

Vickrey vs. eBay: Why Second-Price Sealed-Bid Auctions Lead to More Realistic Price-Demand Functions

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ABSTRACT: Knowledge of consumers' willingness-to-pay (WTP) is critical for marketing managers when designing optimal pricing policies. The large-scale applicability, reliability, and validity of Vickrey auctions as an incentive-compatible method for eliciting WTP in a real-world setting were tested empirically. The results of 6,548 sealed bids in 28 auctions of costly durables on a popular auction Web site show that regular on-line shoppers have little problem understanding and applying the Vickrey auction bidding strategy. As a result, Vickrey auctions can easily produce a reliable and valid distribution of WTP based on several thousand consumers. A comparison of Vickrey auctions with the more commonly used English or eBay auctions shows, both conceptually and empirically, that the latter formats do not fully reflect the complete range of potential customers' WTP and, therefore, lead to systematic overestimation of price-demand functions. In contrast, WTP information elicited through Vickrey auctions is undistorted by strategic behavior such as bid-sniping and incorporates the full range of WTP information, suggesting that it is better suited for estimating realistic price-demand functions for market research purposes.

KEY WORDS AND PHRASES: Market research, on-line auctions, pricing, Vickrey auctions, willingness-to-pay.

Since the infant days of electronic commerce, on-line auctions such as eBay have been a global success story, attracting a steadily growing number of buyers and sellers. This growth has been followed by a large stream of literature concerning bidding behavior, reputation mechanisms, consumer surplus, and optimal design of on-line auctions [5, 6, 13, 21, 44, 54]. However, recent reports show a significant slowdown in the growth of on-line auctions, with traditional trading platforms such as Amazon Marketplace seeming to gain the upper hand [49]. While eBay reacted to this challenge by introducing fixed-price formats and extending its service range (e.g., by buying PayPal), a unique extension of its business model remains untapped—namely, the use of on-line auctions as a market research tool to efficiently elicit consumers' willingness-to-pay [47].

Knowledge of consumers' willingness-to-pay (WTP) is the foundation for optimal pricing decisions. To measure WTP, marketing researchers usually use either actual market transactions (revealed preferences) or surveys (stated preferences) (see [19]). Transaction data, such as scanner data, have high external

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validity because actual purchases are observed. However, since actual transaction prices generally vary only within a limited range, the true distribution of WTP remains unknown. Moreover, transaction data are not available for new products that have not yet been sold under market conditions [55].

Survey data, on the other hand, are often determined by conjoint analysis or directly stated WTP [51]. Marketing and IS researchers frequently apply these methods when actual transaction data are unavailable [see 33]. This is the case, for example, for nonmarket public goods or new product concepts, such as a new on-line service during its beta stage (e.g., [11, 33]). Yet, the external validity of these approaches may be limited because they fail to provide an incentive for consumers to truthfully reveal their WTP [15, 26, 55]. Research has shown that even sophisticated elicitation techniques, such as discrete choice-based contingent valuation, can be subject to response-incentive effects [1].

To overcome this market research problem, researchers have proposed the application of incentive-compatible methods based on either Vickrey auctions or the Becker-DeGroot-Marschak (BDM) mechanism [7, 50]. Results from recent studies show that the data on WTP elicited using incentive-compatible methods are lower than those obtained by other methods, such as direct statements, while at the same time have higher validity [15, 16, 30, 51, 52, 55]. A shortcoming of these studies is that they use rather small samples or settings that differ from a real-world scenario (e.g., laboratory settings).

In a paper published in a previous issue of *IJEC*, Geng, Stinchcombe, and Whinston developed a conceptual framework that describes how to use second-price sealed-bid auctions (i.e., Vickrey auctions) to introduce radically new products [18]. Building on this conceptual framework, the present paper presents an empirical analysis of the ability of Vickrey auctions to elicit the distribution of WTP. The aim of this paper is to analyze the large-scale applicability, reliability, and validity of Vickrey auctions for eliciting willingness-to-pay in a real-world on-line auction setting. Extending prior research, it analyzes the relation between distributions of WTP by non-incentive-compatible methods (i.e., directly stated WTP) and by incentive-compatible Vickrey auctions with a real buying obligation. In addition, it compares the ability of Vickrey auctions to elicit WTP distributions with more popular eBay auctions. In particular, it analyzes the occurrence of bid-sniping, a common form of strategic behavior that would distort the distribution of WTP, and determines how well these different auction formats incorporate the full range of WTP information required for the estimation of realistic price-demand functions. To accomplish these aims, 28 costly durables were sold on a popular auction Web site via Vickrey auctions. The sample consisted of products from different stages in their life-cycles, including innovations not yet available for sale otherwise. The results were used along with a follow-up survey to determine whether bidding behavior and auction results coincided with previous theoretical and laboratory findings on incentive-compatible WTP elicitation. In contrast to the reservations discussed in the literature, it was found that regular on-line shoppers have few problems understanding and applying the dominant Vickrey auction bidding strategy. A second step of the analysis compared, both conceptually and empirically, the bidding behavior and resulting price-demand functions in Vickrey auctions with those of equivalent English or eBay auctions. The two latter formats were

shown to be affected by strategic behavior such as bid-sniping and systematically excluded potential bidders with low WTP due to increasing minimum bid requirements during the auction period. Therefore, these formats are prone to overestimation of price-demand curves.

Literature Review

Within the past decade, on-line auctions have attracted attention in various fields of research, such as economics, information systems, and marketing [3, 5, 37, 44, 46, 51, 57]. So far, researchers have addressed a wide range of topics (see [13] for an overview). For example, scholars have proposed frameworks for optimal auction designs and reputation mechanisms (e.g., [4, 5, 21]). However, most of these studies have shared a common focus on approaches to optimizing sales prices, whether through a trustworthy trading environment or analysis of bidding processes [27, 39, 42, 44, 53]. Another stream of literature focuses on determining the various influences on auction bids, such as trust in the seller, uncertainty concerning the product on offer, and future or parallel auctions [3, 6, 40, 41, 57].

The dominant on-line auction marketplace, eBay, has been used as a primary source of empirical data and as a platform for experimental settings [22]. Such real-life data sets gain even further depth when enriched with additional information gathered, for example, through surveys administered to bidders in auctions being studied [41]. Therefore, auction platforms like eBay have been described as an “online test bed for researchers” [22], and both academics and market research professionals agree on the vast potential of on-line market research [33].

In this context, it is somewhat surprising that no market researcher, so far as is known, has actually employed real-life on-line auction environments to elicit distributions of WTP using incentive-compatible methods, which are considered (at least theoretically) best suited for this purpose.

Thus far, researchers have analyzed the suitability and validity of Vickrey auctions for deriving distributions of WTP only in laboratory settings (see, e.g., [26, 37, 43, 51]). This approach is widely accepted as favorable when addressing such aspects as control for outside influences, administration of information to participants, and options for accompanying surveys. However, the benefits of laboratory settings come at a cost. Studies conducted in a laboratory may not have the same validity as studies in real-world settings. There are several reasons for this: Participants in laboratory studies are frequently compensated for their participation, they have little opportunity to analyze alternative prices, they do not self-select according to their interest in the particular product, and they are aware that they are part of a market research study [15, 16, 26, 30]. In addition, researchers have employed Vickrey auctions mostly for small-ticket items such as candy bars or slices of cake, for which the participants’ involvement is much lower than it would be for expensive items like electronic appliances [30, 51]. Furthermore, participants are often limited to small convenience samples of students [15, 16, 30, 51]. To overcome these limitations, Geng et al. proposed the application of incentive-compatible

Vickrey auctions in an on-line auction setting [18]. The present study, building on the conceptual framework outlined by Geng et al., focuses on the large-scale applicability of Vickrey auctions and the validity of the resulting WTP distributions. As a second step, the analysis makes a conceptual and empirical comparison of bidding behavior and resulting price-demand functions in Vickrey auctions with those in equivalent English or eBay auctions.

