Interregional Price Difference in the New Orleans' Auctions Market for Slaves *

Eugene Choo
Department of Economics
University of Toronto
eugene.choo@utoronto.ca

Jean Eid
School of Business and Economics
Wilfrid Laurier University
jeid@wlu.ca

March 13th 2007

Abstract

Our paper investigates the variation of winning bids in slave auctions held in New Orleans from 1804 to 1862. Specifically, we measure the variation in the price of slaves conditional on their geographical origin. Previous work using a regression framework ignored the auction mechanism used to sell slaves. This introduced a bias in the conditional mean of the winning bid since it depended on the number of bidders participating in the auction. Unfortunately, the number of bidders is unobserved by the econometrician. We adopt the standard framework of a symmetric independent private value auction and propose an estimation strategy to attempt to deal with this omitted variable bias.

Our estimate of the mean number of bidders doubled from 1804 to 1862. We find the number of bidders had a significant positive effect on the average winning bid. An increase from 20 to 30 bidders in an auction raised the average winning bid by around 10 percent.

The price variation according to the geographical origin of slaves found in earlier work continues to persist after accounting for the omitted variable. We also find a new result that a considerable premium is paid for slaves originating from New Orleans. However, this price variation disappears once we account for regional productivity differences.

*We are grateful to Jean Pierre Dube, Gillian Hamilton and Joanne Roberts for invaluable comments. We also thank Siwan Anderson, Winnie Chan, Jon Cohen, Silvia Martinez Gorricho, Leo Teng Wah, Angelo Melino, John Munro, Leo Rezende, Aloysius Siow, Matthew Turner, the seminar participants at the University of Toronto, and session participants at the 2004 Canadian Economic Association Meetings. Eugene Choo also thanks Tim Guinnane, Moshe Buchinsky, Ben Polak and Don Andrews for suggestions and comments on earlier incarnations. He also acknowledges financial support from the Connaught Fund and Social Sciences and Humanities Research Council of Canada.

1 Introduction

One of the most significant recent debates in economic history concerns the profitability and efficiency of slave-based production. This debate was made famous with the publication of Robert Fogel and Stanley Engerman's *Time on the Cross*. This controversial book challenged many of the traditional interpretations of the economics of slavery. Fogel and Engerman made a number of propositions. Among them, they provided new evidence that slave production was profitable and that slave agriculture was more efficient than free labor agriculture. [1] Central in this debate is the use of prices collected from slave auctions. Economic historians have a long history of using price data from slave auctions to infer the returns and hence the profitability of owning slaves. Therefore, prices are the building blocks used to evaluate the economics of slavery. Together with the market value of goods produced and goods consumed by slaves, they were used to calculate measures of the net productivity of slave production.

From auction theory, the winning bid in an oral ascending auction on average equals the willingness-to-pay of the second highest bidder.[2] The tradition in the economics of slavery literature however, has been to interpret the realized price in slave auctions as the valuation of the average slave owner (or bidder) in the market. Calculations of the returns or profitability from owning slaves, and the market valuation of slave characteristics based on this assumption (that the realized price represents the average valuation) is likely to overstate the profitability.

Another concern is whether the sample of slaves at auctions are representative of the population of slaves. For example, are slaves with more highly valued attributes more likely to be brought to market. This is also important when constructing an estimate of slave values. We will provide evidence that the price of slaves varies significantly according to their geographical origin. Our results suggest significant statistical discrimination of slaves based on their geographical origin and that this discrimination is correlated with productivity differences across these regions. Both these concerns would have implications on the calculations of rates of returns. We attempt to deal with these concerns in this paper.

Earlier work using slave prices as a measure of the average value of owning slaves typically regress realized winning bids on market and slave characteristics (examples include Greenwald and Glasspiegel (1983) and Kotlikoff (1979)). Since the winning bid in an oral ascending auction reflects the average valuation of the second highest bidder,

[1] *Time on the cross* generated a lot of criticisms, refutations and rebuttals.
[2] This holds under the hypotheses of the revenue equivalence theorem.

this also means that the conditional mean of the winning bid also depends on the number of bidders participating in the auction. This is typically ignored in these regressions, hence introducing an omitted variable bias in the conditional mean of the winning bid. Unfortunately, information on the number of bidders was not recorded for any of these auctions. This limitation led previous work to ignore the effect of number of bidders on the winning bid.

To deal with the limitation introduced by the omitted variable bias problem, we estimate a proxy for the number of bidders. We construct this proxy from records of sale and hire transactions over the same period. This strategy of constructing a proxy for the potential number of bidders is not new to the empirical auction literature. For example, Hendricks, Pinkse, and Porter (2003) construct a measure of the potential number of bidders in federal wildcat auctions using information from bids in neighbouring areas around a tract. Our estimation strategy allows us to non-parametrically identify the effect of the number of bidders on the winning bid. One caveat is that our approach assumes that our constructed number of bidders is exogenous and measured without error. This is a strong assumption that we currently cannot deal relax.

Our estimated number of bidders participating in New Orleans' slave auctions more than doubled over our sample period.[3] Our analysis finds the number of bidders to have had a significant positive effect on the average winning bid. For example, an increase from 20 to 30 bidders in an auction would raise the average winning bid by around ten percent.

Even after controlling for the competitive effects of the number of bidders, we continue to find significant price differentials based on the geographic origin of slaves. The pattern of this price variation generally conforms to the findings suggested by earlier studies (eg. Greenwald and Glasspiegel (1983)). However, once we account for spatial productivity differences, the regional price variation disappears. Slaves originating from high productivity regions (all else equal) are on average more heavily discounted than slaves coming from relatively lower productivity regions. Based on this slave auction data, we cannot rule out the hypothesis that all regional price variation in the New Orleans market reflected the statistical discrimination of slaves based on regional productivity differences.

We adopt the symmetric independent private value (IPV henceforth) auction model. Our estimation strategy however is also consistent with a common value auction setting

[3]This increase coincided with the growth in demand for cotton textiles in England and Europe over this period and the westward expansion of agricultural land in the 1830's. (See also North (1966), pages 46-47.)

under the assumption that signals conditional on observed slave characteristics are iid across auctions. This assumption (for a common value setting) is very restrictive especially given earlier works which suggest that signals across auctions could be correlated depending on the geographical origin of slaves. As pointed out by Milgrom and Weber (1982), the private value and common value assumptions can lead to very different bidding patterns. Milgrom and Weber (1982) also suggest the 'winner's curse' test to distinguish between these two models. Our primary auction dataset does not contain information on bids nor the number of bidders (which we construct a proxy for). This limited data does not allow us to distinguish between these frameworks or to calculate the winner's curse present in a common value setting. Hence, we chose to adopt the simplest, though restrictive assumption of independent private values. [4]

We employ an estimation strategy that builds on the elegant insight of Rezende (2004). A common starting point in many empirical auction models is to assume that bidders valuations take an additively separable form, $V_i = X\beta + \epsilon_i$, where X are observed covariates of the object on auction and ϵ_i is the bidder's private valuation. Rezende (2004) showed that in a wide variety of auction settings, the equilibrium winning bid will also be additively separable in $X\beta$ and a nonlinear term of the number of bidders in that auction. This structure permits the use of simple ordinary least squares of observed winning bids on the covariates and a nonlinear transformation of the number of bidders. Rezende (2004) also shows that this approach is robust to several types of misspecification and provides a way of making inference about the distribution of valuations. We build on this idea and propose a semiparametric approach to deal with this additively separable nonlinear term. Our semiparametric estimation strategy assumes that the number of bidders in an auction is measured without error. Given that the number of bidders has to be proxied, this assumption will surely be violated. Unfortunately, we are not able to deal with this important limitation in this paper.

The rest of the paper is structured as follows, Section 2 provides a brief historical summary of the period, and a review of the literature follows. Section 4 outlines the model and the estimation strategy. Section 5 discusses the data used in this paper and the issue of sale aggregation. Section 6 discusses the results, and section 7 concludes.

[4]There is a large empirical literature on common value auctions with diverse applications. For example, Hendricks, Pinkse, and Porter (2003) combines bid data with data from the ex-post realized market value of oil from wildcat tracts to quantify the magnitude of the winner's curse in their pure common value model of oil lease auctions. Bajari and Hortaçsu (2003) estimate the winner's curse in eBay coin auctions using a second-price sealed bid auction model with common values and endogenous entry.

2 Historical Setting

The following discussion draws heavily from Bancroft (1931), Fogel and Engerman (1974b) and North (1966).

Agriculture during colonial times in the United States relied on the great abundance of land and labor. The first shipment of African slaves from England arrived in Virginia in 1619. The U.S. international slave trade continued for almost two centuries until its legal withdrawal in 1808. In 1650, there were only some 300 slaves in Virginia, but by 1671, this population had grown to 2,000. The slave population in the colonies reached an estimated 75,000 in 1725 and half a million in 1776 (see Bancroft (1931), page 3). Before the revolution, most of the slave population was concentrated in Maryland and Virginia.

The 1790's saw a growing switch from tobacco and rice to cotton. Eli Whitney's invention of the '*saw gin* made cotton a commercially viable fiber. This coupled with a rise in the demand for cotton sparked an expansion of the cotton industry. Figure 2(a), reproduced from North (1966), shows the remarkable growth in cotton exports in the period after the invention of the saw gin. Cotton exports grew from 488 pounds in 1793 to a staggering 41,106 pounds in only one decade. Overall exports grew by $30 million from 1791 to 1807. Almost half of this growth was in cotton exports. (See North (1966), pages 40-41.)

The switch to cotton production brought with it a major reallocation of the slave population from the states of Maryland and Virginia to the Southcentral and Southwestern states. The lure of large profits attracted planters westward to states like Georgia, Louisiana, Mississippi, Texas and Alabama: states that were better suited for cotton plantations. According to the 1790 and 1860 censuses, the shares of the slave population in Maryland and Virginia fell from 15.8 percent to 2 percent, and 45.07 percent to 12 percent respectively. While the share of the slave population in southwestern states like Louisiana and Mississippi, together grew from 8.5 percent in 1830 to 19 percent in 1860.

This large movement in the slave population created domestic interregional markets for slaves. States of the Old South like Maryland, Virginia and the Carolinas became the main slave exporting states while Alabama, Mississippi, Texas and Louisiana became the main slave importing states. Between 1790 and 1860, a total of 835,000 slaves moved from these exporting states into the Southwestern states, (Fogel and Engerman (1974b)). The bulk of the westward movement was comprised of the migration of owners and their slaveholdings (see Fogel and Engerman (1974b), pages 48-50).

2.1 Slave Auctions and the New Orleans market for slaves

This paper uses sales data from the New Orleans' slave auction market. This market was the largest and busiest market in the interregional trade. In the 1850's, it supported some 200 registered slave traders compared to smaller markets like Montgomery in Alabama which had 164 and Charleston in South Carolina which had only 50 (see Eaton (1974) and Bancroft (1931), Chapter 15).

There is considerable anecdotal evidence suggesting that slaves were typically sold in an oral ascending auction. For examples of typical accounts of a slave auction, refer to Chapters 5 and 15 of Bancroft (1931). To our knowledge, there are no official records of the rules of the auction, beyond anecdotal accounts of auction sales. These rules are important if one aims to model the bidding process of participants in these auctions. Typical auction for slaves had the following similarities. The slave for sale was made available for inspection before the auction. At the time of the auction, the slave normally stood on a raised surface in view of all interested bidders. The auction typically started with an auctioneer advertising the good qualities of the slave on sale and at times he also announces what price he would have expected to pay for such a slave. He then started the bidding at some price.

There were considerable risks associated with buying a slave. The selling of slaves that are inferior and problematic as 'prime' is one example of this dishonest trading behavior. This pooling problem was aggravated by states like Virginia and Maryland that had a reputation of reselling or deporting slaves to nearby states to reduce the cost of prosecuting criminal slaves. The reputation of slave traders and the initial owner of the slave were often important in ensuring a good price for that individual (see Bancroft (1931), Chapter 1). Hence, the vast interregional movement and interstate trade of slaves brought with it significant risk.

2.2 Prices and the Slavery Debate

Much of the recent debate on slavery in economic history concerns the profitability and efficiency of slave based production. The traditional "Phillips school" view embodied in the work of Ulrich B. Phillips and other historians that followed argued that slavery was an unprofitable investment, and that slave-based production was inefficient. They concluded that by the mid 1850's, slavery was at a dead end economically and that slavery had left the South economically stagnate.[5] Phillips published this in his most influential

[5]See Fogel (2003) for a recent summary of these debates.

book, *American Negro Slavery*, in 1918. Using data from plantation documents, probate record, and bill of sales, Phillips provided quantitative evidence in support of his propositions.

