DIVISION OF THE HUMANITIES AND SOCIAL SCIENCES
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA 91125

SEQUENCING STRATEGIES IN LARGE, COMPETITIVE, ASCENDING PRICE AUTOMOBILE AUCTIONS: AN EXPERIMENTAL EXAMINATION

David M. Grether

Charles R. Plott

SOCIAL SCIENCE WORKING PAPER 1253

June 2006

Sequencing Strategies in Large, Competitive, Ascending Price Automobile Auctions: An experimental examination

David M. Grether Charles R. Plott

Abstract

This paper reports on a large scale field experiment testing strategies available to a seller participating in simultaneous competitive sequential, ascending price automobile auctions. Every other week, the seller offered approximately 120 vehicles for sale in an auction environment in which several competitive sellers offered on the order of 3,000 vehicles. The experiment tested various sequences in which the seller could offer the vehicles, such as high values first or low values first. Surprisingly, and contrary to intuition drawn from the theory of single item and single seller auctions, the worst performing sequence from those tested is for the seller to order vehicles from highest to lowest values. The best sequence is to group the vehicles by type and offer the low valued vehicles first and then move to offer the higher valued vehicles. Our conjecture is that this sequence reduces the competition with other sellers for the attention of specialized buyers.

JEL classification numbers: D440, L620, L810, C930, C900

Key words: experiments, auctions

SEQUENCING STRATEGIES IN LARGE, COMPETITIVE, ASCENDING PRICE AUTOMOBILE AUCTIONS: AN EXPERIMENTAL EXAMINATION

David M. Grether, Charles R. Plott

1. INTRODUCTION AND OVERVIEW

This paper reports the results of a field experiment conducted at a single Southern California wholesale automobile auction site. During the latter part of 2003 a large seller of vehicles asked the auction house about alternative strategies for offering vehicles at auction. In particular, the seller was interested in understanding more about the sequence with which the vehicles were presented as well as other variables to which the seller had access. The seller was interested in exploring strategies that might increase the revenue from the sales.

The seller and auction house asked the authors to design and supervise a field experiment to address the question. The seller was offering between one hundred and one hundred fifty vehicles every other Thursday. On these sales days, the auction house auctioned approximately three thousand vehicles brought to the auction by "our seller" and by other sellers. The auction was open primarily to dealers as buyers and sellers. The general public had very limited access, if any at all. We were allowed to control the order with which the seller in question offered the vehicles. The resulting experiments were conducted to explore effects of different orders of presentation as well as determine which order would produce the most profit for the seller.

The experiment is possibly the first controlled experiment of auction sequence in large, competitive auctions using an approach that originated with laboratory experimental economics techniques and exploring ideas based on intuition drawn from modern auction theory. Indeed, in terms of scale the experiment is unique with the seller committing on the order of $13M in assets to the test.

The results were essentially the exact opposite of our expectations. Our expectations were drawn from rather common sense applications of auction

theory as well as auction theory with a single seller selling multiple items with possible asymmetric information, which is the most frequently analyzed environment found in the literature. We expected the most profitable strategy would be to offer vehicles in the sequence starting with the highest valued then and moving on to offer vehicles that would ordinarily have lower values. As it turns out, the data tell us that offering the lower valued vehicles first is more profitable.

2. RESEARCH QUESTIONS AND EXPERIMENAL DESIGN

In the experiment, we implemented four especially crafted selling strategies but were able to study two additional strategies, the first was the strategy traditionally used by the seller and the second was a strategy that is common among large sellers. The strategies examined are:

1. (HL) Offer vehicles from highest potential value to the lowest without regard to make or model.
2. (LH) Offer vehicles from the lowest potential value to the highest without regard to make or model.
3. (GHL) Group vehicles according to make and model and offer vehicles from highest potential value to lowest within groups. The seller was asked to offer groups starting with the highest but it is not clear from the data that this was successfully implemented.
4. (GLH) Group vehicles according to make and model and offer vehicles from lowest potential value to highest within groups. The seller was asked to order the groups beginning with the lowest valued group but it is not obvious from the data that this was successfully implemented.
5. (T) The seller's traditional method, which was to offer vehicles in make and model, groups according to the number of the vehicles, with the most numerous being offered first.
6. (C) Following the experiment, the seller was involved in a merger and after the merger appeared to adopt the same ordering strategy used by other large sellers. The strategy is similar to GHL in the sense that the vehicles are offered with a slight downward trend in value over the course of the auction. This allowed us to include a sixth "treatment", namely the pattern commonly used by large sellers. The change in strategy as a result of the merger allowed us to compare the auction performance of the after merger strategy against other strategies.

In addition to the different sequences, the seller was instructed to implement no reserve prices. That is, the seller was instructed to sell all vehicles regardless of price that might emerge.

The experimental design called for using different selling strategies on different auction days. That is, different sequences would be used by the seller on different sales days. However, the sequencing of vehicles was not strictly under our control. The seller has local managers who are responsible for the sales and these managers are responsible for the selection of vehicles to be placed at auction in any given week and other organizational aspects of the sale including the order with which the vehicles are presented. While our instructions to the manager were always clear, our request was sometime not implemented as strictly as one might want.

The sequence in Table 1 gives the dates and conditions under which various treatments were implemented.

TABLE 1 : EXPERIMENTAL DESIGN

Auction Number	Date	Sequence implemented	Number of vehicles offered/sold*	% Sold
1	1/08/04	Seller Traditional	113/98	87
2	1/15/04	Seller Traditional	66/62	94
4	1/29/04	Seller Traditional	116/108	93
6	2/12/04	Grouped High to Low	131/126	96
8	2/26/04	Grouped Low to High	108/100	93
10	3/11/04	Seller Traditional	123/118	96
12	3/25/04	Seller Traditional	99/94	95
14	4/08/04	Low to High	97/97	100
16	4/22/04	High to Low	87/83	95
18	5/06/04	Low to High	86/75	87
20	5/20/04	Grouped High to Low	111/108	97
22	6/03/04	Grouped High to Low	88/83	94
24	6/17/04	Grouped Low to High	103/94	91
26	7/01/04	Grouped High to Low	95/86	91
28	7/15/04	High to Low	79/76	96
32	7/26/04	Common Pattern	110/103	94
34	8/12/04	Common Pattern	64/55	86

* Vehicles listed with a positive sale price are counted as sold. In some cases, circumstances arising after the auction may cause title not to be transferred.

