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Minimum Prices and Product Valuations in Auctions

Gerald Häubl and Peter T. L. Popkowski Leszczyc

Few bidders come to Internet auctions with rigid ideas about item valuation and price, this study argues. Thus, a seller–specified minimum price "prompts" consumers with a first indication of an item's value. That tends to increase the value bidders assign to an item and the final price the item obtains.

Gerald Häubl is Banister Professor of Electronic Commerce and Associate Professor of Marketing, and **Peter T. L. Popkowski Leszczyc** is Associate Professor of Marketing, both at the School of Business, University of Alberta.

Report Summary

In recent years, consumer-oriented auctions, especially those conducted on the Internet, have grown in popularity. Although a significant amount of research has been conducted on how rational buyers and sellers ought to behave in an auction setting, very little research has been conducted on how auction participants actually do behave. Here, Häubl and Popkowski Leszczyc study the psychological motivation behind the formation of an auction bid. In particular, they look at how a seller-specified minimum price affects a consumer's formulation of both an item's value and the bid for that item he or she is willing to propose.

Häubl and Popkowski Leszczyc focus their study on the effect fixed price components and public reserve prices have in open ascending-bid auctions on an item's final selling price. Underlying their study is their proposal that very few bidders come to an auction with rigid, preformed preferences. Instead, they engage in constructive valuation. That is, they absorb the signals given by the seller and by the other bidders and construct their valuation of an item on the spot. Häubl and Popkowski Leszczyc propose that minimum prices are an important external prompt by providing bidders with their first indication of an item's value.

In this study, the researchers find that the minimum values placed on an item in an auction by a seller tend to increase the value bidders assign to the item and the final price the item obtains. Although both types of minimum prices that Häubl and Popkowski Leszczyc examine have this positive effect, they work in very different ways. Fixed price components, such as shipping costs that must be added to the final price, tend to increase the amount an item obtained, but only because it causes bidders to underestimate the total financial commitment implied by their bids. Reserve prices, on the other hand, tend to actually influence bidders' valuations of an item. As a result, these prices have a more direct positive effect on auction outcomes. ■

Introduction

As a result of the rapidly growing importance of consumer-oriented auctions, particularly those conducted via the Internet, it is becoming increasingly important to understand how consumers behave in an auction context. Economists have studied auctions extensively for the past several decades, and their research has resulted in rich normative theories about how rational buyers and sellers should behave in certain types of auctions and under particular circumstances (for reviews, see Klemperer 1999; Krishna 2002; McAfee and McMillan 1987). But little is known about how auction participants actually do behave (Bazerman 2001).

Researchers in marketing have begun to recognize the need to study consumer bidding behavior in auctions (see Chakravarti et al. 2002). Recent empirical studies have examined the effects of factors such as the number of bids (Dholakia and Soltysinski 2001; Dholakia, Basuroy, and Soltysinski 2002) and the levels of starting bids (Ariely and Simonson 2003; Hardesty and Suter 2002) on auction outcomes. In addition, related work has investigated how the process that determines these selling prices might be influenced by variables such as the bidders' prior auction experience (Wilcox 2000) or an auction's ending rule (Ariely, Ockenfels, and Roth 2002).

Auction outcomes are interactive. The selling price of an item is not determined and posted beforehand as in a traditional market setting; it is based on competing bids submitted by potential buyers (McAfee and McMillan 1987). Auction participants make their own decisions about what amount, if any, they wish to bid for an auctioned product. Therefore, it is important to develop an understanding of how bidders assess an auctioned item's value to them and what factors might influence this valuation.

While the determination of selling prices through interaction among bidders is a fundamental characteristic of auctions, it is common for sellers to specify some form of *minimum price*, thus imposing a lower boundary on the otherwise dynamically determined price. Prior research on minimum prices has focused on their revenue-maximizing use by sellers (e.g., Levin and Smith 1996; Riley and Samuelson 1981). This work is based on the assumption that bidders' valuations of the auctioned product are invariant to the minimum price. By contrast, we propose that a minimum price may provide an informative indicator of an item's quality or value, and that bidders take this signal into account when constructing their own valuations of the item during the auction. More specifically, our key hypothesis is that the magnitude of a seller-specified, public minimum price has a positive effect on bidders' valuations of an auctioned product.

We distinguish between two normatively equivalent types of minimum prices, (1) fixed price components and (2) public reserve prices, and systematically investigate the manner in which each influences both bidders' product valuations and selling prices in open ascending-bid auctions. We present empirical evidence from three studies. The first two of these are controlled field experiments based on real-world Internet auctions. The third is a computer-based laboratory experiment for which we developed an innovative simulated-auction method that allows the direct measurement of valuations at the level of the individual bidder. Overall, the results of the three studies show that minimum prices have a substantial positive effect on bid levels in ascending-bid auctions. Moreover, we find that the two normatively equivalent types of minimum prices affect bidding behavior via entirely different psychological mechanisms. While the positive effect of fixed price components on selling prices is due primarily to bidders' underestimation of the total financial commitment implied by their bids, public reserve prices tend to influence consumers' valuations of auctioned products more directly.

We begin with a brief overview of relevant aspects of auction theory, with a particular focus

on the concept of bidders' valuations. This section is followed by one on the role of minimum prices in ascending-bid auctions. In this second section, we review the basic economic theory of minimum prices in ascending-bid auctions and then introduce our constructed-valuations perspective of minimum prices. After that, we present the results of the three experiments in turn. We conclude with a brief general discussion of our findings.

Auction Theory

Current auction literature distinguishes between four basic auction types or mechanisms: open ascending-bid, open descending-bid, first-price sealed bid, and second-price sealed bid (e.g., McAfee and McMillan 1987). In this paper, we focus on open ascending-bid auctions (also called "English" auctions), in which the price of an item is raised incrementally until only a single bidder remains. This bidder, often referred to as the "winner," buys the product at a price equal to his or her last bid. Under this mechanism, the second-highest bid determines the selling price, as it represents the level at which the winner becomes the only remaining bidder. This type of auction is open in the sense that the current high bid is transparent to all participants.

In addition to the type of mechanism that defines an auction, current research identifies a range of models by which bidders determine their valuation of an auctioned item. One of the most important considerations in these models is the extent to which bidders' valuations are private or common. For our study, we rely on the *affiliated-values model* (Milgrom and Weber 1982). This model occupies a middle ground and encompasses both the individuality of each bidder's preferences and the way bidders make use of each other's signals in regards to their valuations of an item. A detailed discussion of the four auction types and the models of how bidders determine the value of an item is provided in Appendix 1.

Minimum Prices in Ascending-Bid Auctions

Types of minimum prices

While ascending-bid auctions can be designed to allow any positive amount as a winning bid, it is very common for the admissible range of the selling price to be constrained by a minimum price (Riley and Samuelson 1981). For the purpose of this paper, we define a minimum price as a positive monetary amount, specified by the seller and known to all potential bidders, that acts as a lower bound on an otherwise dynamically determined selling price in an open ascending-bid auction.[1] We focus on the two most common types of seller-specified minimum prices in real-world auctions, fixed price components and public reserve prices.

Fixed Price Components. The total amount to be paid by the winner of an auction may include a *fixed price component* in addition to the winning bid that is determined via the auction mechanism. Common forms of such fixed price components are charges for the shipping and/or handling of products. A bidder's total financial commitment corresponds to the bid amount plus any fixed price component that may apply. Consequently, the total selling price is partitioned into multiple components (see Morwitz, Greenleaf, and Johnson 1998).[2] In particular, it is equal to the dynamically determined winning bid plus the fixed price component.

Public Reserve Prices. The second type of seller-specified minimum price that we consider is a *public reserve price*, the minimum price at which the vendor is prepared to sell the product (see Engelbrecht-Wiggans 1987). Reserve prices that are public (i.e., known to all potential bidders from the outset) have the property that they explicitly indicate to potential bidders the lower bound of the range of admissible bids. Consequently, a public reserve price determines an ascending-bid auction's minimum bid level, or the amount at which bidding starts.

Fixed price components and public reserve prices are forms of binding price floors (Isaac and Plott 1981). Each represents a strict lower bound with respect to the total selling price (including any fixed price component) that may be realized in an auction.[3] From a bidder's perspective, these two types of seller-specified minimum prices are normatively equivalent. Both a fixed price component and a public reserve price indicate the amount that, at the start of the auction, a bidder must commit in order to make a valid bid. A minimum price of M should preclude bids from individuals whose valuation of the auctioned item is less than M, irrespective of whether it is framed as a fixed price component or as a reserve price. Thus, from a normative standpoint, the two types of minimum prices ought to have identical effects on bidding behavior and auction outcomes.

Economic theory of minimum prices

The economic theory of the relationship between minimum prices and auction outcomes was developed primarily for the specific case of public reserve prices (e.g., Levin and Smith 1996; Riley and Samuelson 1981). It also applies to fixed price components, however, which are normatively equivalent to public reserve prices. Therefore, we discuss this theory in the more general terms of minimum prices as defined above. We focus on those aspects of the theory that pertain to open ascending-bid auctions.

Of course, a seller can choose not to specify an explicit minimum price, thus indicating to auction participants that any positive amount greater than or equal to the minimum bid increment would be an acceptable starting bid. In this case, the vendor relies entirely on competition among bidders to determine the selling price. In contrast, specifying a non-zero minimum price allows the seller to impose a lower bound on the to-be-determined winning bid. The theory of ascending-bid auctions suggests that, all else being equal, a seller-specified minimum price will have two effects on auction outcomes: a negative effect on the expected number of bidders and a positive effect on the expected selling price (see, e.g., McAfee and McMillan 1987).

