rho} w^{1-\rho}$$

where $\rho \in [0,1)$ is the coefficient of relative risk aversion, w is total wealth, and risk neutrality is a nested case ($\rho = 0$). In this case, utilities may be defined as follows:

$$\begin{aligned} U_g &= \frac{1}{1-\rho}(W + V - P_Y)^{1-\rho} \\ U_b &= \frac{1}{1-\rho}(W - P_e)^{1-\rho} \\ U_e &= \frac{1}{1-\rho}(W + V - P_y)^{1-\rho} \end{aligned}$$

where W is the initial wealth level of the individual. According to the 2000 census, the median household wealth in the US is \$55,000 (US Census Bureau, 2005). Likely on the lower end of the wealth distribution for the online coin-collecting group, this wealth estimate leads to very conservative implied default rates. That is, higher household wealth would result in even higher and less-dispersed default rates. We estimate V as the PCGS book value for the coins, and P_e and P_y as the average revenue by coin by site (Table 2).

Varying ρ, implied default rates range from 12 percent ($\rho = 0.9$,coin 1) to 19 percent ($\rho = 0.1$, coin 8). The average variance of λ by coin is 0.002. Averaging across all coins, λ is 17.6 percent. That is, for a bidder to be indifferent between the sites, he would need to believe that one of six transactions would result in total loss.[22] Even if this is a reasonable estimate of Yahoo sellers' trustworthiness, it

[22] Modeling lower household wealth levels is illustrative. Household wealth levels below \$100 and risk aversion coefficients approaching $\rho = 1$ are required to achieve default rates below 10 percent for some coins. Yet, even with implausibly-low wealth levels and extreme risk aversion coefficients, overall implied default rates average nearly 12 percent across the eight coin types. We modeled higher household wealth levels as well; when $W = \$200,000$, average λ was approximately 18 percent for all values of the risk aversion coefficient.

is not an equilibrium explanation. No credible signal exists for reliable sellers, as both good and bad sellers are motivated to switch to eBay.

Anomalous Data The remarkable price and bidder count differences between eBay and Yahoo that we observe in our field experiments raise the questions: Are these disparities somehow artifacts of the experimental design? And, do these differences persist beyond the experimental time frame? To address these questions directly, we gathered data from over 25,000 Morgan and Peace series coin auctions on eBay and Yahoo in the months of April, May, June and August of 2006. We filtered the original collection of auctions to identify those item with descriptions and grades similar to those used in our experiments to allow us to compare the experimental and field data. For example, from the set of auctions for 1898 Morgan dollar coins, we selected only those auctions for coins graded MS-64. As we observed on the sites during the time of experimental auctions, the market for Morgan and Peace series coins on eBay remains substantially larger than the market for these coins on Yahoo.

Table 9 present summary statistics for the field data. We examine 1652 auctions in total; 371 coins on Yahoo and 1281 coins on eBay. Pooling the eight coin types, the mean price of the coins on eBay is $59, while the average coin price on Yahoo is $54.17. The difference in means of total auction revenue across the sites suggests that the price disparity remains, and compels us to investigate more formally. The inequality of means in bid counts—on average, an eBay seller attracts more than 7 bids per auction, while Yahoo sellers receive approximately 4.5 bids per auction—is also suggestive of a persistent difference in the number of bidders attracted to each auction sites.

To identify these disparities more formally, we use regression specifications similar to equations (1) and (2) described above. Table 10 presents the results from the regressions; models 1 and 2 regress revenue and the log of revenue, respectively, against site, coin and auction characteristics, while models 3 and 4 regress the number of bids and the log of the number of bids, respectively, against site, coin and auction characteristics. Regression coefficients are all statistically significant and confirm the persistence of the revenue and bid count disparities.

Controlling for coin type and opening bid, the coefficient on the site variable in models 1 and 2 suggests that coin auctions on eBay yield a $11 or 15 percent revenue premium relative to equivalent Yahoo auctions. Examining the regressions on the total number of bids received per auction, we conclude that eBay auctions attracted approximately 2 more bidders per seller than comparable Yahoo auctions—controlling for other item and auction related observables, this is equivalent to approximately 70 percent more bids per seller on eBay relative to Yahoo.[23]

The field data suggests that the observed revenue and bid count differences were not an artifact of our particular experimental design or the time at which the experiments were conducted. The differences between the two sites seem to be persistent and systematic.

