Web-based Auctions:

An Economic Analysis

A dissertation submitted to the University of Bristol in accordance with the requirements of the degree of MSc in Economics in the Faculty of Social Sciences.

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September 2000

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Funded by ESRC

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Abstract

Trade on the Internet has grown massively over the past few years, and one major growth area has been in online auctions, with one site, www.ebay.com, growing larger than all others. For auctions to function online, however, some alterations to the standard theoretical English model need to be made, and this paper looks at some of the areas in which new theory is introduced. Special interest is paid to the effects of deadlines, reserve bids, and the possibility of buyout prices. We shall find that the proxy bidding system as used on eBay is inadequate in preventing last-minute bidding caused by deadlines, and that there is a time after which the rate or bid placement increases massively. We shall also find that there is no conclusive evidence that use of a reserve price in an auction will encourage or discourage bidding, although the numbers of sellers using a reserve do not reflect this. Finally, we shall look at maximum prices, and offer a rationale for sellers to use them, concluding that the inclusion of such an option to sellers would have some advantages, especially in encouraging buyers to use proxy bidding.

Declaration

The work included within this dissertation has not been previously submitted, either in whole or in part, for the award of any other academic qualification. The work is the original work of the author; assistance from others has been acknowledged where appropriate, and quotation from other sources is cited in the text.

Tim Miller, September 2000

Dedication

For my family, who always encouraged me to get as far as I could, and taught me the most important lessons of all – Dad, Mum, Pip and Jay, thanks for supporting me.

And for Clare, who's always been with me even when she's been away, and has supported me more than I could wish for. You will never know how much that has meant to me.

Acknowledgements

I wish to thank:

- Dr Nir Vulkan, who supervised this dissertation, provided crucial guidance whenever it was needed, and inspired the topic in the first place
- Prof Ian Jewitt, who assisted with the theoretical aspects of auctions
- Eleanor Scott, for her help in collecting data from the eBay website
- Dr Christine Osbourne, for consultation on econometric methods
- Nic Francis, for his help with structural breaks (!)
- Dr David Lucking-Reiley, for useful contacts and communication

and all others who have helped me, though their names may elude me presently!

Contents

I Introduction

Despite the Internet itself existing since the mid 1960s, it is only recently that it has expanded into a domestic environment, much of it spurred by the introduction of HTML and the world wide web in the early 1990s. With this rapid expansion has come business, and the success of ecommerce looks set to continue to grow over the next few years. As such, it is important for economists to look at how these transactions will differ from those on the high street, and in which ways consumers' behaviour will be altered. This paper concentrates on how auctions have altered to allow them to take place over the Internet, and whether such alterations have any effect on how the auctions run.

When looking at ecommerce, we may wish to consider it as an extension of microeconomic theory, although the move online has introduced many new issues. The consumer has much more power, and is able to perform comparative search more easily and cheaply than before. Also, the vendor faces lower costs, due to no need to own expensive shop space, and a lack of menu costs. These are not the only ways in which the traditional microeconomic models are affected, of course – we must consider the technology used in these markets, which will alter the balance of power. The use of automated agents is a significant factor here, allowing users to compare prices and availability easily, and find goods they would not otherwise have considered. The programming of these agents is another economic consideration, with optimal behaviour being modelled on how a rational consumer should act. Finally, the issue of security of personal details (names, addresses, and credit card numbers, for example) is a factor which has not previously arisen, but may well be a factor in whether consumers choose to shop online. These new aspects of economic transactions will call for an examination as to which economic theory will still apply, and how the broad field of microeconomics can be made more specific.

Ordinary transactions are not the only way the Internet is opening to commerce, however. The availability of a large userbase has made it ideal for dealing with niche markets, and it is this that has encouraged the growth of Internet auctions. Although similar in idea to traditional auctions, the lower cost and higher accessibility has lead to a huge growth in the sites offering a portal for auctions, with one site alone (eBay, which will form the focus of this paper) selling $190million worth of goods per month[1]. Internet auctions do not take place exclusively on the web, however – there are several usenet newsgroups formed specifically for users to perform auctions over, and email lists allow sellers to contact other enthusiasts easily. It is this ease of communication that probably lies behind the success of Internet auctions, since they allow people to buy something that would otherwise be unavailable, or very difficult to locate.

While the background idea is identical for online and offline auctions, the implementation differs considerably, and this paper aims to look at a few of the aspects of this. We wish, specifically, to discover whether we are justified in applying the theory of second-price auctions to web-based auction sites, and how such theory may be narrowed; we also wish to look at how such theory will be affected by the changes made to enable auctions to take place online. Section I a looks at relevant literature, and sections I b and I c outline in detail what this paper will examine, and how it will do so. Sections II to IV look at three areas considered in online auctions, and section V concludes.

I a Literature Review

Much of the literature written on Internet economic interaction concentrates on mechanism and agent design, and optimal combinations thereof. It can be easily seen that it is preferable to look at microeconomics in these markets, where we need make no assumptions over the behaviour of agents (as it is specified in the rules of the market). Many papers concentrate on the design of agents interacting in such markets; Vulkan (1999) is one such example, looking not only at interactions between automated agents but also the interaction with users of the technology. Such agents are especially useful when considering how standard economic theory translates to online interaction – designed correctly, they can act as a rational consumer would,

[1] As at July 1999, referenced from Lucking-Reiley (1999a).

often more accurately than any individual. There exists, therefore, an intrinsic role for economists to engineer these agents to perform as they would in an ideal market, and ensure that interactions are efficient through well-designed rules.

When looking at auctions on the Internet, therefore, we should first consider the literature on the wider field of standard auctions; by looking at how individuals' behaviour is implemented, we may see how the introduction of automatic agents, or other different technological aspects, may affect the basic conclusions drawn. There has been a vast amount of literature devoted to the various auction designs and how a game theory approach (best responses and optimum strategies) may be applied to give a fixed result. The majority of this is considered in Klemperer (1999), which looks at theory dating back, primarily, to Vickrey's 1961 paper on second-price auctions and their efficiencies.

Vickrey's paper looks at auctions in which participants will not pay their true willingness to bid, but it is optimal for them to place this as their bid amount. Two types of these second-price auctions exist (they are called second-price since, under the rules of the auction, the winner pays the second highest bid amount) – the standard ascending-bid English auction, and the sealed bid. The first is as found in a standard auction house – the price rises until there is only one bidder left in contention, and he will pay the last amount he bids, even if it is not as high as his true value. The second is largely accredited to Vickrey (although, as discussed in Lucking-Reiley (2000), such auctions occurred by mail for many years before that), and involves all bidders submitting one single bid, the winner paying the amount of the second highest. Both types result in a disappearance of the 'winner's curse', since the amount paid will not alter if the bid amount is lowered slightly[2]. Indeed, it is this separation of the bid amount and the amount paid that leads to the desired efficiency of second-price auctions.

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[2] The winner's curse occurs in first-price auctions, where the winner may see that he could have paid slightly less if he had bid less (down to but just above the second price). Such thinking may lead to bidders placing bids of less than their true amount in the hope of paying less, and this may lead to the 'wrong' individual winning (and thus inefficiencies in the auction).

Klemperer's survey is extremely extensive, and covers many areas that are irrelevant to this paper; it does, however, allow us an excellent summary of the results we may need to use. Much of this work looks at relaxing the assumptions behind Vickrey's paper, and while this enables us to look at auctions in a more applied context, it also leads us to set a more rigid auction design. This is, in most cases, very different from the design needed for online auctions. We thus wish to consider the Wilson critique, and attempt to find a robust, non-specific model for auctions, including those online and offline, and to do so we must examine those aspects that differ between the two.

The areas of auctions we are most concerned with do not involve revenue specifically, and theories on revenue equivalence and marginal revenues form a large proportion of the literature. Some theory in this area is possibly important, however; we may wish to look at personal valuation specifically. Section 1.5 of Klemperer (1999) looks at the concept of common-value and private-value, while sections 6 and 7 cover the literature of this in more detail. A common-value model is one in which any individual's valuation depends, to some level, on the signals of valuation form other bidders; a private-value model is the opposite, where each potential buyer is independent. Much of the early literature was based on a private-value assumption.

One other important area of auction design is as discussed in section 8 of Klemperer's survey – the costs of participating in the auction, or the entry costs to the auction, will affect the effectiveness and efficiency of the sale due to the number of bidders attracted. In the case of the seller's valuation being lower than the second-price bid, and if a reserve price (that is, a price below which the auction would be declared void) were to be set at the seller's valuation, then the auction would continue as a normal second-price, and no extra theory is needed to see that this will result in a new revenue equivalence. Indeed, disregarding this last point allows us to see that for the seller it will always be optimal to set a reserve price equal to their valuation; any bidders with a lower valuation will be discouraged from bidding, but this is beneficial to the seller.

