December 2003

Transaction Risk Management in Online Auctions

Ram Gopal
University of Connecticut

Steven Thompson
University of Connecticut

Y. Alex Tung
University of Connecticut

Andrew Whinston
University of Texas at Austin

TRANSACTION RISK MANAGEMENT IN ONLINE AUCTIONS

Ram Gopal
Operations and Information Management
University of Connecticut
Storrs, CT USA
Ram.Gopal@business.uconn.edu

Steven Thompson
Operations and Information Management
University of Connecticut
Storrs, CT USA
sthompson@business.uconn.edu

Y. Alex Tung
Operations and Information Management
University of Connecticut
Storrs, CT USA
Alex.Tung@business.uconn.edu

Andrew B. Whinston
Management Science and Information Systems
University of Texas at Austin
Austin, TX USA
abw@uts.cc.utexas.edu

Abstract

The scenario of business sellers utilizing online auction markets to reach consumers and sell new products is becoming increasingly commonplace. We propose a class of risk management tools, loosely based on the concept of financial options, *that can be employed by such sellers. We examine market conditions, and risk and option pricing scenarios where writing options is beneficial to sellers, and purchasing options is beneficial to buyers. We provide a framework to analyze the value proposition of options to potential buyers, option holder behavior implications on auction processes, and seller strategies to write and price options that maximize potential revenues. Preliminary results based on actual auction data suggest that options can provide significant benefits under certain conditions.*

Keywords: E-business, auctions, options, risk management, inventory

Introduction

Over the past few years, online auctions such as eBay and UBid have emerged as a viable mechanism for trading a number of goods. Initially these auction sites catered almost exclusively to used, collectible, or otherwise idiosyncratic and/or unique merchandise. Over time, the range of goods available has expanded to include a wider array of product categories such as commercial electronics, automobiles, and durable consumer products, where bidders can bid on new items directly from the manufacturer or retailer.

The volume of trade in online auctions has grown at a phenomenal pace. For example, eBay, currently the world's largest online auction house, transacted a total of $14.87 billion worth of auction items in 2002. This represents rapid growth from $5 billion and $9.3 billion in 2000 and 2001, respectively. Unsurprisingly, this growth rate shows little sign of abatement (**http://www.ebay.com**). An observation by eMarketer, an e-business research organization (**http://www.emarketer.com/**), is that "more and more companies use online auctions as a means to sell or acquire large quantities of new items." For these companies, auctions represent an opportunity to increase revenues by expanding the reach of the organization to include many more potential customers and by decreasing procurement costs. In addition, auctions also provide an efficient means to liquidate surplus inventory.

In order to highlight the growing importance of business sellers, who typically sell multiple units at online auctions, we collected data on every auction for seven different items from eBay for the period 11/18/2002 through 1/15/2003. We carefully examined these auctions to make sure that the auctions were for new, unopened, identical items. We found that sellers liquidating multiple identical items sponsor a significant proportion of the observed auctions. Table 1 shows the total number of auctions for each item and the proportion of these auctions attributable to sellers moving multiple units.

Table 1. Proportion of Auctions Due to Sellers of Multiple Items

Item	Total # of auctions	Proportion of auctions due to sellers of multiple units
Bose Radio	375	.661
Grand Theft Auto	2178	.814
Palm 515	304	.822
Palm Tungsten	383	.765
Philips MP3 player	250	.932
Play Station 2	1963	.795
Windows XP	691	.768

While auctions are known to be efficient mechanisms from the standpoint of allocating items to the bidders with the highest valuations, the auction mechanism itself creates a scenario where both bidders and sellers of multiple units face a number of risks.

Seller Risks

In a scenario where multiple units are slated for liquidation at auction, a seller faces the dilemma of whether to (1) auction all units in a single auction; (2) divide the units into blocks and auction them either simultaneously or sequentially; or (3) use a combination of single-unit and multiple-unit auctions simultaneously or sequentially. The associated risks with either simultaneous or sequential auctions are described below.

Simultaneous Single- or Multiple-Unit Auctions

- Dilution effect: The greater the number of auctions that are running simultaneously for a given item, the more likely the pool of interested bidders at each auction will shrink. This results in a lower final ending price. The end result is that, while inventory costs motivate a seller to liquidate merchandise as quickly as possible, *the dynamics of the auction market make the seller trade off between minimizing carrying costs and maximizing revenue*.