Measuring WTP with Incentive-Compatible Methods

Basic Principles of Incentive-Compatible Methods

An incentive-compatible method provides consumers with an incentive to truthfully reveal personal information, which in this case is their WTP. Vickrey auctions are the most commonly used incentive-compatible method [50]. The basic idea of a Vickrey auction is to simultaneously collect sealed bids from all the bidders for an item and then to award the item to the highest bidder at the price of the second-highest bid [50].¹ Due to this procedure, and for any selling price p , bidders maximize their utility by placing a bid (b) that is equivalent to their specific WTP (w) [18]. In this case, utility—or the “incentive” (i), which is equivalent to consumer surplus—is defined as the (positive) difference between an individual’s WTP and the selling price (p), which is determined by the second-highest bid (i.e., $w - p = i$). If bidders understate their WTP by bidding $b^- < w$, they forgo the possibility of realizing any consumer surplus from selling prices where $b^- < p < w$. Overstating one’s WTP by bidding $b^+ < w$ does not increase one’s chance of realizing consumer surplus, but it does raise the risk of overpaying (and thereby realizing a negative surplus) for any selling price in the range $w < p < b^+$. Using the second-highest rather than the highest bid to determine the selling price ensures that (1) bidders can gain a positive surplus while revealing their true WTP, and (2) the price-setting mechanism is exogenous and not controlled by any individual bidder [16, 55].

Integration of Buying Obligations

In general, studies find that incentive-compatible methods lead to a lower WTP than traditional, non-incentive-compatible methods, such as direct statements or conjoint analysis [30, 37, 51]. Although the true WTP is an unobservable construct, studies have reported various indications that incentive-compatible methods also lead to more valid results—as would be expected based on theoretical considerations (see, e.g., [15, 55]). Two major obstacles to a valid application of the Vickrey auction have been frequently discussed in the literature: (1) whether participants understand the applied mechanism, and (2) how to limit the distortions to the incentive alignment, such as those resulting from fear of the fraudulent use of the revealed WTP (e.g., [32]). Both aspects have to be addressed carefully when designing an on-line version of a Vickrey auction.

Furthermore, as the study is set in a real-life environment, the Vickrey auction design has to conform to legal requirements. For example, the vari-

ous codes of ethics accepted by market research associations frequently ban companies from contacting consumers for selling purposes under the guise of market research [28; 35, p. 21]. Therefore, companies are not allowed to impose buying obligations on consumers in a commercial setting if the subjects were acquired as participants in a market research study. Any commercial use of incentive-compatible methods for market research must therefore be clearly designated as a selling event [33]. These constraints might be partially avoided if the participants receive financial incentives for participation (see, e.g., [15, 16, 37]), and if the financial incentives offset any payment resulting from the participants' buying obligation, so that participants would always earn rather than spend money during the experiments. However, financial incentives could alter consumer perceptions of prices, especially if they exceed the cost of any possible buying obligation. In these cases, the revealed WTP would mimic only the product vs. cash allocation of an incentive and not the spending of valuable personal funds. The loss-aversion theory suggests that these two situations might not be equivalent [10]. Furthermore, this approach is simply too costly to apply to very expensive items on a large scale.

While selling products is not allowed in a market research setting, it is possible to use regular selling events for market research. Therefore, the present study set up a regular selling event with real transactions based on an incentive-compatible method, that is, the Vickrey auction.

Framework for an Incentive-Compatible WTP Elicitation Method with a Real-World Buying Obligation

Auctions are a widely popular and accepted selling method, especially those conducted on Web sites such as eBay [13]. As will be shown, the implementation of incentive-compatible Vickrey auctions on-line is quite straightforward, even on commercial auction Web sites. Note that the eBay auction mechanism is—although similar—not identical to the Vickrey mechanism, because multiple bids are allowed and information is revealed about the current second-highest bid as well as the number and size of previous bids and the corresponding bidders.

A prerequisite for a successful implementation is an attractive and easy-to-use format that can compete with other, regular retail offerings to ensure a sufficient number of real transactions. This was achieved by collaborating with a major German business-to-consumer (B2C) auction Web site that offered access to an attractive product portfolio. At the same time, it was necessary to address various concerns raised in previous research regarding specific aspects of Vickrey auction applications that could potentially lead to violations of its incentive-compatibility if not properly accounted for.

To meet these requirements, Vickrey auctions were implemented in the following manner:

- They were set up as an additional auction channel with a look-and-feel identical to the existing (English) auction channels. There was no indication that this channel was part of a research project.

- Bidders spent their own money and did not receive any financial incentive to participate. They had a standard choice of payment options, including credit cards, electronic debit, or invoicing that allowed them to use all available financial resources. By law, any winning bid was binding—in other words, there was a real buying obligation.
- The auctioned products were attractive and mostly expensive consumer durables (e.g., a car, a laptop computer) that are generally not purchased spontaneously and represent a significant investment for any prospective bidder.
- Participants were provided with a standard product description, including photos. As required by law, the recommended retail price was furnished for each item. Due to the length of the auction period, participants were free to gather information concerning substitutes or market prices before submitting a bid.
- Participants did not receive any information concerning the number of concurrent bidders during or after the auction to avoid any form of the “herding bias” observable in standard auctions [14]. A correct estimate of the number of concurrent bidders seems highly unlikely because the auctions drew between 12 and 1,300 bidders. Moreover, some products were auctioned only once, and bidders did not know whether they would be auctioned again in the future.
- The auction Web site was very well known (the market leader for B2C auctions in Germany at the time) and fully subject to consumer protection legislation (concerning guarantees and other legal protections). The legal counsel of the company supervised the auctions, and the three highest bids and the corresponding user names were published on the Web site after the auction ended. In contrast to regular offerings on eBay, in the present case the auction Web site itself acted as retailer. Therefore, any variation based on trustworthiness or reputation of the seller among the various auction events can be excluded.
- Automated processes were used to handle the bids of the numerous bidders in a measurable and cost-efficient manner.
- When designing the description and layout of the auction, the primary focus was to inform bidders that it was in their best interest to bid their true WTP.

Empirical Application

The empirical application of the Vickrey auction will now be described in more detail. The aim of this study was (1) to analyze whether Vickrey auctions for eliciting distributions of WTP can be implemented in real-life settings and will be understood by real buyers, (2) to compare the WTP information obtained from a Vickrey auction with directly stated WTP from the same group of bidders, and (3) to compare the findings from Vickrey auctions with more commonly used auction formats such as eBay. The analysis is based on three

main empirical data sets: 6,548 bids gathered through 28 Vickrey auctions on a popular auction Web site, 1,150 responses to a follow-up survey sent to all participating bidders (including 806 directly stated WTP), and 1,818 bids from 158 eBay auctions of similar products provided by Jank and Shmueli [29].

Description of Auctioned Products

Twenty-two different products were auctioned in 28 separate auctions over two successive one-week periods (13 auctions in the first week, 15 in the second). At the start of the first auction week, the regular e-mail newsletter from the auction Web site (with several hundred thousand subscribers) featured the new auction format. The auctions were split into two groups. Group 1 contained 16 different products with a wide range of items auctioned in either the first or the second week. Group 2 contained six products, auctioned in pairs during both weeks, to specifically assess the effects of having different numbers of participating bidders. Since WTP information is relevant for manufacturers and retailers at any stage of a product's life-cycle, the sample was not restricted to radically new innovations, as was suggested by Geng et al., but included products at different stages of their life-cycle [18]. The product range was selected after consulting with category managers of the auction Web site and product managers from participating manufacturers. The selected products mirrored, to a large extent, the regular business-to-consumer offers of the auction Web site, such as cell phones, personal digital assistants (PDAs), and other leading branded durables. Specials included an MCC convertible Smartcar (regular price €11,500.00), a newly released Siemens cell phone and PDA, and a Sharp camcorder (all of which were not yet available in stores at that time). Also offered was a German Lotto ticket especially designed for the study. All auctions ended on the same day (a Sunday) to avoid learning behavior from previous auction results. To continuously attract bidders to the platform, auction periods lasted from one to seven days, so that new auctions started every second day. The reliability of the results was tested by auctioning the same products at two points in time.

In compliance with German and European consumer protection legislation, product descriptions had to contain the manufacturer's suggested retail price (MSRP), which was directly provided by the manufacturers. In experimental settings or for directly stated WTP, such a provision might lead to biased bids, since the MSRP might function as a natural upper limit for a stated WTP. Although one would not expect bids higher than the MSRP in a real-world setting, this should not be the result of a downward bias. As the auctioned products were widely available before the auction event at prices at or below the MSRP, any potential participant with a valid WTP higher than the relevant MSRP should have already purchased the product. If the existence of efficient markets is assumed, only potential buyers with WTPs lower than the actual MSRP should be left to join the auctions. Table 1 provides detailed information from each of the various auctions.