Negative Effect on Number of Bidders. For a given distribution of bidder valuations, a minimum price of M will exclude individuals whose valuation of the auctioned item is less than M. As a result, since the number of bidders has a positive effect on the expected selling price (Holt 1979), minimum prices tend to have

Figure 1

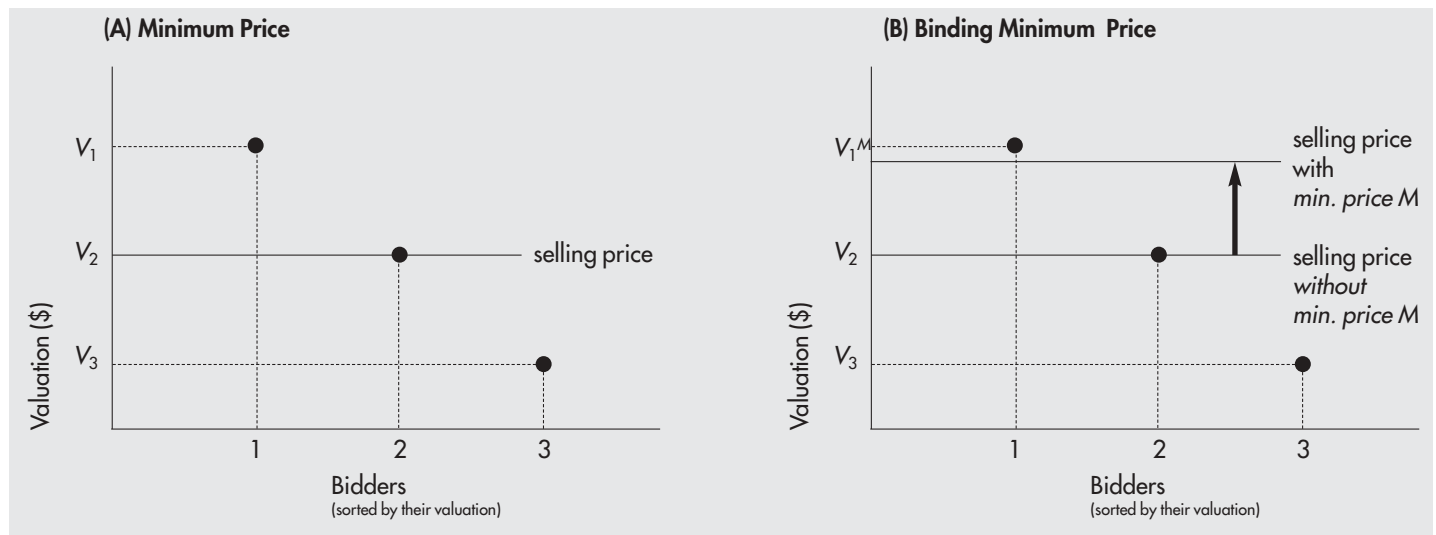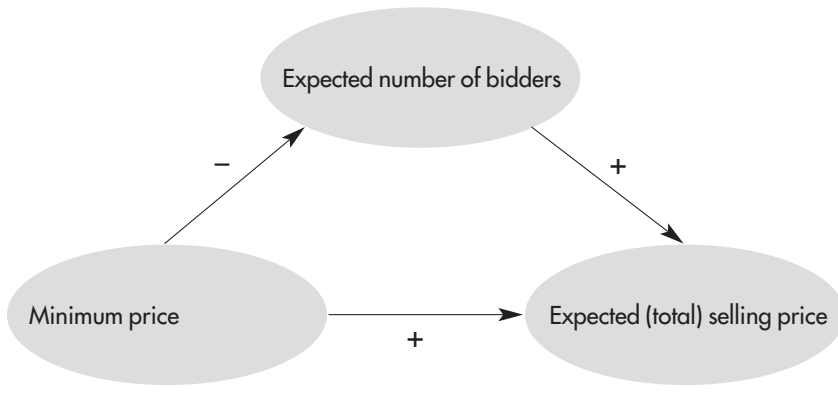**Effect of Binding Minimum Price on Selling Price**

Figure 2
Minimum Price, Number of Bidders, and Selling Price

a negative indirect effect on selling prices via the number of bidders. In fact, if the minimum price exceeds the highest valuation of the good in the group of potential bidders (i.e., $M > V_1$), no sale will occur. The negative effect of minimum prices on the number of bidders is amplified if the latter is treated as endogenous, rather than assumed to be exogenously determined. Endogenous entry implies that individuals make a conscious decision as to whether or not to participate in an auction based on the cost (e.g., effort) required and surplus expected from their participation (Levin and Smith 1994).[4] Since a potential auction participant's expected surplus decreases as the seller-specified minimum price increases, the latter's negative effect on the expected number of bidders is greater when bidder entry is endogenous.

Positive Effect on Selling Price. Based on the assumption that an item will sell, an increase in the minimum price increases the expected selling price (Riley and Samuelson 1981). This results from the fact that a non-zero minimum price represents a lower bound on the range of possible values of the winning bid. Depending on the distribution of bidders' valuations, a seller-specified minimum price may or may not be binding with respect to the outcome of an auction. In particular, the economic theory of auctions suggests that a minimum price will

increase the selling price only if it is between the first and second order statistic of the distribution of bidders' valuations (i.e., if $V_1 \geq M > V_2$) (Engelbrecht-Wiggans 1987). This is illustrated by the simple example shown in Figure 1. Consider an ascending-bid auction with three bidders, indexed in descending order of their valuation, who value the auctioned item at V_1, V_2, and V_3, respectively.[5] Panel A of Figure 1 illustrates how the selling price is determined in the absence of a minimum price. Once the current high bid exceeds V_3, only bidders 1 and 2 remain in the auction. Bidder 2 continues until the bid level reaches his or her valuation of the item (V_2) and then drops out. As a result, bidder 1 wins the auction and pays a price of V_2. This is the price that results purely from competition among bidders. For the given set of valuations $V = (V_1, V_2, V_3)$, any minimum price less than or equal to V_2 will not be binding on bidder 1 and have no effect on the selling price. In such a case, the minimum price's effect would be superseded by the effect of bidder 2's participation in the auction. If the minimum price M is greater than V_2 and less than or equal to V_1, however, it is binding on the participant with the highest valuation, who now pays M, rather than V_2, for the item. This is illustrated in Panel B of Figure 1. We refer to the effect of a minimum price that binds in the sense that it raises the winning bid above what would result merely from competition among bidders as a *price-floor effect.*

The economic theory of the relationships among the minimum price, the number of bidders, and the selling price in an ascending-bid auction are summarized in Figure 2. As this figure illustrates, the magnitude of the seller-specified minimum price has a negative effect on the expected number of bidders, and the number of bidders has a positive effect on selling price. Taken together, these two effects imply a *negative* indirect effect of the minimum price on the winning bid via the number of bidders. In addition, controlling for the number of bidders, the minimum price has a *positive* direct effect on the expected selling price.

From the seller's perspective, setting a minimum price involves a tradeoff between maximizing the probability that the auctioned product will sell and maximizing the selling price that is realized if the item does sell. The normative question of how, in certain contexts and under specific assumptions, sellers should set minimum prices has been the focus of important theoretical work on optimal reserve prices (e.g., Levin and Smith 1996; Riley and Samuelson 1981).[6] That research has assumed that a given bidder's valuation of the auctioned item is invariant with respect to the presence or magnitude of a minimum price (Engelbrecht-Wiggans 1987). By contrast, we propose that minimum prices may actually *influence bidders' valuations* of auctioned products. In the next section, we introduce a constructed-valuations perspective that leads to the hypothesis that minimum prices have a positive effect on valuations.

Minimum prices and the construction of valuations

Most individuals do not have well defined preferences (Fischhoff 1991; Payne, Bettman, and Johnson 1992). Instead they construct their preferences in response to external prompts when they are asked to make a decision or express an evaluative judgment (Slovic 1995; Tversky,

Sattath, and Slovic 1988). In a consumer context, the constructive nature of preferences has the desirable effect of reducing the demand for cognitive resources—consumers do not need to store their specific preferences with respect to a wide array of different products in memory.

Given the constructive nature of preferences, we can assume that bidders do not arrive at an auction with an exact valuation. Instead, bidders most likely construct their valuations in response to various signals that they observe in the course of the auction. Minimum prices are one type of such signals.[7] Specifically, we propose that the seller-specified minimum price may be perceived as an informative indicator of an auctioned item's value, and that bidders may take this signal into account when constructing their own exact valuation of the item. Our central thesis is, therefore, that *minimum prices* have a *positive effect on bidders' valuations.*

Conditional on the sale of the auctioned product, a minimum price has a positive effect on the expected selling price. According to the economic theory of auctions, however, a minimum price will affect the actual selling price *only* if it is between the first and second order statistic of the distribution of bidder valu-

Figure 3

Effect of Minimum Price on Selling Price with Constructed Valuations
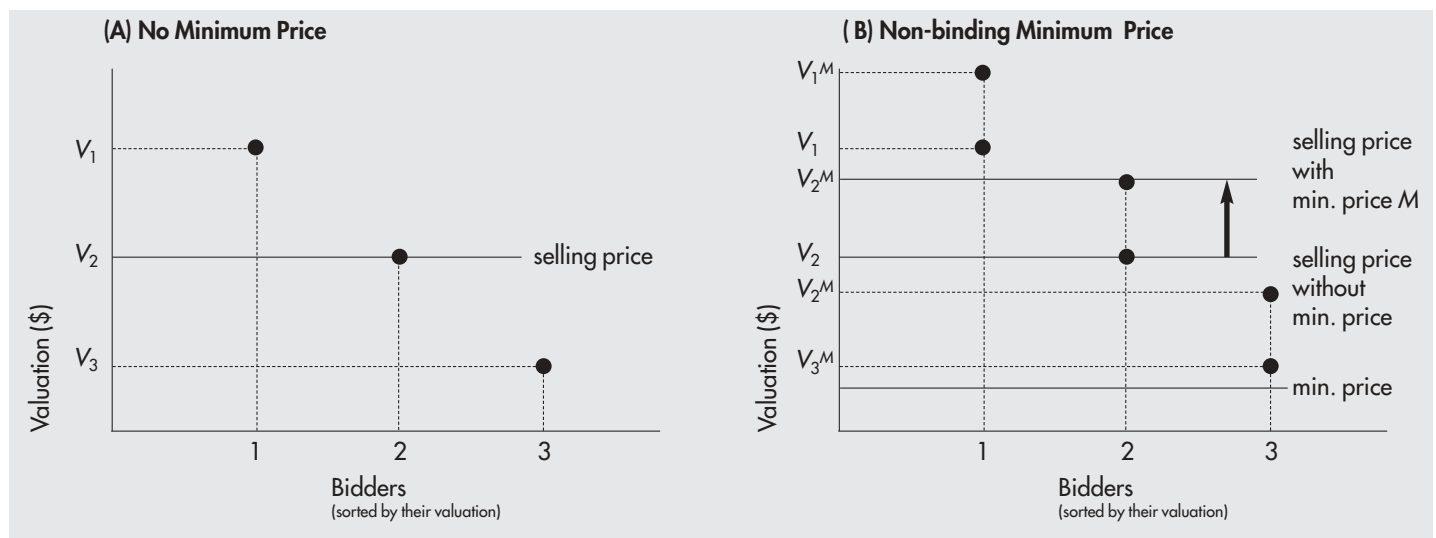
ations, i.e., if it represents a binding price floor (see above). Our constructed-valuations perspective suggests that bidders' valuations are influenced by, rather than invariant to, a seller-specified minimum price. Thus, the latter may have an effect on the selling price *irrespective* of whether or not it represents a binding price floor.

