HOW EFFICIENT WERE THE NEW ORLEANS SLAVE AUCTIONS?: A STRUCTURAL ECONOMETRIC APPROACH

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ABSTRACT:

The disparity in the prices of slaves in the antebellum south could have come from two sources, disparity in the observed characteristics of the slaves, or disparity in the unobserved valuations of the slave buyers. I use standard hedonic regression techniques to rid the Fogel and Engerman (1974) dataset of the effects of slave heterogeneity. Then, using structural-econometric techniques, I estimate that the most likely number of bidders that could have induced the remaining price dispersion is between six and thirteen. Although far from conclusive, this supports the argument that slave auctions were efficient. ***JEL Classifications***: N31, N81, N91

INTRODUCTION:

Previous work on the efficiency of slavery has tended to focus on issues of productive efficiency, comparing the output of agricultural slave labor to that of free labor (for example. Fogel and Engerman 1974). They have attempted to paint slave owners as rationally maximizing profit, so that a slave's price is equal to his marginal revenue product, properly discounted. The focus of this paper is more targeted: the efficiency of the pricing mechanism itself. This efficiency, or lack thereof, many shed light on the issue of the geographical movement of slavery. Inefficiencies in the slave market may have slowed the sale of slaves from areas of declining profitability to more recently settled, high profit areas.

This paper attempts to address the question of efficiency using a framework that has received much attention, albeit not in historical circles. I will examine the efficiency of the slave market by using the game-theoretic auction literature. I will estimate a structural model of the slave auctions in an attempt to determine the effective number of bidders in the auctions. This paper is similar in nature, though not in focus, to Choo and Eid (2004) who estimate an auctions model for slaves—the only other slave auctions model, to the best of my knowledge. Their research focuses on variations in prices in an attempt to determine whether slave quality was heterogeneous across regions. The focus of this paper is different. It uses variation in slave prices to investigate the efficiency of the pricing mechanism for slaves. Was it an efficient market where, ceteris paribus, the law of one price held? Or was it an inefficient market characterized by a wide dispersion in prices?

The data for this study comes from the "New Orleans Slave Sample, 1804-1862", a dataset collected by Fogel and Engerman (1974), representing over 60 years of data on slave prices and slave characteristics. Slave sales, to be enforceable in court, had to be accompanied by a notarial receipt, a copy of which was kept in the

Notarial Archives in New Orleans. The receipts contain a wealth of information regarding the personal characteristics of the slaves, including age, gender, skill level, occupation, and even 13 different gradations of skin color. Also included were whether the slave was sold as part of a group, whether he/she was guaranteed, and the number of months of credit on which he/she was bought. The Fogel and Engerman dataset is a sample of over 5000 such receipts. Following Kotlikoff (1979) I exclude those records that contain slaves sold in groups, as individual characteristics are often not reported, and often only one price is given for the group. Further, the war of 1812 and the Civil War disrupted the proper recording of agricultural prices. Thus, cotton and sugar prices are missing for 1812-14 and 1860-62, so these years are excluded form the present study. This reduces the size of the dataset to roughly 2500 observations, leaving roughly 50 slave receipts per year.

Auction theory can cast light on the level of competitiveness in a market. If a market is efficient then the law of one price should hold. If the number of bidders was high (around 20 or more) then there was not much room for strategic behavior between seller and buyer, or between buyer and buyer, resulting in a price distribution approximating one price. If the number of bidders is low, less than 5, then there can be much more variation in price. First, if there are few bidders in each auction, the price of a homogeneous slave can vary significantly simply based on the random nature of the sample. Second, if there are few bidders, there is more room for strategic behavior with the outcome depending upon the skill of the negotiators. When the number of bidders is intermediate, between 5 and 20 roughly, definitive answers are not possible.

A complicating factor is that the variation in prices is, in part, due to the heterogeneity between slaves. Fortunately, a hedonic regression can help mitigate this source of price variation. Various authors (Kotlikoff 1979, Levendis 2007) have examined the causes of variation in slave prices in the New Orleans dataset. In what follows, I use the hedonic procedure of Levendis (2007) to adjust slave prices for their underlying heterogeneity. The result of the procedure--to be outlined below--is a dataset of prices that are of a more homogeneous quality.