All the participants in the Vickrey auctions were regular users of the Internet auction platform. Users were not preselected or excluded. The 28 Vickrey

Table 1. Characteristics and Results of Vickrey Auctions.

Product	Auction week	Auction period (days)	Number of bids	Recommended retail price (euros)	Maximum bid (euros)	Sold price (euros)	Price elasticity for mean bid*
Group 1							
Palm Vx PDA	1	7	1,360	499.50	500.00	425.00	-1.137
Smart Pulse convertible	1	7	999	11,302.50	10,500.00	10,000.00	-0.862
Junghans watch (lady's)	1	7	241	445.00	325.00	301.00	-1.258
Ericsson 1018 cell phone	1	5	78	250.00	190.00	125.00	-1.330
Ericsson T28 cell phone	1	5	259	675.00	350.00	327.50	-1.277
Siemens S25 cell phone	1	5	329	299.50	249.50	225.00	-1.353
Siemens hair dryer	1	1	20	84.50	35.50	35.50	-1.420
Palm Illic PDA	2	7	207	549.50	405.50	400.00	-1.246
Siemens IC 35 PDA	2	7	180	249.50	250.00	229.50	-1.205
Sharp Viewcam camcorder	2	7	203	749.50	500.00	425.00	-1.231
Nokia 7110 cell phone	2	5	136	525.00	351.00	350.00	-1.449
Nokia 3210 cell phone	2	5	99	224.50	160.00	153.50	-1.290
Siemens S35i cell phone	2	5	148	374.50	375.00	280.50	-1.339
Mountain bike	2	5	61	499.50	400.00	251.50	-1.354
Jaxx lottery ticket	2	3	53	125.00	125.00	125.00	-1.044
Sony KV 29 TV set	2	1	42	949.50	525.00	502.50	-1.327
Total			4,415				

Group 2													
Artemide Tolomeo lamp	1	7	290	219.50	200.00	167.50	-1.199						
Artemide Tolomeo lamp	2	7	60	219.50	150.50	115.00	-1.262						
Fujitsu notebook	1	7	1,041	2,249.50	1,999.50	1,950.00	-1.137						
Fujitsu notebook	2	3	83	2,249.50	1,666.50	1,250.00	-1.218						
Braun dental care set	1	5	106	59.50	44.50	44.00	-1.743						
Braun dental care set	2	1	12	59.50	35.00	29.50	-1.825						
Siemens 3010 DECT phone	1	3	132	114.50	100.00	90.00	-2.039						
Siemens 3010 DECT phone	2	3	67	114.50	94.50	88.50	-1.835						
Palm Ille PDA	1	3	146	199.50	175.00	175.00	-1.464						
Palm Ille PDA	2	3	61	199.50	175.50	150.00	-1.669						
Junghans watch	1	3	54	124.50	90.00	80.00	-1.237						
Junghans watch	2	7	81	124.50	112.50	101.00	-1.363						
Total			2,133										

* Estimated for the mean bid of the logistic function.

auctions received a total of 6,548 bids (4,415 for Group 1 products and 2,133 for Group 2 products; *see Table 1*). The number of bids per auction varied from 12 (for a dental care set) to 1,360 (for a PDA). The products in Group 2 attracted significantly different numbers of bidders during the two auction periods (on average, 295 bids in Week 1 and 61 bids in Week 2). The high number of bidders shows that Internet users accept Vickrey auctions.

Analyzing Information About WTP from Vickrey Auctions

The resulting distribution of WTP from Vickrey auctions was analyzed following the approach of Wertenbroch and Skiera [55]. The first step was to analyze whether the resulting WTP led to reasonable values and demand functions.

Resulting Demand Functions

WTP serves as a basis for estimating demand functions. Of the various kinds of functional forms discussed in field-related literature, the widely applied linear, multiplicative, and logistic functions were chosen for this study [23]. Based on the Vickrey auction bids, the following aggregate, market-level demand functions were estimated, and both shape and parameter estimates were analyzed [55]:

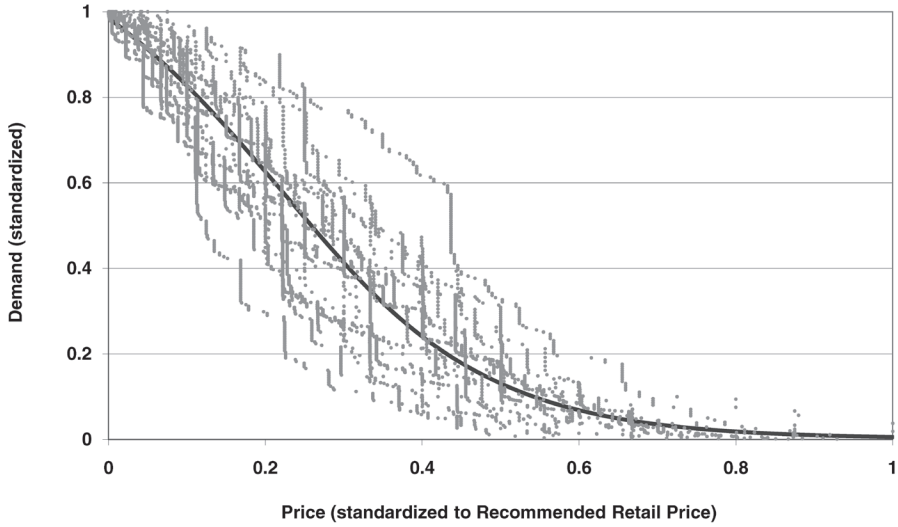
$$q = a + b \cdot p \quad (\text{linear function}) \quad (1)$$

$$q = a \cdot p^b \quad (\text{multiplicative function}) \quad (2)$$

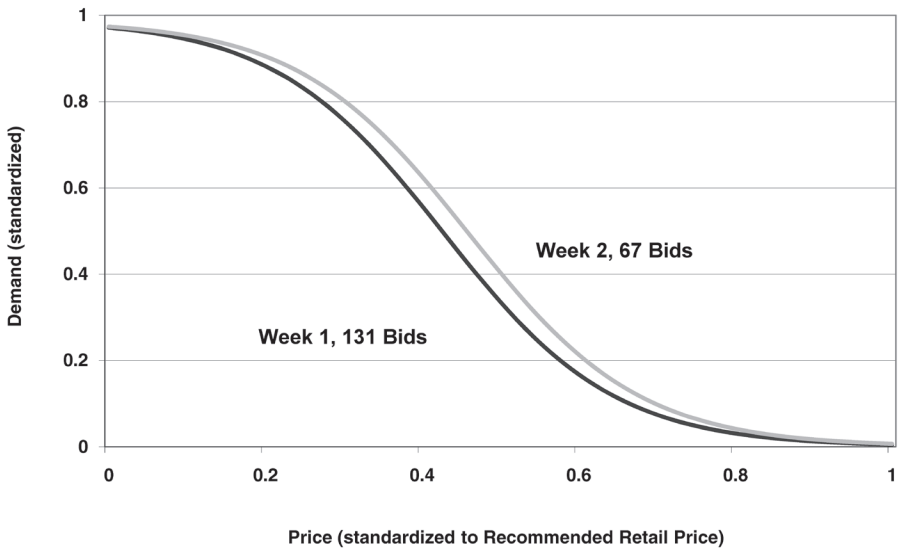
$$q = m / (1 + e^{-(a + b \cdot p)}) \quad (\text{logistic function}) \quad (3)$$

In the preceding equations, q (quantity) is the number of bids received at price p (bid), a and b are estimated parameters, and m is the upper limit of the logistic function. The regressions show a good fit between the bid distribution and various shapes of demand functions, resulting in an average adjusted R^2 of 0.917 for linear functions and 0.982 for logistic functions. Only the multiplicative function does not accurately reflect the data (average adjusted $R^2 = 0.558$). This poor result was mainly driven by the inability to properly capture the distribution of bids in the two tails of the function. For example, the exact shape of the logistic demand function for the auction of a Palm Vx PDA is displayed in Figure 1a.