5 Conclusion

We have shown that there are significant differences in revenues and number of bidder per seller for identical items sold on eBay and Yahoo auctions—an observation that is inconsistent with equilibrium coexistence of the two sites. Even if one accounts for additional considerations such as service differences between the sites, switching costs, and general reputation effects, one cannot reconcile our results with a theory of equilibrium coexistence.

Thus, we are left with a puzzle: This revenue disparity arguably represents an opportunity for arbitrage between the sites. Agents could purchase the relatively inexpensive coins on Yahoo and sell them on eBay for the relatively higher price, taking advantage of the price spread to earn, on average, a 20 to 70 percent profit. While switching costs might reduce this profit somewhat, in our view, the arbitrage opportunity remains.

The possibility of persistent arbitrage opportunities in other areas, such as securities, has not gone unnoticed in the literature. Finance theory has suggested that potential arbitrageurs may be reluctant to exploit some opportunities due to the large fixed costs and capital outlays (Shleifer and Vishny, 1997). Moreover, if there is uncertainty about the distribution of returns from arbitrage activities, especially the mean, price disparities may persist until potential arbitrageurs determine whether their expected payoffs are sufficient to cover their fixed costs (Mitchell, Pulvino and Stafford, 2002). In this case, however, the relatively low capital requirements, as well as the fact that the Yahoo coins sold consistently for less than the eBay coins, make these no-arbitrage arguments less compelling.

So what is going on? Our view is that we are witnessing a market in the process of tipping.

[23] In our discussion of the field experiment data earlier in the paper, we introduced the number of bidders per seller as the variable of interest. However, due to data constraints, unique bidder counts per auction are not available for our field data. Instead, we use the number of bids per auction to proxy for the buyer-seller ratio. To alleviate concerns about potential bias in this proxy, consider the following: according to results from our field experiments, the average number of bids per bidder on eBay and Yahoo are 1.56 and 1.98, respectively (see Table 1). Were these bids per bidder statistics equal, we could describe the total *bid* count as simply a transformation of the total *bidder* count. Instead, because individual Yahoo bidders tend to submit fewer bids, our total bid counts actually underestimate the difference in buyer-seller ratios on eBay and Yahoo. That is, our statistical estimate of bidder count disparity in the field data is actually a conservative measure of the gap.

While we have not offered a formal model of the dynamics of tipping, modifying the Ellison, *et al.* model to allow for platform differentiation yields a tipped outcome as the inevitable consequence of platform competition when there are a large number of buyers and sellers. Moreover, recent changes to the eBay and Yahoo sites provide evidence supporting the idea of a market in the process of tipping. Specifically, in June of 2005, Yahoo eliminated all of its listing-related fees. In addition, Yahoo integrated its auction listings with the Yahoo Shopping platform; searches on Yahoo Shopping now reveal both non-auction and auction listings. In short, Yahoo auctions no longer really has an independent existence as a platform.

The relationship between eBay and Yahoo has also evolved to become less like that of competitors in the space of online auctions. Specifically, on May 25, 2006, Yahoo and eBay announced a US advertising alliance (eBay, 2006) in an apparent bid to dampen Google's internet dominance. The agreement positions eBay's Paypal service as the exclusive payment provider for purchases on the Yahoo site and suggests that eBay's Skype may be integrated into the future Yahoo services. EBay and Yahoo will also collaborate in search-based advertising—advertisements for eBay auctions now appear on Yahoo auctions search results screens. While the elimination of fees on Yahoo might have been interpreted, in isolation, as renewed efforts to fight eBay's auction dominance, the change in the formal relationship between the firms suggests that Yahoo has simply conceded the auction game to eBay and is focusing its business efforts away from auctions and towards its search and advertising services. In short, it suggests a market which has already tipped.