Even after correcting for slave heterogeneity, there is still some fluctuation in slave prices. Are these fluctuations large enough to indicate that the market wasn't close to being perfectly competitive? The formal theory of auctions can be used to answer this question. In an English auction, the winner in each auction pays the second highest valuation (this will be explained briefly below). Large disparities in prices of identical goods imply that the numbers of bidders in each auction was small. With few bidders, the differences in bids can be quite large. If we examine a large sequence of such auctions, we can infer the average number of bidders in each auction from the observed distribution of winning bids across multiple auctions. Estimating a structural equation that describes the auction, one can estimate the number of bidders at the auction, even though we only have data on the winning bids.

Variation in slave prices was not caused solely by the heterogeneity of slave characteristics. Slave prices are also assumed to vary potentially over cotton and sugarcane prices as these would determine the value of a slave's future output. In other words, demand for slaves---just like the demand for other capital goods---is a derived demand. For reasons to be explained below, correction for agricultural prices and time trends will be conducted from within the structural estimation of the auction.

HOMOGENIZING THE DATA—THE HEDONIC STEP:

The price of a slave depends on his characteristics and his profitability. In this section, I will be making use of regressions of the logarithm of slave prices on a set of slave characteristics and monthly dummy variables. In his ground breaking study of slave prices, Kotlikoff (1979) used the set of slave characteristics described in Table 1:

TABLE 1
DESCRIPTION OF THE VARIABLES

Variable	Description
AGE1-AGE6	Sixth degree polynomial in age.
MTHCRED	Months of credit extended.
MTH1-MTH12	Month dummies, September is excluded.
MALE	Dummy for male slave.
LIGHT-F, -M	Dummies for light colored slaves, females and males respectively.
SKLAGE-1, -4	Dummies for artisans aged: 15-25, 25-30, 30-40, 40-60
SKILL	Dummy for slave artisans.
HW-F, -M	Dummies for female and male slaves with house-centered occupations.
OTHOCC	Dummy for slaves with an occupation who were neither artisans nor had worked in a house related activity.
GUAR-F, -M	Dummies for guaranteed females and males respectively.
K12 K345 K6789 K10+	Variables indicating the number of children ages 1-2, 3-5, 6-9, and 10 and over sold with their mothers.

The present study follows Kotlikoff (1979) and Levendis (2007) in the specification of the regression equation. Kotlikoff deflated by dividing each price by the period-average price of a prime aged male field hand. Levendis deflated slave prices by using an index of wholesale commodities prices in New Orleans. Since time-series information was the crucial variable for Levendis (2007), dividing by average prices was inappropriate since it would have eliminated all trend in the prices. In this study, however, we need to eliminate—not account for—the fluctuations in prices that were the result of seasonality and overall trends, as well as variations resulting from changes in agricultural variables. Applying Kotlikoff's method self-adjusts for changes in mean prices while maintaining the variance between prices.

Regarding variable selection, Griliches (1971) and Fernandez-Cornejo and Jans (1995) warn the practitioner against the use of variables which are not direct characteristics of the commodity (or a transformation of them) but an outcome of the market experiment. Therefore, I do not include sugar and cotton prices in my regressions below. I will account for the influence of agricultural prices and overall time trends at a later stage of the paper---i.e. within the structural auction model itself.

Having the correct functional form of the hedonic price regression is crucial, but it cannot be determined from theoretical grounds. Researchers often experiment with various functional forms, most commonly linear, log-linear, log-log, quadratic, and various Box-Cox forms. The final form is an empirical question. Most researchers of slavery have used a log-linear specification (ex: Kotlikoff 1979, Newland and Segundo 1996, Chennny, St. Amour and Vancatachellum 2003, Levendis 2007, among others). In this paper I employ the log-linear form as it provides the best fit to the largely binary data.