WTP is distributed over the complete price range and not only within a smaller price window of “reasonable” prices (*see Figure 1a*). Both very high and extremely low bids were found. A logistic function turned out to be the most suitable demand curve. Compared to common data with a “reasonable” price window, this curve—with supporting values over the whole range—avoids the risk of finding only a local price and not the global price optimum



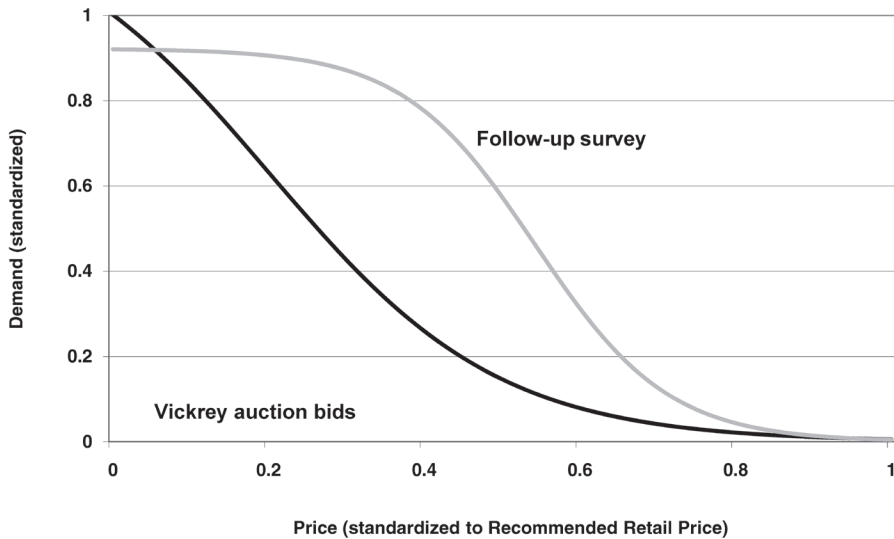
a. Demand function derived from bids of Vickrey auction (Palm Vx PDA)



b. Comparison of demand functions: Vickrey auction week 1 vs. week 2 (Siemens DECT Phone)

(continues)

Figure 1. Plots of Resulting Demand Functions



c. Comparison of demand functions: Vickrey auction vs. directly stated WTP (Palm Vx PDA)

Figure 1. Continued

[55]. This curve also enables the derivation of conclusions about the volume of lower WTP segments. In contrast to conventional methods focusing solely on winning bids (i.e., only one data point per auction), this approach uses the full potential of the Vickrey auction by incorporating information of hundreds or even more than a thousand bidders for a single product.

Resulting Price Elasticities

The second step in assessing the plausibility of WTP distributions from a Vickrey auction entails an analysis of the value for the price elasticity of the logistic function at the mean bid for each product. Table 1 indicates that all elasticities are well within the range of price elasticities reported in other studies, such as the mean values of -0.76 and -2.62 reported, respectively, by Tellis and by Bijmolt, van Heerde, and Pieters [8, 48]. These results imply high plausibility for the bids gathered during the Vickrey auction.

Reliability of the Results

The next step was an analysis of the reliability of the elicited WTP distributions. A major concern was whether the results of a Vickrey auction are dependent on the number of participating bidders. This problem was addressed by auctioning six products in both auction weeks with varying auction periods, thereby attracting significantly different numbers of participants for each (mean Week 1 = 295 bids vs. mean Week 2 = 61 bids). Note that Ockenfels and

Roth found that the bidding patterns of on-line auctions were independent of the length of the auction period [38]. To avoid strategic or forward-looking behavior, bidders were not informed about future auctions until the first week's auctions were closed.

The distribution of bids across both weeks was then compared for each product using Kolmogorov-Smirnov 2-Sample tests.² The results indicated no significant differences for five out of six products (see Table 2). This comparability of results is also supported by the shape of the estimated logistic demand functions (see Figure 1b). Similar results were found for the comparison of price elasticities. At the mean bid, elasticities differed only slightly between the two auction weeks, both on product level (see Table 1) and on average (mean elasticity Week 1 = -1.470 and Week 2 = -1.529). Both results indicate a high reliability for the proposed approach and show that a varying number of bidders did not distort the results.

Follow-up Survey

A regular limitation of studies using real-life data such as eBay bids is that researchers are often barred from gathering additional attitudinal data from participants (e.g., through follow-up surveys). Auction platforms rarely allow contact with their customers for such market research purposes. The close cooperation between the authors and the German auction platform made it possible to conduct a short follow-up survey one week after the auctions closed. Bidders were asked for their opinion of the auction rules, and their WTP was measured via direct statement, that is, by asking for the maximum price they would have paid for the auctioned product. This form of directly stated WTP is widely applied in market research practice and acts as the "simple" alternative to the more "complicated" Vickrey auctions.

A total of 6,548 e-mails were sent, and 1,150 participants responded (17.6%). All respondents took part in a lottery for three wireless phones (with a total value of approximately €350). The check for nonresponse bias across products compared the average bids of respondents and nonrespondents. The results indicate that there were no significant differences ($p = 0.05$) for 18 of the 22 products. The average bids of respondents were significantly higher than the average bids of nonrespondents for only three products and significantly lower for only one product.

Comprehension and Buying Intention

The validity of the results from a Vickrey auction depends on whether or not the bidders understand the dominant bidding strategy. Given that participants were not aware that they were taking part in a field study, the options for ensuring that they understood the dominant bidding strategy were limited to regular help tools, such as FAQs, call-center, and e-mail help, and a special graphic example. Therefore customer care reports were carefully evaluated during the auctions. Out of approximately 100 calls and e-mails, only two were

Table 2. Vickrey Auction Bid Distributions Week 1 vs. Week 2 (results of two-sample Kolmogorov-Smirnov tests).

Product	Maximum difference		Number of bidders		K-S Z	p (two-tailed)	
	Absolute	Positive	Negative	Week 1			Week 2
Artemide Tolameo lamp	0.103	0.103	-0.025	290	60	0.729	0.662
Fujitsu notebook	0.196	0.196	-0.010	1,041	83	1.723	0.005
Braun dental care set	0.242	0.079	-0.242	106	12	0.795	0.552
Siemens 3010 DECT phone	0.089	0.089	-0.046	132	67	0.590	0.877
Palm Ille PDA	0.085	0.085	-0.039	146	61	0.559	0.913
Junghans watch	0.148	0.019	-0.148	54	81	0.843	0.476

Notes: Difference = Most extreme difference between both distributions (absolute/positive/negative); K-S Z = Kolmogorov-Smirnov Z value.

Table 3. Overall Understandability (follow-up survey).

Question (5-point Likert scales)	M	SD	n
A This auction followed a different set of rules than the ones you were used to. How did you get along with these new rules? 1: "very good" to 5: "not at all"	1.238	0.547	1,148
B "In this type of auction, you can bid your maximum price and still make a bargain." Do you agree? 1: "strongly agree" to 5: "strongly disagree"	2.084	1.240	1,146
C How much were you interested in actually buying the product? 1: "not at all interested" to 5: "very interested"	3.253	1.201	1,143
D Would you participate again in this type of auction? 1: "highly unlikely" to 5: "very likely"	4.606	0.748	1,140

specifically related to elements of the Vickrey auction. The rest pertained to forgotten passwords and other administrative issues.

A key aspect of a Vickrey auction is that only one bid can be placed. The auction software prevented participants from submitting additional bids for the same items and tracked attempts by bidders to do so. Whether because of strategic considerations, misunderstandings, or usage failures, only 112 of 6,548 bidders attempted to submit an additional bid (less than 2%).

Additionally, the follow-up survey was used to determine how well participants actually understood the auction. The results in Table 3 show that the majority of participants clearly understood the Vickrey auction rules. Bidders' understanding is indicated both by their own direct judgment (mean of 1.238 on a 5-point Likert scale, with 1 equaling the highest level) and, to a slightly lesser degree, by answers to a control question (*see Table 3, Question B*).

No significant difference was found between Week 1 and Week 2 in terms of auction comprehension (Question A, Week 1 mean = 1.25; Week 2 mean = 1.19; $p = 0.122$). Only the control question (Question B) indicated a slightly more significant understanding of Vickrey auctions by bidders in Week 2 (Week 1 mean = 2.14, Week 2 mean = 1.76; $p = 0.000$).

