A REPORT TO

the HONORABLE W. TAYLOE MURPHY, JR.
SECRETARY OF NATURAL RESOURCES

and the

GENERAL ASSEMBLY OF VIRGINIA

THE AUCTION of NO_X NEW SOURCE SET-ASIDE ALLOWANCES

2003 LEGISLATIVE REPORT
in response to
CHAPTER 899 of the 2002 ACTS of ASSEMBLY

prepared by the

DEPARTMENT OF ENVIRONMENTAL QUALITY

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EXECUTIVE SUMMARY

Subsection D of Item 383 of Chapter 899 of the 2002 Acts of Assembly contains the following provision:

> The Department of Environmental Quality may auction the NO_X emissions credits allocated under the NO_X SIP call as set asides for new sources and any revenue generated shall be deposited to the general fund of the state treasury. Prior to any auction, the department shall report to the Secretary of Natural Resources and to the Chairman of the Senate Finance and House Appropriations Committees on the process by which an auction shall be conducted. The report shall be submitted no later than January 8, 2003.

A range of options is available to auction the NO_X emissions set aside allocations for new sources. Each option has its advantages and disadvantages. Each option will require very specific expertise and management time to be executed successfully. In fact, in a recent e-mail from Michael R. Baye, Bert Elwert Professor of Business Economics, Department of Business Economics and Public Policy, Kelly School of Business, Indiana University, he stated that "auction design is quite complicated and the optimal auction format will generally depend on characteristics of the particular industry or market. Typically, agencies like the Federal Communications Commission hire economic consultants to help design auctions."[1]

Kate Reynolds, author of a number of articles on auctions from Agorics, Inc. describes auction strategy as "numbingly complex with numerous variables coming into play."[2]

And, James R. McGuigan, co-author of Managerial Economics Applications, Strategy and Tactics, while discussing various auction designs states, "Which of these and other auction design characteristics maximize the revenue to the seller and which allocate resources to their highest-valued use are important business questions and public policy issues."[3] This is because auctions are involved in most aspects of our lives form the mortgage rate you pay (in part due to auctions held by the U.S. Treasury for government securities) to which TV. station will broadcast NFL football games on Monday nights.

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[1] E-mail response from Michael Roy Baye to M.E. Major, October 10, 2002.

[2] Reynolds, Kate, "Auction Strategies" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[3] McGuigan, James R., Moyer, Charles, R., and Harris, Frederick H. deB., Managerial Economics Applications, Strategy and Tactics, South-Western, 2002. p. 611.

SUMMARY OF CHAPTERS

Types of Auctions

It is agreed that there are four basic types of auctions; English, Dutch, first-priced sealed-bid and Vickrey, otherwise known as a uniform second-price auction. An English auction is the format that most of us are familiar with and is an ascending-price auction where all bids are known. The Dutch auction also uses an open format rather than a sealed-bid method, however, it is a descending-price auction. The first-price, sealed bid is just that; all bids are sealed such that no one knows anyone else's bid and the highest bid wins. The fourth type of auction is the Vickrey auction otherwise known as uniform second-price auction. In this sealed-bid auction the winner is awarded the item at a price equal to the value of the second-highest bid.

Winner's Curse

Winner's curse occurs when a winning bid is accepted at an inflated price. This is common during an English auction when inexperienced bidders run the price up due to the excitement of the moment or due to the encouragement of the auctioneer.

Winner's curse can have a dampening effect on repeat auctions, therefore, some auction designs will minimize the phenomenon, others encourage it.

Collision

All auction types can be manipulated. Walter Mead[4] has suggested that the English auction or open bid formats are more susceptible to collusion than are sealed-bid auctions. This may explain the popularity of sealed-bid auctions even though the open bid formats usually generate greater revenue. However, under the English auction format it is very easy to form rings.

Reynolds[5] explains that sealed-bid auctions, on the other hand, are vulnerable to collusion involving the auctioneer and one or more bidder. This format is less prone to rings because sealed bidding tempts participants to bid higher than the agreed-upon price in order to cheat the others. This is also true for the Dutch format, even though it is an open format since the first defecting bidder ends the auction. Paul Milgrom[6] points out that the "collusion is hardest to support when secret price concessions are possible, and easiest to support when all price offers must be made publicly.

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[4] Mead, Walter, "Natural Resource Disposal Policy: Oral Auction Versus Sealed Bids", Natural Resources Journal, Vol. 7 (April, 1987), pp. 195-224.