3. THE AUCTION ENVIRONMENT

The experiment took place on alternate Thursday's beginning on February 12, 2004 through July 15, 2004. The results reported also used data from the first second and fourth weeks of January 2004. These are the weeks during which the seller had vehicles offered at the auction. We also include data from the first two weeks after a merger, which resulted in the seller changing the strategy from the strategy traditionally used by the seller.

The Agents

While some participants, especially large sellers, take part only on one side of the auction, others will appear both as sellers and buyers. A car dealer, for example, may receive vehicles as trade-ins that are subsequently sold at the auction, and, also, buy cars to place on sale at the dealer's lot. The majority of the vehicles brought to the auction are brought by a few large sellers. These sellers also account for the majority of the sales as the larger dealers (those bringing 50 to 75 vehicles or more) sell a higher proportion of their vehicles than do smaller sellers. Buyers, on the other hand, generally are small with the majority of purchases made by individuals buying half a dozen or less

Each auction participant is identified by a seven digit number. This number is kept over time so that it is possible to follow an individual through and across auctions.

The Vehicles

The large seller that posed the question for research typically sells hundreds of vehicles per week at various auction houses scattered across the country. The vehicles are generally from one to three years old, have low mileage, and are in good repair. The vehicles also span a large range of vehicle makes and models.

The Information

In these particular auctions, there seems to be public information about the properties of the vehicle. While there might be a common value issue about the possible resale value of a vehicle, the buyers are all professionals who operate car dealerships and used car dealerships and have a detailed understanding of their own market. Other than the reservation price of the seller, there is very little by way of private information about a common value. Basically, all information is shared so there is no particular role for models of information aggregation or the operation of a winner's curse. The vehicles are available for inspection by buyers before the auction and the vehicles are accompanied by a quality assessment report that details any defects. The auction house provides a type of "guarantee" that gives a buyer the right to return the vehicle should it prove to be defective or have some problem about which the buyer was not made aware. In this case, the seller has a reputation for delivering high quality and reliable vehicles.

The auction house is large, with automobile sales operating throughout the United States and other countries. Data used from these sales are used by the auction house to compute an estimate of vehicle value. We will call this the book value or sometimes simply the vehicle value. This estimate is based on nationwide sales and reflects many aspects of the vehicle condition and markets. It is typically based on national market data and it is made available to both buyers and sellers in the auction. The auction house also maintains regional indices, but the one for southern California was not available for all the auction dates.

As will be made clear later, the value index was tested as an estimate of sale price of a vehicle. This estimate was also used in determining key aspects of the experimental design. In particular, it was used to determine the order in which vehicles were offered for sale in the experimental design.

The Physical Environment

The auction site has twelve lanes for vehicles. The vehicles in the lanes move towards the auction stands as vehicles ahead of them leave the sales area. The setting is similar to that described by Genesove (1995). Each auction stand has an auctioneer, clerk, and, often, the seller or a seller's representative. The auctioneers chant during the auction and their chants are amplified, resulting in extremely high volume of sound (the clerks, who type

records of transactions generally wear earplugs). The lanes are adjacent and buyers can, and do, move from lane to lane during the course of the sale. Buyers can see the vehicles approaching the sales area, and the auctioneers "advertise" by putting out lists of the vehicles coming through their lanes. Thus, if buyers want to buy a particular vehicle, they can be in a lane in which that vehicle is offered for sale. When a vehicle is in the sales area, an electronic board gives the details of the vehicle including whether the seller has purchased a warranty. Once a vehicle is within a designated area in front of the sales area, buyers are free to inspect the vehicle including inspecting the motor.

The auction house did allow some bidding from remote sights using the internet, but at the time of the experiment, few cars were sold through that mechanism. During the period of the experiment, fewer than two percent of the vehicles sold were sold to buyers on the net, with the figure for the seller of interest being somewhat higher (four percent). Internet participants must sign up for the auctions and must choose from a limited number of lanes usually those used by manufacturers or large finance companies. These sellers unlike on site buyers may not place bids in all lanes.

The vehicles offered by a seller enter the auction consecutively and in a single lane. Larger sellers typically have the vehicles in low numbered or middle lanes. The lanes are numbered by distance from the entrance. So, anyone leaving or entering the auction must go past lane one. The auctions studied are closed auctions being open only to dealers.

Auction Architecture

The auction architecture is an ascending price, open outcry auction managed by a professional auctioneer. The sale is made when no additional bids are received by the auctioneer and the seller has indicated to the auctioneer that the bid is above an unobserved seller reserve price.

Vehicles are driven in their respective lanes from the parking area. As the vehicle approaches, the auctioneer begins the classical auction chant, lowering price until a bid is received. At that point, the auctioneer asks for higher bids. Active bidders inspect the vehicle while making frequent eye contact with the auctioneer. A nod, yell, finger movement or other signal signifies a bid that the auctioneer repeats and asks for a higher bid. Occasionally, the auctioneer will say "selling" which means that the current

price is above the seller's asking price and that the high bid will result in a sale but this revelation is at the seller's discression.

4. THEORIES AND MODELS

The question posed by the seller focused on the order and grouping in which the vehicles are offered for sale. The issue has been addressed both theoretically and experimentally with the primary focus being on the case of a monopolist who is offering commodities characterized by asymmetric information. The general thrust of the research is that the best strategy from the seller's point of view, if the ascending price auction is to be used, the best strategy is to offer the most valuable items first (Charkraborty, Gupta and Harbaugh, 2006; Goeree, Offerman and Schram, 2006; Pitchik, 2004) with some exceptions (Raviv, 2004). By contrast, this study is focused on a situation in which there is very little asymmetric information about heterogeneous goods and the auction is competitive in the sense that many other sellers are offering the goods in the auction, some of which are offered at the same time. Thus, the elements of strategy must focus not only on the behavior of the bidders but also on the behavior of other sellers and the sequence in which they offer their commodities.