The number of bidders plays a more prominent role in common-value auctions. As discussed in section 8 of Klemperer (1999), it is generally theorised that revenue is higher, and participation is greater, when no reserve price is set; indeed, this situation is advantageous to the seller more than to the buyer.

Much of this literature can be applied to Internet auctions, but there are several specific design points that must be resolved when examining the theory and conclusions of this area. The Internet can, however, be effectively used as a medium for testing any auction hypothesis, since almost any auction model can be simulated in some way – it is only the feasibility of using such models in general use that necessitates the use of different models. Lucking-Reiley (1999b) uses auctions run over Usenet to test the Revenue Equivalence Theorem, and, although the number of bidders is slightly limited[3], the results for second-price and English auctions indicate that revenues are indeed similar (the results for first-price and Dutch auctions were less conclusive).

Perhaps more relevant to the topics discussed below, Lucking-Reiley (1999c) uses online auctions to look at the effect of reserve prices on participation. By running a set of equivalent auctions over Usenet, selling identical items with and without a reserve bid, this paper finds that not only do reserve prices have an affect on the number of bidders (and thus the efficiency), but they also have an effect on the level of the winning bid. The experimental evidence from online auctions thus seems to back up the above-mentioned section 8 of Klemperer (1999); note, however, that Lucking-Reiley here used a first-price sealed bid auction, and it is possible that the lack of information available to the bidders would have had some effect on the results.

Perhaps the currently most important paper on Internet auctions is Lucking-Reiley (1999a), which is a comprehensive survey of how Internet auctions currently operate,

[3] Also, since the same item was auctioned twice, the second auction would be lacking the previous highest valuation, although the order of (English and Vickrey, for example) auctions was varied to compensate for this.

and gives details of some of the differences between online and offline[4] auctions. This paper looks at the differing types of auctions available on the Internet, and the varying mechanisms used; by surveying 142 web-based auction sites, it is found that the most prevalent auction type is based on a standard English auction, with bidders being able to see the current bid level and view details of who else has bid so far. Indeed, sections VIII to XII look at a huge number of differing auction styles, with far greater breadth than will be covered below; we shall not be dealing with multi-unit auctions, for example, nor looking at business-to-business transactions. Such breadth does not always lend itself to completeness, however, and there are some areas which can be expanded upon. Some of these are examined below.

Other papers have recently been published on the subject of Internet auctions, concentrating on varying specific aspects. Of the areas looked at below, the greatest coverage has been of the deadline factor, and Roth & Ockenfels (2000) considers the use of last-minute bidding on both eBay and Amazon, the latter using a deadline extending method (see section II a) to discourage this behaviour. The results found indicate that late bidding does exist, although less often in those auctions with extending deadlines. Several reasons are suggested, many drawing from the private- and common-value arguments as explained in Klemperer (1999) and above – this shall be further explained below.

Further papers look at these arguments in particular (for example, Bajari & Hortaçsu (2000), which looks primarily at coin collecting, and explains why such behaviour is not optimal in private-value auctions), or simply conclude the behaviour of bidders is irrational (or due to inexperience). While this does not help to form an auction in which such behaviour is eliminated, its importance, as described in Wilcox (2000) and Malhotra & Murnighan (2000), cannot be underestimated – even if the automatic agents follow strict economically optimal behaviour, the interactions between users and the agents cannot be controlled, and may not be ideal.

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[4] Offline here is intended to refer explicitly to traditional auctions; it is quite possible that auctions offline could include some of the distinguishing features of online auctions, but it is the difference we are interested in more that the place in which they occur.

I b Areas of Concern

Following from Lucking-Reiley (1999a), it is clear to see that the methods by which auctions are conducted on the Internet must differ considerably to those of the original theoretical auction types. The needs for these differences are discussed in depth in Lucking-Reiley (1999a), but it will prove useful for us to explain and expand a few of these inherent differences, since this paper does not aim to compile as complete a list of how an Internet auction must vary from one of the theoretical types as Lucking-Reiley's does. The eventual aim is to consider whether an abstraction of Vickrey's sealed-bid second-price auction, or an English auction, will give a good enough model for Internet auctions.

One of the most obvious, and possibly fundamental, changes seen when redesigning an auction for use on the Internet is the idea of a deadline. In traditional auctions, it seems fairly obvious that the seller would wish for the auction to continue until there was only one bidder left; since all potential bidders are contained in the same room this is feasible. On the Internet, however, there is no way to ensure that those participating will be online at a particular time; indeed, due to the international nature of the auctions, it could be difficult to even define a time. To minimise this problem, the period over which the auction is held is expanded to a number of days, or even weeks. However, while this ensures that all interested bidders can access the auction during its run, it also means that no bidder can be present at the auction for the whole bidding period. It seems intuitive that any bidder will, therefore, be best advised to only participate at the end of an auction.

While this seems to solve the participation problem, it has in fact only shifted it to a later date – although more people may know of the auction, they must all be online at the time the auction closes to place their bids, and again this may be impossible or impractical. There have been solutions proposed to this problem, and these will be discussed in section II. We shall find that none of these solutions has been effective in totally eliminating last-minute bidding, especially the system used by eBay.

The second area in which auctions on the Internet introduce new elements is in terms of starting (or minimum) and reserve prices. While such elements have been evident in auctions since they first started (even if not formally, the seller could easily refuse to pass ownership to the highest bidder if the bid was not high enough), the ease of setting up Internet auctions (and, more specifically, of repeating failed auctions) gives a new element of strategy to the seller, and the additional informational differences give a new perspective on bidding to the buyer. The aspects contained within this have been only partially explored in Lucking-Reiley (1999a), concentrating mostly on the irrationality of bidders due to risk aversion.

Finally, and almost in direct contrast to the second area, is the possibility of a maximum, or 'buyout' price. This is barely touched on in any of the literature thus far mentioned, mainly due to the inefficiency of such a scheme in a traditional auction marketplace, but in the case of Internet auctions it may well affect buyers' behaviours in the proximity, and such effects will be discussed in section IV.

I c Scope of This Paper

For the purposes of this paper, it will prove useful to narrow down the type of auction being studied. Given this, it makes sense to study the type of auction most prevalent on the current auction sites, and, as found in the literature review above, this would be a dynamic, English, single-unit ascending bid auction mechanism. Indeed, this is the type of auction used by the most popular and largest Internet auction site, eBay[5], and it is this website which shall form the basis of the majority of this paper. This may be used without much academic loss, since many other sites use an exact same model,

[5] http://www.ebay.co.uk or http://www.ebay.com; we shall primarily be using the former site, and there are a few mechanical differences between the two. The UK site, for example, does not currently (as at June 2000) charge sellers to list items, although there will soon be some fee introduced. The UK site will list any items from the international site that are available for delivery to Britain, and provides a rough currency conversion for the benefit of those looking to buy from overseas.

and others only vary slightly – mostly in areas to be examined below. Most of the analysis below can, therefore, be used with respect to other auction sites, with only minor alterations.

eBay, as a company, was founded by an individual (Pierre Omidyar) who saw the potential of the Internet for uniting collectors to facilitate the trading of rarities. Much of this inspiration came from his wife, who collected sweet dispensers. On its own website, the company describes itself thus:

> eBay is the world's largest personal online trading community. eBay created a new market: efficient one-to-one trading in an auction format on the Web. Individuals – not big businesses – use eBay to buy and sell items in more than 1,600 categories, including collectibles, antiques, sports memorabilia, computers, toys, beanie babies, dolls, figures, coins, stamps, books, magazines, music, pottery, glass, photography, electronics, jewellery, gemstones, and much more. Users can find the unique and the interesting on eBay – everything from chintz china to chairs, teddy bears to trains, and furniture to figurines.
>
> (http://pages.ebay.co.uk/community/aboutebay/overview/index.html)

eBay was launched in September 1995, and as such was one of the first auction sites on the Internet; this pioneering aspect meant that the auctions had to be designed from nothing. The structure of auctions on eBay follows (as closely as feasible) the theoretical model of an English auction, though as previously mentioned there are aspects that are necessarily altered. Note that this paper concentrates on the British eBay site, at http://www.ebay.co.uk – see footnote 5.