- Herd behavior (Dholakia et al. 2002; Dholakia and Soltysinski 2001): Herd behavior will result in the loss of high valuation bidders (Alsemgeest et al. 1998). If bidders with the highest valuations all participate in a single auction, or some small set of auctions, while bidders with lower valuations participate in different auctions, the result is that the seller does not realize optimal revenue.

Sequential Single- or Multiple-Unit Auctions

- The timing of bidder entry and exit: If a large proportion of high valuation bidders enter at approximately the same time, then the final prices of the other auctions will be lower than if these bidders were more evenly dispersed.

Buyer Risks

For any auction participant, the auction mechanism itself and the fact that it can be difficult to locate and monitor all auctions of a given item, result in uncertainties. These uncertainties represent risks that are present for all participants but subjective in magnitude. The following risks are relevant to the online auction setting:

1. The inability to acquire an item at auction within a known time interval.

2. Due to non-trivial search costs, a bidder may not be aware of all available auctions. This will result in bid amounts higher than would otherwise be necessary.

In order to address these risks, we propose a set of tools based on the concept of options. We briefly introduce options, address related research, and then discuss the fundamental principals that underlie extant option pricing models. We will show that while the risk management properties of options have appeal to both buyers and sellers in online auctions, the structure of online auctions does not allow for the utilization of any existing option pricing model and thus motivates the need for an alternative framework.

An Introduction to Options

Broadly speaking there are two types of options: calls and puts. A call gives the holder (buyer) the right, but not the obligation, to buy some underlying commodity at a given price within a given time period. A put gives the holder the right, but not the obligation, to sell some underlying commodity at a given price within a given time period. By contrast, the seller of a call assumes the obligation to sell the underlying commodity at the agreed upon price at the buyers discretion. And the seller of a put assumes the obligation to purchase the underlying commodity at the agreed upon price at the buyers discretion. The price at which the underlying commodity may be bought or sold is referred to as the strike price.

A well-known arena for the utilization of options is in securities markets, where options are bought and sold primarily for the purposes of hedging risks associated with future financial obligations, and to an extent for the purposes of speculation. Options are also used for non-financial commodities, as a tool to manage the risks associated with price volatility of commodities such as petroleum derivatives, precious metals, and numerous agricultural products.

In recent years, options have received attention from both academia and industry as a conceptual basis from which risk management tools and strategies can be developed. In the context of e-business, an option framework has been used as the basis for evaluating the impact of dynamic pricing for companies that employ a posted-price business model (for an extensive review of dynamic pricing research, see Elmaghraby and Keskinocak 2003). Options, or alternatively the related concepts of futures or forward contracts, have also been used as the basis for the valuation of contingency contracts on manufacturing capacity (for examples where the underlying asset is considered perishable or otherwise non-storable, see Spinler et al. 2002, 2003; Tanlapo et al. 2002). The question of whether to purchase options to cover the risk associated with uncertain future demand for a non-storable good is addressed in Schummer and Vohra (2001).

From an industry standpoint, a number of e-business companies have emerged that create electronic marketplaces for the buying and selling of spot and future contracts on a number of commodities. For example, ChemConnect and CheMatch offer an online exchange for various chemicals and, in addition, provide for the sale and purchase of forward contracts. Similarly, Energyclear is an industry owned and operated clearing-house for "over-the-counter" energy that also offers futures. In a more general vein, onExchange offers market-clearing services for virtually any commodity. These industry examples share the common strategy of market aggregation in that the value-added service is the creation of a single market place, thereby improving liquidity and stabilizing price volatility.

Another commonality that exists between all of the industry examples above and the research cited previously is the concept of a spot price. In all cases, the nature of the underlying commodity is such that, at any given moment, a unit price can be quoted to a buyer or seller. In the next section, we will show that this, and other assumptions common to a number of financial and real option pricing models, will not hold when extending the general concept of options into the realm of online auctions.