[5] Reynolds, Kate, "Collusion and Tricks" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[6] Milgrom, Paul, "Auctions and Bidding: A Primer", Journal of Economic Perspectives, Vol.3 (Summer, 1989) pp.3-22.

E-Trading

The issue of electric auctions, particularly with regard to NO_X emissions credits, as demonstrated by the above article, is too new to evaluate. However, the above suggests that the already established markets (brokerage firms) will continue to serve as the primary venue for selling and buying allowances as the commodity is just too valuable to risk a less conventional method. At least at this time.

Auction Strategy

James R. McGuigan[7] provides the following summary of auctions design choices.

◆ Auction design choices are multi-faceted but at the simplest level always include who pays, what amount, and how the winner is determined.

◆ Auctions also differ in the resale opportunities available to the participants. Common value auctions lave thick resale markets where the item can be easily resold at a consensual fair market value. Private value auction items have not common resale value and instead involve assets with differing valuations to the auction participants.

◆ The winner's curse implies strategic underbidding is rational when the seller or other buyers have asymmetrically advantage information about a common value auction.

◆ Open bidding is a procedure for posting the offers in multiple rounds with cancellation and modification privileges to induce the winner's curse and raise expected auction revenue in common value auctions.

◆ What simple auction types raise the greatest revenue for the seller-auctioneer depends upon the common value or private value nature of the item being auctioned and on the auction participants' risk-aversion.

◆ Dutch auctions and First-Priced Sealed Bid auctions have identical information structures, identical bidding strategies, and therefore, generate identical expected revenue.

◆ Relative to Dutch or First-Priced Sealed Bid auctions, English ascending price and Vickrey or Second-Highest Sealed Bid auctions raise expected revenue in common value auctions for items like crude oil, forest logging rights, and aircraft because they encourage the most pooling of bidder information. In private value auctions, bidders who are risk-averse offer higher bids and therefore generate more auctioneer-seller revenue in Dutch and First-Priced Sealed Bid auctions.

[7] McGuigan, James R., Moyer, Charles, R., and Harris, Frederick H. deB., Managerial Economics Applications, Strategy and Tactics, South-Western, 2002. p. 623.

RECOMMENDATION

The Department is tentatively inclined to use the first-priced, sealed-bid type auction as the process for auctioning the NO_X allowances. This type of auction is used for selling sulfur dioxide allowances or credits under the U.S. Environmental Protection Agency's Acid Rain Program, which is similar in concept to the Commonwealth's NO_X Budget Trading Program. In order to minimize the addition of resources to the Department, the administration of the auction would be through a contractor to be financed by the proceeds of the auction.

Because the nature of auction design is so very complex, prior to making a final decision, the Department plans to solicit the assistance of experts in the field who understand the complexities of auctions and the many variables associated with them to develop the appropriate auction design to meet the specific needs of the Commonwealth.

The current regulations of the Board governing the NO_X Budget Trading Program (9 VAC 5 Chapter 140) do not accommodate an auction as the means of distributing the new source set-aside allowances and would need to be amended in order to allocate the emission credits set aside for new sources through an auction process. During this collaborative process, DEQ would solicit input from the various stakeholders about the design and implementation of an auction system prior to making any final decisions.

By soliciting the input of experts in the field and stakeholders within the Commonwealth, the Department believes that this would result in an auction process that is effective and efficient and best serves the public interest.

I. INTRODUCTION

This report will review the various types of auctions and associated auction strategies. Simply stated, an auction is a method of allocating scarce goods, a method that is based upon competition. [Reynolds] indicates, that:

> It is the purest of markets: a seller wishes to obtain as much money as possible, and a buyer wants to pay as little as necessary. An auction offers the advantage of simplicity in determining market-based prices. It is efficient in the sense that an auction usually ensures that resources accrue to those who value them most highly and ensures also that sellers receive the collective assessment of the value. What is unique about the auction is that the price is set not by the seller, but by the bidders.
>
> On the other hand, it is the seller who sets the rules by choosing the type of auction to be used.[8]

One must also be aware of the basic two motivations that people have for participating in an auction. The first reason concerns an individual's personal reason for obtaining the object and, therefore, has a private valuation of the item to be auctioned. That information is kept private, as there would be no point in the auction if the seller knew how much the highest valuation of an object might be.

The other reason or motivation for participation in an auction is to acquire items for resale or for commercial use. The object doesn't just have a private valuation but it also has an estimated future value for other buyers. Those who bid in this scenario try to estimate the ultimate price on the items using the same measurements of other bidders. This is called a common-value assumption. It should be noted that bidding behavior will change depending upon the motivation of those participating in the auction.