Figure 1 – Yahoo Screenshot

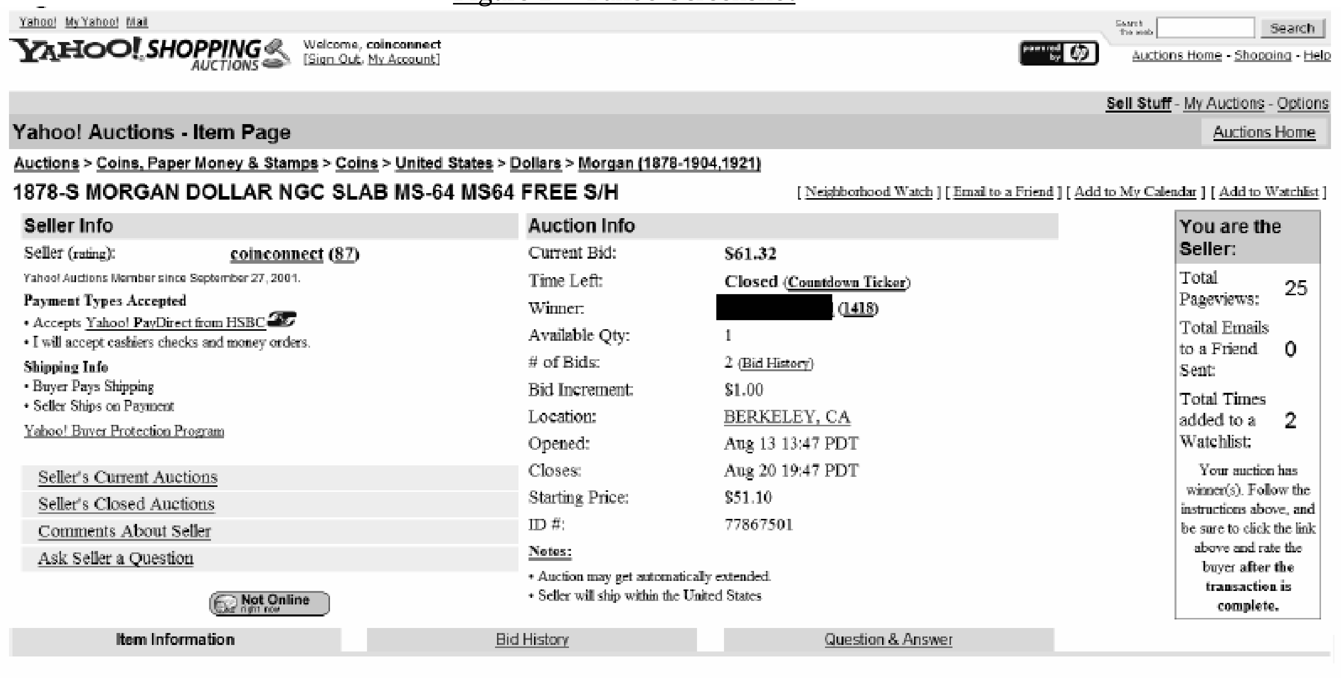

Figure 2: Experimental Design

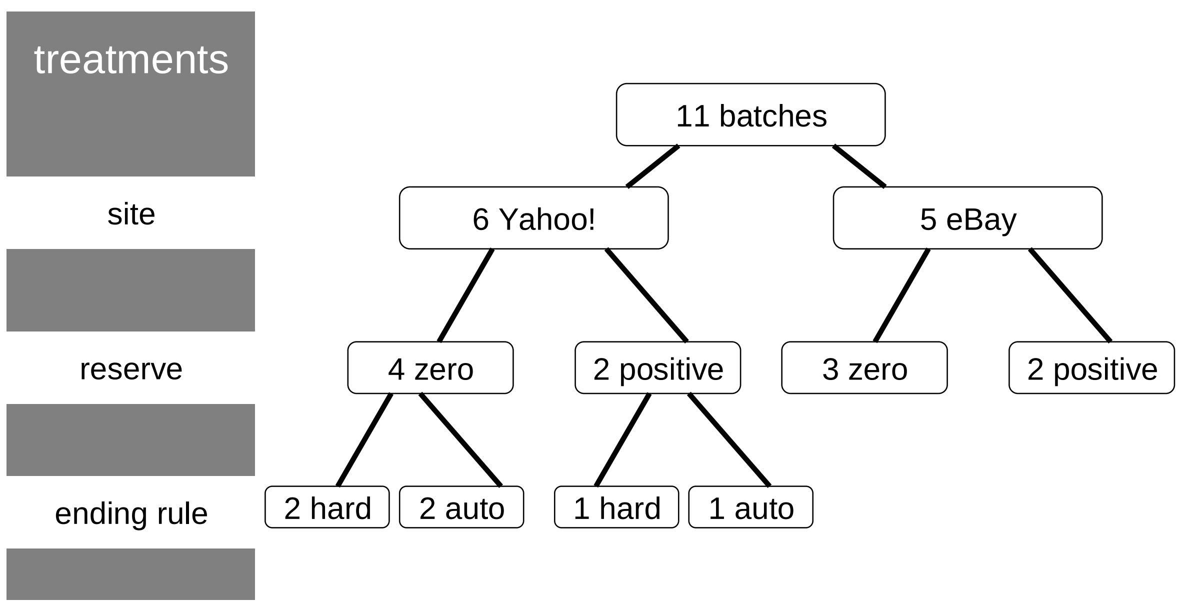

Table 1: Auctioned Coins

Item #	Item Description	PCGS Book Value	Dealer Price
1	1878-S Morgan Dollar NGC Slab MS-64	105	73
2	1885-O Morgan Dollar NGC Slab MS-63	42	35
3	1898-O Morgan Dollar NGC Slab MS-65	145	89
4	1902-O Morgan Dollar NGC Slab MS-65	145	98
5	1904-O Morgan Dollar NGC Slab MS-64	60	41
6	1922-P Peace Dollar NGC Slab MS-63	32	25
7	1923-P Peace Dollar NGC Slab MS-64	55	30
8	1923-P Peace Dollar NGC Slab MS-65	165	79

Notes: Professional Coin Grading Service (PCGS) book values available online at pcgs.com. Above values listed August 1, 2004. Dealer price was our cost from a coin dealer in Southern CA.

Table 2: Field Experiment Summary Statistics

		Mean Values	
		eBay	Yahoo
Revenue ($)	Hard-close, No reserve	59.88	46.71
		(30.94)	(25.39)
	Hard-close, Positive reserve	66.41	50.14
		(35.27)	(29.37)
	Soft close, No reserve	-	49.37
			(23.58)
	Soft-close, Positive reserve	-	47.33
			(29.40)
# of Bidders	Hard-close, No reserve	7.25	5.13
		(2.23)	(3.10)
	Hard-close, Positive reserve	4.38	2.17
		(1.67)	(1.17)
	Soft close, No reserve	-	5.36
			(2.68)
	Soft-close, Positive reserve	-	2.43
			(1.27)
Bids/Auction		9.38	7.88
		(4.74)	(6.61)
Bids/Bidder		1.56	1.98
		(1.44)	(1.62)