The effect of a minimum price on the selling price in the presence of constructed valuations is illustrated in Figure 3, which follows the simple example introduced above. As before, Panel A shows how the auction outcome is determined in the absence of a minimum price—the bidder with the highest valuation wins and pays a price equal to the second highest valuation (V_2). Panel B of Figure 3 provides an example of the construction of valuations based on a seller-specified minimum price M. The presence of the latter has a positive effect on bidders' valuations of the auctioned product.[8] In this example, the introduction of the minimum price M results in the set of valuations $V^M = (V_1^M, V_2^M, V_3^M)$ and, consequently, a selling price of V_2^M. This illustrates that if a minimum price affects bidders' constructed valuations, it may influence the selling price in an ascending-bid auction even if it is considerably lower than the second-highest (constructed) valuation among the auction participants.

Differences between the Two Types of Minimum Prices. Since fixed price components and public reserve prices are normatively equivalent, we have presented a theoretical account of their effects on bidders' product valuations and auction outcomes that pertains equally to both types of minimum prices. Despite their normative equivalence, however, fixed price components and public reserve prices do differ in their perceptual properties and they may, therefore, affect bidding behavior in different ways.

A fixed price component renders a bidder's participation in an auction more cognitively demanding than a corresponding reserve price.

This is due to the fact that the presence of fixed price components results in a partitioning of bids—and ultimately of selling prices—into multiple amounts. As a result of the increased cognitive effort that this partition requires, bidders will be less accurate in their mental operations and more susceptible to judgmental errors (see Johnson and Payne 1985). In particular, they might fail to accurately process, or even attend to, the fixed price component when making bidding decisions and, thus, underestimate the total financial commitment implied by their bids (Morwitz et al. 1998).[9] By contrast, such processing errors cannot occur when a minimum price is specified solely in the form of a public reserve price, since in this case a bid always corresponds to an auction participant's total commitment.

In addition, the two types of minimum prices differ in the range of possible causal attributions that a bidder might make about them. The magnitude of a public reserve price is more likely to be attributed to the seller's assessment of the auctioned item's value than is the magnitude of a fixed price component (Riley and Samuelson 1981). The latter may be viewed as being determined by factors unrelated to the item's value, such as common auction practice, third-party fees, or (in the case of shipping charges) the item's size and weight. Thus, while both types of minimum prices may serve as an informative signal of the auctioned product's value, we expect this effect to be stronger for public reserve prices than for fixed price components.

Overview of Experiments

We report the results of three studies that taken together enhance our understanding of how seller-specified minimum prices influence bidders' product valuations in the context of ascending-bid auctions. The first two of these are controlled field experiments based on real-world auctions that we conducted on a large Internet auction site. Experiment 1 examines

the effects of fixed price components and Experiment 2 focuses on public reserve prices. In these field experiments, auctions are the units of analysis and the dependent variables are the selling price and the number of bidders who participated (see Figure 2 above).

The field experiments have the advantage that they allow for a rigorous examination of the phenomenon of interest under naturalistic conditions, with "subjects" engaging in real-life auction transactions. The results of the two field studies are consistent with our hypothesis that seller-specified minimum prices have a positive effect on bidders' product valuations. But given the nature of the relationship between valuations and selling prices (see above), the outcomes of actual auctions provide only indirect evidence about bidders' product valuations.

In Experiment 3, we use an innovative laboratory method that allows the measurement of valuations in the context of ascending-bid auctions at the level of the individual bidder to examine the effects of both types of minimum prices on product valuations. In addition to corroborating the overall results of the field experiments, this laboratory study allows a more in-depth investigation of these effects in terms of any underlying psychological mechanisms.

Experiment 1

The objective of this study was to examine the effect of *fixed price components* on product valuations in ascending-bid auctions. To that end, we conducted a controlled field experiment on a large Internet auction site. The fixed price component was operationalized as a seller-specified shipping charge, payable by the winner of the auction to the seller above and beyond the amount of the winning bid. The unit of analysis in this study is the auction, and the key dependent variables are the number of bidders and the total selling price realized in the auction.

Normatively, auction participants should take a fixed price component into account perfectly when placing bids—the upper bound on individuals' bids for a product should be equal to their own valuation of the item minus the fixed charge. Thus, the total price paid by the winner should not be affected by the magnitude of this fixed charge. The only exception to this would be a price-floor effect, which may occur if the winner of the auction is the sole bidder.

By contrast, we have proposed that bidders tend to construct their valuations of an item in the course of the auction, and that a seller-specified minimum price may serve as an informative signal in this process. This implies that higher levels of the fixed price component should lead to higher bidder valuations, which in turn, should result in a higher total price—conditional on the item actually selling. In addition to such a constructed-valuations effect, we might also observe a processing-error effect due to bidders' failure to accurately process the fixed price component.

Method
Experimental Design and Procedure. We conducted this field experiment by selling sets of collectable postage stamps in separate ascending-bid auctions on eBay.com, the largest Internet auction site at the time of the study.[10] The fixed price component was varied systematically across auctions, while all other auction characteristics were controlled. The basic experimental design was a 4 (magnitude of fixed price component) × 12 (product) full factorial. Thus, 4 identical replicates of each of 12 sets of stamps were auctioned off, and the magnitude of the fixed price component was manipulated completely within set. This design yields a total of 48 auctions, which were arranged into four blocks of equal size. A replicate of each of the 12 lots was included in each of the blocks. The four blocks of auctions were separated in time and conducted in one-week intervals. To control for potential effects of time (across blocks) and serial position (within block), each

of these factors was varied independently and counterbalanced with the two primary experimental factors. The identity of the vendor was held constant across all auctions.

The electronic interface for each auction included a verbal description and a picture of the set of stamps. The auctions had predetermined ending times and each of them ran for five days. There was no seller-specified reserve price. The minimum bid increment was 1 cent at the start of the auction, and subsequently rose to 5 cents, 25 cents, 50 cents, and $1 as the bid level increased. The fixed price component was operationalized as a shipping charge to be paid to the seller above and beyond the winning bid. (The seller then arranged and paid for the shipment of the auctioned lot to the buyer.) The four levels of the fixed price component were determined as follows. The lowest level was 0, i.e., free shipping. The other three levels of this factor were created by adding equal increments to the preceding level, which yielded a linear order of shipping charges. The actual dollar amount of the increments varied according to the number of stamps in a set. There were three size categories containing four sets of stamps each, and the highest levels of the fixed price component were $1.50 (small lots), $2.25 (medium-sized lots), and $3.00 (large lots). The fixed price component was prominently displayed in the bidding interface throughout the auction.

Survey of Product Experts. To measure relevant characteristics of the sets of stamps used, we conducted a survey of stamp collectors after completion of all experimental auctions. Subjects were recruited via stamp-related Internet bulletin boards. The survey was completed by 36 collectors, who participated in return for a chance to win one of five sets of stamps valued at about $200 each. While most respondents had bought and sold stamps in Internet auctions prior to the survey, none of them had participated in any of the experimental auctions. The lot descriptions in the survey were identical to those used in the

auctions. Subjects were asked to rate their degree of interest in each of the lots and the perceived ease of assessing the value of each lot on separate 11-point scales.[11]

Modeling Approach.[12] We estimate a system of equations corresponding to the model shown in Figure 2. The equation for the number of bidders in an auction is

$$b_{jt} = \alpha_{bj} + \beta_{b1} X_{1jt} + \ldots\ldots + \beta_{bk} X_{kjt} + e_{bjt} \qquad (1)$$

where b_{jt} is the number of bidders in the auction of lot j at time t, α_{bj} is a lot-specific intercept, β_{b1}, ..., β_{bk} are the coefficients for k explanatory variables, and e_{bjt} is an error term. The total selling price realized in an auction is specified as

$$p_{jt} = \alpha_{pj} + \beta_{p1} X_{1jt} + \ldots\ldots + \beta_{pm} X_{mjt} + \beta_{pb} b_{jt} + e_{pjt} \qquad (2)$$

where p_{jt} is the total selling price of lot j at time t, α_{pj} is a lot-specific intercept, β_{p1}, ..., β_{pm} are the coefficients for m exogenous variables, b_{jt} is the log of the number of bidders in the auction of lot j at time t, β_{pb} is the coefficient for the effect of number of bidders, and e_{pjt} is an error term.[13]

For an adequate representation of the phenomenon of interest, the following important features must be incorporated in the model:

- The number of bidders is treated as endogenous—it may be influenced by either our manipulation of the fixed price component or by lot characteristics measured in the survey. The importance of accounting for the number of bidders in assessing the relationship between reserve price and seller revenue has been pointed out in the auction literature (Harstad and Rothkopf 2000; Levin and Smith 1994).[14] Therefore, equations 1 and 2 are estimated as a recursive system.
- A given auction might not result in a sale, particularly if a non-trivial minimum price has been specified. When the latter is true, the observed selling price is censored in the

Table 1
Experiment 1: Parameter Estimates

Equation for Number of Bidders

Explanatory Variable	Posterior mean	Standard deviation	*t*-value	*p*
Mean of lot-specific intercepts [a]	1.373	.087	15.782	< .01
Standard deviation of lot-specific intercepts	.148	.102	1.451	
Week	−.030	.115	−.261	
Serial position	.002	.143	.014	
Fixed price component	−.026	.115	−.226	
Degree of interest	−.150	.228	−.658	
Fixed price component × degree of interest	.110	.187	.588	

Equation for Total Selling Price

Explanatory Variable	Posterior mean	Standard deviation	*t*-value	*p*
Mean of lot-specific intercepts	5.224	.955	5.470	< .01
Standard deviation of lot-specific intercepts	2.780	.950	2.926	< .01
Week	−.127	.393	−.323	
Serial position	.513	.569	.902	
Fixed price component	.874	.377	2.250	< .05 [b]
Ease of evaluation	−.304	1.087	−.280	
Fixed price component × ease of evaluation	−1.129	.639	−1.767	< .05 [b]
Number of bidders	.892	.504	1.770	< .05 [b]

[a] Since the number of bidders follows a Poisson distribution, where the mean has a log-normal distribution (see Appendix 2 for details), the intercept cannot be interpreted in terms of the actual count. This also applies to the results of Experiment 2.
[b] Level of significance based on one-tailed test (directional prediction).

sense that a failure to sell the item merely indicates that, without the minimum price, the auction would have yielded a price between zero and the minimum price. To accommodate the possibility of such censored observations, we use a Tobit specification for selling price.

■ The number of bidders who participate in an auction is a count variable, which is appropriately modeled as a Poisson distribution (see Wang 1993; Engelbrecht-Wiggans 1980, 1987).

■ We are not interested in differences between the 12 specific sets of stamps. Therefore, the auctioned lot is treated as a random rather than a fixed factor in our analyses, and distributions reflecting the unexplained heterogeneity in the lot-specific intercepts are estimated.

The resulting model is a simultaneous recursive system of equations with a random effects Tobit

specification. As this is a complex model to estimate, we resort to a Hierarchical Bayes (HB) approach. Bayesian estimation methods provide superior parameter estimates compared to Maximum Likelihood estimation for small sample sizes (Tanner 1993). A detailed discussion of the estimation procedure is provided in Appendix 2.