The Classical Model And The Crowd

In the absence of issues of common values, the theory of price determination in an ascending price auction is known to operate according to simple principles (McAfee and McMillan (1987), Milgrom (2004), Plott and Salmon (2004)). The basic model is very well known and is illustrated in Figure 1, which is sufficient as a foundation for developing the theoretical intuition of the experimental design.

A key concept is the "crowd", the bidders that are physically able to tender a bid for the vehicle. Unless a bidder has the capacity to bid electronically, the crowd is the set of potential bidders that have eye contact with the auctioneer. During the few seconds that the auction of a particular vehicle lasts the buyers must either be physically or electronically present in the lane where a vehicle is auctioned. Only those in the crowd can tender bids and are thus eligible buyers.

Assume only one item is for sale and that the values of bidders in the "crowd" are represented by the demand function in panel A. The values for the vehicle at auction are shown for each of the bidders in the "crowd". We are abstracting from expectations of later sales, vehicles that might be in other lanes and the number of vehicles that the agent might have already purchased. We focus only on the value placed on that vehicle, at that time by those able to place a bid, the "crowd". The demand curve shown represents the limit prices of that set of potential buyers.

The auctioneer begins with low bids with bids moving upward until the bidder with the second highest limit value drops out which will occur when the price reaches the bidders limit value. The item will be sold to the agent with the highest limit value at a price equal to the limit value of the agent with the second highest limit value. This is shown by P_1.

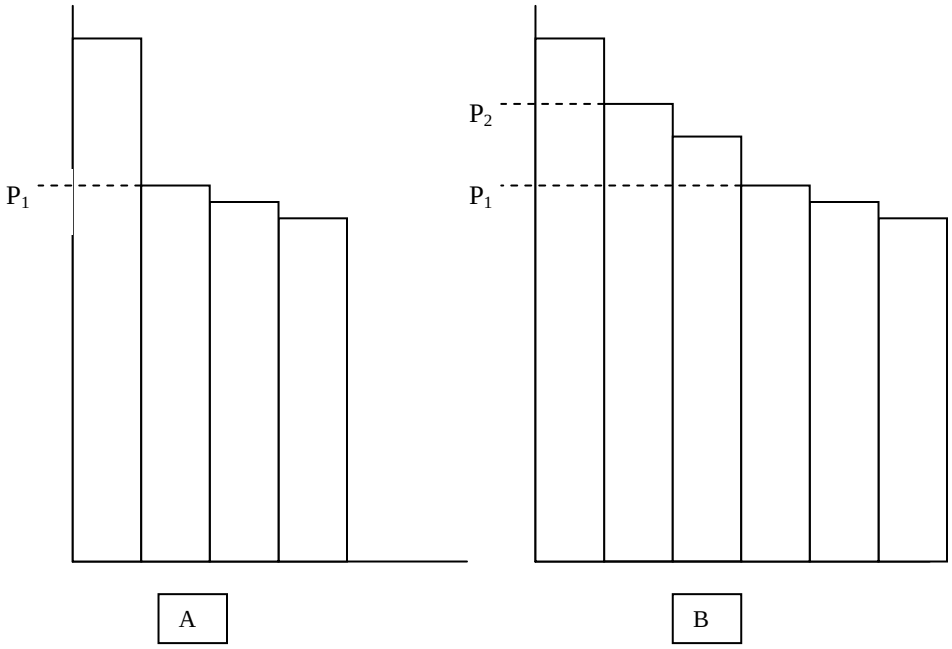

Figure 1

According to this model, the only ways in which the final price will change is if the limit value of the second highest bidder changes. Suppose for example that two additional bidders are drawn to the crowd and that both of their limit values are above P_1 but below the value of the agent in A with the highest limit value. The changed demand function will shift to the curve shown in panel B. The price will be P_2, the limit value of the new bidder.

Thus, the model suggests that the price is determined by the composition of the buyers who happened to be in the crowd at the time of the sale and that the strategy of influencing the prices of a particular seller turns on success in attracting an appropriate crowd for the sales of that seller's vehicles. The buyers should be in the seller's lane and not in a lane in which the vehicles of a competitive seller are being auctioned.

The Auctioneer

Auctioneers discuss many variables as important determinants of a vehicle's value at auction. In some sectors, the auctioneer chant is thought to be important, creating an atmosphere of competition that draws on a primitive value of "winning" and induces higher bids in the process. Auctioneers would like to encourage impulse buying and impatience while encouraging more aggressive bidding. Auctioneers will attempt to lower transactions costs, calling bidders from the restaurant or drawing bidder's attention to specific vehicles that the auctioneer thinks the bidder might like. Typically, an auctioneer works a specific lane during the day but switches do occur.

Seller Characteristics and Policies

Sellers operate differently in an attempt to add value to their vehicles. Some sellers clean the vehicle carefully, including cosmetic repairs while other sellers do not. The policies of sellers are scrutinized according to whether or not the seller is willing to sell the vehicle at the price that emerges from the auction. A seller can get a reputation for placing high reservation prices on vehicles, not selling and using the bidding information as an estimate of the market value of the vehicle. Knowing this, bidders might hesitate to join the crowd. Some sellers bring only quality vehicles to the auction thereby enhancing the confidence of the buyers. Seller size alone could be important since visibility and information about policies both adjust with scale.

Sequence

The question posed for study was whether the sequence that this seller uses to offer vehicles for sale could be used to influence the seller's crowds in a way that will increase sales revenues. Time, physical presence and attention of buyers are scarce resources. The larger the crowd the greater is the likelihood that the second highest limit value is high, so any increase in the size of the crowd, other things equal, could have an upward influence on

price. Thus, strategies that might increase the size of the crowd should be considered. Strategies that attract buyers with high limit values should also be considered.