Winning Bidder Reputation		262.67	232.12
		(692.47)	(420.19)
Minutes from Close (All Bids)		2938.73	3854.58
		(3345.79)	(3404.11)
Minutes from Close (Winning Bid)		296.05	1048.36
		(874.05)	(2351.53)
# of Observations	Auctions	40	43
	Bids	374	368

Notes: Values in parentheses are standard deviations.

Table 3: Descriptive Statistics by Coin Type

		Item							
		1	2	3	4	5	6	7	8
Revenue ($)									
	Yahoo	58.66	25.06	77.81	83.33	37.36	16.75	19.66	54.37
		(5.14)	(2.93)	(4.31)	(6.22)	(4.76)	(0.96)	(4.27)	(6.23)
	eBay	71.54	32.80	97.13	110.52	44.73	23.91	33.33	85.96
		(3.98)	(2.16)	(15.02)	(15.98)	(4.28)	(3.03)	(4.85)	(11.12)
Yahoo-eBay Price Spread (%)		21.95	30.88	24.83	32.63	19.73	42.72	69.52	58.11
# of Bidders / Auction									
	Yahoo	4.17	2.83	5.17	5.50	4.83	2.33	2.67	4.50
		(2.64)	(1.47)	(3.06)	(2.59)	(3.37)	(2.16)	(2.42)	(4.28)
	eBay	5.60	4.60	7.20	7.60	6.40	5.20	4.60	7.60
		(2.97)	(2.70)	(1.92)	(2.41)	(3.36)	(1.48)	(1.82)	(1.52)
Yahoo-eBay Bidder Count Spread (%)		34.29	62.54	39.26	38.18	32.51	123.18	72.28	68.89

Notes: Standard deviations in parentheses.Yahoo-eBay price spread is the price difference of eBay and Yahoo as a percentage of the average price on Yahoo. Yahoo-eBay bidder count spread is the difference in the number of bidders on eBay and Yahoo as a percentage of the average price on Yahoo.