The explanatory variables included in the analysis are as follows. The manipulated factors are the magnitude of the fixed price component in the auction (coded 0,1,2,3), the weekly block in which the auction was conducted (coded 0,1,2,3), the auction's serial position within the block (coded 0,1,…,11), and the auctioned lot (coded 0,1,…,11). In addition, the mean ratings of the degree of interest in, and of the ease of assessing the value of, each lot were included.

Results

All 48 auctions resulted in a sale.[15] The mean number of bidders was 3.28, and every auction attracted at least 2 bidders. The mean total selling price was $6.50. In the absence of a fixed price component, the mean total selling price was $5.89, as compared to a mean of $6.71 when there was such a fixed charge. Thus the presence of a fixed price component, pooled across the three non-0 levels of this factor, increased the total selling price by an average of 14% (paired-samples $t = 2.281$, df = 11, $p < .05$). The highest level of the shipping charge resulted in a mean total selling price of $7.99. In this case, the specification of the fixed price component increased the total price by an average of $2.10 (paired-samples $t = 3.316$, df = 11, $p < .01$), i.e., by an amount almost as large as the average fixed price component in that condition ($2.25). The results of the HB model allow for a more systematic examination of the data. The two equations were estimated simultaneously. The top and bottom portions of Table 1 provide the results pertaining to the equations for number of bidders and total selling price respectively. For each parameter, the table contains the posterior mean, the standard deviation, the ratio of these two quantities

(i.e., the t-value equivalent), and the level of significance (p). The magnitude of an auction's fixed price component had no effect on the number of bidders, and this was the case irrespective of the average level of interest in the auctioned item (i.e., no interaction between fixed price component and degree of interest). Consistent with our key hypothesis, the fixed price component had a positive effect on the total selling price ($\beta = .874$, $t = 2.250$, $p < .05$).[16] On average across the 48 auctions, and all else being equal, increasing the fixed price component by $1 resulted in an increase in the total selling price by $.66. As predicted, this effect was moderated by the ease of assessing the value of the auctioned good. The significant interaction between fixed price component and ease of evaluation ($\beta = -1.129$, $t = -1.767$, $p < .05$) indicates that the fixed price component's positive influence on the total selling price was stronger when the item's value was more difficult to assess. Finally, as expected, the number of bidders had a positive effect on the total selling price ($\beta = .892$, $t = 1.770$, $p < .05$).

The model also includes several parameters that are not of substantive interest, but that must, nonetheless, be taken into account to avoid model misspecification. In both equations, the lot-specific intercepts were incorporated as random factors. The parameter estimates indicate a significant amount of heterogeneity across the auctioned items in terms of both the number of bidders they attracted and the selling price they yielded. Furthermore, neither the week during which an auction was conducted nor an auction's serial position within a weekly block had any noticeable effect on the number of bidders or the total selling price.

Discussion

The results of this study indicate that it is possible for sellers systematically to influence auction outcomes via the magnitude of a fixed price component. In our experimental auctions, we were able to significantly increase total selling prices for identical products by merely setting a higher shipping charge. This clearly

violates the economic theory of auctions, which suggests that total selling prices should be invariant to the magnitude of any fixed price component, but it is consistent with our hypothesis that minimum prices play a role in bidders' construction of their valuations of auctioned items. Our hypothesis is corroborated further by the finding that the effect of a fixed price component on total selling price is stronger when the auctioned product is more difficult to evaluate, since the necessity of using constructive mental processes is greater when bidders are more uncertain about a product's value. Moreover, since each of the auctions in this experiment attracted at least two bidders, we can rule out a mere price-floor effect as an alternative explanation of the positive relationship between minimum prices and selling prices.

We believe that the results of this study are quite compelling. But, there are two important limitations. First, our theoretical focus is on bidders' valuations, and the latter were measured only indirectly in this experiment—i.e., to the extent that they are reflected in selling prices. Second, we cannot rule out the possibility that some bidders may have overbid as a result of their failure to accurately process the partitioned price, which would be an alternative to the constructed-valuations explanation of the positive impact of a fixed price component on total selling price. Experiment 3 is designed to, among other things, correct both of these limitations.

Experiment 2

The objective of this study was to examine the effect of *public reserve prices* on product valuations in ascending-bid auctions. Once again, we conducted a field experiment, using the same general approach as in Experiment 1. As before, the unit of analysis is the auction and the dependent variables are the number of bidders and the selling price.

Normatively, a bidder's valuation of an auctioned item should not be affected by a seller-specified public reserve price. As a result, apart from the possibility of a price-floor effect (when there is only a single bidder), this type of minimum price should have no impact on a product's selling price in an ascending-bid auction. Our hypothesis, however, is that bidders' valuations are positively influenced by public reserve prices. Such a constructed-valuations effect implies that a higher reserve price leads to higher bidder valuations, which in turn, result in a higher price if the item sells. In contrast to the case of fixed price components, a processing-error effect can be ruled out when a minimum price is specified in the form of a reserve price.

In this study, we also investigate the possibility that the proposed constructed-valuations effect of public reserve prices might be moderated by the amount of information about the auctioned item that is provided to bidders. In particular, we examine whether the availability of an objective reference price, such as a published catalog value, reduces the predicted positive effect of reserve prices on bidders' valuations.[17]

Method

Experimental Design and Procedure. The overall method was the same as that used in Experiment 1. The product category was again collectable postage stamps, but the particular lots differed from those used in Experiment 1. The characteristics of the auctions were varied according to a 3 (magnitude of public reserve price) × 2 (availability of objective reference price) × 12 (product) full-factorial design. Thus, 6 identical replicates of each of 12 lots were auctioned off, and the two other factors were manipulated completely within lot. The 72 auctions were arranged into six weekly blocks, with 1 replicate included in each block. Each auction ran for five days. There were no fixed price components. In particular, the seller paid all shipping costs.

The lowest level of reserve price was 0 (i.e., no seller-specified minimum price), and the two other levels were equal to 5% and 10% of a lot's

Table 2
Experiment 2: Parameter Estimates

Equation for Number of Bidders

Explanatory Variable	Posterior mean	Standard deviation	*t*-value	*p*
Mean of lot-specific intercepts	1.235	.171	7.222	< .01
Standard deviation of lot-specific intercepts	.517	.138	3.746	< .01
Week	−.067	.073	−.918	
Serial position	.107	.078	1.372	
Reserve price	−.108	.072	−1.500	< .1 [a]
Degree of interest	.018	.183	.098	
Reserve price × degree of interest	.178	.112	1.589	< .1 [a]

Equation for Selling Price

Explanatory Variable	Posterior mean	Standard deviation	*t*-value	*p*
Mean of lot-specific intercepts	11.270	1.711	7.623	< .01
Standard deviation of lot-specific intercepts	5.082	1.419	3.581	< .01
Week	−.754	.426	−1.719	< .1
Serial position	−.203	.459	−.491	
Reserve price	.936	.434	2.157	< .05 [a]
Objective reference price	−.959	1.300	−.738	
Reserve price × objective reference price	.102	.665	.153	
Number of bidders	2.114	.722	3.191	< .01 [a]

[a] Level of significance based on one-tailed test (directional prediction).

catalog value. The average amounts for the two non-0 levels were $3.35 and $6.70. The reserve price was prominently displayed in the bidding interface throughout the auction. The availability of an objective reference price was manipulated by either including the true catalog value in the description of the auctioned product or not. We controlled for potential effects of time (across blocks) and serial position (within block) by counterbalancing each of these factors with the three experimental factors. The identity of the seller was held constant across all auctions, but differed from that used in Experiment 1.

Modeling Approach. The model differs from that used to analyze the data from Experiment 1 only in the set of experimentally-manipulated explanatory variables. The levels of public reserve price were coded 0 (zero), 1 (5%), or 2 (10%). The availability of an objective reference price was coded 0 (no) or 1 (yes). Finally, the 6 weekly blocks of auctions were coded 0,1,...,5.

Results
Of the 72 auctions, 71 resulted in a sale. The sole auction in which no bids were submitted had the highest level of reserve price, which is consistent with the theoretical prediction that

increasing an auction's minimum price increases the probability of a failure to sell the item. An advantage of our HB Tobit approach is that it provides a theoretically sound way of modeling observations that are missing as a result of a particular experimental treatment (i.e., not at random). The mean number of bidders who participated in an auction was about six. The mean selling price was $12.15 across all auctions, and $11.45, $12.08, and $12.98 for public reserve prices of 0, 5%, and 10% of catalog value, respectively.[18] Thus, all else being equal, specification of a reserve price equal to 10% of the item's catalog value increased the selling price by an average of $1.53, or 13.4% (paired-samples $t = 2.478$, df = 23, $p < .05$).

As in Experiment 1, the HB model allows a more rigorous examination of the results. The parameter estimates are provided in Table 2. In line with the economic theory of minimum prices, the magnitude of the reserve price had a negative, albeit weak, effect on the number of bidders ($\beta = -.108$, $t = -1.500$, $p < .1$). This effect was slightly stronger for items in which the average level of interest was lower, as indicated by an interaction effect between reserve price and degree of interest ($\beta = .178$, $t = 1.589$, $p < .1$). Consistent with our key hypothesis, the public reserve price had a strong positive effect on the selling price ($\beta = .936$, $t = 2.157$, $p < .05$). Thus, all else being equal, increasing the public reserve price by $1 resulted in an increase in the selling price by $.28 (= 93.6 / 3.35). Moreover, this effect was not reduced by the availability of an objective reference price. Finally, as expected, the number of bidders had a strong positive effect on total selling price ($\beta = 2.294$, $t = 3.191$, $p < .01$).

As in Experiment 1, the random effects of the lot-specific intercepts indicate a significant amount of heterogeneity across the auctioned products in terms of both the number of bidders they attracted and the selling price they yielded. Moreover, the period during which an auction was conducted had a weak effect on its selling price. Auctions held at a later time resulted in lower winning bids ($\beta = -.754$, $t = -1.719$, $p < .1$). However, the number of bidders was not affected by the time period of an auction. An auction's serial position within a weekly block did not have any noticeable effect on the number of bidders or on the selling price.

Finally, we examine whether the positive effect of the magnitude of the public reserve price on selling price might be due to a mere price-floor effect. Recall that the latter is possible in auctions with only a single bidder. Of the 72 auctions, 5 had exactly one bidder, and this affected 2 of the 12 products. We reestimated the full HB Tobit model on the 60 auctions associated with the 10 products that never— i.e., in none of the auctions of their 6 replicates—attracted exactly one participant, since a price-floor effect can be ruled out for these auctions. The overall results remained virtually unchanged. In particular, reserve prices still had a strong positive influence on selling prices ($\beta = .894$, $t = 2.013$, $p < .05$). Thus, a mere price-floor effect is *not* a sufficient explanation of the positive effect of public reserve prices on selling prices that we observed.