Several things were considered in developing strategy options. Many buyers have budget constraints. They are professional buyers who are acting on direction of a dealer or used car lot owner who uses the budget as a means of direction and control. Secondly, from the point of view of a buyer, there might be many substitutes for a particular vehicle. Some buyers might find substitutes only in a given make, model, or condition while others might look only to a price range. Some buyers tend to specialize according to make, models, and conditions while others seem to be more flexible. Naturally, these properties of the buyers reflect their assessment of the retail markets in which they will resell the vehicles they purchase at auction.

The tendency to specialize suggests that buyers who have a particular preference will linger in a lane so long as the types of vehicles they want appear in the lane with sufficient frequency. This suggests that grouping vehicles according to make and model could attract and hold a crowd and thus influence the prices on all of the vehicles of a particular type. On the other hand, the existence of the budget constraints suggests that limit prices may decrease as the sale moves on in time. Buyers who have purchased a vehicle have less money to spend on additional vehicles. A strategy that attracts buyers and places buyers with high limit values in competition might be effective. This suggests two possibilities for sequences. Offer the vehicles from highest value to the lowest value and/or group the vehicles according to their similarities such as make, model and condition. By offering vehicles with the highest values first, the buyers with the highest limit values are competing at a time when they had the least constraining budgets. By grouping the vehicles, the potential synergies between vehicles of a given type would hold the crowd.

5. DATA

The full data set includes auctions for every week from the beginning of November 2003 to the present (except for two weeks missing in late February and early March of 2004). Each week between 2,000 and 3,000 vehicles are put up for sale. For every vehicle, the data give the identification number of the seller, lane, time, vehicle identification number

(VIN), make, model, body, model year, mileage, J D Powers category and subcategory, condition at time of auction (frequently blank), value of the vehicle as determined by the auction house (similar to Kelly Blue Book value), floor price if the seller states them, any fees paid by seller and whether the vehicle was sold. The vehicles are all suitable for individual or family use and include pickup trucks, SUVs, vans, sport cars as well as sedans. For sales, the sales price is given as is the identification number of the buyer. Sellers are given a code to distinguish fleet operators, lease sellers, factory, dealers and repossessions. In addition, there is a field labeled "Seller Group" which is usually blank or indicates the seller is a dealer, but serves to identify most of the largest sellers (HRTZ, ENT, GMAC etc.). There are some obvious errors in the data. Transactions taking place at time zero, duplicates, obvious typos, for example a car with a floor price of $350002, vehicles without a seller number or value were all dropped. We also eliminated all sales listed in lanes greater than twelve. These represent transactions, of vehicles often in poor condition, which do not go through the standard auction process and are not considered here.

The data set used in this paper consists of 29,408 vehicles 67% of which were sold. Sellers bringing 50 or more vehicles in a week accounted for 14,202 transactions with a sales rate of 83%. Half the purchases were made by buyers who bought four vehicles or fewer, and for those who made more than one purchase the median time between first and last buys was 68 minutes. Thus, most buyers participate in the auctions over relatively short time periods. Though we do not know this, we assume that once buyers have made the purchases they wish, they simply leave the auction site. Half of those making multiple purchases changed lanes two or more times (the maximum was 18).

Since the VIN is included in the data for each vehicle, we can track vehicles to see how many of them appear multiple times. In the entire sample including those weeks in which our seller was not present, 22 percent of the transactions involved vehicles that had appeared in the auction previously. Some of these are brought back several times by the same sellers (the maximum is twelve times), others are purchased and subsequently resold by their buyers. In the sample used in this paper, 6524 or 35% of the transactions involved known repeaters and only 34% of them were sold.

6. RESULTS

The results are organized in two sections. The first focuses on the development of a baseline against which strategies can be measured. The second subsection develops the broad patterns of strategies that can be recognized as being employed by the sellers.

Baseline Measurement

What would be the price of a vehicle under "normal" selling conditions? Two such background measures were considered for determining baseline measurements. The first is an estimated value provided by the auction house and the second is a floor price that is sometimes imposed by the seller.

The value estimate provided by the auction house is based on the national pattern and historical sales. The auction house operates many auctions and has a broad database from which sales value can be estimated. Our first question is whether or not this value estimate is a good predictor of price in the local auction of the field experiment. It is important to note that this estimate is based on national numbers and the not regional numbers from the region of the auction studied here. The auction house maintains regional indices, but we use the national index as the figures for southern California were not available for all the auction dates.

Result 1. The value estimate constructed by the auction house is a good predictor of selling price.

Support. For the data used in this paper, a simple regression of sales price against the book values given by the auction house gives an R^2 of 0.92 with a coefficient of 0.993 (which, because of the large number of observations; 20,111, is significantly different from one). Recall that this is using the national rather than the regional numbers.

The second potential tool for use as a baseline value measure is a "floor price" sometimes stated by the seller. As noted, most of the vehicles brought to the auctions are brought by a few large sellers. Some of these sellers state what are called “floor prices” for the vehicles they bring to auction, but others do not. Of the vehicles sold for which floor prices are given, between fifty and sixty percent of the sales take place at prices below the floor prices. Thus, these prices should be thought of as target prices or

aspiration levels rather than as reservation prices. The floor price is not listed sufficiently often to use as a consistent baseline, however, we ask if its addition removes some of the error of the auction house prediction. As is stated in the next result the answer is yes.

RESULT 2. Addition of the seller stated floor price to the price prediction equation improves the accuracy of the prediction.

Support. If we add the floor price the R^2 rises from .92 to 0.96 with coefficients on the index and floor price of .463 and .531 respectively (the sum is significantly different from one!). Using floor prices alone yields a coefficient of 0.95 and an R^2 of 0.94.

Thus, as can be inferred from Result 2, a possibility exists that additional dimensions of value of a vehicle that are not in the measures from national data are available to the professional agents participating in the local market. In particular the national averages are not adjusted for the vehicle's condition at time of sale, while floor prices seem to take that into account.

Other Seller Strategies

With the auction house value estimates as a baseline, we can study the strategies used by sellers. The strategies adopted by most of the larger sellers are at least superficially similar. Most of them order the vehicles at the auction with values that decline somewhat with the vehicles offered first being of higher values than those offered last. Figure 2 shows a typical pattern.