I employ a matched models technique to adjust each slave price by the value of their deviation from a baseline slave. First, I perform a regression of price (or log of price) on slave characteristics using all of the observations. This yields an estimate of the value of each slave's characteristics. Second, I define a "standard slave" as consisting of the average of the qualities of all slaves in the sample. Third, I mark up or down every slave's price by the value of their deviation from the baseline slave:

$$\ln P_{i,adjusted} = \ln P_i + \hat{\beta}_{age}\left(24.01 - age_i\right) + \hat{\beta}_{male}\left(0.471 - male_i\right) + \ldots \qquad (1)$$

where the $\hat{\beta}s$ are the estimated coefficients from the hedonic regressions.

Misspecification of the hedonic equation will result in slave prices that are poorly standardized. That is, not enough variation will be removed. The high R^2 from the regressions, however, implies that we are nearing the upper bound of explained variation. There is a possibility that the coefficients are not time-invariant. Kotlikoff (1979), however, compared a single regression with decadal ones, and reported only slight changes in the coefficients.

The results of the first step, the hedonic regression, are reported below in Table 2. Each slave's price is adjusted so that each slave is dark-skinned, male, skilled, a field hand 21 years of age, sold on 2.2 months of credit (the population average), and was guaranteed. Now that the data represents homogeneous labor, we can proceed with the structural estimation of an auction model.

THE MODEL

First I describe a standard auction model. The auction has the following properties: The auction is an ascending price, open bid auction. The winner pays only the highest bid. There is no minimum price set by the seller. The bidders are risk neutral and symmetric. And finally, the independent-private-values assumption applies.

There are *N* bidders, each with their own valuations. Thus there is a sequence of valuations $\{v_i\}_{i=1}^{N}$ which comes from some pdf $f_v(\cdot)$ with corresponding cdf $F_v(\cdot)$. Thus, valuations are i.i.d. from $f_v(\cdot)$ and it is assumed that the distribution of $f_v(\cdot)$ is known to all participants, but that each person's valuation is only privately known (this is the independent-private-values assumption mentioned above). These assumptions correspond to what McAfee and McMillan (1987) call their benchmark model.

TABLE 2

LOG OF SLAVE PRICES DECOMPOSED

Variable	Coeff.	Std. Error	P-Value	Variable	Coeff.	Std. Error	P-Value
MALE	0.105	0.035	0.002	AGE	0.173	0.007	0.000
LIGHT M	0.025	0.024	0.292	AGE2	-0.005	0.000	0.000
LIGHT F	0.067	0.022	0.002	AGE3	0.000	0.000	0.000
GUARM	0.294	0.026	0.000	MTH1	0.109	0.037	0.003
GUARF	0.247	0.027	0.000	MTH2	0.054	0.038	0.156
K12	0.247	0.118	0.036	MTH3	0.058	0.037	0.114
K345	0.205	0.156	0.187	MTH4	0.087	0.037	0.018
K6789	0.195	0.072	0.006	MTH5	0.017	0.037	0.639
K10plus	0.314	0.097	0.001	MTH6	0.009	0.039	0.825
MTHCRED	0.013	0.001	0.000	MTH7	0.013	0.040	0.751
HWM	-0.012	0.058	0.836	MTH8	0.031	0.041	0.452
HWF	0.057	0.033	0.082	MTH10	0.032	0.041	0.437
OTHOCC	-0.065	0.074	0.384	MTH11	0.066	0.041	0.107
SKLAGE1	0.301	0.091	0.001	MTH12	0.067	0.040	0.095
SKLAGE2	0.311	0.106	0.003	Constant	2.449	0.072	0.000
SKLAGE3	0.616	0.102	0.000				
SKLAGE4	0.413	0.159	0.009				
R2	0.438			N	2728		
Adj-R2	0.431			F(31, 2696)	67.69		

As the auction is being conducted, a bidder keeps bidding until the point where the price exceeds what the product is worth to him. The final bids $\{B_i\}$ of the non-winners are then $\{B_i\} = \{\beta(v_i)\} = \{v_i\}$. That is, given my valuation v_i, my bid function $\beta(\cdot)$ tells me that my bid B_i should be equal to my valuation.