In economists' terms, "Optimal mechanism design seeks to elicit value-maximizing behavior while reducing transaction costs.

[8] Reynolds, Kate, "Going...Going...Gone" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

II. TYPES OF AUCTIONS

Auctions are classified in many different ways. There are open auctions and there are auctions where the bids are sealed. Some auctions are conducted in such a manner that the price ascends and there are auctions where the price descends and a variety of additional schemes and formats associated with each.

In general, however, it is agreed that there are four basic types of auctions; English, Dutch, first-priced sealed-bid and Vickrey, otherwise known as a uniform second-price auction. An English auction is the format that most of us are familiar with and is an ascending-price auction where all bids are known. The Dutch auction also uses an open format rather than a sealed-bid method, however, it is a descending-price auction. The first-price, sealed bid is just that; all bids are sealed such that no one knows anyone else's bid and the highest bid wins. The fourth type of auction is the Vickrey auction otherwise known as uniform second-price auction. In this sealed-bid auction the winner is awarded the item at a price equal to the value of the second-highest bid.

A. English Auction

[Reynolds] summarizes the English as follows: "The English auction is the format most familiar to Americans and is known also as the open-outcry auction or the ascending-price auction. It is used commonly to sell art, wine and numerous other goods."[9]

Paul Milgrom defines it as such: "Here the auctioneer begins with the lowest acceptable price--the reserve price--and proceeds to solicit successively higher bids from the customers until no one will increase the bid. The item is 'knocked down' (sold) to the highest bidder."[10] If the auction does not start at the reserve price, i.e. the bidding begins below that mark and the reserve price is not met during the bidding then the item may not necessarily be sold.

Despite the seeming simplicity, the English auction format can be quite complex. Often bids are not voiced out loud but are singled, for example by an ear tug or raising a paddle, etc. Many bidders like the semi-anonymity; if one is a known expert in the field of items being auctioned, art work for example, the knowledge that he is bidding might increase the price. The auctioneer has enormous discretion in this type of auction as the decision to accept the signals or bids is totally up to him. If he suspects a ring he can ignore the bid. (See the section on Collusion for further information about rings.) In another variation the auctioneer

[9] Reynolds, Kate, "Auction types--English" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[10] Milgrom, Paul, "Auctions and Bidding: A Primer", Journal of Economic Perspectives, Vol.3 (Summer, 1989) pp.3-22.

calls out each asking price and bidders lift a paddle to indicate their willingness to pay that amount. Then the auctioneer calls out another price. He can exert great influence to the audience of bidders via voice modulation and his personality, egging bidders on. This can lead to winner's curse, where an individual pays more that what an item is worth. This type of auction is prone to the winner's curse phenomena as it is a very common auction strategy and inexperienced participants tend to bid up the price. However, winner's curse can be evident in other auctions as well. (See section on Winner's curse for further examples.)

It should be noted that, from the seller's viewpoint, the key to a successful auction is the effect of competition on the potential buyers. Reynolds states:

> In an English auction, the underbidder usually forces the bid up by one small step at a time. Often a successful bidder acquires an object for considerably less than his maximum valuation simply because he need only increase each bid by a small increment. In other words, the seller does not necessarily receive maximum value, and other auction types may be superior to the English auction for this reason (at least from the seller's perspective). [Varian][11]

Another disadvantage to the English system is that a buyer must be present which may be difficult and/or expensive. Finally, this auction type is highly susceptible to rings.[12]

B. Dutch Auction

The auction uses an open format rather than a sealed-bid. This is the process used in the Netherlands to sell flowers and bulbs, thus the name, Dutch auction. Reynolds describes the process as follows:

> In a Dutch auction, bidding starts at an extremely high price and is progressively lowered until a buyer claims an item by calling "mine", or by pressing a button that stops an automatic clock. When multiple units are auctioned, normally more takers press the button as price declines. In other words, the first winner takes his prize and pays his price and later winners pay less. When the goods are exhausted, the bidding is over.

[11] Varian, Hal R., "Economic Mechanism Design for Computerized Agents", May 1995.