Figure 2

For the data in Figure 2 a simple regression of value against time measured in seconds gives an R^2 of 0.15 with a significant negative coefficient. Not surprisingly the sale prices also tend to decrease somewhat over time so that these data exhibit the "declining price anomaly" common to art auctions (see Ashenfelter and Graddy, 2003, Beggs and Graddy (1997), van den Berg et al. (2001)). The seller we worked with deviated from this pattern as their values show little of no trend over the course of an auction (Figure 3).

Figure 3

We have labeled this the traditional order as it is the order used prior to the experiments that are discussed later. When asked to explain the order that was used we were told that they simply put "the cars we have the most of first." Given their superior performance in the auction, we suspect that something more sophisticated was being done.

While some large sellers sold their vehicles at prices that were on average equal to or somewhat larger than the values calculated by the auction house, others adopted quite different strategies. One set of sellers (called skimmers) generally only sold their vehicles at premiums over the values and showed average markups substantially above those of the more typical sellers. These sellers held out for higher prices and got them, but sold a lower fraction of the vehicles put on sale. Figure 4 plots the sales prices against the auction house values for a typical large seller.

Figure 4

Figure 5 has a plot of prices and values for a skimmer.

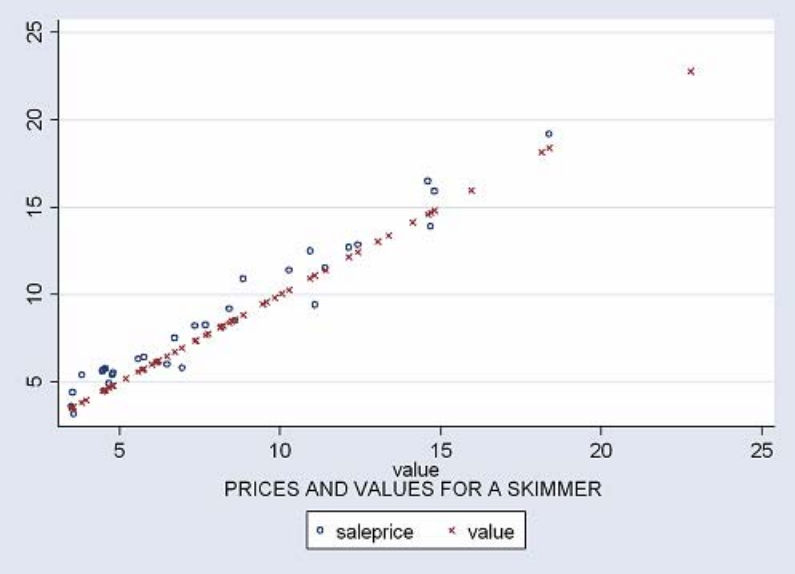

Figure 5

One seller stood out as unlike any other large seller. Most vehicles were sold below the values, often for substantial discounts. Average markups varied from week to week with values in the neighborhood of -.08 or -.14 being typical. Figure 6 plots sales prices against value for this seller at one auction prior to July.

Figure 6

Figure 7

Figure 7 shows the same graph for this seller at an auction in July. Beginning in July and up to the present time, that seller has abandoned the strategy of selling its vehicles below value. While we cannot explain why the seller changed strategies, it appears that what the seller is currently doing is to offer many of its vehicles outside of the twelve numbered lanes. This example illustrates the dynamic nature of the auction as sellers can, and do, change their strategies. This puts limits on how large the effect of changing order of presentation can be. Imitation or other moves to counter any highly effective strategy would possibly follow.

Many of the vehicles sold by this seller were purchased and later resold at the auction. One buyer in particular seemed to specialize in this. This buyer purchased 264 vehicles from January through the present time of which 261 were bought from the one seller. These vehicles were later put up for sale getting prices near book value. Presumably, the buyer had a repair shop and was able to fix whatever shortcomings had depressed the prices at the first sale. The vehicles brought to the auction by the large “discounter” were disproportionately listed with condition “PR” or “RG”. Vehicles with these conditions in their descriptions typically sold for substantial discounts.

Effects of Strategic Choice of Sequence

Two methods of evaluating the effects of sequence were used: a regression method with dummy variables for the six treatments and the second is a comparison of what happened to the seller as compared to various groups of other sellers on the days of the treatments. The controls were for value, time of day, condition of vehicle when known, and date. The first employed a regression based on the sales price of the vehicle as compared to the sales prices of all other vehicles offered for sale at the auction the day of the sale. The second method compared the revenue of the seller using the test strategies against the revenue and sales of selected other sellers on the same day.

As we have stated, the seller that asked about the possible effects of changing the order in which their vehicles were offered for sale had used an ordering that appeared different from the orders used by other large sellers. For this seller, the values of the first vehicles placed on sale were about the same as the values of the later vehicles while other sellers tended to put their more valuable vehicles for sale early in the auctions. We asked the seller to experiment with four methods of ordering vehicles: high values first then low values, low values followed by higher values, vehicles grouped by type arranged within groups from high to low valued vehicles and grouped with the within group order of low values to high. We did not specify the basis of the grouping letting them decide what they thought were the most effective methods. In practice, they tended to group by make with models as subgroups. Thus, Toyota SUVs would be followed by Camrys, etc. Within each subgroup, book values were arranged by the agreed order. As can be seen in Figures 8 through 11, the seller did order their cars as we had suggested.