Another important aspect is the individual's buying intention. When asked directly in the follow-up survey, participants indicated a relatively high interest in actually buying the auctioned products (*see Table 3, Question C*). Their stated interest in buying the product is supported by their actual buying behavior; all winning participants actually purchased the products. All bids were legally binding for the participants. Thus it was assumed that unsuccessful bidders, being aware of their possible buying obligation, would also have purchased the product had their bid been successful.

An additional indicator of comprehension is the *ex-post* evaluation of final sale prices by both successful and unsuccessful bidders. If the bids were placed according to the true individual WTP, one should observe a favorable judgment of sale prices by successful bidders, as they revealed WTP at or above the sale prices. To be consistent with their bids, unsuccessful bidders, in contrast, should rate the sales prices as too steep, since they were not willing to pay the sale price (or more). These expectations were confirmed in the follow-up survey—that is, successful bidders rated the final sale prices as

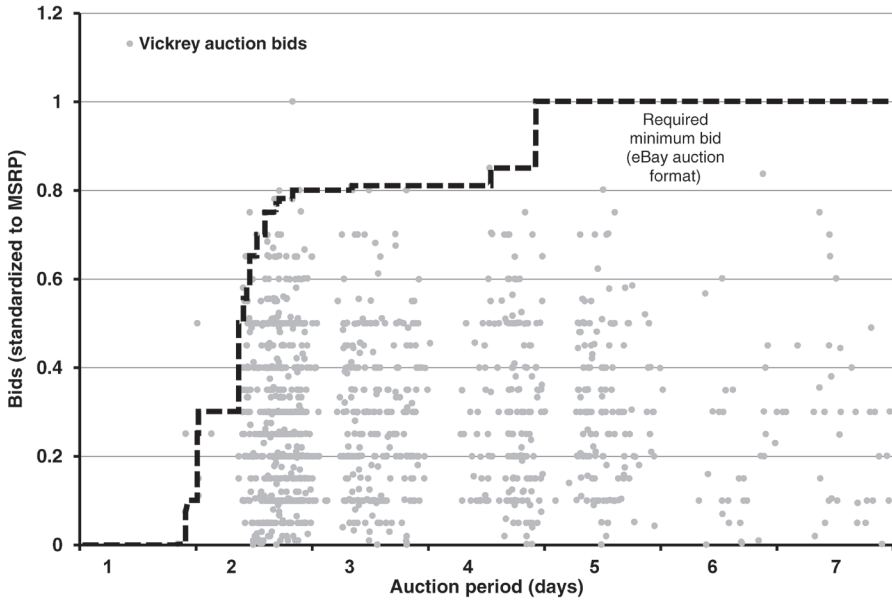
better deals than did the unsuccessful bidders. The mean for successful bidders was 3.83 ($n = 6$), compared to 2.31 ($n = 1,113$) for unsuccessful bidders on a 5-point Likert scale (Question E: “The product was sold for . . . How do you judge this price?” with 1 = “much too high” and 5 = “bargain”). Both a t -test ($p = 0.000$) and a Mann-Whitney U-test ($p = 0.001$) found the difference to be significant.

Testing for Strategic Behavior

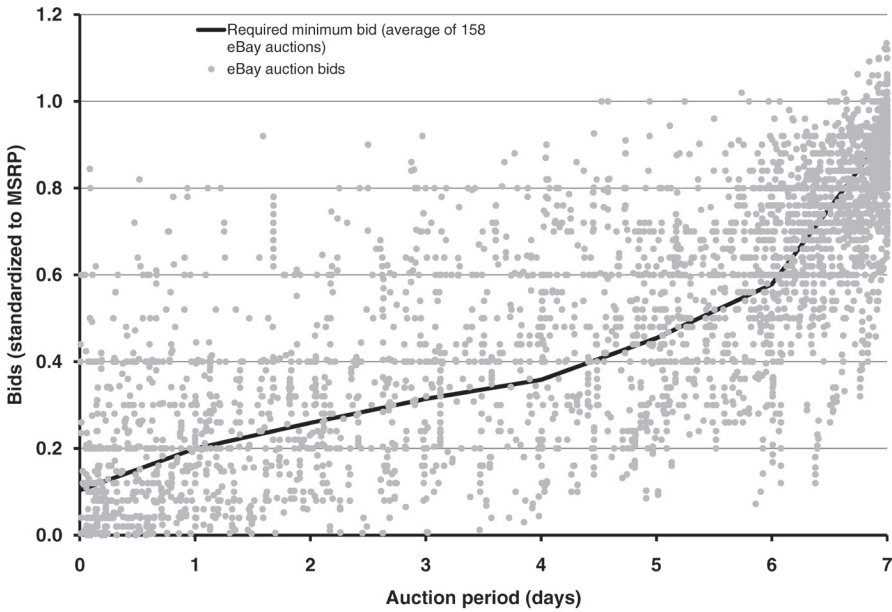
In addition to bidders’ comprehension and buying intention, a third aspect is crucial for the validity of the WTP information: the absence of strategic behavior that would lead to systematic distortions of observed information, as when bidders place low bids to conceal their true WTP. Specific aspects of strategic behavior, such as collusion or shill bidding, have been the subjects of several studies in the auction literature [31, 44, 45, 54]. For on-line auctions, researchers have particularly focused on sniping behavior—that is, bidders holding back their bids until the very last moments of an auction [9, 44]. This widespread strategy has two major advantages from the bidder’s perspective: (1) The bidders withhold as long as possible any information on the potential demand and their willingness to accept the current asking price; and (2) contrary to regular off-line English auctions, on-line auction formats usually set a fixed time for the auction period, such that competing bidders have no opportunity to react if someone bids at the very last second of an auction. Both aspects should lead to a systematic downward shift in the level of the highest bids placed, as potential bidders are deferred by an apparent lack of interest in a specific product or are often prevented from reacting with higher bids due to the automatic auction ending. The empirical evidence for sniping in eBay auctions is highly consistent: Studies report that up to 20 percent of all bids are placed within the last hour, and 6 percent even within the last minute of an auction [9, 44]. Roth and Ockenfels report that nearly 70 percent of winning bids are placed within the last hour of the auction, and 12 percent of these bids within the last 10 seconds before auction closure [44].

In Vickrey auctions, there is theoretically no advantage in late bidding or sniping because potential bidders are aware neither of the number of competing bidders nor of the value of the bids placed. Consistent with these theoretical considerations, no evidence of bid sniping was found in the present Vickrey auction study: Only 0.4 percent of all bids were placed within the last hour of an auction (5.6% within the last 12 hours). None of the winning bids was placed within the last hour of a Vickrey auction.

These results held even after eBay introduced a new auction format using a “bidding agent,” which allows bidders to submit their “highest” bid at any time during the auction period, with the agent bidding only the amount needed to lead the auction—that is, the second-highest bid plus an increment (see [54] for a more detailed discussion). An auction time/bid-amount diagram was plotted for the Vickrey auctions (see *Figure 2a*), but no relation was observed between bid amount and time to auction closure. Not surprisingly, bid amount and time to auction closure are uncorrelated for all Vickrey



a. Plot of bids of Vickrey auction of a Palm PDA



b. Plot of bids aggregated from 158 eBay auctions of Palm PDAs

Figure 2. Distribution of Bids over Time—eBay vs. Vickrey Auctions

auctions (with no Pearson's r for an individual auction being significant at $p < 0.05$, and the average Pearson's r for all 28 Vickrey auctions equal to 0.024). In contrast, aggregated data from 158 comparable eBay auctions reported by Jank and Shmueli show a highly significant correlation of bid amount and time to auction closure (Pearson's $r = -0.78$, $p < 0.000$), i.e., bid amounts submitted increased drastically during the auction period (see Figure 2b) [29].³

The time independence of bid amounts in a Vickrey auction is further confirmed by the sequence of bids, because the number of second-highest bids preceding the highest bid was nearly identical to those succeeding the highest bid (in 46% of the auctions, the highest bid was placed prior to the second highest). In contrast, eBay auctions still showed a classic pattern of second-highest bids preceding the highest bid (for 65% of the auctions, according to [54]), despite the introduction of bidding agents.

The absence of bid-sniping further increased the validity of Vickrey auction bids for gathering "true" WTP information from participants, since these data are not systematically distorted by this common form of strategic behavior.