[12] Reynolds, Kate, "Auction types--English" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

> Dutch auctions have been used to finance credit in Rumania and for foreign exchange in Bolivia, Jamaica, Zambia and have also been used to sell fish in England and in Israel.
>
> Dutch auctions are common in less obvious forms. Filene's, a large store in Boston, keeps in its basement a variety of marked-downed goods, each with a price and date attached. the price paid at the register is the price on the tag minus a discount that depends upon how long ago the item was tagged. As time passes and the item remains unsold, the discount raises from 10 to as high a 70 percent.[13]

As previously stated, from the seller's viewpoint, the key to a successful auction is the effect of competition on the potential buyers. In an English auction, the underbidder usually forces the bid up by one small step at a time. The winner may end up paying well under his valuation and thus the seller does not receive the maximum price. However, in a Dutch auction, if the bidder with the highest interest really wants the item, he cannot afford to wait too long to enter his bid. That means that he will more than likely bid at or above his private or common value price. This means that the seller may receive more for the item via a Dutch auction than via an English auction.

C. First-Price, Sealed Bid

This process involves a sealed bid, no other bidders know your bid price and the individual with the highest bid wins. Reynolds describes it as such:[14]

> Speaking generally, a sealed-bid format has two distinct parts--a bidding period in which participants submit their bids, and a resolution phase in which the bids are opened and the winner determined (sometimes the winner is not announced).
>
> An important distinction must be made as to quantity--how many goods are being auctioned--one or multiple items. The name "first-price" comes from the fact that the award is made at the highest offer when a single unit is sold. when multiple units are being auctioned, it is called "discriminatory" because not all winning bidders pay the same amount.

[13] Reynolds, Kate, "Auction types--Dutch" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[14] Reynolds, Kate, "Auction types--First-Priced, Sealed Bid" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

> It works like this: In a first-price auction (one unit up for sale) each bidder submits one bid in ignorance of all other bids. The highest bidder wins and pays the amount he bid. In a "discriminatory (more than one unit for sale) auction", sealed bids are sorted from high to low, and items awarded at highest bid price until the supply is exhausted. The most important point to remember is that winning bidders can (and usually do) pay different prices.
>
> From a bidder's point of view, a high bid raises the probability of winning but lowers the profit if the bidder is victorious. A good strategy is to shade a bid downward closer to market consensus, a strategy that also helps to avoid winner's curse.

This type of auction is used for selling sulfur dioxide allowances or credits under the Environmental Protection Agency's Acid Rain Program.

EPA released information about its auction for 2002 in March of this year.[15] This auction is conducted by the Chicago Board of Trade and provides private citizens, brokers and power plants the chance to buy and sell sulfur dioxide (SO2) allowances. The news release states"

> SO2 allowance trading, combined with a national emissions cap, has been effective both in terms of cost reduction and environment impacts since it began in 1995. Current estimates indicate compliance costs 75 percent below those originally predicted by EPA. Emissions are already more than five million tons below 1990 levels, and acid rain deposition in the eastern United States has declined by as much as 30 percent, resulting in improvements in lakes and streams.
>
> The Clean Air Act established an annual national cap on SO2 emissions. Each year, EPA issues allowances to existing sources to match a cap established by law. However, the Clean Air Act mandates that a limited number of those allowances are withheld and auctioned. The auctions help ensure that new electric generating plants have a source of allowances beyond those allocated initially to existing units. Proceeds from the auctions are returned to sources in proportion to the allowances withheld. In addition to allowances offered by EPA, private parties may offer allowances for sale in the auction.
>
> The auction, conducted by the Chicago Board of Trade, includes two "vintages of allowances. Vintage describes the earliest year an allowance may be applied against SO2 emissions. In addition to year

[15] EPA Environmental News, EPA Announces Results of Acid Rain Reduction Auction, March 28, 2002.

2002 allowances, the Clean Air Act mandated that EPA auction additional allowances seven years in advance to help provide stability in planning for capital investment. These allowances will be usable in 2009.

Summary Results of the 2002 SO2 Allowance Auction:

Vintage	2002		2009
Offeror	EPA	Private	EPA
Private			
Allowances Offered	125,000	2,388	125,000
2,388			
Allowances Sold	125,000	2,388	125,000
2,388			
Total Bids	53		16
Successful Bids	46		13
Clearing Price (lowest price at which a successful bid was made)	$1650.50		$68.00
Price Range	$150.00-$215.00		$60.00-
$120.00			
Average Price	$167.74		$81.87

Some argue, however, that the EPA auction is indeed not efficient. Bouwe Dijkstra and Marco Hann[16] argue that:

> The auction the EPA used in order to start the market for sulfur allowances, is not efficient. The set-up of the auction gives both buyers and sellers an incentive to understate their valuation of an allowance. Sellers' incentives are even more perverse than Carson[17] suggested. In particular, we show

[16] Dijkstra, Bouwe R. and Haan, Marco, "Sellers' Hedging Incentives at EPA's Emission Trading Auction", University of Groningen, Department of Economics, 1999.