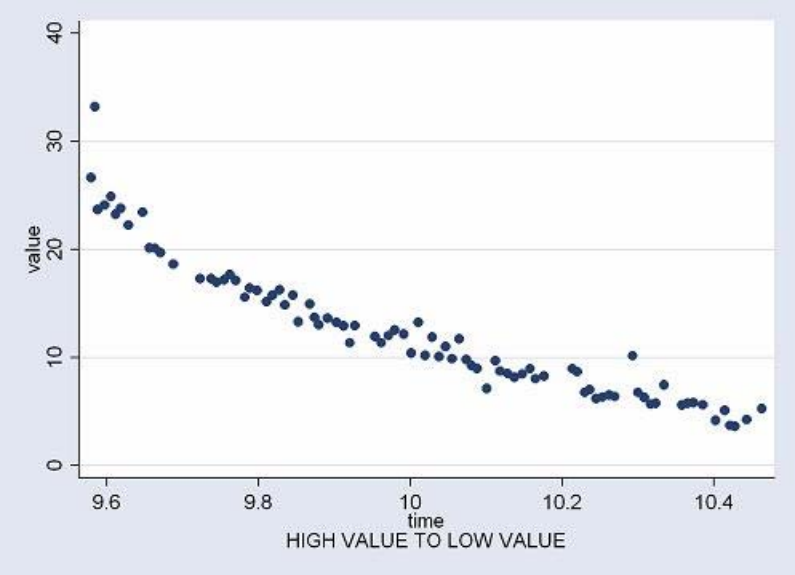

Figure 8

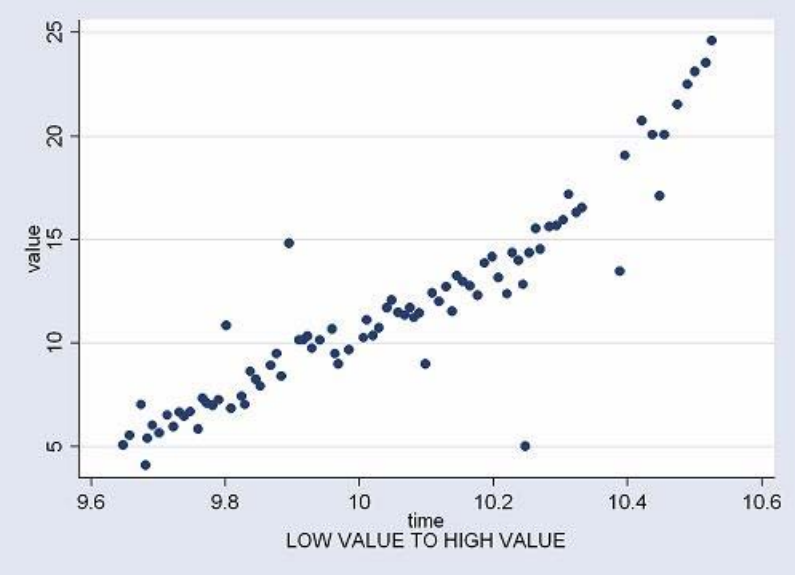

Figure 9

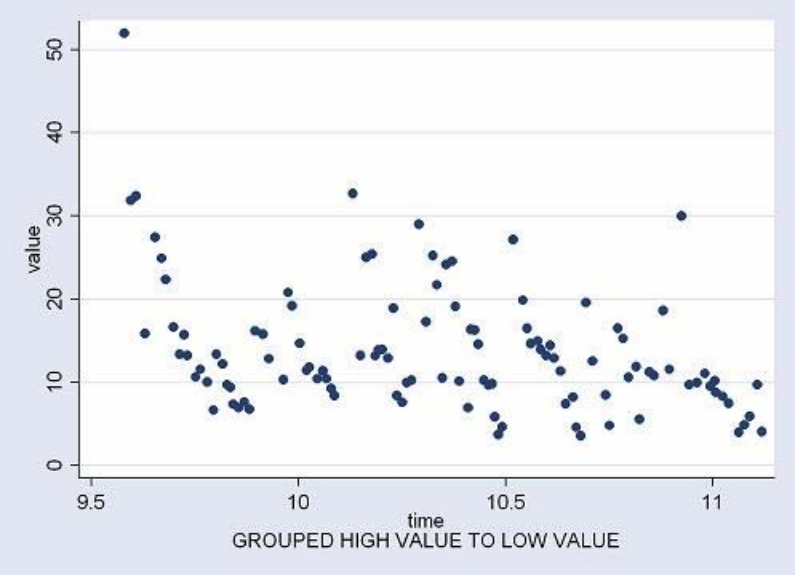

Figure 10

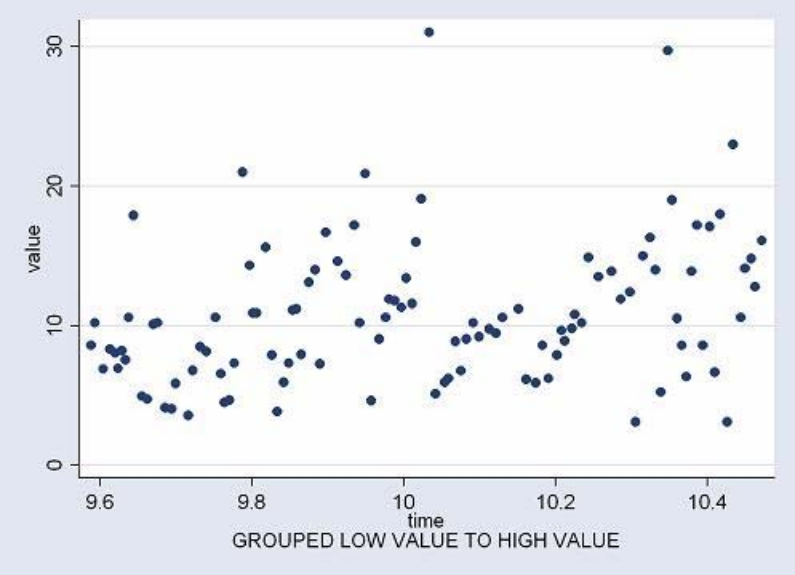

Figure 11

The estimates from the first method of assessment are in Table 2. We estimated regressions with sale price as the dependent variable including the auction house's estimate of the value of the vehicles, dummy variables for vehicles in poor, clean, average, excellent, and rough condition, many vehicles do not have stated condition variables and they are the control category. We also include one dummy variable for each of the orders employed and weekly dummies to allow for changing market conditions (Table 2). We excluded transactions in which the difference between the

sales price ands value exceeded seventy percent. We also excluded all vehicles with estimated values less than $3,000. Including these observations does not change the results significantly. In addition, we estimated an equation with substantially the same results using the logarithm of the sale price as the dependent variable and an equation in which the condition and order variable were interacted with the auction house's estimate of the value of the vehicle. If we restrict the sample to large sellers, only (75 vehicles or more brought to the auction), the results are basically the same.