Table 4: Regression Results under the Baseline Treatment

	OLS Model					
	1	2	3	4	5	6
Dependent Variable	Revenue	Revenue	ln(Revenue)	# of Bidders	# of Bidders	ln(# of Bidders)
β_1: Site Dummy	13.173 **	13.173 **	0.268 **	2.125 *	2.125 **	0.498 *
	(2.480)	(2.420)	(0.036)	(0.817)	(0.818)	(0.192)
Book Value	0.001			0.018		
	(0.099)			(0.017)		
Dealer Price	0.992 **			0.013		
	(0.182)			(0.032)		
Constant	-11.664 **	55.952 **	3.988 **	2.698 *	5.125 **	1.518 **
	(3.405)	(2.757)	(0.048)	(1.118)	(0.675)	(0.129)
Item Dummies	No	Yes	Yes	No	Yes	Yes
# of Observations	40	40	40	40	40	40
R^2	0.93	0.94	0.97	0.34	0.45	0.42

Notes: Robust standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site Dummy" equals 1 if auction site was eBay.

Table 5: Regression Results under Baseline and High-Reserve Treatments

	OLS Models					
	1	2	3	4	5	6
Dependent Variable	Revenue	Revenue	ln(Revenue)	# of Bidders	# of Bidders	ln(# of Bidders)
β_1: Site Dummy	14.832 **	14.945 **	0.295 **	2.126 **	2.118 **	0.570 **
	(2.053)	(1.977)	(0.028)	(0.567)	(0.562)	(0.140)
Book Value	0.029			0.030 *		
	(0.077)			(0.013)		
Dealer Price	1.005 **			-0.014		
	(0.144)			(0.023)		
Reserve Dummy	4.870 *	4.756 *	0.071 **	-2.876 **	-2.868 **	-0.578 **
	(2.106)	(2.042)	(0.026)	(0.423)	(0.446)	(0.108)
Constant	-16.030 **	54.332 **	3.961 **	3.119 **	4.627 **	1.307 **
	(3.114)	(2.169)	(0.034)	(0.864)	(0.570)	(0.141)
Item Dummies	No	Yes	Yes	No	Yes	Yes
# of Observations	62	62	62	62	62	62
R^2	0.93	0.94	0.97	0.51	0.56	0.54

Notes: Robust standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site dummy" equals 1 if auction site was eBay. "Reserve dummy" equals 1 if reserve is positive.

Table 6: Regression Results under Ending Rule Treatment on Yahoo

	OLS Models					
	1	2	3	4	5	6
Dependent Variable	Revenue	Revenue	ln(Revenue)	# of Bidders	# of Bidders	ln(# of Bidders)
β_1: Ending Rule Dummy	-0.010	0.117	0.005	-0.179	-0.168	-0.115
	(1.741)	(1.495)	(0.044)	(0.703)	(0.741)	(0.171)
Book Value	-0.188 **			0.017		
	(0.063)			(0.028)		
Dealer Price	1.199 **			0.008		
	(0.106)			(0.047)		
Reserve Dummy	1.720	1.365	0.030	-2.751 **	-2.714 **	-0.749 **
	(1.647)	(1.546)	(0.042)	(0.549)	(0.571)	(0.142)
Constant	-6.488 *	58.143 **	4.056 **	3.210 **	5.155 **	1.587 **
	(2.513)	(2.417)	(0.051)	(0.800)	(1.109)	(0.205)
Item Dummies	No	Yes	Yes	No	Yes	Yes
# of Observations	43	43	43	43	43	43
R^2	0.95	0.97	0.96	0.37	0.41	0.5

Notes: Robust standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Reserve Dummy" equals 1 if reserve is positive. "Ending Rule Dummy" equals 1 if hard-close ending rule.

Table 7: Bid Timing Regression Results for Yahoo!

	OLS Models	
	1	2
Dependent Variable	Minutes from close	
	All Bids	Last Bids
β_1: Ending Rule Dummy	-223.327	118.351
	(344.95)	(476.84)
Reserve Dummy	-1828.738 **	-1888.365 **
	(485.74)	(551.71)
Constant	5592.761 **	4397.104 **
	(547.05)	(720.68)
Item Dummies	Yes	Yes
# of Observations	375	192
R^2	0.11	0.19

Notes: Robust standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Reserve Dummy" equals 1 if reserve is positive. "Ending Rule Dummy" equals 1 if hard-close ending rule.