Comparison of WTP from Direct Statements and Vickrey Auctions

Results of previous studies in laboratory settings indicate that WTP is significantly higher in direct statements than in incentive-compatible methods, such as the Vickrey auction [36, 51]. To test whether these results also hold in the study's real-world setting, directly stated WTP was collected in the follow-up survey.

Comparison at the Aggregate Level

At the aggregate level, the demand functions derived from Vickrey auctions were compared with similar functions derived from direct statements. The typical shapes of these two functions are shown in Figure 1c for the Palm Vx handheld device. Both demand and price were standardized in terms of the respective total number of bids and the recommended retail price. The WTP distribution derived from direct statements exceeded the Vickrey auction bids, especially in the medium price segment, whereas both functions converged for very high values. For all nine products with a sufficient number of cases for analysis (~ 30), the elasticities at the mean bid (or direct statement, respectively) were higher when based on direct statements (mean elasticity -3.641). Furthermore, the use of a two-sample Kolmogorov-Smirnov test to compare both methods revealed highly significant differences for the price elasticities of all nine products (see Table 4).

Comparison at the Individual Level

The data gathered from the follow-up survey permit an individual-level comparison of WTPs derived from Vickrey auctions and from direct statements.

Table 4. Distribution of Vickrey Auction Bids and Directly Stated WTP (results of two-sample Kolmogorov-Smirnov tests).

Product	Maximum difference			Number of participants			K-S Z	p (two-tailed)
	Absolute	Positive	Negative	Vickrey Auctions	Direct statements			
Ariemide Tolomeo lamp	0.634	0.634	0.000	350	35	3.578	0.000	
Palm Vx PDA	0.619	0.619	0.000	1,360	219	8.506	0.000	
Fujitsu notebook	0.714	0.714	-0.006	1,124	126	7.595	0.000	
Smart Pulse convertible	0.719	0.719	-0.006	999	106	7.036	0.000	
Junghans watch (lady's)	0.821	0.821	0.000	241	30	4.242	0.000	
Ericsson T28 cell phone	0.646	0.646	-0.008	259	29	3.298	0.000	
Siemens S25 cell phone	0.574	0.574	0.000	329	60	4.086	0.000	
Siemens 3010 DECT phone	0.544	0.544	-0.047	199	42	3.204	0.000	
Palm Ille PDA	0.731	0.731	-0.005	207	29	3.687	0.000	

Notes: Difference = Most extreme difference between both distributions (absolute/positive/negative); K-S Z = Kolmogorov-Smirnov Z value.

The results were in line with expectations: 86.6 percent of the respondents stated a higher WTP in the follow-up survey than in the Vickrey auctions, 9.6 percent stated the same WTP, and only 3.8 percent stated a lower WTP ($n = 806$). Subsequently, Vickrey auction bids set a lower limit for the WTP revealed in the direct statement. This result confirms earlier findings by, for example, Neill et al. and Völckner [36, 51]. Interestingly, comprehension of the Vickrey auction format varied significantly among the participants. Participants who bid less or the same in the Vickrey auctions than stated in the follow-up survey understood the auction significantly better (mean Question A = 1.23, mean Question B = 2.04) than participants who bid more in Vickrey auctions (mean for Question A = 1.61, mean Question B = 2.68, with the differences significant at $p = 0.036$ for Question A, and $p = 0.041$ for Question B).

One further aspect of the survey results is that directly stated WTP seemed to be less precise than WTP elicited through Vickrey auction bids because of the characteristics of the stated prices: 77.0 percent of all prices stated in the follow-up survey were even (e.g., €100, €500, or €1,000), in contrast to only 24.4 percent in the Vickrey auction. Almost a third of all bidders (31.6%) bid odd amounts (e.g., €8 or €57) in the Vickrey auctions, but only 4.7 percent stated odd amounts in the follow-up survey (the rest chose other amounts, such as €150 or €1,050, or €60 or €240).

Relation Between Vickrey Auctions and Directly Stated WTP

Even if WTP derived from direct statements is consistently higher than WTP from Vickrey auctions, there may be a systematic relationship between the two that permits a simple rescaling of the values of direct statements. Therefore the correlations between the WTPs from the two methods were analyzed for all the products together, as well as for each of the 22 products separately. The correlation across all the products was 0.322 ($p < 0.000$). Correlation coefficients at the individual product level varied between a minimum of 0.189 (for the Smart convertible; $p = 0.051$) and a maximum value of 0.976 (for the Nokia 3210, albeit with a very small $n = 4$; $p = 0.004$). Scatter plots of individual-level bids and corresponding direct statements showed no further systematic relationship between the different measures. In addition, there was no support for the possibility that differences in revealed and stated WTP could be explained by range effects—that is, the individual WTP being defined as a price range rather than a specific price point [52]. These differences between directly stated WTP and Vickrey auction bids seem to be time-independent: For none of the products in the study was there a significant correlation ($p < 0.10$) between bidding time and the difference between directly stated WTP and Vickrey bid amount. Moreover, there was no significant correlation between the length of the auction periods and differences between directly stated WTP and Vickrey auction bids (Pearson's $r = 0.012$, $p = 0.737$).

Finally, the correlation between the actual buying intentions of consumers (answers to Question C in the follow-up survey: “How much were you interested in actually buying the product?”) was compared with WTP from the Vickrey auction and direct statements. Following the traditional view that

intentions predict actual behavior (e.g., [17]), a positive correlation between WTP and consumer buying intention was expected. The individual coefficients (0.327 for WTP from Vickrey auction and 0.163 for WTP from direct statements) were transformed into Fisher-Z scores (see, e.g., [20]) to determine whether the correlations differed between the two measures. The correlation of WTP from the Vickrey auction with consumer buying intention was significantly higher ($Z_{VA} = 0.34$) than the correlation with WTP from direct statements ($Z_{CV} = 0.16$; $z = 3.500$, $p = 0.000$, for the difference in the two Z-coefficients). This higher correlation indicates that the measures of WTP from the Vickrey auction provide higher face validity.⁴

Comparison of eBay and Vickrey Auctions

A further aim of the study was to compare distributions of WTP derived from eBay with those from Vickrey auctions. Because the preceding discussion has described the theoretical superiority of truth-revealing Vickrey auctions and was able to show the absence of strategic behavior (in the form of bid-sniping), it is now possible to analyze which auction format better incorporates the full distribution of WTP information and thus acts as the superior market research tool to derive realistic price-demand functions.

A key aspect of realistic price-demand functions is that they reflect the full range of existing WTP for different customer segments—that is, no possible bids are systematically excluded (see, e.g., [34]). However, different auction formats cater to this requirement of completeness quite differently [12]. These fundamental differences are grounded in the aspect of required minimum bids during the auction period. In most auction formats, potential bidders are not free to place a bid at whatever amount they assume suitable for a product, but rather are required to bid at least more than the current highest bid (in the case of English auctions) or the second-highest bid (in the case of eBay auctions). The level of the required minimum bid increases continuously during the auction period. Thus, especially at later stages of English or eBay auctions, all potential bidders with WTP lower than the current required minimum bid are barred from participation [12]. Consequently, WTP information from these segments cannot be observed with such auction formats.

This fact is illustrated in Figure 3, where three auction formats are compared over a given auction period. The solid black line defines the required minimum bid of a standard English auction, where the highest bid leads the auction at its full amount, and consequently no bid below this previous highest bid is possible. Thus, all potential bidders from segments II and III with WTP lower than the current highest bid are barred from participation. Over time, only bidders with very high WTP are able to place a bid, and the number of these bidders is continuously shrinking. The dotted black line plots the equivalent eBay auction format, where the bidding agent for the highest bidder enters only the amount necessary to lead the auction. In other words, the minimum bid required is equivalent to the current second-highest bid plus an increment of one. In this format, submitted bids could be lower than the full amount of the (invisible) current highest bid (marked by the solid black line) but must

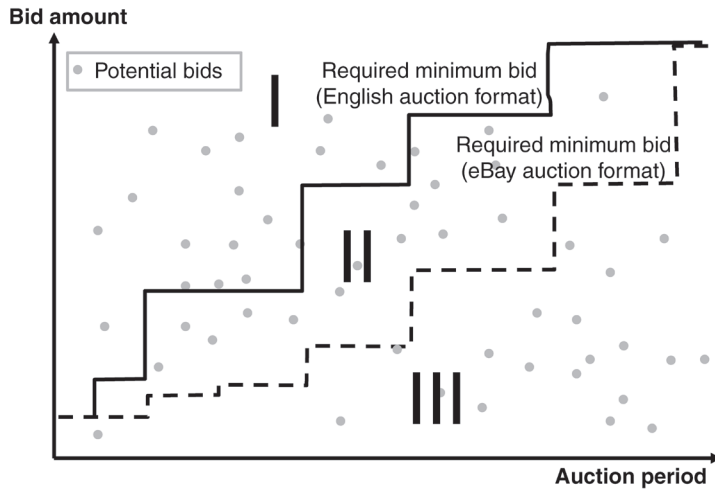


Figure 3. Segments of Total Price-Demand Distribution Incorporated by Different Auction Formats

be higher than the (visible) second-highest bid. Thus, additional potential bidders from segment II could participate, but those in segment III were still excluded.