Beginning with Conrad and Meyer (1958), many historians, like Fogel and Engerman (1974b), attempted to resolve this debate by bringing more empirical evidence to the analysis. Price data of slaves sold in auctions in the south has been the central building block in the economic analysis. These prices were taken as unbiased estimate of slave values. Together with the prices of other inputs like land, food and clothing, they were used to infer productivity and profitability measures. In a recent survey of economic historians published in Whaples (1995), the consensus among economic historians from this debate is that slavery was not economically moribund at the eve of the Civil War. The profession has also generally agreed that slave agriculture was efficient relative to free-labor agriculture.

We argue in this paper that these realized auction prices were on average equal to the willingness-to-pay of the second highest bidder. Using auction prices as the average market valuation as done in existing literature overstates the valuation of slaves. This has important implications on the rates of return and other profitability measure calculations central in the slavery debate. Revisiting this debate and quantifying the bias in these profitability calculations is beyond the scope of this paper. Nonetheless, we hope to provide a convincing argument of how auction data could be better utilized to infer market valuations.

3 Literature Review

The regional differences in average prices of slaves sold in the secondary market in New Orleans was first discussed by Greenwald and Glasspiegel (1983). The authors argued that spatial price heterogeneity arose because slaves came from regions of varying agricultural productivities. The Old South which was comprised of Virginia, Delaware and Maryland had a climate less suitable for cotton and suffered from soil nutrients depletion brought about by overfarming. The more productive Southwestern states of Mississippi, Louisiana and Texas had more suitable climates and more fertile land. They argue that informational asymmetry between slave owners and buyers was responsible for slaves being adversely selected based on their geographical region of origin. In other words, slaves of average abilities had higher values in the more productive Southwestern states than in the less productive Northeastern states. So owners (who are better acquainted with the abilities of their own slaves than a potential buyer) from productive regions were more likely to sell slaves of low quality. In contrast, owners from less productive regions which had an over supply of slaves were more likely to sell slaves of both below and above average quality. This leads to a statistical discrimination of slaves in the New Orleans auction based on their geographical origin. This argument implies that for the same observable characteristics, prices of slaves from a more productive region should be lower than prices of slaves from a less productive region in anticipation of this selection or discrimination problem.

Greenwald and Glasspiegel (1983) tested for this selection using the slave auctions data collected by Fogel and Engerman (1974b) from the New Orleans archives. The data used will be further discussed in the next section. The basis of their testing procedure involved generating a subsample of guaranteed, individually priced slaves that were fairly homogeneous in terms of skills and age. A price index was calculated for a five year interval using these observations controlling for temporal effects using a derived deflator. The authors assumed that their subsamples were sufficiently homogeneous that characteristics still present in these observations were independent of the geographical region of origin and would appear as random errors in their regressions. A measure of the productivities for these geographical regions was obtained from the rental rates presented in Conrad and Meyer (1958). The authors argued that since rental markets for slaves were local by nature, these rates were likely to reflect the respective regional productivities. A negative relationship was found in a regression involving these two sets of indices, consistent with their hypothesis of adverse selection or statistical discrimination.

Pritchett and Chamberlain (1993) tested this hypothesis further using succession data collected by the New Orleans Conveyance Office. A succession sale is basically a forced sale of an estate resulting from the death of its owner. Using the same technique as Greenwald and Glasspiegel (1983), a single price index for the region of Louisiana was calculated. The authors argue that since this succession data recorded forced sales of both high and low quality slaves, the sample of slaves being sold should be representative of the slave population as a whole. This single index was not significantly higher than the price index for Louisiana derived by Greenwald and Glasspiegel (1983) which contradicted the adverse selection or discrimination argument. Instead, they found it to be lower compared to the price indices of slaves from faraway regions, suggesting that imported slaves command higher prices in general compared to local slaves. They argue that the higher average quality of imported slaves can be explained using the cost of transportation and the Alchien and Allen theorem. The latter theorem states that if a fixed cost is applied to two substitutes, the effect is that it makes the higher quality product relatively cheaper. Their story did not rely on adverse selection and they claimed it was consistent with the results obtained by Greenwald and Glasspiegel (1983).

4 Model and Estimation

We now outline our empirical auction model and our estimation strategy. Units of slaves are sold in an open English ascending auction, without a reservation price. The evidence on the presence of a reservation price in the New Orleans' auctions is mixed. We can find many anecdotal accounts of the slave auctions that make no reference to any reservation price or 'expected price', King (1926) (page 279) is one example. To our best knowledge, the one exeption is the account of a New Orleans' auction by Bancroft (1931)(Chapter 5) where a reservation price or 'expected price' is announced before the start of the auction. Ultimately, this modelling assumption is driven by data limitations. Our data do not contain any information on reservation prices, nor information on slaves who were withdrawn from auctions because their reservation prices were not met.

These units on auction comprise of either an individual slave or a group of slaves. We adopt the standard assumptions of a symmetric IPV auctions. That is, the valuation of bidders are assumed to be private, and independently and identically drawn from a common distribution. We also assume that bidder valuations are symmetric.

The IPV assumption is restrictive and there are many features of the New Orleans slave auction which suggest that a common value auction assumption is more appropriate. Bidders are likely to only have partial information about the value of slaves acquired through private inspection of slaves in slave pen before the auction. Accounts from Bancroft (1931) and more recently by Johnson (1999) suggest that this private acquisition of information in an important aspect of the New Orleans slaves auction. Hence, bidders may possess information that is correlated with how other bidders value the slave on auction. This information structure suggest that bidders valuations are likely to be interrelated and not independent. The empirical methodology we propose is robust to both the IPV and common value auction assumptions. We will elaborate on this more when we discuss our estimation strategy. However the data limitations will not allow us to test the validity of either of these assumptions. Not observing the bids nor the number of bidders or bidders' covariates, also means that we are not able to say anything about the typical objects of interest in common value auctions like the winner's curse or the joint distribution of valuations. Our estimates of the expected variation in winning bids by the geographical origin of slaves is invariant to relaxing this restrictive IPV assumption. Our empirical formulation of the bidders' valuations and the winning bid follows that of Rezende (2004). The estimation methodology that we propose is our own.

The valuation of bidder i in auction ℓ is denoted by $V_{i\ell}$. Let the vector of observable characteristics in auction ℓ be (X_ℓ, Z_ℓ), where X_ℓ are covariates that affect the mean while Z_ℓ affects only the variance of the bidders' valuations. These are observed by all the bidders and the econometrician. The variable X_ℓ includes observable attributes such as advertised skill, age, and gender of the slave on auction which affects the mean of bidders' valuations. Z_ℓ denotes the number of slaves that are grouped together in a single auction. Given a single price is paid for a group of slaves in these auctions, buyers face more uncertainty about the value of any given slave. We capture this uncertainty through the interaction of Z_ℓ and the idiosyncratic error $\epsilon_{i\ell}$. The number of bidders in auction ℓ is denoted by n_ℓ. Assume that bidders' valuations have a separable form given by **A1**.

A1 The private valuation for all bidders i, of either an individual or a group of slaves with observable attributes (X_ℓ, Z_ℓ) in auction ℓ is given by

$$V_{i\ell} = X_\ell\,\beta + h(Z_\ell) \cdot \epsilon_{i\ell},$$

where $\epsilon_{i\ell} \sim \mathcal{G}$. The distribution $\mathcal{G}$ is strictly increasing and admits a continuous density $g = \mathcal{G}'$ with finite first moment. The elements $\{\epsilon_{i\ell}\}_{\ell=1}^{n_\ell}$ are i.i.d with mean 0 and variance σ_ϵ^2, for all i, ℓ. As we cannot separately identify $h(Z_\ell)$ from the variance of $\epsilon_{i\ell}$, we normalize the coefficient on $h(Z_\ell)$ to 1. In addition, $\mathcal{G}$ is independent of X and Z.

In words, the mean of the bidder's valuation is linear in the attributes X_ℓ. Any auction specific heterogeneity in bidder's valuation is captured by the function, $h(\cdot)$ which is a function of observed attributes Z_ℓ. The variance of bidders' valuations conditional on observed (X_ℓ, Z_ℓ), is $Var(V_{i\ell} \mid X_\ell, Z_\ell) = \sigma_\epsilon^2 h(Z_\ell)$. As such, it will not be possible to separately identify any scale parameter in $h(Z_\ell)$ from σ_ϵ^2. Assumption **A1** normalizes the scale parameter on $h(Z_\ell)$ to 1 to ensure identification of σ_ϵ^2.

This linear separable structure in bidder's private valuation has been considered extensively in the empirical auction literature. In the symmetric independent private value model, Elyakine, Laffont, Loisel, and Vuong (1994) and Li, Perrigne, and Vuong (2000) are just two examples. The rules and components of each auction, i.e. (X_ℓ, Z_ℓ), $\mathcal{G}$ and n_ℓ, are common knowledge to all bidders participating in auction ℓ. Only the randomly drawn element from $\mathcal{G}$, $\epsilon_{i\ell}$ is private information.

A2 The number of bidders n_ℓ is taken as given or exogenous and is common knowledge amongst all bidders. Bidders are risk neutral and maximize their expected payoffs.

We do not model the process by which bidders enter the auction. This is a restrictive assumption especially when auction participation and information acquisition can be costly. However, given that we do not observe n_ℓ and must proxy it, we feel that this assumption is not unreasonable. There is a growing body of empirical literature with endogenous entry in auctions. For example, Bajari and Hortaçsu (2003) allows for an endogenous number of bidders in eBay coin auctions using a zero-profit condition. The non-parametric test for a common value element in first priced sealed-bid auctions proposed by Haile, Hong, and Shum (2003) also allows for an endogenous number of bidders.

In addition, there has been growing empirical evidence that bidders in certain auctions are risk-averse. Athey and Levine (2001), Campo, Guerre, Perrigne, and Vuong (2003) and Perrigne (2003) are some examples. Campo, Guerre, Perrigne, and Vuong (2003) also considers the identification and estimation of an auction model with independent private values and risk averse bidders. The authors use variation in the number of bidders across auctions to achieve semiparametric identification in the case of risk-averse bidders.

Let $V_{2:n_\ell}$ denote the second highest order statistic of all valuations from auction ℓ. The *ex ante* expected price in auction ℓ is given by the expectation of the second highest valuation of all bidders, that is

$$\begin{aligned} \mathbb{E}\left(p_\ell \mid X_\ell, Z_\ell, n_\ell \right) &= \mathbb{E}\left(V_{2:n_\ell} \mid X_\ell, Z_\ell, n_\ell \right) \\ &= X_\ell\, \beta + h(Z_\ell) \cdot \mathbb{E}\left(\epsilon_{2:n_\ell} \mid X_\ell, Z_\ell, n_\ell \right). \end{aligned} \tag{1}$$

The distribution of valuations, $\mathcal{G}$ is typically not known, and $\mathbb{E}\left(\epsilon_{2:n_\ell} \mid X_\ell, Z_\ell, n_\ell \right)$ would have to be estimated. This first moment will be a function of n_ℓ. Let $\mathbb{E}\left(\epsilon_{2:n_\ell} \mid X_\ell, Z_\ell, n_\ell \right) = f(n_\ell)$, where $f(\cdot)$ is assumed to be a smooth function that depends on the distribution $\mathcal{G}$. In our estimation strategy, we are non-parametric in our assumptions on $f(n_\ell)$. Rezende (2004) shows that $\mathbb{E}\left(\epsilon_{2:n_\ell} \mid X_\ell, Z_\ell, n_\ell \right)$ cannot be a linear function of n_ℓ

for any non-degenerate $\mathcal{G}$. Let the observed winning bid have the simple form

$$p_\ell = \mathbb{E}\,(\,p_\ell \;|\; X_\ell, Z_\ell, n_\ell\,) + \xi_\ell$$

where $\mathbb{E}(\xi_\ell \mid X_\ell, Z_\ell, n_\ell) = 0$, and $Var(\xi_\ell \mid X_\ell, Z_\ell, n_\ell) = \sigma_\xi^2$. From the specification of the *ex ante* expected price in equation (1), the observed winning bid in auction ℓ can be rewritten as,

$$p_\ell \;\; = \;\; X_\ell\,\beta + h(Z_\ell)\,f(n_\ell) + \xi_\ell. \tag{2}$$

Auction theory points out a causal relationship between the number of bidders n_ℓ and the winning bid p_ℓ which has been ignored in previous empirical work. The partial linear model of Equation (2) allows n_ℓ to impact p_ℓ in as general a way as possible. Our goal is to estimate $\beta,$ and $f(n_\ell)$. Assuming that we know the form of the heterogeneity in valuation, $h(Z_\ell)$, we can make the necessary transformation to arrive at the following partially linear model,

$$h(Z_\ell)^{-1}p_\ell \;\; = \;\; h(Z_\ell)^{-1}X_\ell\,\beta + f(n_\ell) + h(Z_\ell)^{-1}\xi_\ell. \tag{3}$$

Reiterating assumption [**A1**], we cannot separately identify the parameters of $h(Z_\ell)$ and the variance of the distribution of valuations σ_ϵ^2. The coefficient on $h(Z_\ell)$ is normalized to 1 and the parameters of interest, β are identified up to this scale normalization.