Table 8: Regression Results under Baseline, Reserve and Ending Rule Treatments

		OLS Models					
		1	2	3	4	5	6
	Dependent Variable	Revenue	Revenue	ln(Revenue)	# of Bidders	# of Bidders	ln(# of Bidders)
β_1:	Site Dummy	14.914 **	15.053 **	0.297 **	2.136 **	2.120 **	0.581 **
		(1.965)	(1.855)	(0.028)	(0.574)	(0.566)	(0.139)
	Book Value	-0.039			0.018		
		(0.073)			(0.016)		
	Dealer Price	1.072 **			0.007		
		(0.129)			(0.026)		
	Reserve Dummy	4.781 **	4.666 **	0.072 **	-2.812 **	-2.793 **	-0.618 **
		(1.789)	(1.766)	(0.028)	(0.378)	(0.379)	(0.096)
	Ending Rule Dummy	0.391	0.508	0.008	-0.183	-0.167	-0.106
		(2.129)	(2.012)	(0.046)	(0.694)	(0.701)	(0.166)
	Constant	-14.078 **	55.602 **	3.993 **	3.233 **	4.992 **	1.452 **
		(3.043)	(2.333)	(0.049)	(0.632)	(0.788)	(0.158)
	Item Dummies	No	Yes	Yes	No	Yes	Yes
	# of Observations	83	83	83	83	83	83
	R^2	0.93	0.94	0.95	0.49	0.53	0.53

Notes: Robust standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site Dummy" equals 1 if auction site was eBay. "Reserve Dummy" equals 1 if reserve is positive. "Ending Rule Dummy" equals 1 if hard-close ending rule.

Table 9: Field Data Summary Statistics

	Mean Values	
	eBay	Yahoo
Revenue ($)	59.900	54.179
	(40.455)	(32.012)
# of Bids	7.064	4.509
	(4.726)	(5.850)
# of Observations	1281	371

Notes: Values in parentheses are standard deviations. Bid count statistics reflect the number of total bids in an auction.

Table 10: Regression Results with Field Data

		1	2	3	4
	Dependent Variable	Revenue	ln(Revenue)	# of Bids	ln(# of Bids)
$\beta_{1:}$	Site Dummy	11.605 ***	0.148 ***	2.002 ***	0.691 ***
		(1.869)	(0.028)	(0.300)	(0.053)
	Reserve (Opening price)	0.456 ***	0.006 ***	-0.083 ***	-0.018 ***
		(0.027)	(0.000)	(0.004)	(0.001)
	Constant	46.366 ***	3.797 ***	7.890 ***	1.513 ***
		(2.164)	(0.035)	(0.352)	(0.060)
	Item Dummies	Yes	Yes	Yes	Yes
	# of Observations	1652	1652	1652	1652
	R^2	0.31	0.31	0.35	0.51

Notes: Robust standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site Dummy" equals 1 if auction site was eBay.

Appendix A: Random Effect Regressions

Table 4A: Regression Results under the Baseline Treatment

	Random Effects Model			
	1	2	3	4
Dependent Variable	Revenue	ln(Revenue)	# of Bidders	ln(# of Bidders)
β_1: Site Dummy	13.173 **	0.268 **	2.125 **	0.498 **
	(2.688)	(0.039)	(0.747)	(0.168)
Book Value	0.001	0.001	0.018	0.003
	(0.083)	(0.003)	(0.026)	(0.005)
Dealer Price	0.992 **	0.018 **	0.013	0.004
	(0.151)	(0.005)	(0.047)	(0.009)
Constant	-11.664 **	2.522 **	2.698 *	0.862 **
	(3.582)	(0.110)	(1.085)	(0.224)
# of Observations	40	40	40	40
R^2	0.93	0.93	0.34	0.35

Notes: Standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site Dummy" equals 1 if auction site was eBay.

Table 5A: Regression Results under Baseline and High-Reserve Treatments

	Random Effects Model			
	1	2	3	4
Dependent Variable	Revenue	ln(Revenue)	# of Bidders	ln(# of Bidders)
β_1: Site Dummy	14.887 **	0.293 **	2.124 **	0.576 **
	(2.125)	(0.029)	(0.532)	(0.126)
Book Value	0.026	0.001	0.030	0.006
	(0.090)	(0.002)	(0.018)	(0.004)
Dealer Price	1.009 **	0.018 **	-0.014	-0.001
	(0.163)	(0.004)	(0.033)	(0.007)
Reserve Dummy	4.814 *	0.073 *	-2.874 **	-0.584 **
	(2.125)	(0.029)	(0.532)	(0.126)
Constant	-16.061 **	2.498 **	3.121 **	0.867 **
	(3.741)	(0.077)	(0.781)	(0.170)
# of Observations	62	62	62	62
R^2	0.93	0.95	0.51	0.5

Notes: Standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site dummy" equals 1 if auction site was eBay. "Reserve dummy" equals 1 if reserve is positive.