In an online auction setting, options would be employed, conceptually, in a very similar manner to a traditional financial or commodity market setting. An interested buyer would pay the writer of the option a sum of money and in return receive the right, but not the obligation, to purchase the item at a specified price by some specified future date. An option holder is then free to act in a manner that maximizes the value of the option. For example, an option holder with high search costs may not participate in any auctions, at which point the option would be used in a manner similar to the "buy it now" feature offered by some auction sites.

By contrast, an option holder with low search costs may decide to participate in a large number of auctions, seeking to win the item at a price lower than the strike price of the option. In this scenario, the option is used as an insurance policy to ensure that the holder does not leave empty-handed. Depending on individual search costs, any type of behavior between these two extremes is expected.

Option Pricing Principles

While the conceptual definition of an option is the same whether referring to financial, commodity, or auction markets, the fundamental differences between the markets create marked differences in how options are used and priced, and the impact of the options on the underlying market. Table 2 summarizes the differences between financial markets and auction markets.

Table 2. Differences Between Financial and Auction Markets

	Financial Markets	Auction Markets
Price Movements*	Follow lognormal distribution	May not follow lognormal distribution
Arbitrage	No arbitrage opportunities	Arbitrage is possible
Price Volatility*	Constant	May be variable
Impact of Options on Underlying Asset	Options are a redundant security	Options can impact the price of the asset on which they are written
Valuation	Objective	Subjective
Market Structure	Centralized Double Auction, one prevailing price at any given moment	Decentralized, no one price

* Comparison is specific to the Black-Scholes option-pricing model.

It is important to note that with the exception of price movements and volatility, these properties are fundamental to all option pricing models. We incorporate properties specific to the Black-Scholes model because this model is often the basis for more elaborate option-pricing models. Existing research, cited previously, extending options into e-business and supply-chain management also invoke, either explicitly or implicitly, many of these assumptions. Therefore, testing the assumptions of the Black-Scholes model provides insights into the difficulties of pricing options in an online auction setting. We use the auction data collected to test the key assumptions of the Black-Scholes option-pricing model.

We can show that not only do auction prices not follow a lognormal distribution or necessarily show constant volatility, but also that the more general fundamental conditions of no-arbitrage, options as a redundant security, and the law of one price do not hold either.

Auction Option Framework

Since it is not clear that any existing option-pricing methodology can be employed, we begin by defining an option framework that determines the number of options that should be written and the contract parameters based on market tolerance. That is, the framework is fundamentally based on the principle of supply and demand. In an auction setting, the impact of an option, in terms of risk management and market impact, can only be felt if the option is purchased. It then seems reasonable that there exists some option price and strike price such that the number of buyers that are interested in purchasing an option with said contract parameters is roughly equal to the number of options a seller would be willing to write under those conditions. To better understand the nature of the supply-demand relationship as option prices and strike prices change, we explore the value propositions of options to both buyers and sellers.

The Value Proposition of Options to Potential Buyers

All individuals have some personal valuation for any given item. In addition, all individuals have some valuation for their time as well. Auctions differ from posted price venues in that when an individual goes to an auction, they must be prepared for the possibility that they will spend a certain amount of time trying to acquire an item, but leave empty-handed. This problem is compounded when not only is time valuable, but a time constraint exists with respect to the latest date that the item can be acquired. If a bidder wants to increase the likelihood that she will win an auction, she is forced to place bids that are close to her valuation for the item. Even assuming that the bidder will never bid an amount greater than her valuation, the act of having to bid at amounts close to her valuation detracts from the appeal of participating in an auction.

The following decision tree characterizes the choices that individuals must make when considering whether to purchase at a posted price venue, participate in an auction, or participate in an auction and purchase an option.