The auction proceeds as follows: firstly, the seller decides on the auction style they wish to use, and then the auction is opened to the public. Each potential bidder will find the auction either from searching on the eBay site for key words in the description, or from a direct referral (for example, the seller may post an advertisement on a newsgroup pointing directly to the auction page), and will then view the item’s description, and look at how the seller has constructed the auction. If they then decide to bid, they are faced with a 'maximum bid' box, which asks for users to input the maximum they would be prepared to pay. While this seems contrary to the above attempt to recreate English auctions, it is the way this maximum is handled that is important. By specifying a price beyond which they would be unwilling to bid further, the user is in fact creating an automatic bidding agent (known as an 'elf') which will increase their current bid each time another user (or another user's elf) places a higher bid, until the maximum price is reached. The automatic bidding is an attempt to allow people to participate in auctions without the need to constantly check the auction's website to ensure they have not been outbid.

Some users, of course, do not use this feature as they should, preferring to visit the site themselves at regular intervals, and look to see if they need to place a higher bid. Some prefer to wait until the last minute to bid, and the reasons for this, and how automatic (or proxy) bidding should alleviate this problem, will be discussed in section II. We shall find that proxy bidding is not always used by bidders, and indeed may be seen to be absent from the majority of auctions. The use of proxy bidding can be considered to have failed in two respects – it has not increased participation in auctions, and it does not prevent people from bidding at the last minute.

As mentioned above, the seller has much of the power over the auction design, since they are given a large number of options. These can include whether to have a reserve price set, the description of the item, whether to have a picture or not (the latter would obviously be preferred if the item were in a bad state), the starting (or minimum) bid, and how long they wish the auction to last. Such decisions can affect the willingness of bidders to participate, and from looking at the variety of auction styles used, it seems that there is no fixed style that people consider to be optimal[6]. This does not mean, of course, that design does not affect auctions, and in section III

[6] In a more detailed survey of auctions than that contained here, however, we may wish to consider the 'experience' of sellers when looking at the auction styles chosen. Whenever someone buys or sells on eBay, the other party in the transaction is allowed to leave a piece of feedback on that user's profile page, and the number of pieces of feedback could be used as a rough indicator of how often the user had participated in auctions.

I hope to examine how the selection of reserve or minimum prices should, and does, affect buying behaviour. We shall find that the use of reserves does not significantly affect the likelihood of an item being sold, and there are only small effects on the numbers of bids cast and participation rates.

The other aspect of auction design mentioned in section I b, maximum bids, do not feature in eBay auctions, and it is interesting to ask the questions of why not, and whether they should. By examining how behaviour is affected, I hope to answer these questions, and in the process give an explanation of the effect of a maximum bid. This analysis can be found in section IV, and finds no disadvantage to eBay or its sellers of offering a buyout price on most goods – indeed, one advantage could be a higher use of proxy bidding.

II Deadlines in Auctions

The first aspect that this paper will look at is that of the deadline. A deadline is a preset time at which an auction will finish, and at which time the winning bidder will be set, as will his price. It is obvious that this is a new concept when compared to the original auction format (although it may not be a new concept purely for Internet auctions – many other auction mechanisms such as sealed-bid and postal auctions will have required deadlines before online auctions began), but its use is necessary due to the participation constraints on buyers.

In an original auction design, all potential buyers are assembled in one room, so each can see the actions and behaviour of all others. Since all bidders are in the one room, they can be expected to know the current bid level instantaneously and respond in real time, and as a result an auction can be held with consecutive bids within ten minutes. With online auctions, however, not all bidders will be available at any one time, and in order to maximise the potential revenue, sellers will wish to have the auction going over a longer period of time; however, were auctions to follow a similar format to original, with no closure until all bidders have seen the new bid after one has been placed, it is possible that auctions could continue for an infeasibly long period of time.

Thus a deadline is set, at one specific point in the future[7], by which time all bids must have been placed, and at which time the auction will close.

The introduction of a fixed final point, however, substantially changes the optimal strategies of bidding. Whereas the timing of bids is traditionally unimportant (it matters not whether you place your bid last or first; if you are placing the winning bid, you will win the auction), the existence of a deadline introduces a new type of strategy which may prevent others from counter-bidding, and may allow bidders to reduce the amount which they will pay. By waiting until the last minute (or, due to the existence of software specifically programmed to delay bidding as much as possible, the last second[8]), bidders prevent others from knowing that they plan to make a bid, and prevent them from making a higher winning bid. The optimum strategy is thus to place a bid as late as possible, just above the current bid amount, and hope that your bid is not exceeded in the few seconds afterwards.

Such an equilibrium is obviously not necessarily efficient – the highest valuation stands as much chance of winning as the lowest, if both are above the current bid. However, for the bidder, there is the possibility of the winning amount being significantly lower than would be otherwise, so they may be more likely to take that risk; obviously, this is detrimental to the seller, and as such eBay should aim to eliminate this optimal strategy, or at least ensure that other strategies are as attractive. As shown in Lucking-Reiley (1999a), there are two methods proposed to overcome this problem, only one of which is implemented at the eBay site.

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[7] In the case of eBay, this period is precisely seven days after the auction starts. In some cases the seller appears to have set a different length for the auction, but most use the default level.

[8] Such software is examined in Roth & Ockenfels (2000), along with a more detailed study of last-minute bidding. In addition to the analysis here, it is assumed that a bid placed near the end does not have a certain probability of reaching the auction before the deadline (due to the nature of Internet communications), and since agents are risk averse they will not actually wait until the last second, but until a time not negligibly before the end (that is, it is possible that somebody could bid after them).

II a Extended Deadlines

In a traditional English auction, each time a bid is cast, the auction is effectively reset with a new minimum level (ignoring informational concerns) – the auctioneer will begin asking for new bids within a similar time period as was allowed for the last bid to arrive. The placing of a bid, therefore, effectively extends the 'deadline' of the auction[9]; it makes sense, therefore, to consider a form of this for use in online auctions. It should be noted, however, that eBay does not use this method, and therefore we shall only look briefly at it – a more thorough explanation can be found in Lucking-Reiley (1999a).

Obviously, the easiest way to combat the problems caused by a fixed deadline is to abolish that deadline. The model used by Amazon Auctions[10] consists of a brief 10 minute extension period at the end of an auction, to allow a response from previous bidders. This therefore ensures that nobody will win the auction simply by placing their bid at the last second, and it also ensures that all those who wish to bid at the end of the auction will have their bids recognised by the system. Each further bid placed extends the period by another ten minutes, until the highest bidder is uncontested. Such a method is obviously analogous with the traditional style, and carries the same benefits, in that the auction could be considered efficient since the highest valuation would win, and the benefits of last-minute bidding are seriously reduced.

Such gains are not necessarily true, however. The issue of participation as previously explained is reintroduced, with those unable to connect to the Internet at the time of the auction's end at a significant disadvantage; if the bidder with the highest valuation

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[9] Although, as previously explained, traditional auctions have no fixed deadline, the auctioneer must make a decision on how long to allow the auction to continue, and how long to wait for a new bid. There, is, therefore, some element of a deadline, but not in the same sense as used in Internet auctions.

[10] Found at http://auctions.amazon.co.uk

was in this position, the auction's outcome may not be efficient. Such problems are solvable, of course, by lengthening the extension (to several hours, say), but this may lead again to infeasibly long auctions, and may prevent another group from participating at the end.

It is important to note that I was unable to find an auction site that relied solely on extendable auctions to combat the problem of last-minute bidding. This strongly indicates that the auction sites do not expect people to generally be available at the end of an auction, and other measures are implemented to ensure this is not necessary. Also, as per Roth & Ockenfels (2000), such a measure is not totally effective in eliminating last-minute bidding, even when coupled with a proxy system.

II b Proxy Bidding

The idea of proxy bidding has already been described above, in section I c, under the guise of automatic bidding agents. The process can be further compared to a traditional auction, which a certain individual is unable to attend personally. In such cases, it is common for the individual to appoint a proxy, who is given a maximum price that they will be allowed to bid up to. They then follow a formulaic pattern of raising the bid level by a set amount, until either all other bidders drop out (so the proxy wins the auction), or until the maximum level is reached. On eBay, these proxies are replaced by the automatic bidding agents, but theory remains the same.

One interesting note here regards the underlying auction type – by submitting a single (maximum) bid at or near the beginning, the auction will appear to be a sealed-bid, rather than simultaneous, type (from the bidder's viewpoint). Since the price paid is approximately that of the second highest bidder, we may consider the strategies used under a Vickrey auction to see how the outcome, and optimal decisions, will be settled. There are, of course, some differences, mainly informational – bidders may be unwilling to reveal their true valuation if they feel it will give those bidding afterwards an unfair advantage. This is particularly true with more than two bidders; the third to enter will be able to observe at least the lower of the two original valuations (eBay does not reveal amounts directly, but this can be taken by looking at the current bid level). While such information may seem trivial, it could be important in the case of common-value goods, and also when it is possible for previous bidders to submit a new, higher bid later in the auction.