[17] Cason, T. N., "Seller Incentive Properties of EPA's Emission Trading Auction," Journal of Environmental Economics and Management, 1993, 25(2), pp. 177-195.

> that sellers have an incentive to set their price equal to zero, while simultaneously hedging their bets by submitting a positive bid.

In conclusion the authors state: "We now know that the EPA auction was a failure in the sense that hardly any private parties sold allowances a the auctions. As a result, it took several years before an efficient market in sulfur allowances developed...Therefore, it does not come as a surprise that potential sellers preferred to bypass the auctions altogether and waited for an efficient market to develop.

D. Vickrey or Second-Highest Sealed Bid

This auction strategy is named after the winner of the 1996 Nobel Prize in Economic Sciences, William Vickrey who classified it in the 1960s. As explained by Reynolds this is like the first-price, sealed-bid auction because each bidder is ignorant of other bids:[18]

> The item is awarded to highest bidder at a price equal to the second-highest bid (or highest unsuccessful bid). In other words, a winner pays less than the highest bid. If, for example, bidder A bids $10, bidder B bids $15, and bidder C offers $20, bidder C would win, however, he would only pay the price of the second-highest bid, namely $15.
>
> There is one interesting and crucial point and that is that when auctioning multiple units, all winning bidders pay for the items at the same price (the highest losing price). The U.S. Treasury Department is experimenting with this type of auction to sell the national debt.
>
> One wonders why any seller would choose this method to auction goods. It seems obvious that a seller would make more money by using a first-price auction, but, in fact, that has been shown to be untrue. Bidders fully understand the rules and modify their bids as circumstances dictate. In the case of a Vickrey auction, bidders adjust upward. No one is deterred out of fear that he will pay too high a price. Aggressive bidders receive sure and certain awards but pay a price closer to market consensus. the price that winning bidder pays is determined by competitors' bids alone and does not depend upon any action the bidder undertakes. Less bid shading occurs because people don't fear winner's curse. Bidders are less inclined to compare notes before an auction.

[18] Reynolds, Kate, "Auction types--The Vickrey Auction" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

III. WINNER'S CURSE

As previously explained, winner's curse occurs when a winning bid is accepted at an inflated price. This is common during an English auction when inexperienced bidders run the price up due to the excitement of the moment or due to the encouragement of the auctioneer.

Sometimes the curse can be a result of other variables. A Time Magazine article in 1998 illustrates this point.[19] When bids for the right to televise *Monday Night Football* for the next eight years reached $4 billion, NBC dropped out to the bidding and figured that the winner would be cursed with losses of $150 million to $175 million annually. ABC continued in the bidding and won the contract for $4.4 billion. ABC had televised this show and had sold commercial slots for 30 years and they obviously thought that they were in the best position to know its current value. However, ABC's bid was over $25 million per game, more than double their previous contract with the NFL. Viewer-ship had tumbled by 33% since the peak in the 1980s. And even though the rights permitted more commercial TV time-outs, the $25 million per game worked out to be a total of 84 $300,000 15-second slots of commercial air time that would need to be sold per each game just to break even. The article concluded that ABC might be hard-pressed to recover their investment. Clearly a case of winner's curse.

[19] Based on "Thrown for a Loss by the NFL", Time, 26 January 1998, p. 52.

IV. COLLUSION

Which auction is best for the seller, for the bidder? As mentioned, there are many variables that must be determined to answer that question. What is being auctioned, how many units, is there a reserve price, are just a few of the considerations. Another variable to consider is the potential for collusion and to what extent the different auction types present opportunities or incentives to collude. One such method involves rings.

Reynolds explains the process as follows:[20]

> A subset of bidders gather together and agree not to outbid each other which has the overall effect of lowering the winning bid. Later the item is re-auctioned amongst ring members and the profits are shared. (This poses an interesting conflict because in this instance, the ring-bidders are also owners/sellers. Motivations of buyers and sellers are quite different.) In essence, these buyers agree to reduce competition by not competing against each other.