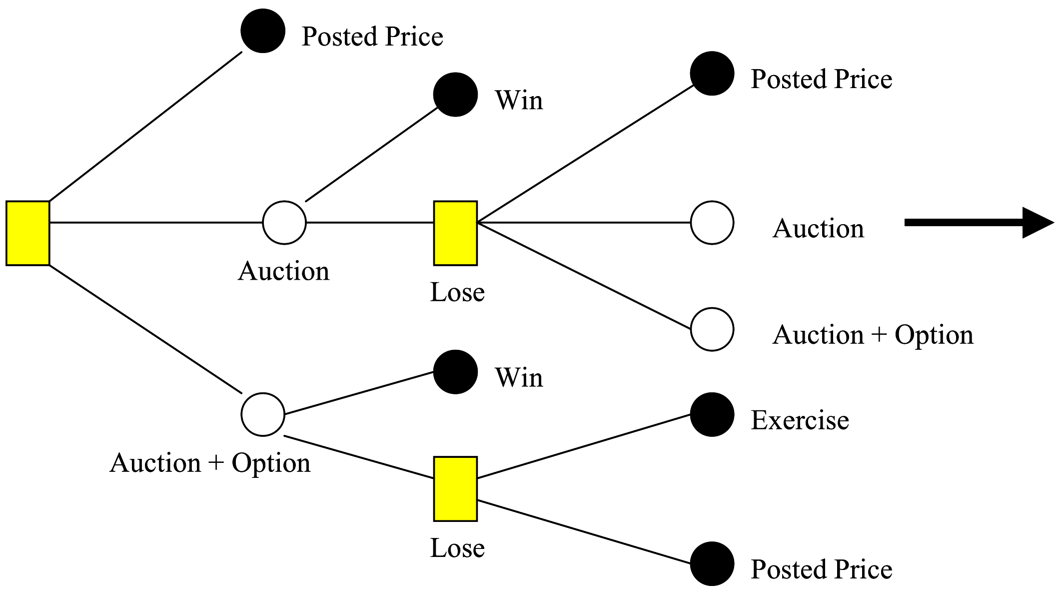

Figure 1. The Decision Tree for Auction Bidders

Figure 1 shows that introducing options into an auction setting allows buyers to obtain some of the desirable characteristics of a posted price channel (e.g., guaranteed acquisition of the item, known price) while retaining the desirable characteristics of an auction (e.g., the opportunity to get a "good deal"). Any potential buyer must determine whether the price of the option and the associated strike price is a worthwhile investment. Clearly if the option price plus the strike price is greater than a known posted price, the option will not be considered attractive. Likewise, if a potential buyer has a very low search cost and is under no firm time constraints as to when the item must be acquired, paying for the right to purchase the item would not necessarily be considered a value-adding proposition. In addition, if a given participant is looking for, say, a Sony camcorder or "something like it," then an option that specifies a particular good may be seen as overly restrictive and therefore unattractive.

However, for a large number of participants we see that the risk of leaving an auction empty handed is considered a real risk. Presently a number of auction sites offer a "buy it now" feature that allows bidders who *must* have the item to terminate the auction at a particular price. We observe that a substantial number of auctions end with "buy it now." Table 3 illustrates the proportion of auctions ending with "buy it now" for the seven items we monitored.

Based on the information in Table 3, it seems clear, that given the right price and strike price, options would be desirable to some auction participants. We must then address whether a seller would be interested in writing options with a set of contract parameters that would be seen as desirable by some of the auction participants.

Table 3. Auctions Ending with "Buy It Now"

Item	Total # of auctions	Auctions ending with "buy it now"	Proportion of auctions ending with "buy it now"
Bose Radio	375	125	.333
Grand Theft Auto	2178	461	.212
Palm 515	304	110	.362
Palm Tungsten	383	140	.365
Philips MP3 player	250	120	.48
Play Station 2	1963	437	.223
Windows XP	691	132	.191

The Value Proposition of Options to Sellers

In order to better understand the value proposition of options to sellers we begin by assuming a scenario in which the seller conducts one or more auctions during one or more discrete time periods. The seller is interested in writing options that originate at time t and expire at time $t + 1$. These time periods do not imply that all auctions within a time period run simultaneously. For example, a time period could span a two-week time frame with multiple auctions starting and ending at different times during that period. We now introduce some notations:

Let K and C represent the strike price and option price respectively.

Let n and m represent the number of bidders and the number of items to be auctioned respectively.