More than half of our sample involves sale transactions of individual slaves, while the remaining record group sales. Typically, the invoice for group sale transactions record one price for the whole group. We posit that a significant factor affecting heterogeneity in bidder's valuation is the number of slaves grouped in a single auction. This is analogous to the loss of efficiency arising from regressions using aggregate data. Denote the size of the lot for sale in auction ℓ by s_ℓ. We assume that the variance $h(Z_\ell)$ has the known form, $h(Z_\ell) = s_\ell^{-1/2}$.

Estimation of equation (3) requires that we have data on $\{p_\ell, X_\ell, Z_\ell, n_\ell\}$. However, as stated previously there are no records of the number of bidders n_ℓ. Ignoring this variable would generate the classical omitted variable bias problem. Even if (X, ξ) are orthogonal to each other, unless (X, n) are also orthogonal to each other, simply regressing p on X will give biased estimates of β. In general, economic factors like the demand and supply of cotton and the socio-economic environment are factors that we would like to include in X. It is hence unreasonable to assume that these factors are independent of the number of bidders participating in any auction. Ignoring these correlations would lead to biased estimates of the β's.

4.1 Estimation

We treat the sample (p_1, X_1, Z_1, n_l), (p_2, X_2, Z_2, n_2), $\ldots$, (p_T, X_T, Z_T, n_T) as i.i.d. observations. The function $f(n_\ell)$ in Equation (3) is assumed to be non-parametric and smooth. Robinson (1988) and Speckman (1988) propose a method to estimate a partially linear model similar to equation (3). They show that β can be estimated at the parametric $\sqrt{T}$ rate despite the presence of the non-parametric function $f(\cdot)$. This method is known as the double residual procedure and is standard to the non-parametric econometrics literature. Yatchew (2003) provides an excellent treatment of this procedure. This procedure is often referred to as the 'double residual' method because the second stage regression involves using the residuals from the nonparametric regression of $\tilde{p}_\ell$ on n_ℓ against the residuals from the regression of $\tilde{X}_\ell$ on n_ℓ. For convenience, let $\tilde{p}_\ell = h(Z_\ell)^{-1} p_\ell$, $\tilde{\xi}_\ell = h(Z_\ell)^{-1}\xi_\ell$ and $\tilde{X}_\ell = h(Z_\ell)^{-1} X_\ell$. Rewriting Equation (3) and conditioning on the nonparametric variable n_ℓ yields:

$$\tilde{p}_\ell - \mathbb{E}\left(\tilde{p}_\ell \mid n_\ell\right) = \left[\, \tilde{X}_\ell - \mathbb{E}\left(\tilde{X}_\ell \mid n_\ell\right) \,\right] \beta + \tilde{\xi}_\ell \tag{4}$$

If $\mathbb{E}\left(\tilde{p}_\ell \mid n_\ell\right)$, and $\mathbb{E}\left(\tilde{X}_\ell \mid n_\ell\right)$ are known, we can estimate β in (4) by ordinary least squares. Let $\sigma_\xi^2 = Var(\tilde{p}_\ell \mid \tilde{X}_\ell, \tilde{Z}_\ell, n_\ell)$ and $\Sigma_T^2 = Var(\tilde{X}_\ell \mid n_\ell)$. Robinson (1988) shows the estimator to have the following distribution.

$$\sqrt{T}(\hat{\beta} - \beta) \xrightarrow{D} N(0, \sigma_\xi^2 (\Sigma_T^2)^{-1}).$$

In practice, $\mathbb{E}\left(\tilde{p}_\ell \mid n_\ell\right)$, and $\mathbb{E}\left(\tilde{X}_\ell \mid n_\ell\right)$ are not known and need to be estimated. Robinson (1988) proposed a non-parametric kernel estimator for these quantities that converges sufficiently quickly that substitution into equation (4) does not affect the asymptotic distribution of the least squares estimator. Thus, in the first stage, we estimate $\mathbb{E}\left(\tilde{p}_\ell \mid n_\ell\right)$ and $\mathbb{E}\left(\tilde{X}_\ell \mid n_\ell\right)$ nonparametrically by assuming both are smooth functions of n_ℓ. In the second stage, we take the residuals from the estimated models and regress them on each other, and thus estimate β. In the last stage, we take $\tilde{p} - \tilde{X}\hat{\beta}$ and nonparametrically regress it on n thereby obtaining an estimate for $f(n)$. Since the standard asymptotic distribution continues to apply in the second stage estimation, all conventional tests for linear models such as the Wald test, also carry through.

To estimate any of the nonparametric regressions above, we use the local linear estimator. This estimator generalizes the Nadaraya Watson estimator. For example, the local linear estimator for $\mathbb{E}\left(\tilde{p}_\ell \mid n_\ell\right)$ at some point n_o solves the following problem:

$$\min_{\gamma_0,\gamma_1} \sum_{\ell=1}^{T} \{\tilde{p}_\ell - \gamma_0 - \gamma_1 \left(n_o - n_\ell\right)\}^2 \omega\left(n_\ell - n_o, h\right) \tag{5}$$

where $\omega\left(x_i - x, h\right)$ is a kernel function, and h is the bandwidth parameter. The function $\omega(\cdot)$ integrates to 1 and weights observations n_ℓ according to its distance from n_o where the function is being estimated. Due to computing restraints, we have set the bandwidth by rule of thumb given by .2× the range of the number of bidders in the data set. This procedure is conducted for each data point n_o in the data set. A nonparametric estimate of the function $f(\cdot)$ at n_o is given by the intercept of the weighted least square regression which minimizes the criterion given in Equation (5) above (i.e. $\hat{\gamma}_0$ provides a non-parametric estimate of $f(\cdot)$ at n_o). Note that the Nadaraya Watson estimator is a special form of the above estimator where γ_1 is set to zero. It has been well documented that the two estimators behave similarly within the center of the data whereas the local linear estimator has better properties at the boundaries of the data.

4.2 Limitations

Measurement error

The semiparametric approach of (4) assumes that n_ℓ is measured without error. Since n_ℓ is not observed and needs to be proxied, this condition would surely be violated in our context. Accounting for this limitation of our analysis is however beyond the scope of this paper. Some aspects of non-parametric estimation involving errors-in-variable has been resolved. For example, the kernel-deconvolution estimator (Carroll and Hall (1988) and Liu and Taylor (1989)) can be used to estimate the density of a variable that is measured with error when the density of the error is known. More recently, Schennach (2004) extends the traditional Nadaraya Watson kernel regression estimator of the conditional mean to allow for the independent variable to be contaminated with error from an unknown distribution. Identification in this estimator requires two error contaminated measurements of the independent variable. Repeated measurements of a variable in empirical work is not uncommon, for example the same quantity may be reported by different members of a household or different employees in a firm. However, this is not a luxury that our current dataset provides. Not to belabor the point, we do acknowledge that measuring n_ℓ with error will bias our results. However, we are not able to deal with this limitation given our data.

Relaxing IPV assumption

In this section, we briefly sketch the arguments why our estimation strategy is robust to relaxation of the IPV assumption. If we are willing to maintain the assumption that signals conditional on observed slave characteristics are iid across auctions, then our proposed estimation strategy is also consistent with a common value auction setting. This assumption of independence of signals across auctions in a common value setting is very restrictive. Our discussion of earlier works also suggest that signals across auctions could be correlated depending on the geographical origin of slaves. Hence, we chose to adopt the lesser of two evils, the restrictive assumption of independent private values.

Our exposition borrows heavily from Milgrom and Weber (1982) and Rezende (2004). Suppose we allow bidders' valuations of the unit on auction $V_{i\ell}$ to be correlated. For convenience, we adopt the structure of the 'button auction' of Milgrom and Weber (1982) where bidders exit observably and irreversibly as the bidding price increases until only a single bidder remains. We maintain the assumption that bidder valuations are symmetric. Let $s_{i\ell}$ denote the private signal of bidder i, $s_{-i\ell}$ the vector of signals of the other bidders, and $s_{o\ell}$ be the information common to all bidders that the seller may publicly annnounce. Let the $s_{(1)}, \ldots, s_{(n)}$ denote the largest to smallest order statistics of the vector of signals $(s_{i\ell}, s_{-i\ell})$. Before the start of the auction, bidder i knows his or her signal $s_{i\ell}$ but not $(s_{-i\ell}, s_{o\ell})$ and is uncertain about his own private valuation $V_\ell(s_{i\ell}, s_{-i\ell}, s_{o\ell})$. Assume that $V_\ell(\cdot)$ is increasing in all its arguments.

In this common value setting of an ascending price english auction, the prices at which bidders drop out of the auction as the auctioneer raises prices become relevant information. Assume that there is a one to one mapping between prices at which bidders drop off and their corresponding private signal. Bidder $i's$ valuation in auction ℓ given earlier in [**A1**] now takes the form

$$V_{i\ell} = V_\ell(s_{i\ell}, s_{-i\ell}, s_{o\ell}, X_\ell, Z_\ell) = X_\ell\, \beta + h(Z_\ell) \cdot \epsilon_\ell(s_{i\ell}, s_{-i\ell}, s_{o\ell}).$$

That is, each bidder i observes his/her own private signal $s_{i\ell}$ and the observables (X_ℓ, Z_ℓ) but not $V_{i\ell}$. Assume that $(s_{i\ell}, s_{-i\ell})$ are iid across auctions ℓ, and that the joint distribution $\epsilon_\ell(s_{i\ell}, s_{-i\ell}, s_{o\ell})$ is constant across auctions ℓ. Let $\boldsymbol{s}_\ell = \{s_{\ell(2)}, \ldots, s_{\ell(n)}\}$ be the vector of ordered signals where $s_{\ell(2)}$ is the second largest and $s_{\ell(n)}$ the smallest signals. When the second last bidder drops out, we get the auction price of

$$p_\ell(X_\ell, Z_\ell, \boldsymbol{s}_\ell) = \mathbb{E}(V_{2:n_\ell} \mid s_{\ell(1)} = s_{\ell(2)}, \boldsymbol{s}_\ell, X_\ell, Z_\ell).$$

Hence, the ex-ante expected price is

$$\mathbb{E}\,(\, p_\ell \;\mid\; X_\ell, Z_\ell, n_\ell\,) \;\;=\;\; X_\ell\,\beta + h(Z_\ell) \cdot \tilde{f(n_\ell)} \qquad (6)$$

where $\tilde{f(n_\ell)} = \mathbb{E}\left[\mathbb{E}(\epsilon_{2:n_\ell} \mid s_{\ell(1)} = s_{\ell(2)}, \boldsymbol{s}_\ell) \mid n_\ell\right]$. Allowing for correlated valuations still allows us to maintain the additive separable structure of (1) present in the IPV case. The expectation of $\tilde{f(n_\ell)}$ is now taken with respect to the joint distribution of $\epsilon_{2:n_\ell}$. The estimation procedure that we propose above still follows.

5 Data

5.1 Slave Sales Data

The slave sales data used in this paper come from the *The Economics of American Negro Slavery* series developed by Robert Fogel and Stanley Engerman. The data were collected from the notarized bills of sale at the New Orleans Notarial Archival Office. The data is currently part of the data holdings of the Inter-University Consortium for Political and Social Research (ICPSR 7423) at the University of Michigan.