Table 2 : Regression of sales price estimated vehicle value and dummy variables for the sequence, time in the auction, vehicle condition and week in which the sale was made

Number of observations = 20111
F(29,20081) = 6143.11
Prob > F = 0.0000
R-squared = 0.9357
Root MSE = 1.41

sale price	Coef	Robust Std. Err	t	P> |t|	95% Conf. Interval	
value	.9854	.0028	343.63	0.000	.9798	.9911
D_TR	.2081	.0725	2.87	0.004	.0659	.3502
D_HL	-.3134	.1147	-2.73	0.006	-.5385	-.0884
D)LH	-.1926	.0958	-0.20	0.841	-.2071	.1685
D_GHL	-.0875	.0770	-1.14	0.256	-.2386	.0635
D_GLH	.1550	.0918	1.69	0.091	-.0249	.3350
D_C	-.1100	.1054	-1.04	0.297	-.3166	.0965
time	-.2257	.0118	-19.00	0.000	-.2490	-.2024
D_PR	-2.3189	.1401	-16.54	0.000	-2.5937	-2.0442
D_RG	-1.2223	.0388	-31.43	0.000	-1.2985	-1.1461
D_EC	.1129	.0921	1.23	0.221	-.0677	.2936
D_CL	.2323	.0427	5.43	0.000	.1484	.3162
D_AV	.0088	.0253	0.35	0.726	-.0407	.0584

All estimates included binary variables for the individual weeks (not shown). "value" is the auction house's estimate of retail value not corrected for condition at time of sale. The variables D_TR, D_HL, D_LH, D_GHL, D_GLH, and D_C are dummies for the seller's vehicles in the weeks in which they ordered the cars in the traditional way (TR), from high value to low (HL), low value to high (LH), grouped high to low within the groups (GHL), grouped with low value to high within groups (GLH) and using the Commonly Used method that was adopted after the merger (C). The

variables D_PR, D_AV, D_CL, D_EC, and D_RG are indicator variables for vehicles listed in condition poor, average, clean, excellent, and rough respectively. The control category is condition not reported. Prices and values are in thousands of dollars and time is measured in hours.

The table provides measurements that account for the sales price of the vehicle. Sales price of vehicle is the (coefficient on the value given the sequencing strategy) times value plus adjustments for quality, week and time of day. Thus, a vehicle that was sold using the traditional sequence (TR) will typically sell for .985 (auction house value estimate in dollars) +.208 ($1000). For a vehicle with an estimated value of 10,000 the sale price under TR would on average be $10,058 = .985($10,000)+.208($1000) and the same vehicle is sold according to the strategy of offering high valued vehicles at the first of the sequence of auction, i.e. HL, would be $9,762.40 = .985($10,000)- .0876 ($1000). We are ignoring the week of dummies and the constant term.

While it is not our focus at this time, Table 2 can be used to form a general impression of the nature of these auctions. Generally, the price of a vehicle with a given set of characteristics will decrease with the time at which the vehicle is sold. The condition of the vehicle has a big impact on the price. On average, a vehicle in poor condition (PR) will sell for $2,300 less than a vehicle with no condition report, which is equivalent to a vehicle in average condition (AV). A vehicle reported as condition RG (rough) will ell for $1,200 less than a vehicle with no condition report. If the vehicle is clean (CL) it will sell for $200 more.

TABLE 3.Tests of equality of coefficients of the strategies in the regression model F(1,20081) and Prob>F

	Strategy	Strategy and regression coefficient					
	and regression coefficient	TR 0.21	GLH 0.15	LH -0.02	GHL -0.08	C -0.11	HL -0.31
	TR 0.21						
	GLH 0 .15	TR=GLH 0.21 .6465					
	LH -0.02	TR>LH 3.66 .0557	GLH=LH 1.75 .1860				
	GHL -0.08	TR>GHL 8.07 .0045	GLH>GHL 4.18 .0409	LH=GHL 0.31 .5747			
	C -0.11	TR>C 6.33 .0119	GLH>C 3.65 .0560	LH=C 0.41 .5206	GHL=C 0.03 .8620		
	HL -0.31	TR>HL 15.01 .0001	GLH>HL 10.27 .0014	LH>HL 3.92 .0477	GHL>HL 2.71 .0997	C=HL 1.73 .1888	

Result 3. The regression result suggest that the most profitable methods from the point of view of the strategic seller are the traditional method (T) and the grouped from low to high method (GLH) and the worst method is the method of offering vehicles from high to low (HL).

Support. The results follow from the statistics reported in Table 3. Group from low to high (GLH) and the traditional sequencing (T) have roughly the same benefits to the seller as measured by the regression coefficients. The benefits of these two are significantly better than all other rules. The exception is GLH, which has a higher coefficient than LH (.15 vs -0.02) the difference is not significant. The strategy that is unambiguously the worst as

measured by the regression model is the strategy of offering the vehicles from high value to low value (HL) without grouping. The overall difference is not as clean as could be since LH and several of the rules (GLH, GHL and C) do not differ siginficantly.

The estimates from the second method of evaluation of the different vehicle sequencing strategies are contained in Table 4. The first three columns give the average markups for the strategic seller, other large sellers and all other sellers during the weeks in which the various treatments were used together with t-statistics for testing equality with the strategic seller. The last three columns give the ratios between the total sales revenues and the total value of the cars sold together with t-statistics for comparing the seller with the other large sellers and all other sellers.

Table 4. Average Markups and Returns.