It should be noted that ALL auction types can be manipulated. Walter Mead[21] has suggested that the English auction or open bid formats are more susceptible to collusion than are sealed-bid auctions. This may explain the popularity of sealed-bid auctions even though the open bid formats usually generate greater revenue. However, under the English auction format it is very easy to form rings.

Reynolds[22] explains that sealed-bid auctions, on the other hand, are vulnerable to collusion involving the auctioneer and one or more bidder. This format is less prone to rings because sealed bidding tempts participants to bid higher than the agreed-upon price in order to cheat the others. This is also true for the Dutch format, even though it is an open format since the first defecting bidder ends the auction. Paul Milgrom[23] points out that the "collusion is hardest to support when secret price concessions are possible, and easiest to support when all price offers must be made publicly.

In a first-price sealed auction it is hard to prevent buyers from cheating in a one-shot game (only one trading period). By the time the cheater has been discovered, the auction is over. By the same reasoning, some economists consider that the Dutch auction is the

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[20] Reynolds, Kate, "Collusion and Tricks" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[21] Mead, Walter, "Natural Resource Disposal Policy: Oral Auction Versus Sealed Bids", Natural Resources Journal, Vol. 7 (April, 1987), pp. 195-224.

[22] Reynolds, Kate, "Collusion and Tricks" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[23] Milgrom, Paul, "Auctions and Bidding: A Primer", Journal of Economic Perspectives, Vol.3 (Summer, 1989) pp. 3-22.

least susceptible to collision because ring members will have trouble enforcing collusive behavior. When a ring member bids more aggressively than was agreed, his actions are obvious, but once the auction is overt before anyone can react.

Many auction techniques share a serious problem with trust. An auctioneer is required to be totally trustworthy and that is not easy to attain or certify.

Matthew K. Franlkin and Michael K. Reiter[24] point out that "there are numerous possibilities for corruption and misbehavior in a sealed-bid auction. Possibly the most difficult to counter are those that involve the misbehavior of agents in charge of executing and overseeing the auction (e.g., employees of the auction house), especially when this behavior involves collaboration with certain bidders."

They list several ways to cheat:

The agent opens bids prior to the close of the bidding period and informs collaborator of the amounts bid.

An agent closes the bidding prematurely so as to preclude certain bids.

The agent allows a bidder to withdraw (or insert) his bid after the bidding period has ended.

The agent collects money from losing bidders.

The winning bidder refuses to pay claiming insufficient funds.

They point out that in the future, as more and more auctions are conducted via computer, the above listed problems must be addressed.

[24] Franklin, Matthew K. and Michael K. Reiter, "The Design and Implementation of a Secure Auction Service". franklin,reiter@research.aatt.com

VI. E-TRADING

A recent article in *Air Daily, September 23, 2002* reports the recent problems of an attempted sale of NO_X allocations by U.S. Steel.[25]

> The first ever auction for NO_X credits ended in total failure last Friday after an online auctioning system botched proposed price bids leading U.S. steel to cancel its auction and reschedule for early next week.
>
> "It was a total failure, a total catastrophe," said one trader who had placed a bid.
>
> The dismal outcome of the emissions market's first online auction does not bode well for participation in future auctions. Market sources said they would not be participating in U.S. Steel's second auctioning attempt, which will be held September 24.
>
> Several traders balked at the fact that they had exposed their highest bids to other traders in the auction process, essentially revealing their price ceilings and making a second auction not worthwhile.
>
> U.S Steel spokesperson were not available for comment. Makers of the auctioning software, Atlanta-based Procuri, denied comment for this story.
>
> U.S. Steel, which is not usually active in the emissions markets, announced earlier this week its intent to hold an online auction for NO_X vintage 2003-2004, with bids starting at a minimum of $4700 for 03s and 04s and $3200 for 05s through 07s.
>
> At 11:00 a.m. Friday morning, when the bidding wars began, several traders found the setup of the online system confusing. Auction participants said that bids could be entered in the form of price per ton, or price per 50-ton package, making the system difficult to work around.
>
> Early on in the auction for '04 vintages, one trader mistakenly entered a bid for a 50-ton package in a slot reserved for the "per-tom" prices, thereby excluding every other trader from making further offers since new bid had to be larger than the existing price.
>
> The auctioning software also allowed U.S. Steel to extend the 10-minute time limit for bidding should the company believe prices could escalate further. Traders said time extensions thwarted their bidding tactics, which often centered around offering their best price toward the last seconds of the auction.

[25] "Bad E-Trading Platform Leaves NOx Auction Cancelled in Defeat", Vol.9, No. 181, September 23, 2002.