For private-value items, economic theory gives a clear optimum strategy of submitting the true maximum bid at the earliest opportunity; the timing is relatively unimportant, but in the event of a tie for highest bid, the bid made earlier has precedence. Since they will pay only the second highest bid, as in a Vickrey auction, there is no advantage in submitting a lower bid and raising it later; similarly, since no others can see your maximum bid, their behaviour should not be affected. The timing of bids is the important aspect here – we shall see later that it is useful to assume that bidding should take place at the same rate as arrival.

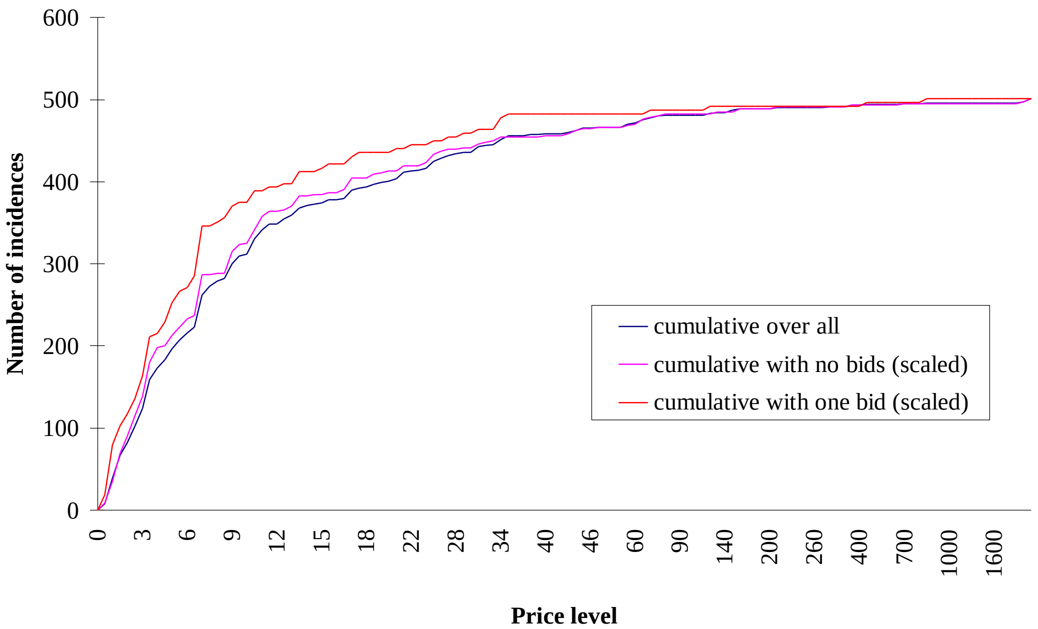
The main advantage of proxy bidding is the increase in accessibility to those with limited Internet access. By providing those who are unable to attend the end of an auction a method of participating in a potential bidding war, auction sites will encourage those who would otherwise believe they had no chance of winning. If another user attempts to place a last-minute bid, the proxy can instantly reply, and while this means the original bidder will pay more than they previously thought, it does mean that the person with the highest valuation wins the item[11].

The seller thus benefits in two ways; firstly, since bidders are allowing others to view their bids earlier in the auction, there is a chance that a war could force prices to a higher level than otherwise. Secondly, since more people are encouraged to participate, there is less of a chance of the auction ending with no or one bidder. The adverse nature of having no bidders is evident (the item goes unsold), but when there is only one bidder, the item can be theoretically sold for close to zero, if the minimum bid is negligible. In practice, all the power of the auction passes to the buyer, as they can bid an insignificant amount greater than the minimum, and the seller is obliged to

[11] Unless, of course, the last-minute bidder has the higher valuation, and does not submit their bid in time for it to be recognised.

continue with the transaction (by the rules of eBay trading). The seller may, of course, protect themselves against selling the item at too low a price by using minimum or reserve bids, but this may affect the auction in other ways; we explore this further in section III.

Our first question is thus whether proxy bidding has eliminated (or reduced in number) auctions with less than two participants. Of 500 observations collected at random (see Appendix 1 for details of how this data was collected), 245 had no bidders, and 107 had only one potential buyer. This would seem to indicate that proxy bidding has failed, but it must be remembered that there may be other reasons for non-participation, such as price or simply the desirability of goods. If minimum prices were set high, for example, it would be unsurprising to find goods unsold. It is interesting to note, however, that by looking at how prices are distributed over all goods, and over just those goods with one or no bidders, we can see there is little difference.

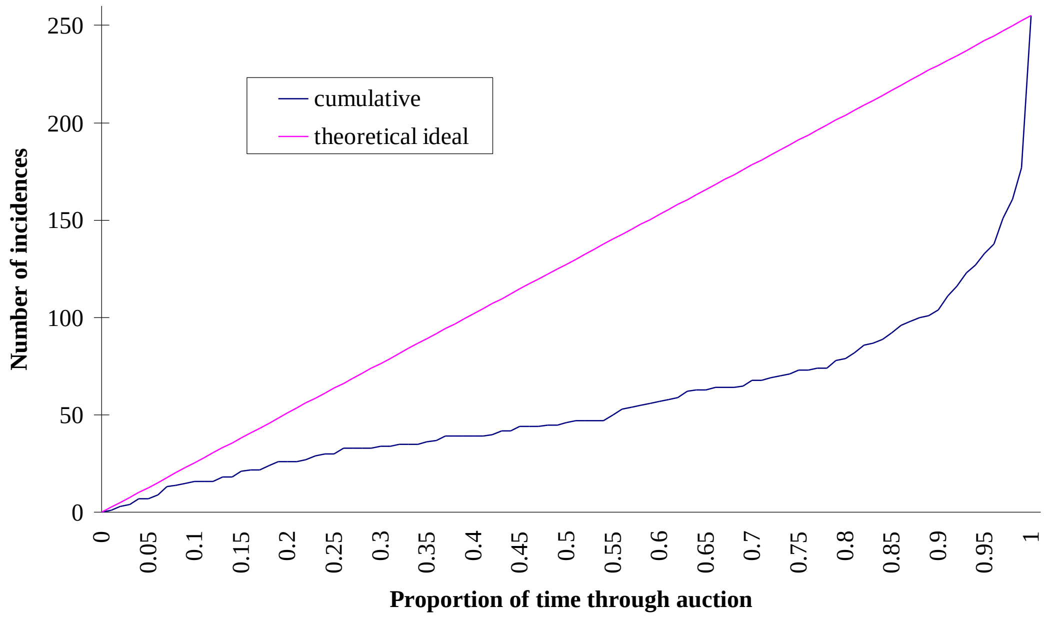


Graph 1: Price levels of auctions

Graph 1 shows the cumulative distribution of prices for the three sets of data mentioned, scaled by the end points. Prices here are the minimum price (for auctions with no or one bid), or the eventual winning bid amount, which is normally not entirely dissimilar from the opening bid. In fact, only 61 of the 500 observations were judged to have a minimum set significantly below the expected or eventual price, and of these 12 had reserve prices anyway. It is clear to see that there is no significant difference between the distributions (if there is one, it appears to show that the cheaper items are the ones that do not attract as many bids, but this may be because bidding raises the price), and, for this small sample of data at least, the pure price level may not be a factor in attracting bids. We must consider, however, that in such a small sample the distribution of item types may not be consistent, and it is possible that the auctions with no bids were, generally, for items with a lower value, despite their opening prices.

We may use the same sample of data to ask whether the problem of last-minute bidding has been resolved by the introduction of automatic proxy bidding. The data on timings of winning bids shows the time at which the bid was first placed by the eventual winner, and not that of the last visitor to the auction or when the proxy bidding system raised to the eventual final price. Since the auctions are nominally world-wide[12], and so the winning bidder may visit at any point, we may assume for simplicity that there would be an ideal cumulative distribution of uniformity, were the problem of last-minute bidding to be completely eliminated. This may seem to be an unrealistic assumption, but can be justified by considering that each individual will first look at the website at a time independent of all others, and with proxy bidding would place their maximum price at that time. Indeed, were we to believe that most bidders visit the site more than once during an average auction's lifespan, we should expect a concave distribution, since bidders will only place bids at their first visit.

[12] We are ignoring here the possible side-effects of shipping on the desirability of goods. It will make a good more expensive to the consumer if it is bought from a different country, since the buyer pays the postage costs – this is obviously an important point, and may have to be considered carefully.