The collection comprises of either a 2.5% or 5% random sample of total annual sales. Records of slaves sold in the New Orleans slave market were required by law in order to give owners legal claim to the title, see Fogel and Engerman (1974b), page 52. The full sample of 5009 sale records spans the period from 1804 to 1862. For each sale, information was recorded on the date and term of the sale, the number of slaves on the invoice, the geographical origin of the slave, the identity of the buyer, the seller, the sale price, previous transactions involving the slave and various slave characteristics such as age, sex, family relationship, occupation, etc. These bills often contain information on several persons who were sold in a group or as a "lot." (Interested readers should also refer to Oberly (2002)). Almost half of these records consist of individual sales while the rest are group sales with either a single price or multiple prices.

Details of the construction of the final sample used in the estimation is left to the appendix. Given our main interest is in investigating how winning bids vary according

Table 1: Geographical Regions in the sample

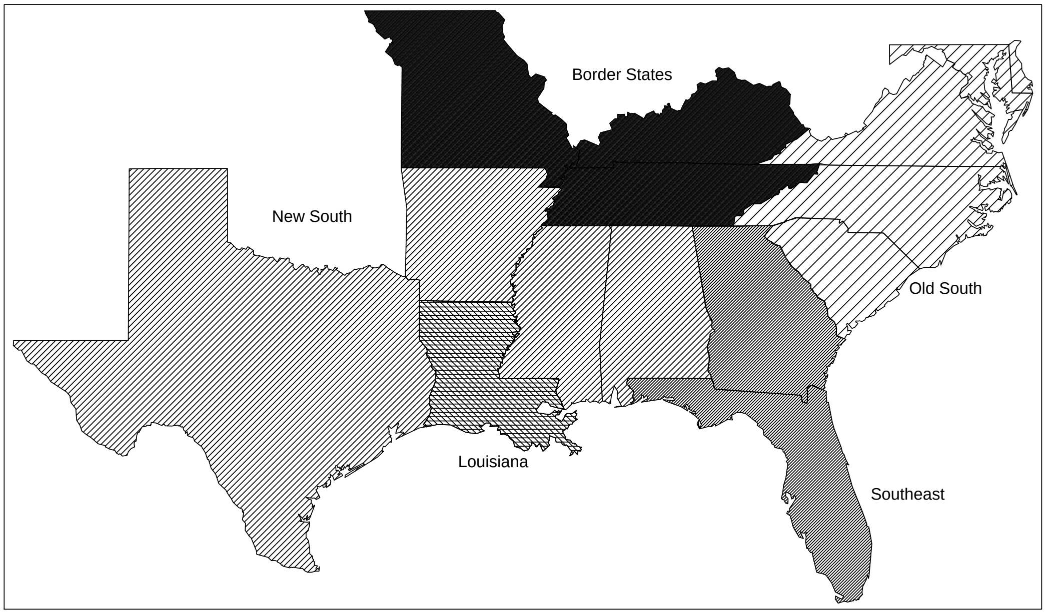
Variables	Geographical area
New Orleans	Slaves originating from New Orleans
Louisiana	Slave originating from all other areas in Louisiana
New South	Mississippi, Alabama, Texas,and Arkansas
Southeast	Georgia, and Florida
Border states	Kentucky, Tennessee, and Missouri
Old South	Maryland, Virginia, North and South Carolina, Delaware, and the District of Columbia
Unknown	Specific origin unknown but known to be from out of Louisiana.

to the geographical origin of slaves, we require records containing this geographical information. A total of 225 observations were lost because of missing price, age and/or sex information. Another 322 observations were lost because of incomplete information on the place of origin. From the initial sample of 5009 records, we lose a total of 547 observations due to incomplete information leaving a final sample of 4462 observations. In section 8.3 of the data appendix, we also provide summary statistics comparing the deleted observations and the selected sample. The histogram plots for prices and age suggest that there is no obvious systematic difference between the deleted and selected observations. We are reasonably confident that our data construction process is not systematically throwing away observations of a particular type.

The selected 4462 observations were classified into 8 different regions based on the geographical origin of the slaves. They are New Orleans, Louisiana, New South, Old South, Border states, and out of state, origin unknown. Table 1 gives the states for these regions and Figure 1 maps these states. For ease of the reader, a few tables are within the text, but the remainder are attached at the end of the paper.

As a check of our sample, we compare a price deflator derived as the mean price for a male field hand slave between the ages of 21 and 35 with that derived by Ulrich B. Phillips (1929). This age interval is the same as that used by Kotlikoff (1979) and Fogel and Engerman (1974a). A comparison of the derived price deflator and the commonly cited deflator by Phillips (1929) is given in Figure 2. The derived deflator appears to be more volatile than the Phillips' series. The Phillips' series also exceeds the derived deflator for part of the sample most notably for the years between 1827 and 1832. However, the two series are highly correlated with a correlation coefficient of 0.82. The two series suggest a depression in slave prices occurring in the 1820's and in the 1840's. The later coincided with a depression in cotton prices (also shown in Figure 3). After

Figure 1: Geographical Origins of slaves



around 1845, we observe an upward trend in the prices of slaves which continues until the pre-Civil War years of the 1860's. This increase coincides with a boom in the export market for cotton, as shown in Figure 4. (Data is taken from North (1966).) For most of the period considered, the derived deflator seems comparable to the Phillips' series suggesting that our sample is representative of the slave population over this period.

Table 2 gives the distribution of male and female slaves by geographical origin of all slaves. More than fifty percent of the sales transactions involve slaves originating from New Orleans, while only 13% came from the Old South. The remaining five regions each account for less than 10% of the total sales transactions. Table 3 provides a more detailed description of the data. Looking at the cumulative age profile, it appears that the majority of sales involve individuals aged 30 years and below. Around 40 percent of the sample are below 20 years old and another 40 percent between the age of 20 to 30 years. Given that slavery was closely connected with agriculture, this concentration in age groups where the individual is in their physical prime is not surprising. Around 87 percent of the sample are guaranteed, that is the seller ensures that the individual slave is physically healthy. When a slave is not guaranteed, it is often because the individual was physically challenged or afflicted by an ailment which affected their ability to work. We find later that this status greatly affects individual sales prices.

The proportion that boast specific specialized skills like artisans and house-centered skills are small, totalling less than 10 percent. Artisan slaves are considered those slaves that acquired the following skills: Sail-maker, Blacksmith, Carpenter, Cabinet maker, Cooper, Bricklayer, Mason, Butcher, Slater, Engineer, Tailor, and Shoe maker. House workers are those slaves with the following occupations: Gardner, Seamstress, House servant, Waiter, Domestic, Carriage driver, Hair dresser, Child nurse, and Baker. The majority of slaves in the sample are field-hands. We observe that 60 percent of the slaves were sold in the first two quarters of the year while only 15 percent of sales actually occurred in the third quarter. This is something that we control for in our estimation. Around a third of the slaves (36 percent) are sold as part of a group, with half of these with a single group price. We also find that more females were sold individually than males (35 percent versus 27 percent). The majority of group sales involve groups of 2 to 5 individuals. Sales involving large groups of more than 10 individuals comprises around 10 percent of the sample. The proportion of sales involving children are small, that is, a child of age 10 or less. Louisiana state law also prohibited the importation of a child of less than 10 years of age without the child's mother.

5.2 Aggregation

Group sales with a single price on the invoice are aggregated to yield an average price for the vector of average characteristics of slaves on the invoice while group sales with individually listed prices are left as is. This aggregation leaves us with a final sample with 3896 observations. Of these, 222 observations are of aggregated group sales, and 214 observations are of single priced group sales. These amounted to 823 observations. The rest of the data are individually priced slaves. Of the individually priced slaves, males accounted for 1207 observations while females accounted for the other 1644 observations (see Table 2). Of the individually priced females, 336 are sold with accompanying children. None of the males had kids accompanying them. This aggregation of group sales introduces group heterogeneity that is captured by the term $h(Z_\ell)$ in the estimating equation (2). This is one dimension by which we differ from Greenwald and Glasspiegel (1983) and Pritchett and Chamberlain (1993), which ignored observations involving group sales. In addition to the group heteroskedasticity, we also account for time heteroskedasticity by including year and month fixed effects.

5.3 Slave Hire Data

The slave sales data described above does not contain information on the number of bidders. As a consequence, we estimate the number of bidders participating in an auction using information from the slave sales data and an alternate slave hire dataset.

The demand for slaves is driven by the need for labor inputs in agriculture. At any period in the sample, we assume that demanders of slave labor could either purchase slaves from a secondary slave market like New Orleans, or hire slaves from slave owners. In other words, the pool of individuals who either purchased slaves or hired slaves implicitly define the number of bidders participating in the New Orleans market. Using information about hiring transactions over the period of the sample, we construct an estimate of this quantity.

The slave hire data that we use can also be obtained from ICPSR (7422) at the University of Michigan. These data were obtained from a non-random sample of probate records for southern counties, located on microfilm at the Genealogical Society Library of the Church of Jesus Christ of Latter-Day Saints in Salt Lake City, Utah. This annual data contains the records of 20253 slave hires in the south between 1775 and 1865. The data contains information on the year of the transactions, key identifiers for states as well as counties and variables describing the slave hired as well as the conditions of the hiring itself. We combine the annual hiring transactions with the monthly total auction sales to construct a proxy of the number of bidders for each month for which we have sales transaction data. We are implicitly assuming that the number of bidders are on average the same across auctions for each month of the sample. We feel that this approximation is not unreasonable. There is also evidence that the mean length of time it took a seller to sell a slave in New Orleans was about 40 days, see Freudenberger and Pritchett (1991).

Let m_{ty} be the weighted number of sales transaction in month t in year y, where $y = 1804, \ldots, 1862$. The sampling weights for the sales data are either 2.5 percent or 5 percent. These weights are not arbitrarily chosen but are defined by Fogel and Engelman who collected the data. h_y is the number of hiring transactions in year y. The daily estimate of the number of bidders in auctions in month t of year y is given by

$$n_{ty} = \frac{1}{30}\Big(\frac{m_{ty}}{\sum_{t=1}^{12} m_{ty}} h_y + m_{ty}\Big).$$

In words, our estimate of the number of bidders is equal to the sum of the number of sales transactions and the number of hiring transactions weighted by the relative proportion of sales transaction for that month, divided by thirty days. Given that we have no prior on how hiring transactions are distributed over the months of the year, we thought using relative weight defined by sales fluctuations was a reasonable approximation.

Figure 3 also graphs the estimated average number of bidders per day, participating in the New Orleans auctions and the price of cotton from this period. Our estimates suggest that the number of bidders more than doubled over our sample. At the beginning of the sample around 1810, the average number of bidders participating in an auction was around 5, and this grew to around 10 by 1860. The estimated series shows two sharp increases over the sample period. The first which began around 1825 appears to lag a sharp increase in cotton prices which began in 1823. This also coincides with a sharp increase in the proportion of cotton exports to total exports in that same year as shown in Figure 4(a). The second major increase in the estimated bidders occurs in the late 1830's. Like the earlier increase, this seems to follow closely the 1835 boom in the cotton industry (prices and exports). Another significant event that explains this increase in demand for slaves is the expansion of agricultural land as reflected by the big increase in public land sales in this region around 1835. This is shown in Figure 4(b) which plots the revenue from public land sales in five Southern states measured in millions of dollars. The five states are Alabama, Arkansas, Mississippi, Louisiana and Florida. The period between 1814 to 1960 saw enormous growth in the demand for cotton from the British textile industry. (See Engerman et. al (2003)) Despite this increase in demand, the general downward trend in cotton prices from 1814 to 1860 reflect the massive increase in supply brought about by the opening of new lands for cotton and the great westward migration over this period. North (1966) provides an excellent discussion of these events. These series, taken from North (1966), provide a gauge of whether the constructed series are a reasonable reflection of demand for slaves over this period. In general, the evidence in Figures 2, 3 and 4 suggest that the constructed series provide a reasonable approximation of the demand for slaves over this period.

6 Results

The sample is a repeated cross section with varying numbers of observations for each month from 1804 to 1862. One would expect the price of slaves to fluctuate over this period according to the economic forces of supply and demand of the cotton textile industry, and the socio-political climate of that time. These changes in demand (which are unobserved to the econometrician) affect the price of all slaves and could potentially be correlated with any regional variations in slave prices. We need to control for these price fluctuations to ensure that any identified regional variation is not directly caused by demand changes. The inclusion of the number of bidders controls for the competitive environment at the time of the auction. We consider two approaches to control for unobserved demand conditions. The first deflates each price by a price index that would account for any economy wide change in demand. The second accounts for these demand shifts using year, month, and year-month interaction dummy variables.