> Traders said they had been wary of the auction even before it started. Many sources in the emission markets, brokers included, questioned why U.S. Steel would hold an auction when the NO_X market provided a forum to dump allowances at prices near or above U.S. Steel's asking price.
>
> "Maybe an auction is a good way to [sell] other things, like office equipment, not so much for a standardized, common commodity." one trader said.
>
> Other traders questioned why U.S. Steel did not go through a broker to sell its allowances or use the Intercontinental Exchange, known as ICE, which is another electronic trading platform emissions traders use.
>
> Although U.S. Steel has rescheduled its auction for this week, supposedly giving it time over the weekend to work out the kinks, it is unclear how many buyers will participate.

The issue of electric auctions, particularly with regard to NO_X emissions credits, as demonstrated by the above article, is too new to evaluate. However, the above suggests that the already established markets (brokerage firms) will continue to serve as the primary venue for selling and buying allowances as the commodity is just too valuable to risk a less conventional method. At least at this time.

VII. AUCTION STRATEGIES

As already stated by Reynolds, "The truth is that the entire subject of auction strategy is numbingly complex with numerous variables coming into play."[26]

> Is a bidder risk-averse or risk-neutral? Is the auction for one item or multiple units? do you plan to resell the acquired object or to use it yourself? If you plan to resell it, are the other bidders symmetric? That is, do they use the same measurements to estimate their valuations? Do you have secret information about the object? Might others have secret information?

All of these issues play a part in auction strategy including other variables that would pertain to the specific commodity to be auctioned.

Reynolds continues:

> Buyers really do bid differently depending upon the rules of an auction and it is worth understanding the rules of an auction thoroughly. In fact, the one piece of information available to all is the rules.
>
> Economists use a framework called game theory to think about auction behavior. Using game theory economists examine rational behavior and decisions made in varying conditions. A seller, on the one hand, is faced with choosing an auction type, and so he must predict the behavior of the bidders. On the other hand, a bidder tries to predict the behavior of the other bidders. Each bidder makes an estimate of his own value of the object and also an estimate of what others will bid on it. Good bidding is often the result of correct predictions about the behavior of others and sometimes that means guessing the extent of someone else's information correctly.[27]
>
> Economists try to devise sets of rules to determine dominant strategies under a huge array of variables. Bidders, of course, tend to worry more about their bids than their strategy.

Lets evaluate the view from the sellers point.

> In any auction a seller can influence results by revealing information about the object. Intuitively, a bidder's profits rise when he can exploit information asymmetries (when the bidder has information not available to others). In general,

[26] Reynolds, Kate, "Auction Strategies" copyright 1996, Agorics, Inc. as posted at http://www.gaories.com/Library/Auctions/auction8.html, October 20, 2002.

[27] Mester, Loretta J. 1998. "Going, Going, Gone: Setting Prices with Auctions" Federal Reserve Bank of Philadelphia Business Review (March/April): pp. 3-13.

the more information a bidder has, the more the price-dampening effect of winner's curse is lessened. So a seller's optimal strategy is to reveal information and to link the final price to outside indicators of value (an authoritative evaluation). It is also a good idea because if a seller seems reluctant to disclose something, a buyer always assumes the hidden information must be unfavorable.

Revealing information removes uncertainty. Theoretical literature demonstrates that, under assumption of private value (objects acquired for personal use), all four basic auction types can be shown to yield the same expected price and revenue to the seller when bidders are risk neutral and symmetric. This implies that auction choice is not critical because each format yields on average the same payoff.

But revenue equivalence does not hold true under common value (objects acquired primarily for profitable resale) assumption (when bidders have similar evaluations). It has been shown that the four auction types can be ranked from highest to lowest as follows: English ascending-price; the second-priced, sealed bid auction; Dutch (descending) auctions and first-price, sealed bid auctions tied. The rankings illustrate advantages of increased information. Remember that an English auction reveals information about rival bidder valuations and permits dynamic updating of personal valuation (which leads to more aggressive bidding). In comparison, bidders, recognizing winner's curse, bidding in first-price auctions bid less aggressively and shade their bids. Similar reasoning applies to Dutch auctions. In contrast, in second-priced sealed-bid format, the winner pay the bid of the next highest so bidders raise bids, secure that they will not de disadvantaged if rival bids are lower.