Graph 2: Cumulative distribution of auctions' winning bids

By plotting the actual cumulative distribution, we can see (in Graph 2) that we are very far from the ideal. Of the 255 auctions which actually ended with a sale (it does not matter here whether there is only one bidder, since the timing of that one bid remains valid), less than half are 'ended' before 90% of the auction has passed. On this basis alone, it is impossible to accept the proposal that proxy bidding is effective at eliminating last-minute bidding.

On further examination, we may see that in the early stages of an auction, we do indeed have a uniform distribution of bid placements (in fact, for the first third of an auction we have slight concavity, but this is not strong enough to be used as evidence). We may wish to consider that there is an underlying model with a structural break at some point towards the end of the auction, and by running a regression with a dummy variable, and looking at values of R^2, we may set this at 0.97 – that is, with all but three hundredths of the auction left to run. At this level, we have a goodness of fit of 0.923366, and the F-test value is 164.1737; this can be compared to the critical $F_{1,98}$ value of 3.1 (at 5% confidence) to reject the hypothesis that there is no break[13]. Such a high goodness of fit also indicates that the first part of the graph is, as previously derived, uniform, and so the arrival rate assumption can be justified.

Having determined that proxy bids do not, in general, encourage participation, nor do they solve the last-minute bidding problem, we may have one final question we wish to answer, to help explain why the economic theory does not hold in this case – that is, why would people not use proxies to put their true valuation as their maximum bid? We can see from the data that, of the 255 auctions which ended with a sale, 104 had instances when at least one bidder submitted a later, higher bid. While it is unclear from this specific data, this may indicate that these auctions have some common-value aspect; when others submit their (higher) bids, the first bidder may realise the item is worth more than he initially thought.

The final possibility is a simple question of trust. While the Internet has improved considerably, it is not as reliable as sometimes supposed, and problems of security could dissuade people from relying on an automatic agent, preferring instead to watch the auction regularly as it progresses. If those who have used proxies did not enter their true maximum, the presence of only one participant bidding at the end of the auction is enough to upset the equilibrium, and all those who set up proxies less than their valuation will need to be present also.

III Minimum and Reserve Bids

We now turn away from looking at the buyer's decisions to looking at the seller's. When creating an auction on eBay, the user not only writes his own description, and designs the layout of the page, but he must also make some fundamental decisions over the design of the auction. As well as the period of bidding, and the shipping details (which will alter the worth, and therefore desirability, of the item), the seller

[13] See Appendix 3 for statistical working.

must make the decision whether to include one (or both) of a starting price and a reserve price.

A starting price (or minimum bid) is exactly how it sounds; it is a price level specified by the seller at which bidding must start, and no bids for less than this level can be submitted. The starting bid is presented to all bidders on the auction page – even after the first bid has been submitted, a separate entry informs visitors of how the auctions started. The use of a starting price seems twofold: firstly, it allows the seller to indicate in which price range they are expecting to bid; secondly, it ensures that if the auction only attracts one bidder, the item will not be sold at an unacceptable price. If there is at least one bidder, however, the item is sold, and the transaction must be completed[14]. In effect, therefore, the seller is present at the auction, and is casting the first bid.

A reserve price, however, is not known to the buyers, in anything more than it exists. On the auction page, next to the current bid level, is a notice saying either "reserve not yet met" or "reserve price met", and this thus informs bidders that such a reserve is in place, and whether it is greater or lower than the current bid level. Bidding for the good will continue as normal until the end point, at which time whether the reserve has been exceeded will determine whether the transaction takes place. It is possible, of course, that the seller may wish to offer an item which has not reached its reserve price to the highest bidder if the bids are sufficiently close, but this transaction is not registered on eBay, and it is not subject to any of the feedback facilities, for example.

There are two major differences between the use of minimum and reserve bids. The first is evident from the above descriptions – the information during the auction is altered (and reduced) once a reserve bid is introduced. As mentioned in section II,

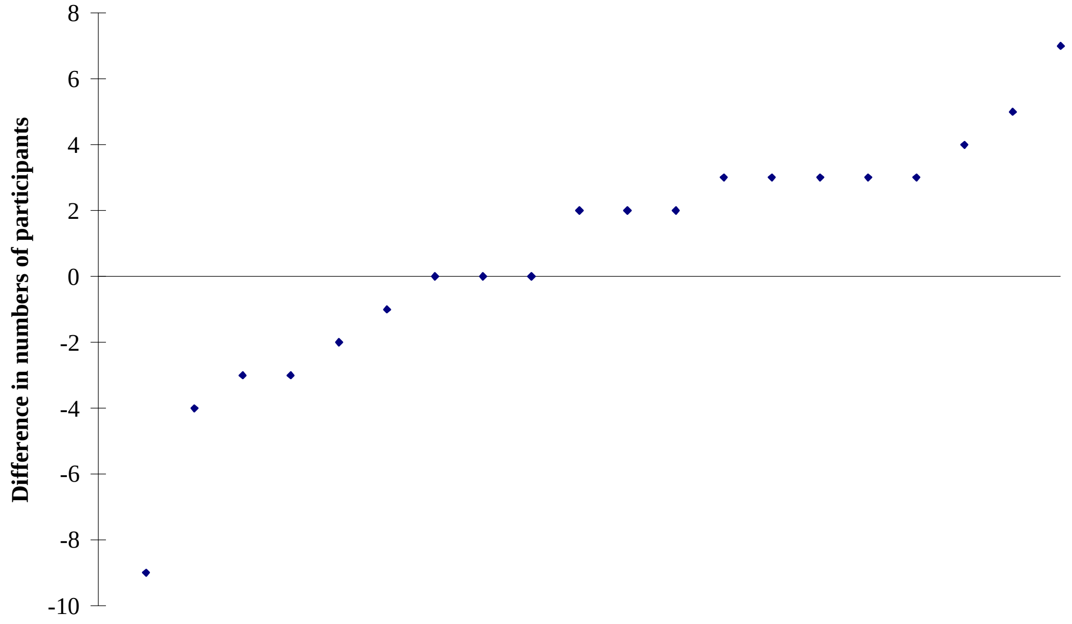
[14] Obviously, there is no legal power that will force the seller to send out the item rather than returning the bidder's cheque, but eBay encourages the use of its feedback system to report unhonoured auctions. Negative feedback can lead to bidders being less willing to participate in a certain seller's auctions, or, in extreme cases, the seller being ejected from eBay.

these informational differences may have an effect on participation – we may argue that the lack of information will discourage some from participating. The second difference, however, may lead to the opposite effect – unlike with a minimum bid, a reserve allows people to place bids lower than what the seller believes the item to be worth. Although this may not initially seem desirable, it allows the auction to gather momentum and attracts those who will only bid if they believe an item to be desirable. If there is a difference between auctions, therefore, we wish to see which of these effects is the greater.

Naturally, the effect of minimum and reserve bids are the same – if nobody wishes to pay above either, the item does not get sold. The seller obviously desires for the item to be sold, and so will wish to design the auction so this does not happen. We wish, therefore, to look at whether the decision to use a reserve price affects the number of people willing to bid.