Equation E1 below gives the empirical specification of our model (3) where we account for demand fluctuations using time dummy variables. This specification generates a string of coefficients for each year and month. A baseline specification of this model where we omit the effect of the number of bidders on the winning price is given by E1b.

As discussed in Section 5, we construct a reliable deflator using the average price for individually priced, male field hand slaves between the ages of 21 and 38. These criterion allow us to construct a reasonably homogeneous subsample with which to construct the price deflator. Equation E2 below gives the empirical specification of our model (3) with deflated prices as the dependent variable and equation E2b gives the corresponding baseline regression (where we omit $f(n_{\ell,t})$).

A time series plot of the derived deflator and the dummy variable coefficient estimates from the first approach are shown in Figure (5). We observe that after accounting for an interaction of year and month effects, the deflator index and the year coefficient estimates trend in the same direction. Both series showed a depression in slave prices in the 1820's and the 1840's. The results from both approaches are found to be very similar.

$$P_{\ell t} = X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R + S_{\ell t}\,\beta_S + h(\,Z_{\ell t}\,) \cdot f(n_{\ell t}) + \xi_{\ell t} \tag{E1}$$

$$P_{\ell t} = X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R + S_{\ell t}\,\beta_S + \xi_{\ell t} \tag{E1b}$$

$$P_{\ell t}/d_t = X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R + h(\,Z_{\ell t}\,) \cdot f(n_{\ell t}) + \xi_{\ell t} \tag{E2}$$

$$P_{\ell t}/d_t = X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R + \xi_{\ell t} \tag{E2b}$$

The variables in these equations are:

$P_{\ell t}$ is the winning bid on auction ℓ at t,

$R_{\ell t}$ are the regional dummy variables with coefficients β_R,

$S_{\ell t}$ includes year and year interacted with month dummy variables; its coefficients are denoted by β_T,

$X_{\ell t}$ are the remaining characteristics of the slave (other than age and geographical origin) which also include the month when the slave is on auction,

$n_{\ell t}$ is the estimated number of bidders participating this auction with the non-parametric effect captured by $f(n_{\ell t})$,

$h(\, Z_\ell \,)$ is a matrix with the reciprocal of the 'lot' size on the diagonal and zero elsewhere (to control for group heterogeneity) and

d_t is our derived price deflator for time t of the auction.

We use the Robinson's (1988) double residual method to estimate the β's. Previous authors such Greenwald and Glasspiegel (1983) and Pritchett and Chamberlain (1993) claim that there was a significant structural change in the market for slaves before 1830 and after. A number of incidents may have had a significant effect and have contributed to this structural change. For example, the first railroad which ran from the Elysian fields to Milnburg was built in 1830. This would have a significant effect on transportation costs, see Martin (1975) page 13. New Orleans also had a cholera epidemic outbreak in 1831 which made it riskier to go to New Orleans. The cholera epidemic killed 6,000 people in just 20 days in New Orleans, see Martin (1975) pages 13-14. The 1830's also brought major changes in legislation governing the importation of slaves from outside of Louisiana. As a result of dishonest trading behavior of selling 'undesirable' or problematic slaves as prime slaves, the Louisiana legislature passed an act in April 1829 which requires a certification of good character for all imported slaves. As a robustness check, we also consider a specification that allows for this structural change in the coefficient estimates in 1830. Our numerous tests for structural break confirm that these changes in the 1830's had a significant effect on the parameter estimates. Some of the results of these specification tests have been put in Section 8.2 of the Appendix. We eventually arrive at the specifications in equations E3 and E4 below, which allow for the coefficient of the age polynomials and regional dummies to be different for the period before and after 1830. We also consider the baseline model where we omit the correction term accounting for the number of bidders in Equation E3b and E4b.

$$\begin{aligned} P_{\ell t} =& (1-\mathbb{I}_{30})\,[X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R] + \mathbb{I}_{30}\,[X_{\ell t}\,\beta_{X\,30} + R_{\ell t}\,\beta_{R\,30}] + S_{\ell t}\,\beta_S + \\ & h(\,Z_{\ell t}\,)\cdot f(n_{\ell t}) + \epsilon_{\ell t}, \end{aligned} \tag{E3}$$

$$P_{\ell t} = (1-\mathbb{I}_{30})\,[X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R] + \mathbb{I}_{30}\,[X_{\ell t}\,\beta_{X\,30} + R_{\ell t}\,\beta_{R\,30}] + S_{\ell t}\,\beta_S + \epsilon_{\ell t}, \tag{E3b}$$

$$\begin{aligned} P_{\ell t}/d_t =& (1-\mathbb{I}_{30})\,[X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R] + \mathbb{I}_{30}\,[X_{\ell t}\,\beta_{X\,30} + R_{\ell t}\,\beta_{R\,30}] + \\ & h(\,Z_{\ell t}\,)\cdot f(n_{\ell t}) + \epsilon_{\ell t}, \end{aligned} \tag{E4}$$

$$P_{\ell t}/d_t = (1-\mathbb{I}_{30})\,[X_{\ell t}\,\beta_X + R_{\ell t}\,\beta_R] + \mathbb{I}_{30}\,[X_{\ell t}\,\beta_{X\,30} + R_{\ell t}\,\beta_{R\,30}] + \epsilon_{\ell t}. \tag{E4b}$$

In equations E3 and E3b, we use year and month fixed effects to account for demand fluctuations. While in E4 and E4b, we use our constructed price deflator. In our test of the coefficient of the remaining covariates, we fail to reject the null that the coefficients over these two periods are equal. The indicator variable $\mathbb{I}_{30}$ takes the value 1 for the period 1830 to 1862 and zero otherwise.

Our semi-parametric estimation methodology allows us to identify the effect of the number of bidders on the winning price of slaves up to an additive constant. The left panels of Figures 6 and 7 graph the non-parametric estimate of the number of bidders, $f(n_{\ell t})$, for the specification in E1 and E3 together with the standard error bands for these estimates. These standard error bands are pointwise 95 % confidence intervals for our estimates of $f(n_\ell)$. The right panels of Figures 6 and 7 graph the marginal effect of the number of bidders on the average price of slaves on auction computed by numerically differentiating our estimates of $f(n_{\ell t})$. Recall that the dependent variable in both these specifications is $P_{\ell t}$. The shape of $f(n_{\ell t})$ and its corresponding derivatives for specifications E2 and E4 are very similar. Our estimates from both specifications suggest that the number of bidders have a significant positive effect on the average winning bid. For example, all else equal, the estimates from E3 suggest that increasing the number of bidders from 20 to 30 would raise the average price of an individually priced slave by around \$73. The predicted average prices from specification E1 for male and female field-hands (evaluated at their respective averages) are around \$692 and \$606 respectively. So the competitive effect from increasing the number of bidders by 10 would raise the average prices for male and female fieldhands by around 10% and 12% respectively.

Table 4: Regional coefficients from double residual regression of E1 and E2

Dep. Variable	$P_{\ell t}$		$P_{\ell t}/d_t$	
Equations	E1	E1b(Baseline)	E2	E2b(Baseline)
Louisiana	-64.09***	-64.59***	-0.046***	-0.046***
	(17.71)	(17.71)	(0.021)	(0.021)
New South	-70.31***	-72.20***	-0.088***	-0.088***
	(19.31)	(19.31)	(0.023)	(0.023)
Southeast	25.36	23.44	-0.034	-0.034
	(30.89)	(30.93)	(0.038)	(0.038)
Border States	-69.95***	-73.31***	-0.1014***	-0.099***
	(19.21)	(19.17)	(0.023)	(0.023)
Old South	-4.431	-8.587	-0.052***	-0.052***
	(15.41)	(15.33)	(0.017)	(0.017)
Year & year-month dummies included	No		Yes	
Adj. R^2	0.786	0.606	0.705	0.352
Degree of freedom	3196	3196	3851	3851

Wald Test of the null that the regional coefficient are jointly insignificant

χ^2 (df=6)	69.48	69.76	80.06	78.07
p-value	5.22e-13	4.58e-13	3.48e-15	8.93e-15

Significance codes: '***':1%, '**':5%, '*':10%, Month fixed effects are included in all specifications, no. of obs = 3896

Table 5: Regional coefficients from double residual regression of E3 and E4

Dep. Variable	$P_{\ell t}$		$P_{\ell t}/d_t$	
β_R	E3	E3b(Baseline)	E4	E4b(Baseline)
Louisiana	-27.28	-25.66	-0.028	-0.030
	(27.72)	(27.74)	(0.030)	(0.030)
New South	-119.4***	-125.6***	-0.149***	-0.146***
	(38.33)	(38.33)	(0.045)	(0.045)
Southeast	-39.31	-37.35	-0.111***	-0.111***
	(46.44)	(46.50)	(0.055)	(0.055)
Border States	-130.5***	-129.9***	-0.181***	-0.174***
	(30.74)	(30.77)	(0.036)	(0.036)
Old South	-47.92***	-50.67***	-0.066***	-0.064***
	(24.48)	(24.49)	(0.027)	(0.027)
β_{R30}				
Louisiana	-94.53***	-96.13***	-0.077***	-0.076***
	(22.75)	(22.75)	(0.028)	(0.028)
New South	-51.54***	-51.53***	-0.058***	-0.059***
	(22.02)	(22.04)	(0.026)	(0.026)
Southeast	53.47	49.15	-0.006	-0.002
	(40.89)	(40.89)	(0.050)	(0.050)
Border States	-33.68	-40.64***	-0.065***	-0.063***
	(24.68)	(24.61)	(0.029)	(0.029)
Old South	21.81	17.04	-0.041***	-0.041***
	(19.62)	(19.51)	(0.021)	(0.022)
Year & year-month dummies included	No		Yes	
Adj. R^2	0.794	0.619	0.720	0.384

Wald Test of the null that the regional coefficient are jointly insignificant

χ^2 (df=12)	78.68	78.76	83.19	80.99
p-value	7.35e-12	7.12e-12	1.014e-12	2.67e-12

Significance codes: '***':1%, '**':5%, '*':10%, Month and year-month fixed effects included in all specification, No. of obs = 3896, degree of freedom = 3163

Table 4 gives the estimates for the regional coefficients for specifications E1 and E2 and their corresponding base regression described above. The omitted regional dummy variable is that of New Orleans. The estimates involving structural change from E3, and E4 are tabulated in Table 5 on the next page. The estimates of the remaining covariates are left to the end of the paper. Although the estimated coefficients of the model are quantitatively different, the qualitative interpretation for all four specifications are similar.

Focusing on the estimate of Equation E3 in Table 5, the estimates pre-1830 suggest that slaves originating from 'Old South', 'Border States', and 'New South' were discounted relative to slaves from 'New Orleans.' Slaves from the 'Border States' like Kentucky, Tennessee and Missouri are the most heavily discounted followed by slaves from the 'New South' and the 'Old South'. All else equal, slaves from the 'New South' were on average \$70 cheaper relative to slaves from the 'Old South'. Slaves originating from Louisiana (but outside of New Orleans) are not priced differently compared to slaves from New Orleans. When compared to the unconditional mean of singly priced slaves of \$750, 'New South' slaves were on average 9% cheaper relative to 'Old South' slaves and almost 16% cheaper relative to slaves from New Orleans.

The post-1830 parameter estimates from Equation E3 suggest no significant price differential between slaves from the three regions of 'Old South' and the 'Border States' and those from 'New Orleans'. However slaves originating from the 'New South' and Louisiana remain heavily discounted compared to slaves from New Orleans. The discount on Louisiana slaves increased while that on 'New South' slaves lowered in this later period. After 1830, Louisiana slaves were the most heavily discounted followed by slaves from the New South. When we omit the semi-parametric correction $f(n_\ell)$ in E3b, we get some small changes in the magnitude of the parameter estimates. The qualitative results remain largely unchanged. The one notable difference is that the discount on 'Border State' slaves post-1830 is now significant.

The qualitative results using deflated prices from Equation E4 are very similar to those from E3. The main notable difference is that pre-1830, there is a systematic discount on slaves originating from all regions outside of Lousiana. This includes the 'Southeast' regions which include states like Georgia and Florida. In specification E3, slaves from the 'Southeast' earned a premium statistically similar to slaves from New Orleans. Slaves from the 'Border States' remain the most heavily discounted followed by those from the 'New South', the 'Southeast,' and the 'Old South'. Post-1830, there are no significant discounts on slaves originating from the 'Southeast' while there is a small discount on Louisiana slaves.