In Dutch and first-priced auctions, bidders behave in the same way, and so, it does not matter which of these auctions a seller chooses nor odes it matter whether the bidders have private values or common values. The reason that a bidder behaves the same in both kinds of auction is that he makes the same decision and this decision is based upon the same information. In both auctions a bidder knows that if he wins he must pay exactly what he bid. He knows also that he only wind if his bid is higher than that of everyone else. He must also decide upon his bid without knowing what others will do.

There is disagreement over this. Paul Milgrom[28] argues that in general an English auction generates more money in more environments than the Dutch or sealed bid auction types (on average) and this probably helps explain its popularity.

In the case of choosing between a second-priced and an English auction, however, the decision must be based upon whether bidders know their private valuations or whether they are uncertain about the single common value of the item for sale. In

[28] Milgrom, Paul R., "The Economics of Competitive Bidding: A Selective Survey", Social Goals and Social Organizations: Essays in Memory of Elisha Puzner (Cambridge:Cambridge University Press, 1985).

an auction wherein bidders have independent private values, the auctions both yield the same.

However, in a common value auction the English and second-priced auctions do not yield the same revenue. Remember that in an English auction a bidder can gain useful information by observing other bidders. He can watch to see how many bidders drop out of the auction (they value the object less) and he can see also exactly when they dropped out (how high was their last bid?). If lots of bidders remain in an auction this gives a bidder confidence that ha high valuation was correct, and so he tends to bid higher.

In the independent value behavior when all bidders are risk neutral, a seller receives the same revenue from both the English and second-priced auction.

However, if the bidders are risk adverse, then the first-priced (and also Dutch) yields greater revenue than an English and second-priced auctions.

James R. McGuigan[29] provides the following summary of auctions design choices.

◆ Auction design choices are multi-faceted but at the simplest level always include who pays, what amount, and how the winner is determined.

◆ Auctions also differ in the resale opportunities available to the participants. Common value auctions lave thick resale markets where the item can be easily resold at a consensual fair market value. Private value auction items have not common resale value and instead involve assets with differing valuations to the auction participants.

◆ The winner's curse implies strategic underbidding is rational when the seller or other buyers have asymmetrically advantage information about a common value auction.

◆ Open bidding is a procedure for posting the offers in multiple rounds with cancellation and modification privileges to induce the winner's curse and raise expected auction revenue in common value auctions.

◆ What simple auction types raise the greatest revenue for the seller-auctioneer depends upon the common value or private value nature of the item being auctioned and on the auction participants' risk-aversion.

◆ Dutch auctions and First-Priced Sealed Bid auctions have identical information structures, identical bidding strategies, and therefore, generate identical expected revenue.

◆ Relative to Dutch or First-Priced Sealed Bid auctions, English ascending price and Vickrey or Second-Highest Sealed Bid auctions raise expected revenue in common

[29] McGuigan, James R., Moyer, Charles, R., and Harris, Frederick H. deB., Managerial Economics Applications, Strategy and Tactics, South-Western, 2002. p. 623.

value auctions for items like crude oil, forest logging rights, and aircraft because they encourage the most pooling of bidder information. In private value auctions, bidders who are risk-averse offer higher bids and therefore generate more auctioneer-seller revenue in Dutch and First-Priced Sealed Bid auctions.

VII. RECOMMENDATION

The Department is tentatively inclined to use the first-priced, sealed-bid type auction as the process for auctioning the NO_X allowances. This type of auction is used for selling sulfur dioxide allowances or credits under the U.S. Environmental Protection Agency's Acid Rain Program, which is similar in concept to the Commonwealth's NO_X Budget Trading Program. In order to minimize the addition of resources to the Department, the administration of the auction would be through a contractor to be financed by the proceeds of the auction.

Because the nature of auction design is so very complex, prior to making a final decision, the Department plans to solicit the assistance of experts in the field who understand the complexities of auctions and the many variables associated with them to develop the appropriate auction design to meet the specific needs of the Commonwealth.

The current regulations of the Board governing the NO_X Budget Trading Program (9 VAC 5 Chapter 140) do not accommodate an auction as the means of distributing the new source set-aside allowances and would need to be amended in order to allocate the emission credits set aside for new sources through an auction process. During this collaborative process, DEQ would solicit input from the various stakeholders about the design and implementation of an auction system prior to making any final decisions.

By soliciting the input of experts in the field and stakeholders within the Commonwealth, the Department believes that this would result in an auction process that is effective and efficient and best serves the public interest.

APPENDICES

A. Subsection D of Item 383 of Chapter 899 of the 2002 Acts of Assembly

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