Discussion

The results of Experiment 2 demonstrate that it is possible for sellers to influence the outcomes of ascending-bid auctions through public reserve prices. In our experimental auctions, we significantly increased selling prices for identical products by merely setting a somewhat higher reserve price. Moreover, we were able to do so without substantial risk of failing to sell an item—only 1 of 72 auctions did not result in a sale. In addition, the reserve price represented a binding price floor for the bidder with the highest valuation in only five cases. Thus, in the vast majority of the auctions, the public reserve price did not preclude the sale of the item or represent a binding minimum price.

The results of this study support our prediction that minimum prices play an important role in bidders' construction of their valuations of

auctioned products. Since the positive effect of public reserve prices on selling prices in our auctions cannot be explained by a mere price-floor mechanism, the findings suggest that as hypothesized, the reserve prices influenced bidders' valuations of the auctioned products. But, we measured valuations only to the extent that they are reflected in selling prices. In Experiment 3, we use an innovative method that enables us to *directly* measure bidders' product valuations in the context of an open ascending-bid auction.

Experiment 3

This experiment is designed both to examine the influence of seller-specified minimum prices on bidders' product valuations *directly* and to investigate possible *differences* between the two types of minimum prices, fixed price components and public reserve prices, in terms of their effects on valuations. Unlike the first two studies, which were based on real-world auctions, Experiment 3 was conducted in the laboratory.

We wish to examine the influence of both types of minimum prices on auction participants' product valuations in a more direct, and more rigorous, manner than was possible in the field experiments. In the latter, we sought to draw conclusions about bidders' valuations from the outcomes (i.e., selling prices) of experimental auctions that we conducted. In Experiment 3, we measure valuations directly, at the level of the individual bidder. This has the important advantage that any positive effect of minimum prices that we might observe can be interpreted unequivocally as one that is consistent with our notion that bidders are influenced by seller-specified minimum prices when constructing their valuation of a product.

To investigate whether the way in which a seller-specified minimum price is framed, either as a fixed price component or as a public reserve price, moderates its effect on bidders' product valuations, it is critical to systematically manip-

ulate this frame while controlling for all other potential sources of influence. In Experiment 3, we include both types of minimum prices as treatment conditions, while holding everything else constant. Although fixed price components and public reserve prices are normatively equivalent, they do have distinct perceptual properties and may, therefore, affect product valuations differently. As discussed above, we expect that a reserve price tends to be seen as a more informative signal of the auctioned product's value than a fixed price component, with the latter being more easily attributable to factors other than the item's value. Consequently, our hypothesis is that the positive effect of a public reserve price on valuations is stronger than that of a normatively equivalent fixed price component.

Method

AuctionSimulator. Given our theoretical interest in bidders' product valuations, a weakness of any experiment that involves actual auctions, irrespective of whether it is conducted in the laboratory or in the field, is that it provides only indirect evidence about valuations. To overcome this limitation, we developed AuctionSimulator, a method for obtaining direct individual-level measures of bidders' product valuations in the context of ascending-bid auctions. AuctionSimulator creates in subjects the illusion that they are participating in an actual computer-based auction along with other individuals. In fact, they are interacting with a bidding machine that mimics the bidding behavior of other human auction participants and reciprocates a subject's bids according to a pre-determined protocol that is controlled by the experimenter.

A crucial property of the AuctionSimulator paradigm is that subjects believe that they are participating in an actual ascending-bid auction and that they are committing their own money whenever they submit a bid. Participants are required to follow the auction on the computer screen until its end, irrespective of when they themselves stop bidding. This ensures that the valuation-elicitation mechanism is incentive-

Figure 4
Experiment 3: Products

compatible in the sense that subjects have no incentive to drop out of the auction before the high bid reaches their own valuation. To obtain a measure of an individual's valuation of the "auctioned" item, the bidding machine is programmed to outbid subjects persistently until they drop out of the (simulated) auction. A person's highest bid is used as an indicator of his or her valuation of the product. AuctionSimulator uses a soft ending rule such that an auction ends as soon as a pre-specified period of time has passed without the submission of a new bid (see Roth and Ockenfels 2000).

By holding the protocol for the bidding machine's reactions to subjects' bids constant, AuctionSimulator allows us to control for the possible influence of others' bids, and of the perceived number of bidders, on a subject's product valuation, which might be present in actual auctions when valuations are affiliated (Milgrom and Weber 1982). Consequently, this paradigm helps isolate the effects of the factors of theoretical interest. These properties allow us to examine the effects of seller-specified minimum prices on bidders' product valuations in a substantially more rigorous fashion than was previously possible.

Experimental Design and Procedure. In a laboratory setting, AuctionSimulator was used to create the illusion that subjects were participating in an actual open ascending-bid auction. Three substantive between-subjects conditions were used in this experiment:

1. no seller-specified minimum price (i.e., bidding starts at the minimum increment),
2. fixed price component of $15 (i.e., bidding starts at the minimum increment), and
3. public reserve price of $15 (i.e., bidding starts at $15 + the minimum increment).

Subjects were randomly assigned to one of these treatment conditions. The auctioned product was the participant's choice of either a fleece sweater or a down jacket.[19] Participants were instructed that, if they were to win their auction, they would be able to select one of six sizes and one of six colors for their product.

The experiment was administered in a research laboratory equipped with networked computers. A total of 109 subjects completed the study in groups ranging in size from 15 to 20. They had been booked to participate in another study and were informed at the beginning of the session that, before starting the actual study, they would have an opportunity to participate in an auction for one of two products. Subjects saw descriptions of a fleece sweater and a down jacket side by side (see Figure 4) and were asked to select one of these two products for the purpose of the auction. They were informed that they would be randomly assigned to one of several auctions for that product along with nine other participants, and that some of the other bidders would be in another room similar to the one they were in.[20]

After reading detailed instructions, which included a reference to the pertinent minimum price, subjects completed a "bidder agreement" stating that they understood the rules of the auction and were aware that any bid they submitted would represent a binding commit-

Figure 5
Experiment 3: Bidding Interface

exceeding the current high bid by $1. The bidding machine submitted at most two consecutive bids. If the subject did not respond to the second of these with a bid of his or her own within (a conservative) 62 seconds, the auction ended.

Subjects then completed a short computer-based questionnaire, which included an open-ended question as to what they recalled to be the total financial commitment implied by their highest bid in the auction. In addition, they rated their degree of interest in the auctioned product, their current need for the product, and their level of product expertise on separate 11-point rating scales with endpoints 0 = "low" and 10 = "high".[21] Finally, participants proceeded to another experiment—the "actual" study. They were debriefed by e-mail after all sessions of the experiment had been administered.

ment on their part. Participants were informed that bidding was optional and that they should submit a bid only if they were willing to purchase the product for that amount. They then proceeded to the entry portal for the auction. After a 30-second delay, purportedly required to randomly assign and connect the 10 bidders to each other, subjects were alerted that their auction had started.

Once the auction was in progress, subjects saw a real-time auction screen consisting of a description of the product, as well as a bidding interface that displayed the current high bid and allowed subjects to submit a bid of their own (see Figure 5). Where applicable, the seller-specified minimum price was prominently displayed in the bidding interface throughout the auction. The minimum bid increment was $1. The ending rule was that the auction ended as soon as 60 seconds had passed without a bid being submitted. AuctionSimulator's bidding machine was programmed to behave according to the following protocol. Any bid placed by the subject was reciprocated 20 seconds later with one that was $1 higher. If the subject did not submit another bid within 30 seconds, the machine placed yet another bid, again

Modeling Approach. In Experiment 3, the unit of analysis is the bidder and the dependent variable is his or her valuation of the auctioned item. We model a bidder's valuation as a function of the set of explanatory variables as follows:

$$v_{ij} = \alpha_1 + \alpha_2\, p + \beta_1 f_{ij} + \beta_2\, r_{ij} + e_{ij} \qquad (3)$$

where v_{ij} is bidder i's valuation of product j, α_1 is a product-specific intercept for fleece sweaters, α_2 is a product-specific intercept difference for down jackets, p is a dummy variable indicating the product (0 = fleece sweater, 1 = down jacket), f_{ij} is a dummy variable indicating the presence of a $15 fixed price component for consumer i and product j (0 = no, 1 = yes), r_{ij} is a dummy variable indicating the presence of a $15 reserve price for consumer i and product j (0 = no, 1 = yes), β_1 and β_2 are the coefficients for the effects of the two types of minimum prices on valuations, and e_{ij} is an error term.

Since only two products were used in this experiment, we estimate a fixed-effects model, including a separate intercept for each of the two products. As in experiments 1 and 2, we use an HB model with a Tobit specification to

Table 3

Experiment 3: Effects of Minimum Prices on Product Valuations

	Before Correcting for Processing Errors				After Correcting for Processing Errors			
Explanatory Variable	Posterior mean	Standard deviation	t-value	p	Posterior mean	Standard deviation	t-value	p
Intercept for fleece sweater	27.360	3.216	8.507	< .01	27.080	3.468	7.809	< .01
Intercept difference for down jacket	31.023	4.691	6.613	< .01	31.070	4.974	6.246	< .01
$15 fixed price component	8.907	5.394	1.651	< .05 a	3.840	7.222	.532	
$15 public reserve price	11.910	5.604	2.125	< .05 a	12.950	5.734	2.258	< .05 a

a Level of significance based on one-tailed test (directional prediction).

obtain the parameter estimates. For those experimental conditions in which a $15 minimum price was in effect, the Tobit specification is a theoretically sound way of modeling bidder valuations below that amount, which are unobservable. In addition, this approach allows the model-based imputation of such unobserved valuations, given the values of the exogenous variables, for descriptive purposes.

Results

Of the 109 subjects, 69 selected the fleece sweater and 40 chose the down jacket for the purpose of the auction. The means of subjects' highest total bids—i.e., including the fixed price component, where applicable—for the fleece sweater and the down jacket were $30.71 and $63.90 respectively. Of the 109 participants, 106 submitted a bid. All three non-bidders were in one of the $15-minimum-price conditions and as a result, their valuations are treated as censored observations in the HB Tobit model.