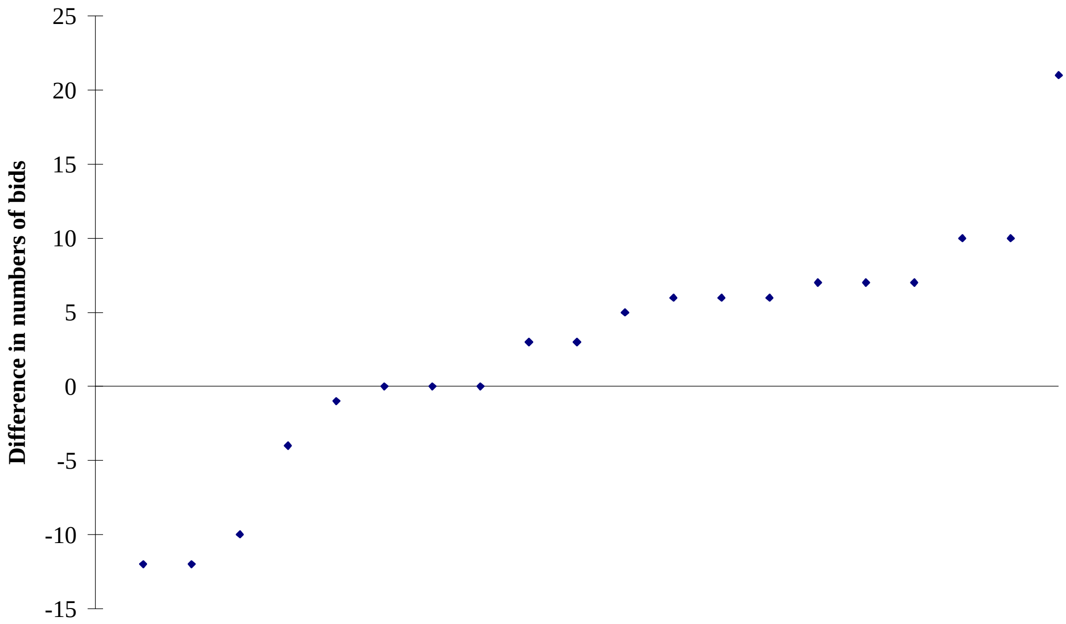
Of the 500 auctions surveyed in section II, only 25 used reserve bids, which seems to indicate sellers believe using such a system will adversely affect their auctions (in all but 61 auctions, in comparison, a minimum price was set). To see whether this is the case, we wish to collect data for two sets of observations, consisting of similar items with and without reserve prices. However, due to the rarity of auctions with reserves, it is very difficult to assemble a large dataset, and so firm conclusions will only be able to be drawn when eBay release data in a larger sample. The data here consists of only 20 observations – the reserve auctions were taken from the larger dataset formed for the previous section, and close matches were found from a search of recent auctions. Again, for more information on data collection, see Appendix 1.

Data from these observations, however, gives a very interesting picture of how both bidder numbers and levels of participation are affected by a reserve price. When sorted by the number of participants, we may see a distribution thus:



Graph 3: Numbers of participants in similar reserve and non-reserve auctions

The difference in number of participants here is calculated by subtracting the number of bidders in the non-reserve auction from those in the reserve auction. In six cases, therefore, there were more bidders in the auction with no reserve, whereas eleven cases give the opposite result. This appears to imply that the second of the two effects mentioned above is the stronger, and this is more strongly implied when we look at the differences in number of bids cast:



Graph 4: Numbers of bids in similar reserve and non-reserve auctions

Again, the difference here is the number of bids cast in reserve auctions minus the number cast in the equivalent non-reserve auction. Note that the order of auctions is not the same; in some cases, two bidders may place two bids, but it is also possible for a (non-automated) bidding war to take this up to any number. The auctions have thus been reordered to enable us to see the distribution more clearly.

It is interesting to note that now we have an even stronger result (although see the statistical tests outlined later) – of the twenty auctions, only four have strong results in which the non-reserve auction attracts more interest. This is particularly indicative of the second effect, as it could be that there was a bidding war to get the reserve price. Indeed, it could have been one cautious individual slowly increasing his bid until he reached the maximum. There is, theoretically, no need for this (the proxy bidding system will automatically increase your starting bid to the reserve price if the maximum price you enter is above the reserve[15]), but as seen in the previous section, not all users make full use of the proxy bidding facilities.

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[15] Another method of implementing reserve prices, although not used on eBay, is also feasible. By only considering the reserve price to be exceeded when a bidding war takes the price above it, the site ensures that at least two bidders are participating at that point, and, as described before, this is often

It seems from this sample, therefore, that the widely believed result – that reserve prices discourage participation – does not apply in web-based auctions. This is, however, a small sample, and we would wish to analyse a much larger sample before any firm conclusions can be made. It is true, however, that those interviewed over auction design believed that their auctions had received more interest when a reserve price was used in conjunction with a low minimum.

When looking at this data statistically, we find a t-test value of 1.457766348, which lies well within both one- and two-tailed 5% confidence intervals – we are therefore unable to reject the null hypothesis that reserve and non-reserve auctions attract the same number of bidders. Note that the same conclusion can be drawn for participation – in this case the t-test value is 0.91420847. Such questions should thus ideally be repeated with a larger dataset, when one is available.

It may be interesting to consider further how a buyer should theoretically react to a reserve being in place. There will exist two possibilities for a reserve auction; one with a negligible minimum price, and one where the starting bid is actively used (of the 25 reserve auctions in the original sample, thirteen had a very low starting price (less than £1), and of these only one failed to attract any bids at all). The first case has been given an overview already, with a low starting price attracting initial bidders, and possibly giving the auction momentum to roll over the reserve. The second is maybe more interesting – in this case, we may consider the starting price as some sort of signal of what the seller is expecting the price range to be (obviously, he will not set the starting price at or above the reserve price, as this will warrant it worthless). The high starting price may also prevent speculative bids (those hoping for a low reserve price, and no competition, to secure a bargain), and by only encouraging those seriously looking to buy the good, the resulting bidding war may be more intense.

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more efficient. However, the idea of a reserve price is to protect the seller against sub-normal prices anyway, and so this procedure will make only marginal difference anyway.

Providing the highest bidder is above the minimum or reserve price, there should, in theory, be no difference in final price between reserve and non-reserve (with minimum bid) auctions with the same participants, *ceteris paribus*. To test such a result would take some specially generated data (much the same as that created for Lucking-Reiley (1999b); indeed, David Lucking-Reiley is currently working on such a dataset[16], but this looks set to only include one type of good – collectable cards – and as such may show some common-value bias), but a less extreme result can be considered here. Provided reserves and minimum prices are used effectively, the number of goods actually sold in either case should be the same. Of the data collected:

- 10% of cases ended in no sale in either types of auction
- 25% of cases ended with a sale in both types
- 30% of cases ended only with a sale in the non-reserve auction
- 35% of cases ended only with a sale in the reserve auction

We can therefore not reject the null hypothesis that the type of auction does not have an effect on the possibility of the item selling in this case; with a larger set of data clearer conclusions could be made.

Since the use of proxy bidding will mean that it should not matter to the outcome whether a reserve or minimum bid is used (since if the highest bidder is above this, the item will get sold), we must consider external reasons for the results being dissimilar. The most obvious of these will be a question of trust; with a reserve price, there exists asymmetry of information biased towards the seller. In a non-reserve auction, if someone places a valid bid, it is guaranteed that the item will be sold; this guarantee does not exist when a secret reserve is in place, and bidders may be unwilling to bid if it is possible that nobody will win the auction. This will be mainly due to a mistrust of the seller, and the possibility of him using the information given (of bid levels) to his own gain.

Although this may seem overly paranoid, it is a worry of a few of the bidders questioned that sellers may set reserve prices artificially high simply to judge the willingness to pay of bidders, before they relist their item at a more reasonable reserve

[16] From private communication.

price, or a high starting price. Indeed, since listing items is currently free on the UK eBay site, it is possible that sellers could run an artificial Dutch auction[17], with slowly reducing reserve prices until somebody exceeded the reserve and won the item. It is possible that the frustration of constantly failing to pass the reserve may cause some bidders to increase their maximum bid, so the seller would gain. There is, of course, the question of time, since each step would run over a minimum of three days, but in a lot of cases the seller is not desperate to get rid of an item.

IV Maximum bids

On a few auction sites, another of the seller's decisions is whether to set a maximum, or 'buyout', price for their auction. A maximum price is set so that any buyer whose bids exceed this level will win the auction automatically, and no further bids will be considered. The buyer, therefore, is guaranteed to win the auction if they are willing to pay a certain amount. There are two auction types that can be used in this case; firstly, as with the reserve prices above, any proxy bid placed over the maximum can automatically win instantly (and if the maximum price is known this would be equivalent to a non-auction transaction). Secondly, the maximum could only come into effect once the bidding passes the buyout price, with the time of placing the bid taking priority (simply the first bid to pass the maximum would not work, since with the use of proxy bidding this would be entirely random).

The latter case here would seem to be the most beneficial to the buyer, since it means that the maximum price would not be invoked unless bidding would take the cost above it anyway. This case does, however, significantly reduce the other benefit of using a maximum price – that of reducing the time period an auction runs over. This is, of course, beneficial to both parties, since it will reduce the cost to the seller of keeping the item in good condition (which may be considerable – occasionally, cars are auctioned on eBay, and until they are sold garage fees will have to be paid), and

[17] Dutch here is used as in the economic auction theory (first-price descending) sense of the word; eBay actually uses the term 'Dutch' for a multi-unit auction, which does not bear any resemblance.

the seller will get use of the good sooner than otherwise. If it were machinery or land being auctioned, on which rent must be paid until the day it is sold, the seller would obviously prefer the previous type.