The person with the highest valuation wins and pays what the 2nd highest opponent was willing to pay (plus epsilon, but epsilon can be put arbitrarily close to zero and so is ignored). Thus, there is a one-to-one correspondence between valuations and bids, excluding the winning bid which is equal to the 2nd highest valuation. Thus, the study of English auctions such as this one involves the study of the distribution of the 2nd order statistics. I will turn to this shortly.

Having drawn N independent valuations $\{u_i\}_{i=1}^{N}$ from $f_v(\cdot)$ we can reorder these from greatest to least and re-index without loss of generality so that we have $v_1 > v_2 > ... > v_N$. Ordered as such, these random variables are called “order statistics”.

The distribution of the highest order statistic v_1 is derived easily: the probability that one $v_i < v$ is given by $F_v(v)$. Using the i.i.d. assumption, the probability that all N valuations are less than v is given by $\left[F_v(v)\right]^N$. The distribution of the second order statistic v_2 is just a small step further. The event that v_2 is less than or equal to v can happen in two different ways:

1. all u were less than v, the probability of which is $\left[F_v(v)\right]^N$, or
2. all but one u were less than v (leaving one that is greater), the probability of which is given by $\left[F_v(v)\right]^{N-1}\left[1-F_v(v)\right]$. There are N different ways that this could occur: (either u_1 was the 2nd-order statistic, or u_2, or ... u_N), so $\mathrm{N}\left[F_v(v)\right]^{N-1}\left[1-F_v(v)\right]$.

Thus the CDF of the 2nd-order statistic (the winning bid) is

$$F_2(v)=\left[F_v(v)\right]^N+N\left[F_v(v)\right]^{N-1}\left[1-F_v(v)\right]=N\left[F_v(v)\right]^{N-1}-(N-1)\left[F_v(v)\right]^N \quad (2)$$

Associated with this CDF is the PDF:

$$f_2(v)=\frac{\partial F_2(v)}{\partial v}=N(N-1)\left[F_v(v)\right]^{N-2}\left[1-F_v(v)\right]f_v(v). \quad (3)$$

If we are given values of the winning bids from a series of similar auctions, and the distribution of valuations was common across each of the auctions, then one can determine the relationship between the distribution of valuations $F_v(\cdot)$ from the distribution of winning bids $F_w(\cdot)$.

Then, given T auctions the likelihood function is

$$L(\theta)=\prod_{t=1}^{T}\left\{N(N-1)\left[1-F(w_t;\theta_1,\theta_2)\right]\left[F(w_t;\theta_1,\theta_2)\right]^{N-2}f(w_t;\theta_1,\theta_2)\right\} \quad (4)$$

The pdf of valuations is usually assumed to be from a parametric class of distributions. Say we have a set of T different auctions, indexed by t. Then we can have $f_t(v)=F(v_t;\theta,\beta_t,N)$ where β_t is a vector of observable characteristics, θ is a $p\times 1$ vector of unknown parameters that characterize the shape of $F(\cdot)$ ($p=2$ for the case of the Weibull, Normal, Gamma, and Beta, for example), and N are the number of potential buyers in each auction. Estimating the most likely number of bidders is then a simple exercise in Maximum Likelihood estimation.

ESTIMATION

Having adjusted the data on slave prices (standardized to correct for heterogeneity), I turn to estimating the number of bidders. I carry out the structural estimation under the assumption that the underlying distribution of valuations comes from a parametric family of distributions. Two commonly used distributions will be examined: the Weibull and Exponential. If their conclusions are in agreement, this is evidence that the model is correctly specified. Otherwise, results depend crucially on the assumed distribution--I would in effect be assuming my results. Fortunately, the results are consistent across the two models.

Weibull:

The pdf for the Weibull is

$$f_v(v;\theta_1,\theta_2) = \theta_1\theta_2 v^{\theta_1 - 1}\exp(-\theta_1 v^{\theta_2}) \tag{5}$$

which has support on [0,∞). It is a flexible functional form and is numerically very stable.