The results of the model estimated on subjects' valuations, measured by their highest total bids, are provided in the left panel of Table 3. Each type of minimum price had a positive effect on valuations (fixed price component: $\beta = 8.907$, $t = 1.651$, $p < .05$; reserve price: $\beta = 11.910$, $t = 2.125$, $p < .05$).[22] This is consistent with our key hypothesis that seller-specified minimum prices influence bidders' valuations. The means of

subjects' highest bids for fleece sweaters in the three treatment conditions are $28.48 (no minimum price), $31.90 ($15 fixed price component), and $36.93 ($15 reserve price).[23] The corresponding values for down jackets are $54.88 (no minimum price), $66.25 ($15 fixed price component), and $75.40 ($15 reserve price). When the minimum price was framed as a public reserve price, subjects' highest bids are direct measures of their valuations of the auctioned product. When the minimum price was specified in the form of a fixed price component, however, it is possible that participants bid more than their valuation as a result of their failure to accurately process the fixed price component when making bidding decisions. To detect such possible processing errors, we asked subjects after the auction what they recalled to be the total financial commitment implied by their highest bid in the auction. Of the 27 participants in the fixed-price-component condition, 13 underestimated their total commitment.[24] By eliminating these subjects from the analysis, we can decontaminate the highest-bid measure of a possible processing-error effect. The remainder of the observations represents clean direct measures of bidders' valuations.

We re-estimated the HB Tobit model without the 13 participants that appear to have failed to process the fixed price component accurately.
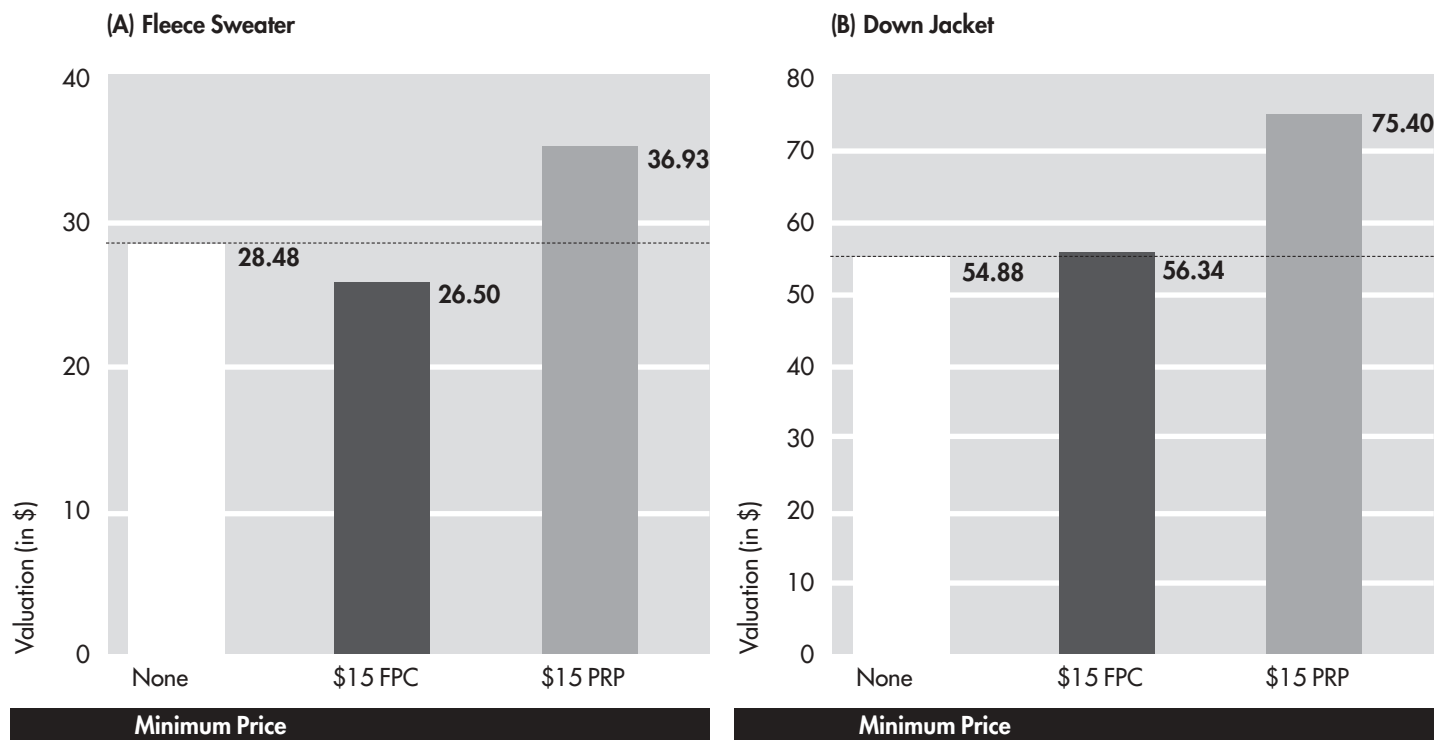
The parameter estimates for this model are provided in the right panel of Table 3. Correcting for processing errors in this manner does affect the results—the effect of the fixed price component on bidder valuations is no longer significant ($\beta = 3.840$, $t = .532$), while the other estimates remain virtually unchanged. Thus, not only is the positive effect of a public reserve price on bidders' valuations stronger than that of a corresponding fixed price component, as predicted, but the impact of the latter is in fact no longer detectable once we correct for possible processing errors.[25]

Figure 6 shows the mean valuations of the fleece sweater and the down jacket after correcting for processing errors in the $15-fixed-price-component conditions. This illustrates the difference between the two types of minimum prices on product valuations. Adding a $15 fixed price component had virtually no influence on subjects' valuations of the two

products. By contrast, specifying a $15 public reserve price had very substantial effects on valuations of both products. Bidders' valuations of the fleece sweater increased by an average of $8.45, or 30% (independent-samples $t = 2.133$, df = 41, $p < .05$), and those of the down jacket increased by an average of $20.52, or 37% (independent-samples $t = 2.387$, df = 23, $p < .05$). Interestingly, in the latter case, the average increase in bidders' valuations as a result of the specification of a reserve price was *greater* than the reserve price itself ($15).
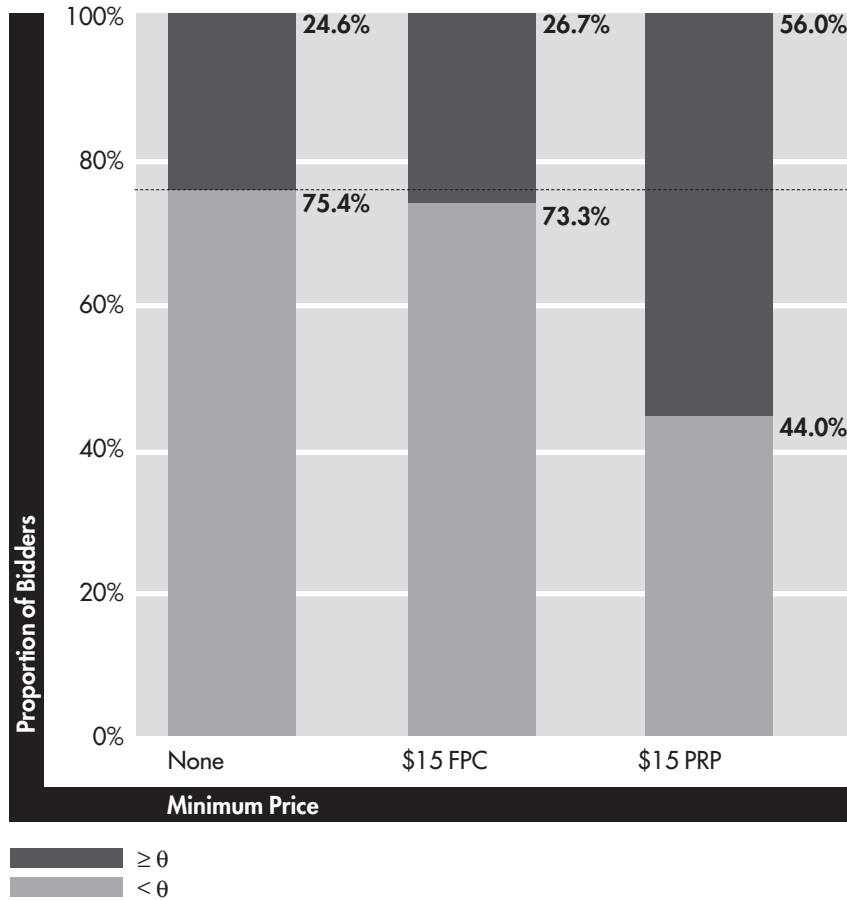
Another way of examining the effects of the two types of minimum prices on bidders' product valuations is to compare the three treatment conditions in terms of the proportion of subjects with a valuation greater than some common threshold. As long as this threshold exceeds the level of the minimum prices used in the experiment ($15), such a comparison does not require the model-based imputation of any

Figure 6
Effects of Minimum Prices on Product Valuations

(A) Fleece Sweater

Bars: None = 28.48, $15 FPC = 26.50, $15 PRP = 36.93. Y-axis: Valuation (in $). X-axis: Minimum Price.

(B) Down Jacket

Bars: None = 54.88, $15 FPC = 56.34, $15 PRP = 75.40. Y-axis: Valuation (in $). X-axis: Minimum Price.

Note: FPC = fixed price component, PRP = publicc reserve price

Figure 7

**Proportion of Bidders Whose Product Valuation Exceeds a
Common Threshold (Both Products)**

Note: The threshold (θ) is $40 for fleece sweaters and $70 for down jackets.

resulted in a significant increase in this propor-
tion from 25% to 56% (χ^2 = 7.638, df = 1, p <
.01). These findings are consistent with the
mean valuations reported above.

Experiment 3 allowed us to examine the effects
fixed price components and public reserve
prices have on bidders' product valuations in a
highly rigorous manner. Using the
AuctionSimulator paradigm, we were able to
isolate the critical causal relationships and elim-
inate various influences that might otherwise
have obscured the effects of interest. The results
provide clear evidence that the two normatively
equivalent types of seller-specified minimum
prices affect bidding behavior in fundamentally
different ways. Fixed price components tend to
have a positive effect on auction participants'
total bids (including fixed components), but
this is due primarily to a failure to correctly
process the pertinent price information rather
than changes in bidders' valuations of the
auctioned product. By contrast, our findings
show that public reserve prices have the poten-
tial to actually influence bidders' valuations of
the auctioned product.

Discussion
The laboratory experiment provided deeper
insights into the effects of seller-specified
minimum prices on bidders' product valuations
than was possible in experiments 1 and 2. Using
the AuctionSimulator paradigm, we were able
to obtain direct measures of bidders' valuations
in the context of an ascending-bid auction. This
made it possible to examine our key hypothesis
at the appropriate level of analysis—the indi-
vidual bidder. In addition, this method allowed
us to disentangle the predicted constructed-
valuations effect of minimum prices from
possible alternative explanations of the influ-
ence of minimum prices on the outcomes of
ascending-bid auctions, namely price-floor and
processing-error effects.