Table 6A: Regression Results under Ending Rule Treatment on Yahoo

	Random Effects Model			
	1	2	3	4
Dependent Variable	Revenue	ln(Revenue)	# of Bidders	ln(# of Bidders)
β_1: Ending Rule Dummy	0.078	0.005	-0.179	-0.115
	(1.478)	(0.042)	(0.720)	(0.170)
Book Value	-0.199 *	-0.003	0.017	0.000
	(0.088)	(0.005)	(0.025)	(0.006)
Dealer Price	1.218 **	0.026 **	0.008	0.011
	(0.159)	(0.008)	(0.044)	(0.011)
Reserve Dummy	1.471	0.030	-2.751 **	-0.756 **
	(1.645)	(0.046)	(0.798)	(0.189)
Constant	-6.739	2.420 **	3.210 **	0.870 **
	(3.453)	(0.181)	(0.997)	(0.248)
# of observations	43	43	43	43
R^2	0.95	0.9	0.37	0.44

Notes: Standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Reserve Dummy" equals 1 if reserve is positive. "Ending Rule Dummy" equals 1 if hard-close ending rule.

Table 7A: Regression Results under Baseline, Reserve and Ending Rule Treatments

	Random Effects Model			
	1	2	3	4
Dependent Variable	Revenue	ln(Revenue)	# of Bidders	ln(# of Bidders)
β_1: Site Dummy	15.005 **	0.296 **	2.127 **	0.583 **
	(2.111)	(0.036)	(0.535)	(0.125)
Book Value	-0.042	0.000	0.018	0.003
	(0.095)	(0.003)	(0.022)	(0.005)
Dealer Price	1.079 **	0.021 **	0.006	0.005
	(0.171)	(0.006)	(0.039)	(0.009)
Reserve Dummy	4.706 **	0.072 *	-2.801 **	-0.620 **
	(1.836)	(0.032)	(0.465)	(0.109)
Ending Rule Dummy	0.468	0.008	-0.174	-0.107
	(2.410)	(0.041)	(0.611)	(0.143)
Constant	-14.271 **	2.463 **	3.230 **	0.965 **
	(3.968)	(0.121)	(0.924)	(0.216)
# of observations	83	83	83	83
R^2	0.93	0.92	0.49	0.5

Notes: Standard errors are in parentheses. * and ** denote significance at the 5% and 1% levels, respectively. "Site Dummy" equals 1 if auction site was eBay. "Reserve Dummy" equals 1 if reserve is positive. "Ending Rule Dummy" equals 1 if hard-close ending rule.

Appendix B: Proofs of Propositions

Proposition 1 *As the number of buyers and sellers grows arbitrarily large, the fraction of buyers and sellers at one of the sites goes to zero.*

Proof. Fix the ratio of sellers to buyers at $\gamma < 1$ and consider equilibria as the number of buyers $N \to \infty$. For a given number of buyers, N, an equilibrium is described by the pair $\{S_y(N), B_y(N)\}$. Suppose that, contrary to the proposition, there exists a sequence of equilibria $\{S_y(N), B_y(N)\}$ such that $\{S_y(N)\}_{N=1}^{\infty}, \{B_y(N)\}_{N=1}^{\infty}, \{N\gamma - S_y(N)\}_{N=1}^{\infty}, \{N - B_y(N)\}_{N=1}^{\infty}$ are all divergent.

Define the limit buyer-seller ratios in each market as

$$\rho_e = \lim_{N\to\infty} \frac{\frac{N}{\gamma} - S_y(N)}{N - B_y(N)}$$

and

$$\rho_y = \lim_{N\to\infty} \frac{S_y(N)}{B_y(N)}$$

Recall that equilibrium requires that the following system of inequalities hold for all N :

$$\begin{aligned}
\frac{B_e(N) - S_e(N)}{B_e(N)+1} q^S &\geq \frac{B_y(N) - S_y(N) - 1}{B_y(N)+1} \\
\frac{B_y(N) - S_y(N)}{B_y(N)+1} &\geq \frac{B_e(N) - S_e(N) - 1}{B_e(N)+1} q^S \\
\frac{S_e(N)(S_e(N)+1)}{2B_e(N)(B_e(N)+1)} q^B &\geq \frac{S_y(N)(S_y(N)+1)}{2(B_y(N)+1)(B_y(N)+2)} \\
\frac{S_y(N)(S_y(N)+1)}{2B_y(N)(B_y(N)+1)} &\geq \frac{S_e(N)(S_e(N)+1)}{2(B_e(N)+1)(B_e(N)+2)} q^B
\end{aligned}$$