The estimates from Equations E1 and E2 in Table 4 tell a very similar story of discounting on slaves from 'Louisiana', 'Border States', and 'New South'. The general pattern of regional discounts are similar to the results of E3 and E4. In E1, the estimates suggest that slaves from the 'Old South' are not systematically different in price than slaves from New Orleans. Nonetheless slaves from the 'Old South' still on average earn a $65 premium relative to slaves originating from the 'New South'.

One result that seems robust in all of the specified models is that slaves originating from New Orleans on average commanded a premium relative to slaves from other regions. This result is new to this literature and was not noted in earlier studies. This positive premium could reflect the lower risk associated with local slaves or an informational advantage of a local seller's reputation. Comparing 'New South', 'Border States' and 'New Orleans' region, we also find strong evidence of a negative premium paid on slaves from 'New South' and 'Border States,' with the latter on average more heavily discounted. There is some anecdotal evidence alluding to the high risk associated with slaves imported from the 'New South' and the 'Border States'. We also find some evidence that slaves from the 'Old South' receive a premium relative to slaves from the 'New South'. This result confirms the findings of earlier work using this data. We will defer the discussion of possible explanations for these persistent regional price variations to the next section. The last two rows of Tables 4 and 5 also provide the Wald test statistics of the null that all the regional coefficients are equal to that of New Orleans. The χ^2 test statistic strongly rejects the null in all specifications confirming that there is significant regional price variation.

We also test for the equality of coefficients pre and post 1830, that is $\beta - \beta_{1830} = 0$. These test are done for varying subsets of coefficients from specifications E3 and E4 and their corresponding base specifications. The results are given in Table 6. When we test for equality of the coefficients on all covariates over the two periods, we consistently reject the null. With one exception, in the base regressions E3b and E4b where we do not account for the omitted number of bidders, we find that we accept the null of equality of the regional dummies coefficients over the two periods. In other words, failing to account for the competitive effects of the number of bidders will lead to the incorrect conclusion that the regional coefficients over the two periods are equal.

Figure 8 (a) graphs the age polynomials of males and females for each of the periods implied by the estimates from Equation E3. Figure 8 (b) gives the partial derivative of the price of slaves with respect to age. We note that infant females were more valued

Table 6: Wald Tests for Structural Break

	Variables	χ^2	df	p-value
E3	equality of all covariates	145.96	33	3.72e-16
	equality of all except regional and age coef	73.41	21	9.89e-8
	equality of regional dummies	20.01	6	0.0028
E3b	equality of all covariates	1.24e7	33	0
	equality of all except regional and age coef	1.15e5	21	0
	equality of regional dummies	9.13	6	0.166
E4	equality of all covariates	211.94	33	5.26e-28
	equality of all except regional and age coef	155.10	21	1.88e-22
	equality of regional dummies	14.15	6	0.028
E4b	equality of all covariates	1.214e7	33	0
	equality of all except regional and age coef	9.02e4	21	0
	equality of regional dummies	9.36	6	0.154

than infant males (in both periods). However, this price differential diminishes quickly with age. Male slaves age 9 and above (all else equal), on average received a higher price than female slaves. Interestingly enough, male prices outgrew female prices at the same age in the periods pre and post 1830. The estimates on the remaining covariates are shown in Tables 10 to 12 of the Appendix. Reassuringly, these results conform to those of earlier work in this literature.

6.1 Explaining Regional Price Variation

Even after controlling for the competitive nature of the auction market, significant price variation across slaves' geographical origin continues to persist. This price differential between the 'Old South' and the 'New South' has been noted in earlier work. Two competing explanations have been put forward to explain the price differential between these two regions. In this section, we test these two competing explanations.

6.2 Testing for the Alchien Allen Theorem

The initial description of the data in Table 2 provides an avenue for testing the Alchien Allen theorem put forward by Pritchett and Chamberlain (1993). The Alchien Allen theorem states that if two substitutes of differing quality have the same transportation cost, the higher quality good will be relatively cheaper at the destination location than at the departure location. According to this theory, we are more likely to observe slaves with more valued characteristics being shipped from further regions. A common finding from earlier works like Kotlikoff (1979), Greenwald and Glasspiegel (1983) and our results, is that males on average (all else equal) are more valued in the secondary slave market. Hence, if this theorem holds, the proportion of males from distant regions, like the Old South, would be higher relative to females. Let $\theta_{i,j}$ be the proportion of gender j from region $i = 1, \ldots, I$. If θ denotes the $(2 \times I)$ vector of population proportions, then the maximum likelihood estimator of θ is the observed empirical proportions $\hat{\theta}$. This estimator will have a multinomial distribution with mean θ and variance-covariance matrix $\Lambda(I_{2I} - \Lambda)$, where Λ is the matrix with θ on the diagonal and zero elsewhere. We posit the following hypothesis to test this theorem:

$$H_o \,:\, \frac{\theta_{New\,South\,Male}}{\theta_{New\,South,\,Female}} \leq \frac{\theta_{Old\,South,\,Male}}{\theta_{Old\,South,\,Female}} \qquad H_a \,:\, H_o \text{ is false.}$$

This hypothesis is tested using a likelihood ratio test for the entire sample (of individually and group priced observations) and a subsample containing only individually priced slaves. We estimate the vectors of multinomial probabilities implied by the restricted and unrestricted models using the method of maximum likelihood. The likelihood is simply the multinomial probability function and the unrestricted estimates are the observed empirical proportions reported in Table 2. Table 7 reports the estimates of the unrestricted and restricted models for both tests and the corresponding likelihood ratio test statistic. In the first test involving the entire sample, we fail to reject the null at the 5 percent level, but reject it at the 10 percent level of significance. The test using only individually priced observations provides much stronger empirical evidence against this hypothesis. This suggests that the proportion of males to females from the 'New South' is significantly larger than the ratio originating from the 'Old South'. Since male slaves on average earn a higher price in New Orleans, this contradicts the Alchien Allen theorem.

Table 7: ML Estimates of regional proportions from the Restricted and Unrestricted Model

	Full Sample				Ind. Priced sample			
	Unrestricted		Restricted		Unrestricted		Restricted	
	M	F	M	F	M	F	M	F
New Orleans	25.37	29.96	26.25	29.68	25.46	39.17	27.39	38.68
Louisiana	4.39	4.42	4.34	4.51	4.06	4.59	3.79	4.44
New South	3.00	2.44	3.07	2.36	2.91	2.56	2.53	2.86
Southeast	1.41	1.41	1.41	1.34	0.77	0.91	0.74	0.88
Border States	3.36	3.00	3.33	2.99	2.49	2.52	2.32	2.4
Old South	7.44	5.29	7.0	5.37	4.45	5.01	4.17	4.71
Unknown	5.09	3.41	4.93	3.40	2.17	2.87	2.26	2.78
Likelihood Ratio	2.99				9.07			
p-value	0.084				0.0025			
df	1				1			
sample size	4462				2851			

6.3 Testing for Regional Productivity differences

Greenwald and Glasspiegel (1983) argued that the regional price differentials reflected selection or discrimination based on regional productivity differences. The preceeding section 3 provides a discussion of their hypothesis. The authors tested this hypothesis by running a regression of the regional price index on the corresponding productivity index for the six regions in 1860. A significant negative coefficient on the productivity index was taken as support of their hypothesis. We adopt a test similar in spirit to that of Greenwald and Glasspiegel (1983). If this discrimination argument is correct, then the estimated price variations would not persist once we control for regional productivity differences over this period. To do this, we need some measure of regional productivity over the period of our sample. The slave hire data provides average rental rates for 15 to 35 year old field hands for each year and each region in our analysis. This allows us to derive an annual average rental rate for these various regions for this fairly homogeneous group of slaves. Using our auction sales data, we construct a comparable sub-sample comprised of individually priced field hands from this age group. To ensure that our result is comparable with that of Greenwald and Glasspiegel (1983), we drop any transactions involving group sales, the presence of a child, non-guaranteed slaves, skilled slaves, credit sales and coloured slaves. We also only consider sales between 1831 to 1862. The model that we estimate to test this hypothesis is given by,

$$P_{\ell t} \quad = \quad Prod \cdot \beta_P + \mathbb{I}_{\text{Female}} \cdot \beta_F + f(n_{\ell t}) + R_{\ell t} \cdot \beta_R + S_{\ell t} \cdot \beta_S + \epsilon_{\ell t}, \qquad (7)$$

where $Prod$ is the productivity index constructed from the slave hire data and $\mathbb{I}_{Female}$ is an indicator variable for female slaves. The specification in (7) does not have $h(Z_{\ell t})$ multiplying the nonparametric function of the number of bidders because we are only considering slaves that are sold individually, hence $h(Z_{\ell t}) = 1$ for all ℓ and t. The remaining variables are as previously defined. As in the previous specification of our model, we adopt the Robinson double residual method to estimate the β's. Table 8 gives the coefficient estimates of Equation (7).

In the first column, we perform a test similar to that of Greenwald and Glasspiegel (1983) using our data and the Conrad and Meyer (1958) 1860 rental rates as a measure of productivity. This is the measure used by both Greenwald and Glasspiegel (1983) and Pritchett and Chamberlain (1993). The dependent variable is $(P_{\ell t})$ of individually priced field hands between the ages of 15 to 35. This is regressed on regional average productivity in 1860 taken from Conrad and Meyer (1958). Although, the coefficient is negative, it is not significant. However, a shortcoming of this test is that the productivity index was assumed to be constant over time but allowed to vary across regions. Any variation across time is controlled for using year and month dummies and the nonparametric term, $f(n_{\ell t})$, which controls for the competitive effect of the number of bidders at each auction.

In the second column, we perform a similar test using average annual rental rates as measures of productivity, constructed using the slave hire data. We lose more than half of the sample since in some years we do not observe hiring transactions for this group of individuals. This alternate measure of productivity controls for productivity variation across time and regions. We now get a negative and significant coefficient on $Prod$ providing further evidence that slaves from regions of higher productivity are on average more heavily discounted as first suggested by Greenwald and Glasspiegel (1983).

In the third column, we include the regional fixed effects and exclude the productivity index from the model. The ommitted regional dummy variable is that of New Orleans. In this subsample of individually priced field hands between the ages of 15 and 35, slaves originating from the 'Old South' on average earn a 21 percent premium relative to slaves from New Orleans. The estimates on the remaining regional coefficients are

Table 8: Robustness checks

Dep. Variable	$P_{\ell t}$	$P_{\ell t}$	$P_{\ell t}$	$P_{\ell t}$
Prod	-1.001*			
from Conrad and Meyer (1958)	(0.4706)			
Prod		-2.157**		-0.9183
from rental rates		(0.749)		(1.13)
$\mathbb{I}_{Female}$	-103.62***	-107.23***	-99.69**	-100.38**
	(20.90)	(35.35)	(35.81)	(35.85)
Southeast			-91.32	-88.80
			(153.71)	(153.87)
Border.States			-97.11	-125.66
			(88.24)	(95.01)
Old.South			180.62**	123.80
			(63.52)	(94.35)
Unknown			-65.50	-62.53
			(129.14)	(129.30)
Louisiana			-56.85	-56.45
			(67.48)	(67.54)
New.South			37.80	15.54
			(65.98)	(71.46)
Regional dummies included	No	No	Yes	Yes
Sample size	562	244	244	244
Adj. R^2 (second stage)	0.449	0.49	0.496	0.495
Wald Test: Regional coefficient are jointly insignificant				
χ^2			15.97	8.23
p-value (df=6)			0.014	0.22

Significance codes: '***':1%, '**':5%, '*':10%

Month and Year fixed effects are included in all these regression.

not significant. The estimates on $\mathbb{I}_{\text{Female}}$ suggest that female slaves in this age group are priced 15 percent lower on average than male slaves. We also report the Wald test of the null of no regional price variation at the bottom of Table 8. We reject the null of no regional price variation.

Finally, in the fourth column, we include the regional dummy variables in the regression together with the average annual rental rates. The coefficient on the productivity index is no longer significant. A Wald test that the regional coefficients are jointly equal to zero also leads us to accept the null. This provides strong evidence that the identification of the coefficient estimates on the regional dummy variables relies on productivity differences across these regions. We can also conclude that in this slave auction data, we cannot rule out the argument that any regional price variation in the New Orleans market reflect shadow prices for the selection of slaves based on regional productivity differences. We also plot the regional rental rates in Figure 9. The series for the four regions all show a positive trend during this period. The rates for the 'Old South' is the lowest for this period. The series for the 'New South' shows larger fluctuations that seems to follow the large swings of the cotton textile industry at that time. Refer also to the price and export variation in cotton in Figures 3 and 4.