The location parameter θ_1 of the Weibull distribution is assumed to depend on time and the prices of cotton and sugarcane. Since θ_1 in [0,∞) for the Weibull, I replace it with

$$\theta_1 = \exp(X_1^{'}\beta_1 + X_2^{'}\beta_2 + X_3^{'}\beta_3) \tag{6}$$

where X_1 is a $T\times 1$ vector of cotton prices, and β_1 is a $T\times 1$ constant vector corresponding to the importance of cotton prices to the determination of slave prices. An analogous statement applies for X_2 and β_2 with respect to sugarcane prices. From these data and the given likelihood function I attempt to extract the number of bidders *N* as well as the parameters that determine the Weibull (i.e. I estimate θ_2, as well as β_1 and β_2 which determine θ_1.

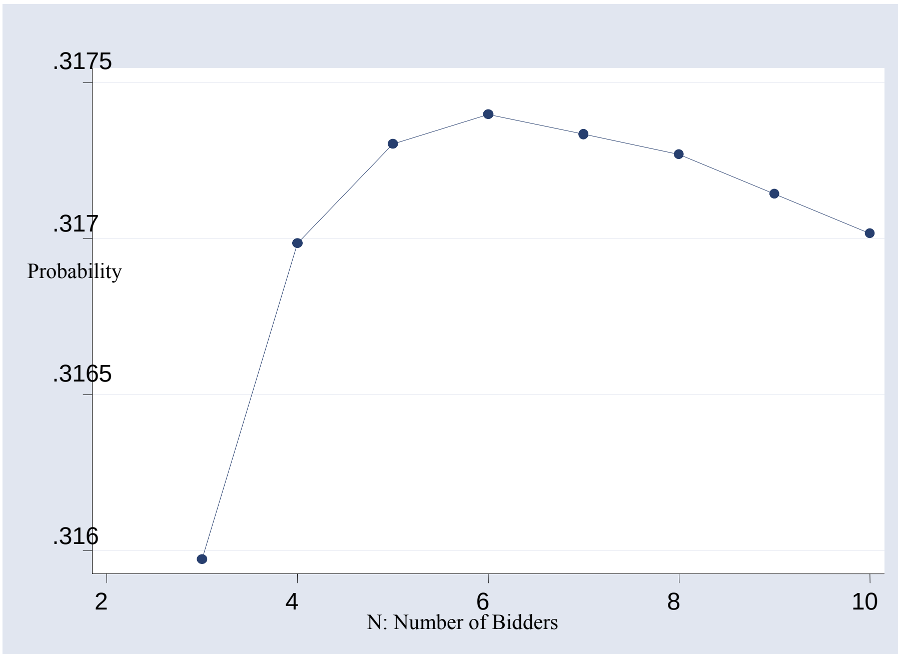
Estimating the optimal coefficients $\beta_{1-}\ \beta_6$, and running a grid-search of *N* from 3 to 20, my best five estimates of the parameters are listed below in declining order.

TABLE 3
WEIBULL LIKELIHOOD

Preference	Coeff on cotton	Coeff.on sugar	θ1	θ2	N	Probability
1	5	-9	0	1	6	0.3174
2	-5	9	0	1	7	0.3173
3	4	-7	0	2	5	0.3173
4	-3	6	0	1	8	0.3173
5	-8	13	0	1	9	0.3171

In other words, the log-likelihood function is maximized where the most likely number of bidders is six. The second most likely number of bidders is five, and so forth… Graphically, the relationship between the value of the maximized log-likelihood function, and *N* is given in the graph below:

FIGURE 1
WEIBULL LIKELIHOOD



Under the assumptions given above, the dispersion in final bids is most likely to have come from a pool of six bidders

Exponential:

The pdf for the Exponential is

$$f_v(v;\theta) = \frac{1}{\theta}\exp(\frac{-x}{\theta}) \tag{7}$$

so that $E(v) = \theta$. For estimation of an exponential pdf, I replace θ in the likelihood function with

$$\theta = \exp(X_1^{'}\beta_1 + X_2^{'}\beta_2) \tag{8}$$

where the βs as before represent the effect of cotton prices and sugarcane prices.