Let β represent the number of options purchased

Let $D_t(\beta; K, t+1, C)$ be the discrete demand function representing the demand for options with a given set of contract parameters

Let γ represent the number of options exercised

Let m^t represent the number of auctions run during time period t

Let $G_t(\gamma; K, t+1, E(D), n, m_t)$ be a discrete function representing the number of options exercised given a set of contract parameters, the demand for options, the number of participants in the auctions, and the number of items available to auction

Let $E(\overset{A}{R}_{E(D_t)})$ represent the expected revenue from auctioning an item when $E(D_t)$ options are active

In order to maximize revenue the seller must determine optimal values for m_t, K, and C according to the following:

$$Max \sum_t E(D_t)*C + E(G_t)*K + E(\overset{A}{R}_{E(D_t)})*(m_t - E(G_t)) \quad (1)$$

Subject to:

$$E(D_t) \leq \sum_{t+1}^{T} m_t \qquad \forall\, t \tag{2}$$

$$K,\ C \geq 0 \tag{3}$$

$$m_t \geq 0, \text{int} \qquad \forall\, t \tag{4}$$

Since options are not currently used in online auctions we do not have the data necessary to solve the problem defined by equations (1) through (4). The approach we take is to develop a set of heuristic algorithms that utilize bid-by-bid data from recent auctions to approximate the expected demand for options. Based on expected demand, we approximate the revenue implications of the impact of the options on the auctions that are conducted.

Conclusions and Deliverables

By analyzing bid-by-bid data from a number of real auctions, we have been able to demonstrate that, with a proper strike price, options are both attractive to buyers and beneficial to sellers. Options are attractive to buyers as risk management tools that place an upper bound on the maximum price that will be paid and removes the uncertainty of acquisition. The benefit to a seller due to options is from three sources: (1) increased revenue from the tendency of options to allocate goods toward bidders with higher valuations, (2) the potential for options to induce behavioral changes on the part of the option holder, and (3) the sale price of the option.

The next steps are to complete the empirical tests to determine whether the assumptions of the Black-Scholes option-pricing model hold in an online auction environment. With this knowledge we can then begin to develop a more formal framework for this option-pricing scenario. Then final step is to complete a set of heuristic algorithms, based on recent bid histories, which sellers can employ to begin writing options.

The results of this research should motivate managers in organizations that utilize online auctions as a sales channel to begin to evaluate the potential impact of writing options on the revenue realized from these auctions. The utility of options in an online auction setting is potentially more profound when considering business to business auctions. In these settings, time constraints are significant and risks from non-acquisition are substantial. These are precisely the conditions under which options as risk management tools are most beneficial. Since a large proportion of business to business auctions are reverse auctions, we intend to explore the utilization of *put* options on these auctions.

References

Alsemgeest, P., Noussair, C., and Olson, M. "Experimental Comparison of Auctions Under Single- and Multi-Unit Demand," *Economic Inquiry* (36:1), 1998, pp. 87-97.

Dholakia, U. M., Basuroy, S., and Soltysinski, K. "Auction or Agent (or Both)? A Study of Moderators of the Herding Bias in Digital Auctions," *International Journal of Research in Marketing* (19:2), 2002, pp. 115-130.

Dholakia, U. M., and Soltysinski, K. "Coveted or Overlooked? The Psychology of Bidding for Comparable Listings in Digital Auctions," *Marketing Letters* (12:3), 2001, pp. 225-237.

Elmaghraby, W. , and Keskinocak, P. "Dynamic Pricing in the Presence of Inventory Considerations: Research Overview, Current Practices and Future Directions," *Management Science*, Special Issue on E-Business, October 2003.

Schummer, J., and Vohra, R. "Auctions for Procuring Options," *Operations Research* (51), 2003, pp. 41-51.

Spinler, S., Huchzermeier, A., and Kleindorfer, P. R. "An Options Approach to Enhance Economic Efficiency in a Dyadic Supply Chain," in *Cost Management in Supply Chains*, S. Seuring, and M. Goldbach (eds.), Physica Verlag, Heidelberg, 2002, pp. 350-360.

Spinler, S., Huchzermeier, A., and Kleindorfer, P. R. "Risk Hedging via Options Contracts for Physical Delivery," *OR Spectrum*, 2003, forthcoming.

Tanlapo, E., Lawaree, J., and Liu, C. C. "Hedging with Futures Contracts in a Deregulated Electricity Industry," *IEEE Transactions on Power Systems* (17), 2002, pp. 577-582.