However, it is the buyer who seems most likely to benefit from a maximum price being in place. Providing bidding will naturally take the amount over the maximum (in the second case above no provision is necessary), the buyer will pay less than or equal to the amount that would otherwise be necessary. There are, however, some disadvantages to the bidders, including one concerning efficiency. To give a rough example, say there was a good being sold with a buyout price set at £800. The highest valuation among bidders is £1000, but the first bid placed (using proxies) sets an upper limit at £900 (being the second highest valuation). Under both the systems described above, the good is won by the person with the second highest valuation rather than the highest, and it is therefore reduced to luck whether any particular bidder will win an item they want by visiting the site at an appropriate time.

It should be noted that maximum bids are not evident offline, since the advantages are heavily diminished – the time constraint does not exist, since auctions generally only last ten minutes, and the seller will therefore gain nothing by allowing the bidder to pay less than necessary for the good.

Of those sites which do operate a buyout price system (three were mentioned in Lucking-Reiley (1999a), but only one of these still seems to offer the option), it seems to be closer to the second system, with an 'NE' (not exceeded) level available to view[18]. Interestingly, however, there also sometimes exists a 'PP' (private purchase) price, at which any bidder can immediately bid and win the auction there and then, without the need to wait for other bidders. The 'PP' price is uniformly lower than the 'NE' price, and this could be considered as a first-case maximum price in addition to the 'NE' second-case. The bidder is then, in effect, given the option of a buyout if he feels his maximum price is sufficiently high, or he may elect to put in a proxy system

[18] See http://www.mackley.com for details.

in case the final price is lower – the decision will depend on risk-aversion, and the differences in price.

We may wish to examine how the existence of maximum prices will affect the behaviour of buyers. There will exist several states of the auction, depending on the relative values of the buyout price and of the bidder's valuation. Obviously, if the valuation is lower then the maximum price, then the buyer will not wish to take up the option of ending the auction – although were the valuation to be only slightly less, the certainty this brought may be worth the extra money. If the valuation of the buyer is above the maximum price, it seems likely that the buyer will wish to bring this into play, but under the first system above, he may be better off waiting until the bid levels are nearing the maximum. This would therefore appear to increase the problem of late bidding as discussed in section II.

However, the use of proxies (in the second case above) would eliminate this last point, since there would be no benefit in waiting to try and keep prices down. Indeed, if the first to place a bid over the maximum were deemed the winner, the use of proxies would be encouraged (additionally so if the value of the maximum were not known, so all those bidding could have a chance of exceeding it).

The question we aim to answer is whether eBay should allow its users to set maximum prices. While there seems to be small benefit in most cases, there can be no doubt that in a few areas there may be benefit to the seller from selling an item early, and if such an option is desirable, eBay should offer it.

V Final Discussion

Overall, we can see that the role of online auctions has expanded considerably over the last few years, with many individuals congregating to one site in particular. There is a very good argument for this convergence, and that is seen in analysis above – increased participation will often lead to more efficient sales and higher benefits for sellers. It is this high participation rate that should concern the sites that run online auctions, and the methods used to encourage this should be refined.

V a Proxy Bids

Proxy bidding, as a way of improving accessibility, is undeniably sensible. Without allowing those with less Internet access to participate on equal terms, the advantages to those with 'always-on' access will cause the auctions to run inefficiently. There are disadvantages to bidders, however, with the informational deficiency contributing heavily to a reluctance to use proxy bidding. This problem cannot be solved for common-value goods – bidders will still want to see how others value an item – but there are some ways of encouraging bidders to use proxies for private-value auctions. The main issue seems to be one of trust, and if the site can explain the system clearly to potential bidders, and ensure that they understand (and believe) the method is secure, the use of proxy bidding could be increased far beyond its current level. It would be interesting to see how the disparity between the numbers of bids and bidders had changed over time.

V b Reserve Bids

Given the evidence found above, it seems that the benefits of reserve bids and starting prices are roughly similar (although, as explained, the dataset was limited). The low usage of reserve prices, however, seems to indicate that sellers do not believe this to be the case, and it may be that eBay would wish to increase their use through information over the relative benefits of low starting prices and using secret reserves.

The findings above do indicate that those auctions with reserve prices do generally lead to higher participation rates, and also higher use of proxy bidding. Reserve prices will not suit all auctions, of course, and it is important that a choice is available. Further analysis could be conducted into which areas are most affected; however, the current uniform bias towards non-reserve auctions seems to be unfounded.

V c Maximum Bids

Although in a lot of cases, especially those in which there is little benefit through time savings, maximum bids will not be effectual, there will exist some cases where either the seller or the bidders will find their existence beneficial, without detriment to the other party. If eBay were to include such an option amongst its auction design, therefore, it is quite possible that some auctions would run more efficiently if they were to include it. While it could be expected that relatively few sellers would include such a clause, the cost to the site of including it would be minimal.

There is a slight risk of users being confused, but this could be overcome with clear instruction and worked examples. The extra incentive to use proxy bids can only reinforce this idea, and it is certainly a major argument for the availability of buyout prices, although there may be others.

V d Conclusion

While Internet auctions are clearly contained within auction theory, there are several specifications which distinguish them from other areas. These changes can have an effect on the behaviour of both seller and buyer, and when large-scale data becomes available the behavioural differences will be more evident. Further work should, therefore, look at the effects on prices and participation for similar goods, from which much stronger conclusions may be able to be drawn.

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Appendix 1: Data Collection

For the purposes of this survey, it would have been desirable to gather data directly from eBay, to cover a period of (say) three months. With such detailed data, it would have been possible to draw substantially stronger conclusions than offered here over the effectiveness of certain auction designs. However, currently eBay does not release data on auctions, although it has plans to do so in the future – it may be interesting, therefore, to run the tests considered in this paper when the complete dataset is available.

As a result, the data in this dissertation was collected by hand during the month of August 2000. eBay has a search facility allowing users to see how auctions for a specific good have progressed, and a specific search looking at completed items (at http://search-completed.ebay.com/, although this must be approached through the main site's search engines). Using this specific search, with nothing entered in the search box, we may find a list of recently completed auctions thus:

http://search-completed.ebay.com/cgi-bin/texis/ebaycomplete/
results.html?ht=1&query=&SortProperty=MetaEndSort&SortOrder=%5Ba%5D

Note: these links may point to expired auctions. If so, a browse of eBay's auctions will give a good picture of how the data was collected in conjunction with this explanation.

As you can see, the items returned vary greatly in all aspects, such as type, price, number of bidders, and even country of origin (we can tell this last one since some of the auctions are in German; indeed, on looking at the auction details we can see they are based in Germany). The data included on this list is not, however, sufficient, and we must look at each individual entry to gather the data needed (see Appendix 2). This is achieved by clicking on the entry, to return a page similar to[19]:

http://cgi.ebay.com/aw-cgi/eBayISAPI.dll?
ViewItem&item=393610390&ed=965297508

The description of this item seems a little vague, but in most cases buyers and sellers on eBay are proficient in the fields they deal in, and the informal style in which the buyer has written has been successful in this instance! The important areas to note are:

- The number of bids
- The start and end dates (and times)
- The time left on the auction (bidding has closed)

The instructions to bidders and sellers are self-explanatory, although note that shipping is not included (and thus may be a distortion on the results). The feedback system is another interesting feature – by allowing users to comment on others' reputation, eBay hopes to discourage fraud.

Note, however, that not all the data required appears on this webpage. We wish to see when the winning bid was placed, and to do this we must click on the bid history link (next to the number of bids). This takes us to the following page:

http://cgi6.ebay.com/aw-cgi/eBayISAPI.dll?ViewBids&item=393610390

Here we see a list of all the bidders that bid for the item, and top of the list is the eventual winner. Note that the list is sorted in magnitude of bid, not by time – in this case, the winning bid was placed by the last bidder (a mere six seconds before close of bidding), but the second highest bid was placed before the third highest (which was another case of sniping).

[19] This is from the third item on the previous list, chosen since it has a good list of bidders and allows greater clarity of explanation.

We are interested, however, in the winning bid, and so we would record the time Aug-03-00 03:11:42 PDT as the time the auction effectively ended (although all bids were closed at Aug-03-00 03:11:48 PDT). Note also that, although there were thirteen bids, only nine individuals participated in the auction. This indicates that some users bid more than once, and so the proxy bidding idea was not fully used.