Therefore, bids collected from English auctions and their derivatives such as eBay represent an incomplete sample of the total range of WTP in the marketplace, and any price-demand function estimated on the basis of such data is potentially biased [12]. Chan, Kadiyali, and Park proposed to account for the missing data (labeled *latent bidders*) by inferring WTP information from parallel or subsequent auctions of similar items—that is, they assumed that bidders facing required minimum bids that are too high in one auction tend to place their bids in a concurrent auction [12]. This approach to inferring latent bidders, however, requires the existence of concurrent auctions, awareness of the current auctions among bidders, and a significantly lower level of required minimum bids in the concurrent auctions.⁵ Furthermore, any such inference approach is statistically complex and imperfect in its representation of real bidding intentions, and thus is always inferior to an actual observation of a full range of bids.

In a Vickrey auction, however, there are no boundaries for bid amounts during the auction period. Bidders can place bids as high or low as they want during the complete auction period. Consequently, in a Vickrey auction bidders are not excluded because their WTP is lower than the highest or the second-highest bid in an English or eBay auction, respectively. All potential bidders (illustrated by the gray dots in Figure 3) can participate, and their WTP is incorporated in price-demand functions based on these data.

These theoretical considerations are supported by empirical observations. Figure 2b plots the bids of 158 eBay auctions for Palm Pilot PDAs as reported by Jank and Shmueli [29]. The solid black line represents the average required minimum bid during the auction period of seven days. For example, the aver-

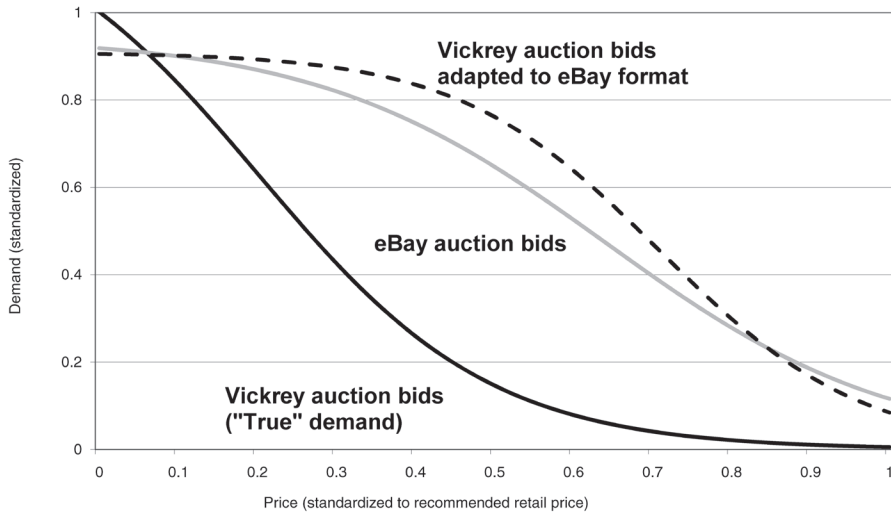


Figure 4. Plots of Resulting Demand Functions of Different Auction Formats

age starting price of these auctions was equivalent to 10.3 percent of the MSRP. After the first day of the auctions, bidders are required to bid at least 20.0 percent of the MSRP, at day four 35.8 percent, and on the final day 57.8 percent of MSRP (the average selling price is 92.3%). Thus, potential buyers who are willing to pay, say, 40 percent of the MSRP for the product will be able to place their bids only until the fourth day of the auction. As a consequence, bidders with high WTP have a systematically higher probability of placing a bid than bidders with low WTP and are, therefore, overrepresented in any sample of WTP information gathered through English or eBay format auctions.

This exclusion of bidders has consequences for derived price-demand functions. An obvious consequence is a significantly lower number of participating bidders. With the (Vickrey) auction of a single Palm Pilot device, a total of 1,360 bids were collected (*see Figure 2a*). Jank and Shmueli had to observe 158 auctions of Palm Pilot PDAs to gather a similar number of individual bids (i.e., 1,818 bids; *see Figure 2b*) [29].

To analyze the consequences of different auction formats for resulting price-demand functions, such functions were estimated from the empirical data sets for the above-mentioned Palm PDA device (*see Figure 4*).⁶ The first logistic price-demand function was based on 1,360 bids from the Vickrey auction (solid black line in Figure 4). The second price-demand function was based on the pooled data of 158 eBay auctions of Palm PDA devices as reported by Jank and Shmueli (solid gray line in Figure 4) [29]. Note that for any bidder, only the highest bid was included in case of multiple bids. The third price-demand function was set up by applying the eBay auction rules to the bid data gathered through the Vickrey auction of a Palm PDA. That is to say, only those bids were included that would have been valid in an equivalent eBay auction (*see dotted black line in Figure 2a*), whereas all bids that were lower

than the current second-highest bid at the time of placement were excluded. Based only on the remaining “eBay format” bids, a third logistic price-demand function was estimated.

Figure 4 shows two highly relevant aspects. First, the slope of price-demand functions based on eBay bids seems to be consistently higher than the comparable slope of the “true” demand based on Vickrey auction bids. Using a two-sample Kolmogorov-Smirnov test of both functions, this difference was found to be highly significant (Kolmogorov-Smirnov- $Z = 14.548$, $p < 0.000$). Second, when the eBay auction format was applied to bids gathered through Vickrey auctions (i.e., systematically excluding bids from participants with low WTP), the price-demand function observed had a nearly identical slope to that of the comparable eBay-based price-demand function. A two-sample Kolmogorov-Smirnov test of both functions found no significant difference, with Kolmogorov-Smirnov- $Z = 0.559$, $p = 0.914$. Full results are reported in Table 5, including a test for the pooled data of all Vickrey auctions of the focal Palm PDAs.

These results clearly confirm the theoretical considerations. Due to their specific bidding rules, eBay-style auctions systematically exclude a significant share of potential bidders with low WTP. Therefore, any price-demand function based on such data is prone to overestimation, and, consequently, pricing based on such functions might be suboptimal because WTP information from certain segments is ignored. This empirical finding contrasts clearly with the assumption of Chan, Kadiyali, and Park that the incorporation of latent bidders has no substantial effect on price-demand functions [12].

Vickrey auction formats are able to elicit the full range of consumers’ WTP. Consequently, price-demand functions based on such data should lead to a more valid depiction of actual price-demand functions. In this context, it is worth noting that for electronic devices such as mobile phones, digital cameras, game consoles, or PDA devices, prices usually decline drastically during or between product generation(s). For example, Sony introduced the PlayStation 2 game console with an MSRP of €445 (in Germany) and subsequently lowered the official MSRP in several steps to €99 (or 22.2% of the original price).⁷ Therefore, information about customers with seemingly low or very low WTP is still highly relevant for market research purposes because those segments reflect future customer groups. Thus, any elicitation method must incorporate the full range of potential customers’ WTP—a key characteristic fulfilled by Vickrey auctions, as opposed to other auction formats, such as English or eBay-style auctions.

Conclusions

Previous applications of incentive-compatible methods to elicit WTP led to promising results but had several limitations due to their laboratory setting. The validity of their results might differ from those in real-world settings for several reasons. For example, participants are frequently compensated for participation, they have little opportunity to analyze alternative prices, they do not self-select according to their interest in the particular product,

Table 5. Distribution of Vickrey Auction Bids and eBay Auction Bids (results of two-sample Kolmogorov-Smirnov tests).