7 Conclusion

This paper analyzed the structure of winning bids in the New Orleans auction market for slaves. These prices are the building blocks used to evaluate the economics of slavery. Together with the market value of goods produced and goods consumed by slaves, they were used to calculate measures of net productivity of slave production. Earlier works using this data typically ignored the structure of the auction market where these prices are realized. Interpreting the realized price in slave auctions as the valuation of the average slave owner (or bidder) in the market is at odds with what we know from auction theory. Calculations of the returns or profitability from owning slaves based on this assumption is likely to overstate the profitability. To correct for this bias, we need to account for the competitive effects of the number of bidders participating in these auctions.

We proposed a way to overcome the lack of available information on the institutional details of the market. The number of bidders was linked to the number of transactions in the slave hire data set. An empirical independent private value auction model was estimated. Our model also allows for the regional differences in the price of slaves. We find that the number of bidders has a significant positive effect on the average winning bid for slaves. We also find that the price variation by the slaves' geographical origin continues to persist after correcting for this ommitted variable. Further investigation suggests that this price variation reflects the selection of slaves based on the productivity differences of the regions where they come from.

Figure 2

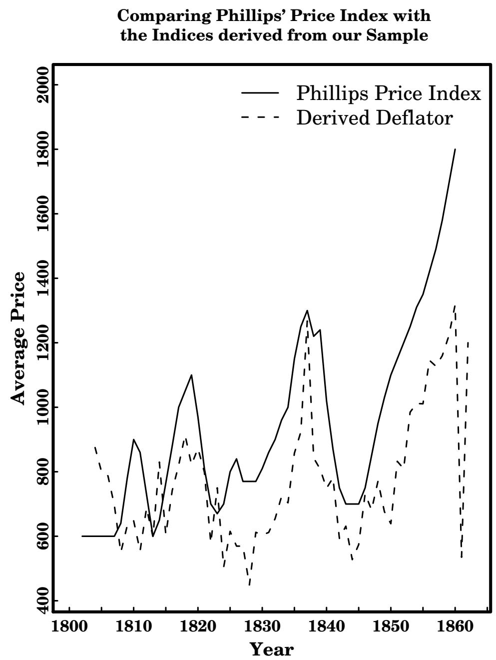


Figure 3

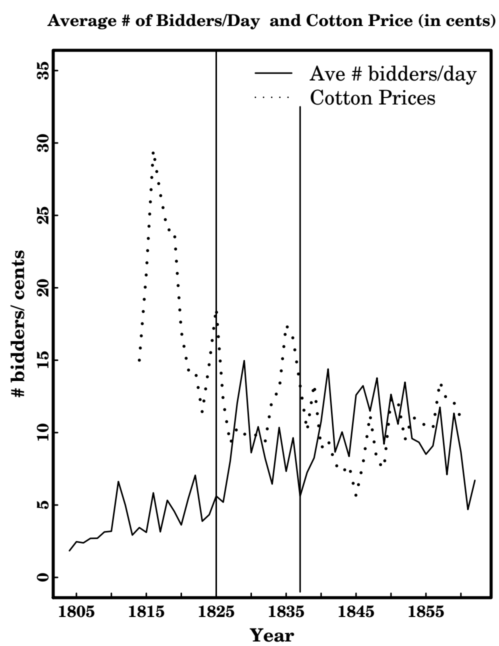
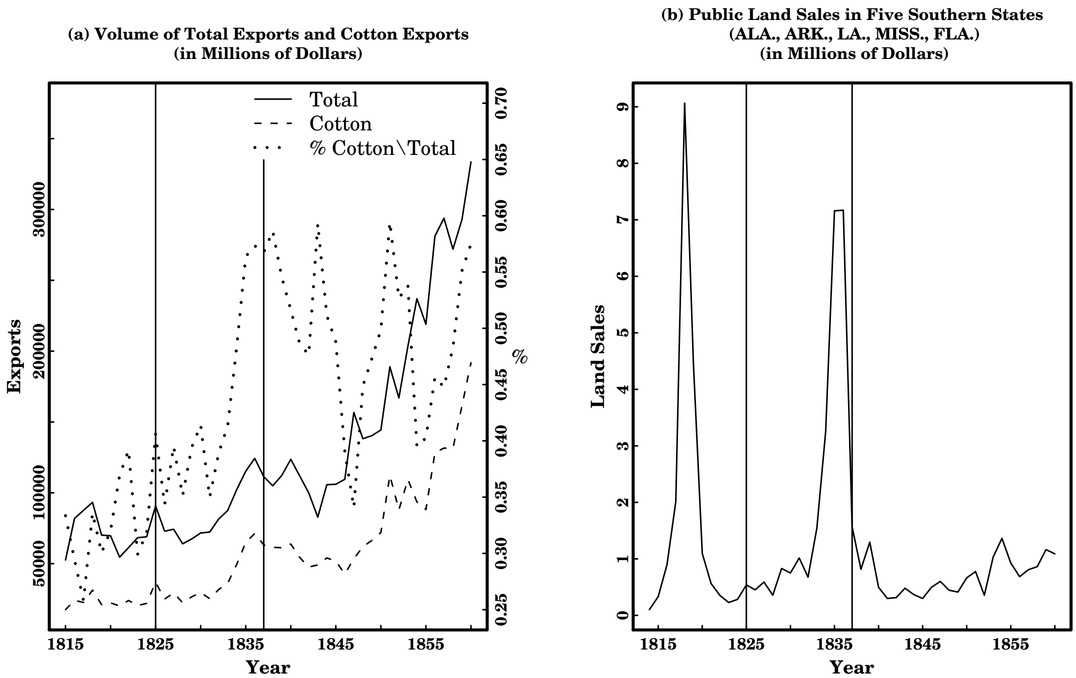


Figure 4



Note the scales on the left and right axes

Figure 5: Comparing the price deflator and year month coefficient

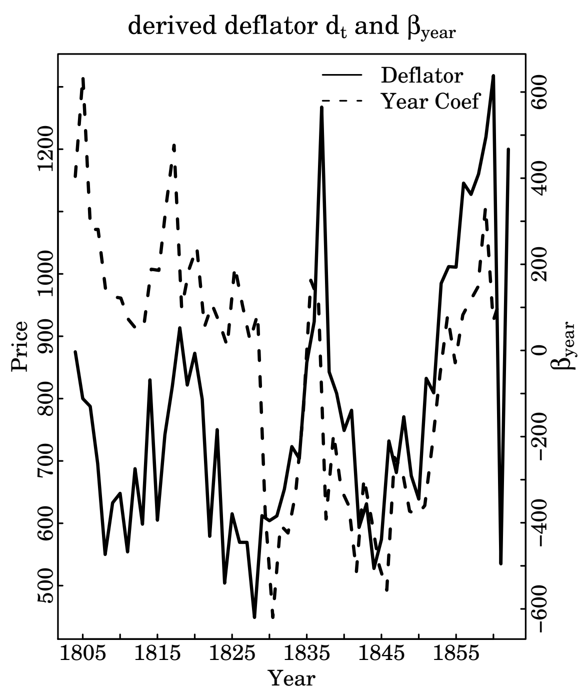


Figure 6: Estimates of $f(n_{\ell t})$ and $df(n_{\ell,t})/dn_{\ell,t}$ for Equation (E1)

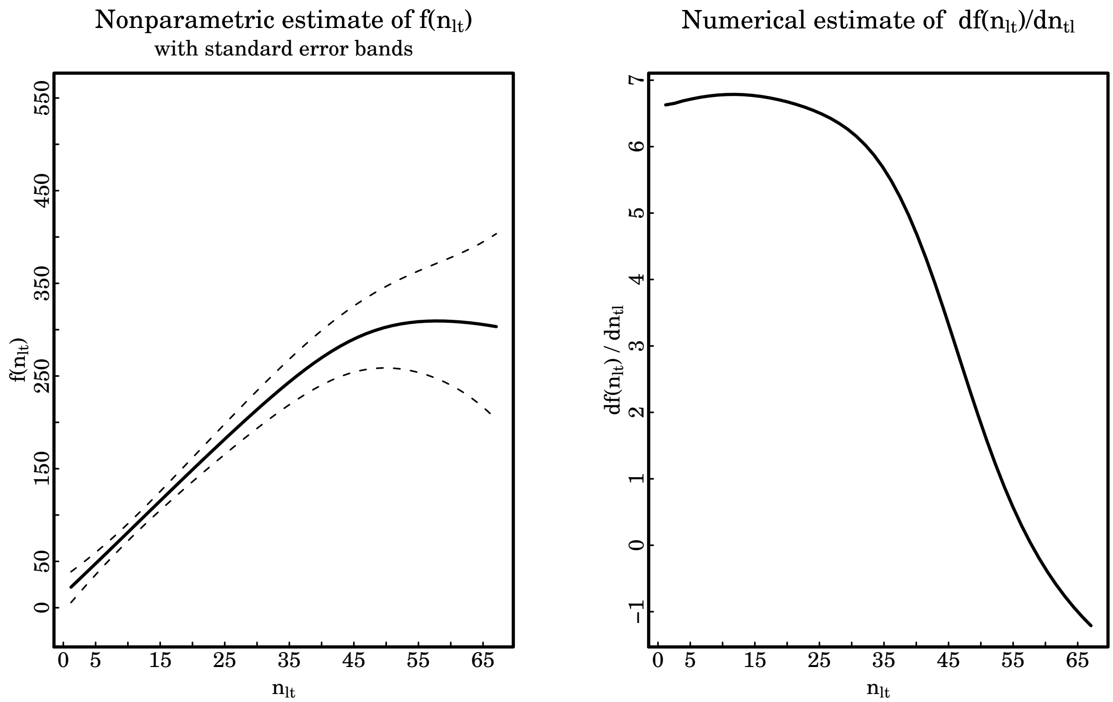


Figure 7: Estimates of $f(n_{\ell t})$ and $df(n_{\ell,t})/dn_{\ell,t}$ for Equation (E3)