The overall findings of the two field experi-
ments were corroborated in Experiment 3,
although this was done at the level of the indi-

unobserved valuations. This is due to the fact
that the true level of any unobserved valuation
is known to be between $0 and $15, and the
specific amount is therefore immaterial with
respect to the proportions of interest. We use
the 75th percentile of valuations in the no-
minimum-price condition—$40 for the fleece
sweater and $70 for the down jacket—as the
common threshold (θ). The proportions of
bidders whose valuation were greater than or
equal to the relevant θ under each of the three
treatments are shown in Figure 7. While the
$15 fixed price component did not increase the
share of subjects whose valuation was greater
than or equal to the relevant θ (χ^2 = .028, df = 1,
p > .85), specification of a $15 reserve price

vidual bidder and for an entirely different product category. In particular, the magnitude of both fixed price components and public reserve prices had a positive influence on participants' highest bids, and this is consistent with the effects of these same variables on the selling prices realized in the experimental auctions in experiments 1 and 2. The results of Experiment 3 indicate, however, that the mechanisms that underlie these effects are very different for the two types of minimum prices. Our evidence suggests that the positive influence of fixed price components on bids and, in turn, selling prices is due primarily to the bidders' failure to accurately process the fixed component when making bidding decisions. In fact, after correcting for processing errors, we no longer observed an effect of the fixed price components on bidders' valuations. By contrast, the magnitude of a public reserve price had a strong positive effect on bidders' product valuations, which is consistent with our hypothesis that a seller-specified minimum price is perceived to be an informative indicator of an item's value and taken into account by bidders when constructing their valuations of auctioned products.

General Discussion

The three experiments described in this paper significantly enhance our understanding of one specific aspect of bidding behavior in ascending-bid auctions—the influence of seller-specified minimum prices on bidders' product valuations. Prior work in this area has considered the effects of minimum prices on auction outcomes, i.e., selling prices, and focused on theoretical analyses of sellers' optimal minimum-price strategies (e.g., Engelbrecht-Wiggans 1987). In that line of research, it is commonly assumed that a bidder's valuation of an auctioned good is invariant with respect to the presence or magnitude of a minimum price. By contrast, we have introduced a constructed-valuations perspective according to which minimum prices play an important role in bidders' construction of their valuation of a product. In particular, we have

hypothesized that seller-specified minimum prices serve as an informative indicator of an item's value and, therefore, have a positive influence on bidders' valuations of the product.

Our results demonstrate the importance of minimum prices as a determinant of auction outcomes. We focused on two, normatively equivalent types of minimum prices, fixed price components and public reserve prices, and showed that the magnitude of each can have a substantial positive effect on selling prices in open ascending-bid auctions. Furthermore, we observed these effects even in auctions where multiple participants placed bids that exceeded the minimum price, which shows that the latter's influence on selling prices cannot be characterized as a mere price-floor effect. More importantly, we have obtained an understanding of the psychological mechanisms that underlie the positive effects of minimum prices on auction outcomes. Although normatively equivalent, the two types of minimum prices affect selling prices via entirely different mechanisms. The presence of a fixed price component tends to cause bidders to underestimate the total financial commitment implied by their bids as a result of their failure to accurately process, or even attend to, the fixed component when making bidding decisions. In this case, the effect on auction outcomes is driven by a type of processing error on the part of bidders, rather than by a change in their valuations. On the other hand, reserve prices tend to convey some information about the auctioned item's value and, as a result, have a direct positive effect on bidders' valuations of that product.

From a consumer welfare perspective, the findings of this research illustrate the susceptibility of auction participants to being influenced, in a systematic and predictable fashion, by properties of an auction that are under the complete control of the seller. We have demonstrated that minimum prices in open ascending-bid auctions have the clear potential to affect consumers' bidding behavior and, when

presented in the form of public reserve prices, to actually shape consumers' valuations of a product. ■

Acknowledgements

Appendix 1. Auction Theory

An auction is a market institution, organized by an auctioneer, with an explicit set of rules for determining the allocation and prices of goods on the basis of bids from market participants. Typically, the auctioneer is the seller of the good and the bidders are potential buyers.
It is possible, however, to conduct procurement auctions in which the auctioneer is a buyer and the potential sellers submit bids. Our focus is on the former type of auction.

A large body of literature in economics is devoted to the study of auctions (see Klemperer 1999 for an overview). Typical issues addressed in this literature include the optimal design of auction mechanisms for particular settings, strategies for maximizing the seller's revenue, and bidders' equilibrium strategies (Bulow and Roberts 1989; Milgrom 1989). Auctions are often analyzed as non-cooperative games among competing bidders with incomplete information, and typical solutions consist of Bayesian Nash equilibria with respect to participants' bidding strategies (Krishna 2002; McAfee and McMillan 1987). The vast majority of auction research in economics has been theoretical in nature. But some empirical work, aimed at testing specific assumptions of theoretical auction models or predictions of market outcomes derived from these models, has been done (see Kagel 1995).

The auction literature distinguishes between four basic auction types or mechanisms, (1) open ascending-bid, (2) open descending-bid, (3) first-price sealed bid, and (4) second-price sealed bid (see, e.g., McAfee and McMillan 1987). As noted above, our study focuses on open ascending-bid auctions. An *open descending-bid* auction (also known as "Dutch" auction) starts with a high initial price which is then lowered incrementally until one bidder indicates a willingness to buy the product at the current price. In a *first-price sealed-bid* auction, each bidder submits a single private bid. The highest bidder wins the auction, and pays his or her bid amount for the product. Finally, in a *second-price sealed bid* auction, the participant who bid the highest amount is again the winner, but she or he pays a price that is equal to the second highest bid (Vickrey 1961). In this paper, we focus on open ascending-bid auctions, the most common auction type in current practice (Lucking-Reiley 2000).

Bidders' Valuations of Auctioned Products
In posted-price markets, a buyer's decision to purchase a product, for the most part, boils down to whether or not his or her valuation of the product exceeds the seller-specified price. But in these markets, buyers are not required to articulate their exact valuation of a product. Moreover, many "buy/no-buy" decisions that consumers make on a regular basis are actually not very difficult. For many purchases, their valuation of a product or service clearly exceeds the posted price, with the difference between the two constituting consumer surplus. At the same time, a consumer's valuation of a product that he or she might be interested in will often be considerably lower than the product's posted price, and there are many products that, even though they might be of some value to us, we would never buy at the posted price. It is often sufficient for a consumer to know his or her valuation of an offered product approximately, rather than precisely.

In auctions, by contrast, selling prices are determined interactively based on competing bids submitted by potential buyers and according to a publicly-known set of auction rules (e.g., McAfee and McMillan 1987). Because auction participants must make decisions about what amount, if any, they wish to bid for an item, the auction mechanism provides a strong incentive for potential buyers to determine their valuation of the auctioned good with high accuracy. Therefore, it is important to understand how bidders' product valuations are formed, and what factors might influence these valuations in systematic ways.

An important factor in theoretical models of bidders' valuations is whether, or to what extent, valuations are private or common (Milgrom and Weber 1982). In the *independent-private-values* model, participants' valuations of a good may differ based on their individual preferences; each bidder knows his or her own valuation with certainty and this valuation is independent of other participants' valuations of the object. In the *common-value model*, by contrast, the true value of the auctioned good is the same for everyone, but bidders are uncertain as to what that value actually is, and any indication of other participants' estimates of the item's value, any private "signal," provides useful information about the item's value (Rothkopf 1969). These two models represent polar cases. Real-

world auctions, particularly those in which the bidders are consumers, typically contain aspects of both (McAfee and McMillan 1987; Laffont 1997).

The *affiliated-values model* (Milgrom and Weber 1982) is a general framework that encompasses both the independent-private-values model and the common-value model as special cases. It allows for heterogeneity in valuations across bidders, as well as for interdependency, or "affiliation," among bidders' valuations. The concept of affiliation is based on the notion that each bidder obtains a signal—i.e., a set of information—regarding the good's value. A bidder's valuation depends not only on his or her own signal, but also on the signals of the other participants. An auction participant may use the observable bidding behavior of another individual as a basis for making inferences about that person's valuation of an item. In turn, such inferences may influence his or her valuation of the auctioned good. The affiliated-values model is a suitable framework for bidders' valuations in the three experiments presented in this paper.

Bidders' Valuations and Selling Prices in Ascending-Bid Auctions

It is important to distinguish between individual bidders' valuations of an object and the selling price, or winning bid, of that object as determined by an auction. In general, the selling price is a function of the interaction between individual bidders' valuations of the auctioned item. Fortunately, the nature of this relationship is relatively straightforward in the case of open ascending-bid auctions, which are the focus of the present research.

The strategic simplicity of ascending-bid auctions is illustrated by participants' optimal bidding strategy, which is to bid up to one's own valuation and, if subsequently outbid

by someone else, drop out of the auction (Cramton 1998). Consider an open ascending-bid auction of an item with N bidders ($i = 1,2,...,N$) whose valuations of the item, $V = (V_1, V_2,..., V_N)$, are indexed in descending order such that V_1 is the highest valuation, V_2 is the second-highest valuation, and so forth. Participant i drops out of the auction as soon as the current high bid exceeds his or her valuation V_1. The bidder with the highest valuation, V_1, wins the auction and pays a price of V_2 for the item. Thus, the second highest valuation determines the selling price. This is strictly correct only as the minimum bid increment, i.e., the amount by which a new bid must exceed the current high bid, approaches zero. While minimum bid increments may be non-negligible in real-world auctions (see Sinha and Greenleaf 2000), most theoretical auction models assume that they do not affect selling prices (see, e.g., Milgrom and Weber 1982).

All else being equal, the magnitude of the winning bid in an ascending-bid auction is positively related to the mean of bidders' valuations, $\mu_V = (V_1 + V_2 + ... + V_N) N^{-1}$. Even controlling for μ_V, however, the selling price may be affected by several other factors. First, greater variance in bidders' valuations (σ^2_V) will, all else being equal, lead to a higher price because the latter is driven by the upper tail of the distribution of valuations (McAfee and McMillan 1987). Second, a greater number of bidders (N) will, controlling for both μ_V and σ^2_V, tend to result in a higher winning bid because of an increase in the density of valuations in general, and a decrease in the difference between the first and second order statistic of the distribution of bidders' valuations, $V_1 - V_2$, in particular (Bulow and Klemperer 1996). Finally, if the seller has specified a minimum price, the latter may moderate the relationship between bidders' valuations and the selling price.

Appendix 2. Model Estimation

The data from experiments 1 and 2, including the data obtained in the survey, were analyzed using Hierarchical Bayes (HB) models. We provide only a concise description of the HB method used in connection with our models, and refer the interested reader to other sources for a more detailed discussion (e.g., Gelman et al. 1997; Lenk et al. 1996). Estimation of our HB model can be viewed as a three-stage process (Neelamagham and Chintagunta 1999). The first stage consists of specifying the models for the number of bidders and for the selling price in an auction. At the second stage, we specify the means of these distributions as a function of explanatory variables. Finally, at the third stage, we incorporate variability in the parameters to be estimated.