Taking limits, we obtain

$$\begin{aligned}
(1-\rho_e) q^S &\geq 1 - \rho_y \\
1 - \rho_y &\geq (1-\rho_e) q^S \\
\rho_e^2 q^B &\geq \rho_y^2 \\
\rho_y^2 &\geq \rho_e^2 q^B
\end{aligned}$$

The first two inequalities imply that

$$\rho_y = 1 - (1 - \rho_e)\, q^S$$

while the second two inequalities imply that

$$\rho_y = \rho_e \sqrt{q^B}$$

Thus, for any such sequence, it must be the case that

$$\rho_e = \frac{q^S - 1}{q^S - \sqrt{q^B}}$$

while

$$\rho_y = \frac{q^S - 1}{q^S - \sqrt{q^B}} \sqrt{q^B}$$

If $q^S = 1$ and $q^B > 1$, then $\rho_e = \rho_y = 0$. If $q^S > 1$ and $q^B = 1$ then $\rho_e = \rho_y = 1$. Finally, if $q^S > 1$ and $q^B = 1$, then $\rho_e > 1$ and $\rho_y > 1$. Notice, however, that since the aggregate seller-buyer ratio is less than one and more than zero, all of these conditions are impossible.

It remains to show that it is not that case that only one of $\{S_y(N)\}_{N=1}^{\infty}$, $\{B_y(N)\}_{N=1}^{\infty}$, $\{N\gamma - S_y(N)\}_{N=1}^{\infty}$, $\{N - B_y(N)\}_{N=1}^{\infty}$ is convergent while the rest diverge. To confirm this, suppose that $\{S_a(N)\}_{N=1}^{\infty}$ was convergent for one of the sites. In that case, buyers using that site earn zero payoffs in the limit when they could earn positive payoffs from switching to the other site. This is a contradiction. Similarly, if $\{B_a(N)\}_{N=1}^{\infty}$ is convergent for one of the sites, then sellers on that site earn zero payoffs in the limit and have a profitable deviation as well. QED

Proposition 2 *When there are a sufficiently large number of buyers and sellers, fewer than half of each visit the eBay site. Formally, for N sufficiently large, in any interior quasi-equilibrium, $B_e(N) < \frac{N}{2}$ and $S_e(N) < \gamma\frac{N}{2}$.*

Proof. To establish the proposition, we will show that there are no equilibria in which a finite number of buyers and sellers go to the Yahoo site in the limit. This implies that, for all interior equilibrium sequences, the share of buyers and sellers on the eBay site becomes vanishingly small as N gets large. Suppose to the contrary that there exists a limit equilibrium in which a finite number of buyers and sellers go to the Yahoo site while the rest go to eBay. In such a limit equilibrium, it must be that

$$\frac{S_y\left(S_y+1\right)}{\left(B_y+1\right)\left(B_y+2\right)} \leq \gamma^2 q^B \leq \frac{S_y\left(S_y+1\right)}{B_y\left(B_y+1\right)} \tag{5}$$

and

$$\frac{B_y-S_y-1}{B_y+1} \leq (1-\gamma)\, q^S \leq \frac{B_y-S_y}{B_y+1} \tag{6}$$

Suppose that $\left(S_y+1\right)/\left(B_y+1\right) \leq \gamma$. Then

$$\frac{S_y\left(S_y+1\right)}{B_y\left(B_y+1\right)} < \gamma^2 < \gamma^2 q^B$$

and this contradicts the inequality required in equation (5) .

Next, suppose that $\left(S_y+1\right)/\left(B_y+1\right) > \gamma$. Then

$$\frac{B_y-S_y}{B_y+1} = \frac{B_y+1-\left(S_y+1\right)}{B_y+1} = 1-\frac{S_y+1}{B_y+1} < 1-\gamma < (1-\gamma)\, q^S$$

and this contradicts the inequality required in equation (6) . QED

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