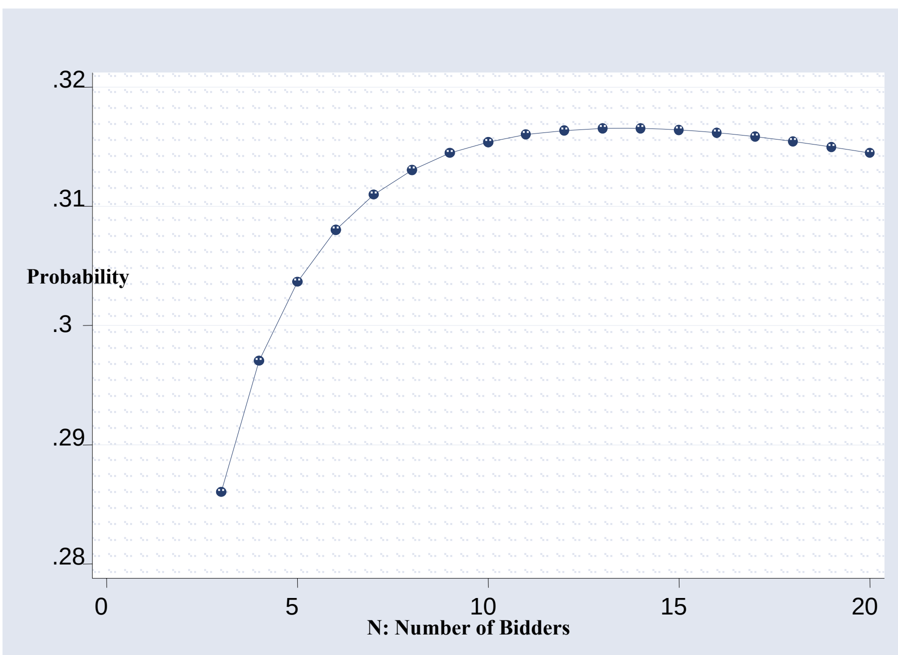
Estimating the βs and running a grid-search of N from 3 to 20, the five most likely values of the parameters are listed below in declining order.

TABLE 4
EXPONENTIAL LIKELIHOOD

Preference	Coeff. on cotton	Coeff. on sugar	θ	N	Probability
1	0	0	37	13	0.3165
2	0	0	35	14	0.3165
3	0	0	34	15	0.3164
4	0	0	38	12	0.3164
5	0	0	33	16	0.3162

Under the assumption that the underlying distribution of valuations is distributed exponentially, the most likely number of bidders is thirteen, with 14 and 15 running 2nd and 3rd respectively. The likelihood function, as a function of the number of bidders N is:

FIGURE 2
EXPONENTIAL LIKELIHOOD



Again, given the assumptions above, and the observed dispersion in final bids for slaves, the most likely number of bidders to have generated this dispersion is thirteen.

CONCLUSION AND RECOMMENDATIONS FOR FUTHER RESEARCH:

There has been much discussion as to the efficiency of slave markets. The evidence presented in this paper suggests that the most likely number of bidders in each auction is rather small, between six and twelve, depending on whether one assumes the underlying heterogeneity in valuations is distributed Weibull or Exponentially. Unfortunately, the number of bidders lies in an intermediate range where definitive statements as to the efficiency of the slave market are problematic. The study provides support that the market was reasonably competitive.

Further research should focus on constructing a more complete dataset--one that includes height and weight along with the other dozen or so variables included in the Fogel and Engerman dataset. Armed with such a dataset, the hedonic procedure would remove more variability from slave prices. This in turn, might increase the estimated number of potential bidders, and indicate greater efficiency for the slave market than we have presently found. Clearly more research in this area should be encouraged.

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