We first specify the distributions for the two endogenous variables, the number of bidders and the (total) selling price. The number of bidders for lot j at time t, denoted b_{jt}, is a count variable, which is modeled using a Poisson

distribution (Wang 1993; Engelbrecht-Wiggans 1980, 1987). Therefore, b_{jt} follows a Poisson distribution with rate λ_{jt}, and the density is specified as:

$$b_{jt} \mid \lambda_{jt} = (\exp(-\lambda_{jt}) \lambda_{jt}^{b_{jt}}) / b_{jt}! \tag{A1}$$

We allow for the possibility that the dependent variable price is censored. Hence, we use a Tobit specification for the (total) selling price realized in an auction. Therefore, price for lot j at time t, denoted p_{jt}, is modeled using a conditional censored normal distribution with mean μ_{pjt} and variance σ_p^2, which vary over the experimental manipulations. Then, the density for p_{jt} is defined as follows (see Maddala 1983, p. 5):

$$p_{jt} \mid \mu_{pjt}, \sigma_p^2 = \left[\frac{n}{n_1} \left[\Phi_p \left(\frac{mp_{jt} - \mu_{pjt}}{\sigma_p} \right) \right]^{n_1} \prod \frac{1}{\sqrt{2\pi\sigma_p^2}} \exp\left(\frac{-1}{2\pi_p^2}(p_{jt} - \mu_{pjt})^2 \right) \right] \tag{A2}$$

where p_{jt} = the selling price, mp_{jt} = the minimum price, n

= the number of observations, n_1 = the number of censored observations, $n_2 = n - n_1$, and Φ_{jt} = the cumulative normal distribution. (For the analysis of the data from Experiment 3, we used a Tobit specification analogous to the one described here, but with bidders instead of auctions as the unit of analysis, and with bidders' valuations instead of selling prices as the dependent variable.) We use the subscripts b and p for the coefficients to distinguish between the equation for the number of bidders and that for selling price, respectively.

Next, we specify λ_{jt} and μ_{pjt} as a function of explanatory variables. First, to incorporate variability in the rate parameter λ_{jt}, the latter is modeled using a log normal distribution (see Neelamagham and Chintagunta 1999). Therefore, $\log(\lambda_{jt}) \sim$ Normal (μ_{bjt}, σ_b^2). Making this a function of the explanatory variables, $X_{1jt}, ..., X_{kjt}$, we obtain:

$$\mu_{bjt} = \alpha_{bj} + \beta_{b1} X_{1jt} + ... + \beta_{bk} X_{kjt} \qquad (A3)$$

where α_{bj} is the lot-specific intercept of the equation for number of bidders, $\beta_{b1}, ..., \beta_{bk}$ are the k coefficients to be estimated for this equation. We also tested for heterogeneity in the coefficients for the explanatory variables, but this did not lead to an improvement in model fit.

The mean selling price, μ_{pjt}, is specified as a function of both the set of exogenous explanatory variables, $X_{1jt}, ..., X_{mjt}$, and the number of bidders. Since the number of bidders is endogenous, we use the predicted number of bidders obtained from Equation 3, leading to the following specification:

$$\mu_{pjt} = \alpha_{pj} + \beta_{p1} X_{1jt} + ... + \beta_{pm} X_{mjt} + \beta_{pb} b_{jt} \qquad (A4)$$

where α_{pj} is the lot-specific intercept of the equation for

selling price, $\beta_{p1}, ..., \beta_{pm}$, and β_{pb} are the coefficients to be estimated for the price equation, and b_{jt} is the log of the number of bidders.

Finally, we specify the distributions of the parameters in equations A3 and A4. Following standard practice, diffuse but proper priors were specified for these hyperparameters. The lot-specific intercepts were modeled as follows: $\alpha_{bj} \sim N(0, \sigma_{b\alpha}^2)$ and $\alpha_{pj} \sim N(0, \sigma_{p\alpha}^2)$, where $\sigma_{b\alpha}^2$ and $\sigma_{p\alpha}^2$ reflect the extent of unobserved heterogeneity across lots. The parameters for the explanatory variables have independent normal distributions: $\beta_{bk} \sim ind\, N(\mu_{\beta k}, \sigma_{\beta k}^2)$, for $k = 1, ..., K$ and $\beta_{pm} \sim ind\, N(\mu_{\beta m}, \sigma_{\beta m}^2)$, for $m = 1, ..., M$, where $\mu_{\beta m}$ is the mean effect of variable m over all auctions, $\sigma_{\beta m}^2$ is the dispersion of that effect, and gamma priors are used for the inverse of the variances ($\sigma_{b\alpha}^2, \sigma_{p\alpha}^2, \sigma_b^2, \sigma_p^2$). We estimate the posterior distributions of $\alpha_{bj}, \alpha_{pj}, \beta_{pm}$, and β_{bk}, and report their posterior means and standard deviations in the results sections of the paper.

Model estimation was performed using Gibbs sampling as implemented in the BUGS software (Spiegelhalter et al. 1997). A burn-in period of 10,000 iterations was used, after which we ran another 20,000 iterations to estimate the parameters. As suggested in the literature, we used several different procedures to test for convergence (see, e.g., Cowles and Carlin 1996). Two sets of parameters were obtained by running two different chains, each of which had different starting values. Geweke's (1992) convergence tests were conducted on all parameters. This is a simple Z-test of the equality of the means, which was estimated for the first 10% of a chain and the last 50% of the iterations. We did not reject equality of the means, which implies convergence of the model. In addition, we plotted the trace, the kernel density trace, and autocorrelation functions of the different chains. All of these indicators suggested that the chains were in equilibrium.

Notes

1. A lower bound on the selling price can also be kept secret by the seller, at least initially, as in the case of a hidden reserve price. However, we focus on minimum prices that are public from the outset.

2. Incidentally, Morwitz et al. (1998), in one of their studies, used an auction mechanism to examine the effect of partitioned prices on demand for a good. However, in contrast to the present research, their auction study involved a buyer's premium equal to a percentage of the winning bid, rather than a fixed price component. Furthermore, they used a sealed-bid auction, rather than an open ascending-bid format.

3. In the remainder of the paper, we use the term "selling price" to refer to the total selling price including, where appropriate, a fixed price component.

4. The expected surplus is equal to the bidder's valuation of

the auctioned item minus the expected winning bid.

5. Without loss of generality, these could also be viewed as the three participants with the highest valuations of the item in an auction with an arbitrary number of bidders, i.e., the last three remaining bidders.

6. Recent work by Greenleaf (2003) complements this body of research by examining the seller's choice of reserve price from a behavioral perspective.

7. Consistent with Milgrom and Weber's (1982) notion of affiliated values, the bidding behavior of other participants in an open ascending-bid auction is another important type of such signals. However, we do not examine this in the present paper.

8. For simplicity, the increase in valuations due to the presence of the minimum price is shown here as constant across bidders.

9. This is also consistent with work on consumer price knowledge in fixed-price settings, which suggests that consumers often fail to process price information in a complete and accurate manner (see, e.g., Dickson and Sawyer 1990).

10. During the period of data collection, the average number of stamp auctions on eBay per day was approximately 67,000. The auctions were conducted according to an ascending-bid mechanism with a proxy bidding system. The latter allows for an element of automation of auction participants' bidding in that they have the opportunity to enter a proxy bid, i.e., the maximum amount that they are willing to bid, and request that the system generate actual bids on their behalf that are just sufficient to render the current high bid, up to the specified amount. Bidders are free to increase their proxy bids for an auction at any time, and it is common for bidders to do so multiple times during the course of an auction (Wilcox 2000).

11. The actual questions were "How interested are you personally in this set of stamps?" (0 = "not at all" to 10 = "very much") and "How easy or difficult is it for you to assess the value of this set of stamps to you personally based on the information provided here?" (0 = "very difficult" to 10 = "very easy"). The mean and variance of the lot-specific mean ratings of degree of interest are 3.13 and 1.09, respectively, and the mean and variance of the mean ratings of ease of evaluation are 6.38 and .93, respectively.

12. The general modeling approach described in this section is used to analyze the data from experiments 1 and 2. Furthermore, a simpler version of this method is used to model bidder valuations in Experiment 3.

13. Because we estimate a recursive system of equations, the error terms e_{bjt} and e_{pjt} are not independent.

14. Failing to treat the number of bidders as an endogenous variable may lead to selectivity bias, resulting in biased parameter estimates and the underestimation of standard errors (Greene 1993).

15. Most of the auctions had unique winners. However, two individuals won two auctions each. (In Experiment 2, four bidders won two auctions each.) To examine the robustness of our findings, we re-estimated the models for both experiments 1 and 2 without the auctions that had non-unique winners. The results of these additional analyses are virtually identical to the ones reported here.

16. We also ran the model with two reasonable alternatives to the single-factor linear coding of the fixed price component. First, we estimated a quadratic term in addition to the linear term, but found no evidence of such a nonlinear effect. Second, we included a separate dummy variable indicating whether or not any fixed price component was specified. This binary variable has no effect as long as the linear relationship is accounted for.

17. Seller-specified reserve prices and objective reference prices may be viewed as different types of external reference prices. However, while the former are under the seller's control, the latter are not. Although external reference prices have been studied extensively in posted-price settings (e.g., Mayhew and Winer 1992; Mazumdar and Papatla 2000), their effects on consumers' product valuations and bidding behavior in an auction context are not well understood.

18. The mean price for the 10% condition includes the model-based imputation of the one unobserved selling price.

19. The results of a pilot study (n = 43) suggested that a large portion of the relevant population of consumers perceived these two products as highly attractive. By allowing participants in the experiment to self-select one of the two products, we further reduced the probability of a subject participating in an auction of a product that s/he was not interested in.

20. This was done for two reasons: (1) we wanted to discourage subjects from trying to observe the behavior of other participants and (2) it was difficult to ensure that the number of subjects in each experimental session was an exact multiple of 10.

21. Subjects were also asked to describe their auction experience and prompted to report anything that they felt was extraordinary. None of the subjects made a comment suggesting that they had any doubt that they were bidding against other humans.

22. We also tested for possible moderating effects of product category by including product × fixed-price-component and product × public-reserve-price interaction effects in the model. We found no evidence of such moderating effects.

23. These means entail imputed values for the unobserved valuations (based on the Tobit model).

24. All other subjects, including those in the other two experimental conditions, recalled their financial commitment without error.

25. We controlled for subjects' degree of interest in the auctioned product, their current need for the product, and their level of product expertise by including each of these three variables, measured on 11-point scales, separately as main effects in the model. While, as one would anticipate, both interest and need had a significant positive effect on valuations, their inclusion had virtually no influence on the effects of the two types of minimum prices. Expertise had no main effect on valuations, and it also did not moderate the effects of fixed price components or reserve prices. As in the original model, we found no evidence of any moderating effects of product category.

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