In this auction, there was no reserve price, and with the item selling for 31 times the starting price, we may consider there to be effectively no minimum either. It is important for section III, however, that we are able to find items with a reserve price, and while eBay has no facility for searching just reserve auctions, we are able to see which items have reserves from their descriptions. When there is a reserve in place, a note appears next to the current price (in the case of completed auctions, the final price) advising whether or not this reserve has been exceeded. Note that the use of a reserve does not mean a minimum bid cannot be used as well, often as a guide, as in this case:

http://cgi.ebay.com/aw-cgi/eBayISAPI.dll?
ViewItem&item=390799235&ed=965297514

http://cgi6.ebay.com/aw-cgi/eBayISAPI.dll?ViewBids&item=390799235

Note that I have included the bid history for this item as well. Here we may see that there are over three times more bids than bidders, and this indicates that at least one individual has placed several bids to find where the minimum is. This is not needed, of course, as proxy bidding will only place a bid equal to the reserve if the maximum is higher. From the eventual winner’s feedback rating, however, we may consider him to have reason not to trust the system fully.

In this case, the reserve price was met, and the transaction continued as normal. In some cases, however, the reserve price is not met, and when this happens we may observe:

http://cgi.ebay.com/aw-cgi/eBayISAPI.dll?ViewItem&item=393610547&ed=965297591

http://cgi6.ebay.com/aw-cgi/eBayISAPI.dll?ViewBids&item=393610547

Although there were several bids placed (from two bidders), the reserve on this auction was not met. We are not able to observe on the site the amount of the reserve; we may only see it is greater than $29.84 (or £19.92). While no transaction has occurred here, it is possible that the seller will wish to contact the highest bidder and try to reach an agreeable price for both parties. Alternatively, the seller may wish to relist the item, and hope it sells in the second instance.

Contacting the highest bidder is not an option in the most extreme case, however; in the following auction there were no bidders, and so the reserve was not met:

http://cgi.ebay.com/aw-cgi/eBayISAPI.dll?ViewItem&item=398507875&ed=965297573

Note that this auction was ended prematurely by the seller, however. This would have prevented those bidders who had intended to bid within the last day from doing so, and as such is not a valid auction for our survey. Such cancellations are easy to spot – the end time is not a round period from the start time – and were eliminated to the best of my ability.

Finally, I asked a few of the sellers and buyers listed on eBay (from the seller and high bid entries) to respond to a few questions regarding the use of minimum and reserve prices. Those that did reply confirmed the results found in the text. Sellers generally believed a reserve price would deter people from participating, although they recognised it as a useful tool in some cases (one respondent cited uses in collectable goods, since with only one bidder there is the possibility that that bidder will not realise the true value). The best way to ensure a good sold was to have a low minimum, but reserves could be used in conjunction to ensure the price is not too low.

Meanwhile, bidders believed that the main factors affecting their personal participation concurred with this, although more than one believed they were more likely to bid in an auction with a low starting price. As mentioned in the text, buyers are distrustful of reserve auctions, since they may be abused to find willingness to pay by the seller, and so may cause a higher price to be paid in the long run.

Appendix 2: Data Lists

Following from Appendix 1, the data was collected into a spreadsheet thus. For reference, the item number and description were collected first:

Item #	Description
393610404	100 - 9/0 MUSTAD Tuna Hooks
393610390	Jungle Comics No. 91 VG+ NR
397235492	GREG BEAR - STRENGTH OF STONES - 1992 PB NR
390799234	the grid: swamp thing
390799235	Selmer (Paris) Mark VI Tenor Saxophone

Note that these five examples will be used for each of these lines of data below. For section II, it was important to note the times at which the auction started, finished, and at which time the last bid was cast:

Opening	Closing	Winning bid time
27/07/00 03:11:47	03/08/00 03:11:47	30/07/00 22:57:19
27/07/00 03:11:48	03/08/00 03:11:48	03/08/00 03:11:42
31/07/00 03:11:49	03/08/00 03:11:49	
24/07/00 03:11:49	03/08/00 03:11:49	25/07/00 08:30:16
24/07/00 03:11:54	03/08/00 03:11:54	03/08/00 03:11:51

Note that the centre observation has no winning time. This is purely due to it not having a bid placed, as we can see when looking at the number of bidders, and the number of bids (separate observations were needed to consider whether proxy bidding had been used by all individuals). At the same time, we would wish to see the structure of the auction, to consider (for section III) whether the use of reserve prices has affected the number participating:

# bids	# bidders	Minimum	Reserve	Reserve met?	Price in $	Price in £
2	2	y	n		16.00	10.68
13	9	n	n		31.00	20.70
0	0	y	n		7.00	4.67
1	1	n	n		1.00	0.67
10	3	y	y	y	4,300.00	2,871.18

The price is also included here to consider the use of minimum prices. While each auction must include a starting price, some sellers will set an infeasibly low price to encourage bidders. This is certainly true in the second example here – the original starting price was $1, while most bidders placed bids much higher than this. Very few auctions had (effectively) no minimum, possibly because of the danger which has befallen the fourth example – with only one bidder, the item has been sold for the minimum of $1. The 'reserve met?' column is obviously only used when there has been a reserve price. Prices in Pounds Sterling are only included to allow easy comparison for myself.

With this data collected, we wish to look at the time before the end that the last bid was placed. We calculate the length of the auction, the time before the end, and the proportion of time this represents. Finally, we find the proportion of time that has already passed:

Length of auction	Time before end	Proportion	1 - Proportion
07 00:00:00	03 04:14:28	0.453816138	0.546184
07 00:00:00	00 00:00:06	9.92064E-06	0.99999
03 00:00:00			
10 00:00:00	08 18:41:33	0.877885417	0.122115
10 00:00:00	00 00:00:03	3.47222E-06	0.999997

Again, for the third observation, there were no bids so the last three columns remain blank. It is this last column which allows us to form a cumulative distribution for winning bid placement time. Finally, as a measure of whether proxy bidding is failing, we may take the number of bidders from the number of bidders, and thus find how many bids were placed surplus to the ideal.

For reserve prices, each of the observations collected in the first run of 500 with a reserve price was copied to a separate database, and an item as close as possible (in terms of item description, age, price and length of auction), without a reserve price, was found. The data listed was similar to the above, but with no need for the winning bid time. From these two sets of data, the following were calculated:

Sample #	R Item #	N Item #	Greater R participation	Greater R bids	Greater R sold
1	390799235	401823915	3	10	1
2	390799059	409147110	5	7	1
3	402326296	406950220	0	-12	0

Here R stands for Reserve, and N stands for Non-reserve. The ‘Greater R’ columns represent the number of bidders in the reserve auction minus the number in the non-reserve auction, and so on; thus in the third observation there were twelve more bids in the non-reserve auction. The last column compares which of the items were sold overall – here 1 represents that the reserve auction sold but the non-reserve did not, while -1 will mean the opposite. A zero can mean either that both of the auctions resulted in a sale, or that neither did. This data then leads to the conclusions shown.

Appendix 3: Statistical Working

Section II b: Structural Breaks

The difference from the ideal in section II b for timings of the end of auctions is quite evident, but it is interesting to look at when a structural break does occur. The cumulative distribution was formed automatically in the form:

Time	Number ended
0.01	1
…	…
0.95	133
0.96	138
0.97	151
0.98	161
0.99	177
1	255

and regressions were run on this data alone. A dummy variable was then added:

Time	Number ended	Dummy
0.01	1	0
…	…	…
0.95	133	0
0.96	138	0
0.97	151	1
0.98	161	1
0.99	177	1
1	255	1

at various time points, and it was found that the value of R^2 was lowest with a dummy changing at time point 0.97. At this point, R^2 had a value of 0.923366, compared with a value of 0.794984 for the model with no dummy. To test for a structural break here, we may use the test:

$$\frac{R_U^2 - R_R^2 / q}{1 - R_U^2 / n-k}$$

which is compared to the critical value $F_{q,n-k}$, where q is the number of variables under investigation (here 1), n is the number of observations (101), and k is the number of variables in the unrestricted model (3). The subscripts U and R refer to the restricted (no dummy variables) and unrestricted (with dummy variables) models respectively. In this case, the value returned is (as disclosed in the main text) 164.1737.

Section III: Number of Bids

We use a standard t-test here; the list of differences in bids has an average of 2.6 and an estimated standard error of 7.976280626 (found using the AVERAGE and STDEV commands in Microsoft Excel respectively). The test statistic is thus:

$$\frac{2.6-0}{7.9763 / \sqrt{20}} = 1.457766348$$

which is then compared to the standard Normal critical values. Note the 20 here is the sample size, since we are using the estimated standard deviation.

Section III: Likelihood of a Sale

No explicit statistical working is needed here. With only one more auction ending biased towards the reserve side, it is obvious that no firm conclusion can be drawn, and so we may not reject the null hypothesis of no effect. When data is released from eBay, and more auctions can be compared, it would be interesting to reconsider this analysis.