Product	Maximum difference			Format of auction mechanism	K-S Z	p (two-tailed)
	Absolute	Positive	Negative			
Palm Yx PDA	0.522	0.006	-0.522	Original Vickrey format	14.548	0.000
Palm Yx PDA	0.129	0.121	-0.129	Vickrey adapted to eBay format	0.914	0.914
Palm Ille PDA	0.481	0.053	-0.481	Original Vickrey format	6.552	0.000
Palm Ille PDA	0.251	0.251	-0.136	Vickrey adapted to eBay format	0.967	0.308
Palm Ille PDA	0.531	0.020	-0.531	Original Vickrey format	7.242	0.000
Palm Ille PDA	0.284	0.092	-0.284	Vickrey adapted to eBay format	0.940	0.339
Pooled data (Palm)	0.514	0.011	-0.514	Original Vickrey format	15.388	0.000
Pooled data (Palm)	0.136	0.117	-0.136	Vickrey adapted to eBay format	0.900	0.393

Notes: Difference = Most extreme difference between both distributions (absolute/positive/negative); K-S Z = Kolmogorov-Smirnov Z value.

and they know that they are part of a market research study. This study is the first to extend the application of incentive-compatible methods for eliciting willingness-to-pay beyond the laboratory environment into a real-world setting, thereby increasing the external validity of the resulting price-demand functions.

In contrast to reservations discussed in the literature, the present study shows that the Vickrey auction is an incentive-compatible method that can easily be implemented in existing on-line auction offerings and is both accepted and well understood by regular on-line auction users. WTP elicited through a Vickrey auction varies significantly from directly stated WTP on both the individual and aggregate levels (price-response functions). As with the results from previous laboratory settings, there were indications that WTP elicited through such incentive-compatible methods is more elaborate and more valid than what is obtained by means of other elicitation methods. The results hold for a wide range of new as well as established products and varying numbers of participating bidders.

In a second step, the study shows, both theoretically and empirically, that traditional English auctions or derivatives like the one used by eBay are affected by strategic behavior of bidders such as sniping. In addition, such auction formats systematically exclude segments of potential bidders with low WTP. Therefore, price-demand curves derived from bidding data of such auction formats are prone to overestimation. In contrast, no bid-sniping was observed in the Vickrey auctions, and it was possible to estimate price-demand functions incorporating all segments of potential buyers when applying this auction format. Therefore, data gathered through Vickrey auctions provide an excellent basis for estimating realistic and unbiased price-demand functions.

Limitations and Future Research

Despite their high external validity, studies in real-world environments encounter several limitations that also hold for the present study. The study design could not control for all potential aspects and influences: Replications on other on-line auction platforms, using different products or product categories, and maybe even in different regions or countries, would be useful approaches to confirm the validity of the results and broaden their general applicability. As described in the study, legal requirements must be met and little control exists for outside influences, such as competing offerings (see, e.g., [24]). Furthermore, options for providing instructions to participants or gathering additional information are limited because these approaches would potentially distort the real-world character of the transactions. This shortcoming was one reason why it was not possible to reach a comparable number of responses for every auctioned product when comparing Vickrey auction bids with directly stated WTP. Therefore, researchers (as well as marketing managers) should consider combinations of both approaches when eliciting willingness-to-pay to complement the external validity of real-world settings with the internal validity of laboratory settings. Given the low incremental cost (or even, as in the present case, the positive profit contribution) of adding

a real-world Vickrey auction study to elicit willingness-to-pay, this additional study could be achieved without significantly increasing the required (market) research budgets. Large-scale applications generally require the cooperation of an established on-line auction Web site or retailer to ensure sufficient sample sizes for estimating price-demand functions. Such support might not be readily available to future researchers. Nonetheless, based on the positive experiences from this study, barriers due to common risk-awareness may be significantly lower in the future.

Managerial Implications

Implementations of this approach have great potential for expensive durables, such as mobile phones, digital cameras, laptop computers, or even cars. Such goods are increasingly bought on-line (as in this study), they require frequent price adjustments during their life-cycle, and therefore frequently update WTP information from the full range of customer segments. At the same time, WTP information for costly durables is very difficult (if not impossible) to capture in laboratory settings, as any meaningful buying obligation would conflict with ethics code requirements.

Therefore, the study has the following managerial implications: Vickrey auctions can be integrated into regular on-line auction Web sites with little effort and a great deal of upside potential. Minimal technical adjustments are needed to convert existing formats (such as those used on eBay) into incentive-compatible Vickrey auctions—that is, allowing only one bid per user per item, no open listing of bids, and selection of the second-highest instead of the highest bid to determine the price at the end of the auction period. Of course, the process of determining the highest bid and the selling price must be transparent and trustworthy to the consumers. Constant monitoring by an external certification bureau or a legal counsel could avoid any suspicion of a repeat of the fraudulent pricing that hampered early applications of Vickrey auctions in the last century. This is not meant to imply that Vickrey auctions should be used as a primary auction mechanism for selling goods. Rather, such auction formats would be a suitable extension of the currently offered range of selling procedures (such as English-type auctions or “Buy it now”). From a consumer’s perspective—for example, a potential buyer currently deterred by the prevalent sniping behavior—this extension might be a welcome addition. Vickrey auctions may not offer the entertaining thrill of English auctions, but they provide an efficient buying channel without the risk of getting carried away in the bidding process, and they eliminate the need to be on-line in the final moments of an auction.

Such implementation would provide both researchers and marketing managers a new efficient and ethics-code-compatible market research method. It would increase the scope and validity of willingness-to-pay elicitation by incorporating data from all potential customer segments with no need for complex inference approaches. Furthermore, the integration of market research services could act as a welcome extension of the mostly commission-based business model of auction Web sites such as eBay, because this method of estimating

distributions of WTP specifically requires an auction environment. Thus, it would offer companies such as eBay a valuable and sustainable competitive advantage over traditional marketplaces such as Amazon.com and, as well, potentially significant revenues from market research services.

NOTES

1. A multiple-unit version of the Vickrey auction mechanism also exists, where n products are sold at the price of the $(n - 1)$ th bid. However, since the incentive-compatibility of this version has been challenged, special precautions would be required [2, 25]. Therefore, only single-unit Vickrey auctions are applied in this study.

2. The Kolmogorov-Smirnov test was used rather than a parametric t -test for independent samples because Kolmogorov-Smirnov is also sensitive to differences in the general shapes of the distributions in the two samples (i.e., to differences in dispersion or skewness). In the context of WTP and, especially, price-demand functions, these shape aspects are crucial because statistics such as means are easily distorted by outliers (e.g., extremely high bids). For a more detailed discussion of the advantages of Kolmogorov-Smirnov tests, refer to Wilcox [56].

3. The eBay auctions reported by Jank and Shmueli [29] were assessed to be comparable to the Vickrey auctions since the data were gathered in a similar real-life auction setting (regular on-line auction bidders were not aware of the ongoing market research, a real buying obligation existed, and no monetary incentives were offered to participants) using products comparable to those in this study (same product category [PDA devices] and brand [Palm]), and very similar price points and positions in the product life-cycle.

4. One additional effect of the present approach, albeit a relevant one for commercial applications, is the resulting cost of gathering WTP information. Traditional approaches using directly stated WTP, as well as other incentive-compatible procedures (e.g., Ding [15]), would have incurred costs upward of several tens of thousands of euros for products and participation incentives. The present study actually generated a positive profit contribution of about €3,000, if the resulting selling prices and product costs are considered. Therefore, in contrast to other market research methods, the research approach led to additional profits rather than the significant usual costs.

5. An alternative route to correcting biases in demand function estimations based on eBay data could be to implement approaches that use a truncated distribution to account for missing data. We thank an anonymous reviewer for this suggestion.

6. Since the observed demand functions for the three different Palm PDA devices tested in the study reveal no significant differences, the Vickrey auction results of a Palm Pilot Vx PDA are used as an example for this comparison. Full results for all PDA devices are reported in Table 5 and reveal the comparable outcomes for other PDA versions.

7. See <http://blog.us.playstation.com/2009/03/playstation-2-will-be-available-for-under-100/>.

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