Strategy applied by strategic seller	Average Markup			Return		
	Strategic Seller	Other large sellers	All other sellers	Strategic Seller	Other large sellers	All other sellers
Traditional	.058	.061 (-0.4)	.025* (4.5)	.050	.052 (-0.2)	.021* (3.5)
High low	.019	.051* (-2.7)	.024 (-0.3)	.012	.039* (-2.8)	.012 (-0.0)
Low High	.050	.034 (1.5)	.022* (3.0)	.034	.028 (0.7)	.007* (2.6)
Grouped High Low	.017	.019 (-0.4)	.014 (0.7)	.009	.014 (-0.8)	.010 (-0.8)
Grouped Low High	.048	.008* (3.5)	.020* (2.4)	.029	.024 (0.5)	.009† (2.0)
Commonly used	.019	.023 (-0.4)	0.15 (0.3)	.016	.019 (-0.3)	.012 (0.4)

Figures in parentheses are t statistics for testing difference with the corresponding Seller column.
Traditional Sales 1 2, 4, 10 and12
High Low Sales 16 and 28

Low High Sales 14 and 18
Grouped High Low Sales 6, 20, 22 and 26
Grouped Low High Sales 8 and 24
Commonly Used Sales 32 and 34
Markup (Sale Price-Book Value)/Book Value
Return= (Total Revenue/Total Book Value of Cars Sold) -1
Large Sellers are those bringing 75 or more cars excluding Seller Low
*Difference significant p<.01. Other markup differences are not significant.
† Difference significant p<.05. Other return differences are not significant.
Standard errors for returns computed by the delta method.

Application of the second approach, the comparison of sellers on the same days, yields the following result, which is consistent with Result 3.

RESULT 4. The second approach, the study of returns when compared with other sellers, are consistent with Result 3. The most profitable strategies are the Traditional (T) and the strategy of offering groups of vehicles in the order of low values to high values. The worst strategy is the strategy of offering the vehicles from high values to low values (HL). Other strategies show no evidence of differences among the users.

Support. Table 4 compares sales prices and returns across sellers on the days that the strategic seller employed each of the strategies. Where the measured markup or returns between the strategic seller and other groups of sellers the strategic seller is better off than the other groups and using either T or GLH or is worse off than the other groups and using HL. The estimates shown indicate that, except for the instances discussed, the order treatments do not significantly affect the markup or returns to the strategic seller when compared to others on the same day.

7. SUMMARY AND CONCLUSIONS

The study is based on a large experiment in which approximately 1000 vehicles were sold at auction that had on average a value of approximately $12,000 each. So, millions of dollars of goods were manipulated as controls. Management of the experiment involved several large organizations and the personnel that deal with day to day auctions, none of whom were aware that an experiment was underway. The variables and

controls were implemented as we requested. All vehicles were sold without reserve price as requested.

The basic conclusions are that the sequence in which vehicles are offered for sale in a competitive, large scale auction has implications for profitability. In particular, for some reason open for theoretical speculation the traditional sequence chosen by the strategic seller is one of the two best rules. Grouping the vehicles according to type and offering from low valued vehicles to the higher valued vehicles is also a "best strategy". The worst strategy is the one drawn from theoretical intuition drawn from models of a monopoly seller – namely that the vehicles should be offered from the highest values offered first followed in sequence by lower valued vehicles.

Of course, a key element is the fact that the auction is a competitive auction that lasts several hours with buyers who want several vehicles. The result suggests that a sequence that is almost the opposite used by other sellers is a key. While other sellers compete for the attention of the customers that want the high valued cars the strategy that seems most profitable for the strategic seller is to capture the attention of the all of the buyers who want low valued cars. Then when the other sellers are competing for the attention of the buyers who want low valued vehicles, the strategic seller captures the attention of all of the sellers who want high valued vehicles.

Interestingly, except for the experiment described above, the strategic seller had used what we have called the traditional sequence (TR) until the company merged and the selling team was replaced. After the merger, the strategic seller adopted the strategy that appears to us to be indistinguishable from the strategy of other sellers and in doing so experienced reduced selling prices. This change of strategy along with other examples of the willingness of auction participants to change their strategy underlines the fact that the strategies are endogenously determined with the implication that strategies that prove successful in the short run might not do so over the long run. Nevertheless, this experiment suggests that some sequences produce better results for the seller than do others.

REFERENCES

Ashenfelter, Orley and Kathryn Graddy (2003) "Auctions and the Price of Art" *Journal of Economic Literature* 41:3 pp. 763-787

Beggs, Alan and Kathryn Graddy (1997) "Declining Values And The Afternoon Effect: Evidence From Art Auctions" *RAND Journal of Economics* 28:3 pp. 544-565

Chakraborty, Archishman, Nandini Gupta, and Rick Harbaugh (2006) "Best Foot Forward Or Best For Last In A Sequential Auction?" *RAND Journal of Economics,* forthcoming.

Genesove, David (1995) "Search ar Wholesale Auto Auctions" *The Quarterly Journal of Economics* 110:1 pp.51-72

Goeree, Jacob, Theo Offerman, and Arthur Schram (2006) "Using First-Price Auctions To Sell Heterogeneous Licenses" *International Journal of Industrial Organization* 24:3 pp.555-581.

Goeree, Jacob, Theo Offerman, and Randolph Sloof (2005) "Demand Reduction and Preemptive Bidding in Multi-Unit License Auctions"

McAfee, R. Preston and John McMillan (1987) "Auctions and Bidding" *Journal of Economic Literature* 25:2 pp. 699-738

Milgrom, Paul (2004) *Putting Auction Theory to Work* Cambridge University Press New York

Pitchik, Carolyn (2004) "Budget-Constrained Sequential Auctions with Incomplete Information"

Plott, Charles R. and Timothy C. Salmon (2004) "The Simultaneous, Ascending Auction: Dynamics of Price Adjustment in Experiments and in the U.K. 3G Spectrum Auction." *Journal of Economic Behavior and Organization* 53:3 pp.353-383.

Raviv, Yaron (2004) "New Evidence on Price Anomalies in Sequential Auctions: Used Cars in New Jersey" Claremont McKenna College Working Paper.

Van den Berg, Gerard J. van Ours, Jan C. and Menno P. Pradhan (2001)
"The Declining Price Anomaly in Dutch Dutch Rose Auctions"
American Economic Review 91:4 pp. 1055-1062