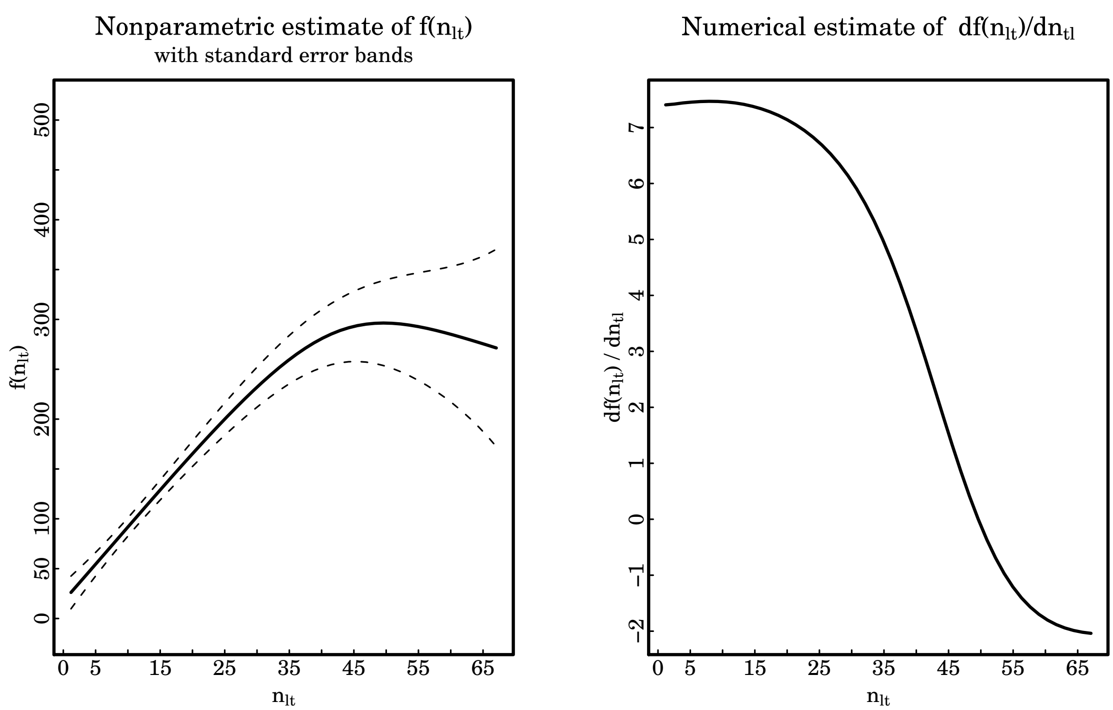


Figure 8

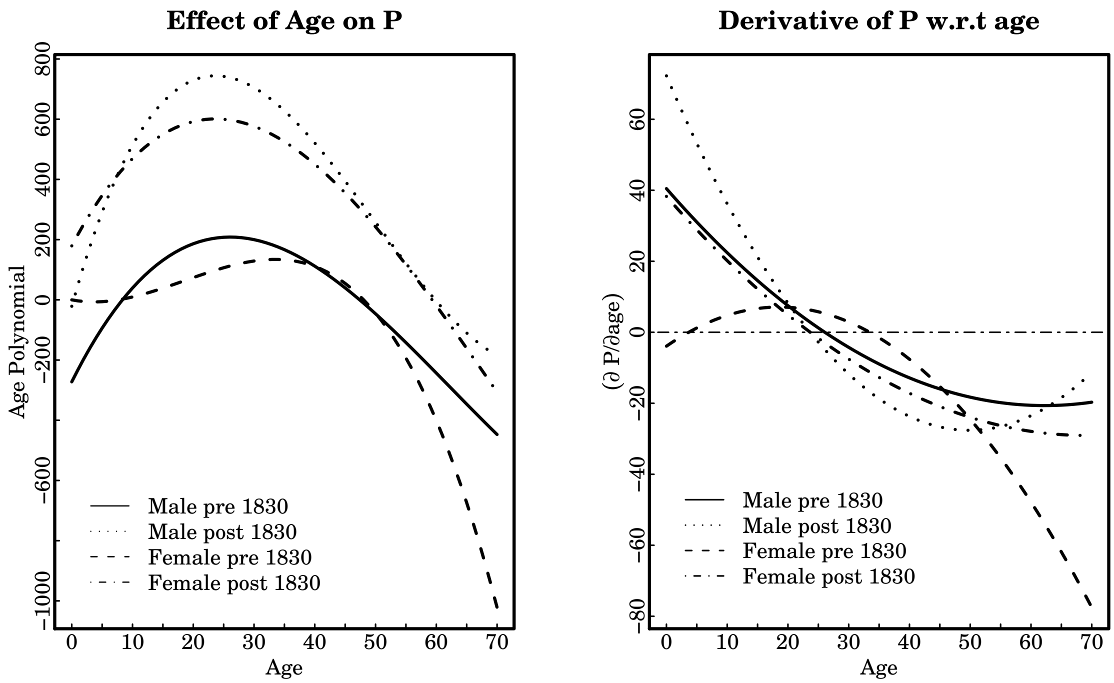


Figure 9

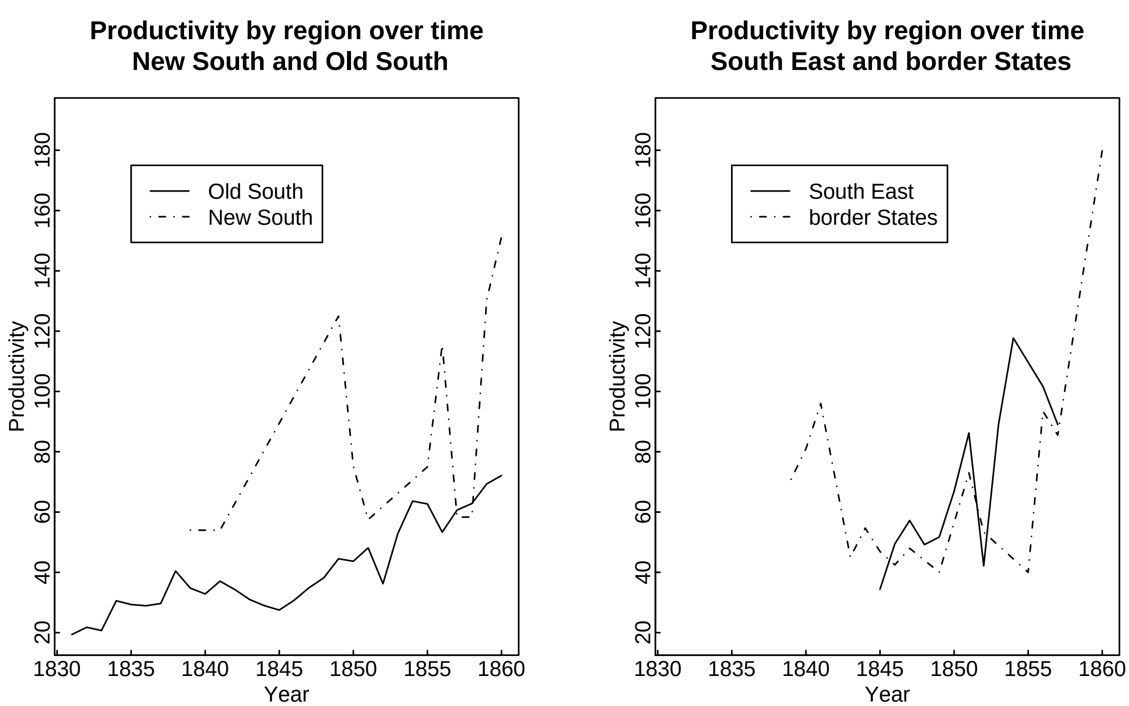


Figure 10

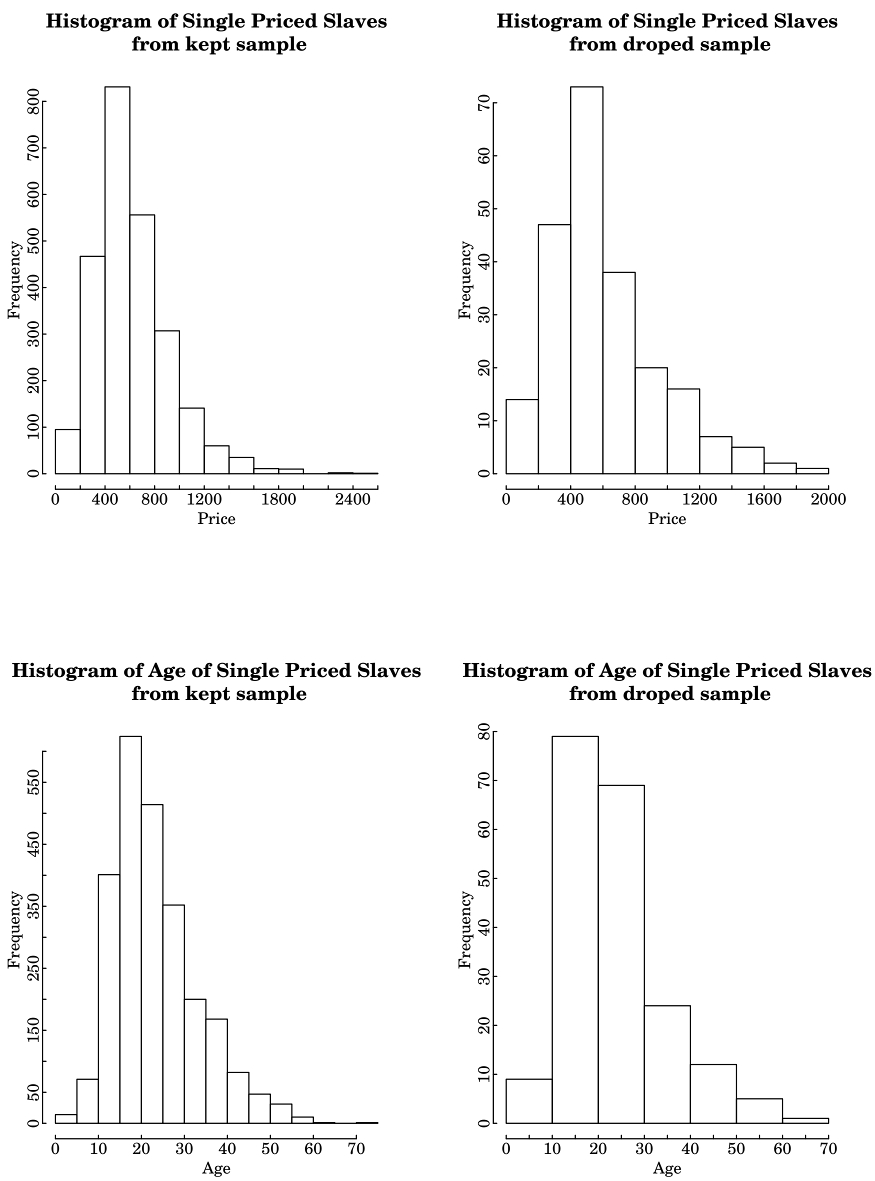

Histogram of Single Priced Slaves
from kept sample
Frequency
0
100
200
300
400
500
600
700
800
0
400
800
1200
1800
2400
Price
Histogram of Single Priced Slaves
from droped sample
Frequency
0
10
20
30
40
50
60
70
0
400
800
1200
1600
2000
Price
Histogram of Age of Single Priced Slaves
from kept sample
Frequency
0
50
150
250
350
450
550
0
10
20
30
40
50
60
70
Age
Histogram of Age of Single Priced Slaves
from droped sample
Frequency
0
10
20
30
40
50
60
70
80
0
10
20
30
40
50
60
70
Age

Table 2: Distribution of primary slaves by geographical origin and gender

Region	No. of Obs.		Males		Females	
New Orleans	2469	55.33	1132	25.37	1337	29.96
Louisiana	393	8.81	196	4.39	197	4.42
New South	243	5.45	134	3.00	109	2.44
Southeast	126	2.82	63	1.41	63	1.41
Border States	284	6.36	150	3.36	134	3.00
Old South	568	12.73	332	7.44	236	5.29
Unknown	379	8.49	227	5.09	152	3.41
Total	4462	100.00	2234	50.07	2228	49.93

Table 3: Some Descriptive Statistics on the final sample in percentages

i) Age Distribution of principle slaves

Age Categories	% Males	% Females
Age < 10 years old	2.11	1.84
Age 10 to 20 years old	18.33	21.04
Age 20 to 30 years old	21.36	16.56
Age 30 to 40 years old	5.65	7.44
Age > 40 years old	2.60	3.05
Total	50.07	49.93

ii) Distribution by skills and time of transactions (in percents)

Sales transactions in Q1	35.10	Field Hands	87.76
Sales transactions in Q2	31.16	Artisans	1.41
Sales transactions in Q3	15.00	House workers	5.00
Sales transactions in Q4	18.74	Other skills	5.83

iii) Distribution of individually and group priced slaves

Categories	No. of obs.	percent
Individually priced male slaves	1207.00	27.05 %
Individually priced female slaves	1645.00	36.87 %
Individually priced slaves sold in groups 2 to 5.	439.00	9.84 %
Individually priced slaves sold in groups of 6 or more.	384.00	8.60 %
Group priced slaves sold in groups 2 to 5.	482.00	10.80 %
Group priced slaves sold in groups of 6 or more.	305.00	6.84 %

Table 9: Explanation of Covariates

Coefficient	Explanation
$\mathbb{I}_{1830}$	Indicator for years 1830-1862
Cash	Indicator for cash payment
Int Payed	Interest on Invoice
Credit.Period	Length of credit period when no interest is stated
MColor, FColor	Indicator for griff, yellow, mullato,
	creole or light colored male and female
Orphan	Indicator for orphan
MOrphan	Indicator for male orphan
Guar	Indicator for guaranteed slave
HOCC	House worker dummy
	includes seamstress, cook, washer, ironer, servant,
	waiter, carriage driver, hair dresser, child nurse, Baker
HOCCM	male house worker dummy
Skill	Skill dummy
	The skills include sailmaker, blacksmith, carpenter,
	cabinet maker, bricklayer, mason,
	butcher, slater engineer, tailor, shoe maker
Family	Indicator that slaves are related
No Kids	Number of kids with Primary slave
Louisiana	Louisiana
New.South	Alabama, Texas, and Arkansas
Southeast	Georgia, and Florida
Border.States	Kentucky, Tennessee, and Missouri
Old.South	Delaware, District of Columbia, Maryland, Virginia,
	North and South Carolina
Unknown	Specific origin unknown but outside Louisiana
Male, Female	Indicator for males and females
Age.M, Age.M2, Age.M3	Age of male, and corresponding square and cublic terms
Age.F, Age.F2, Age.F3	Age of female, and corresponding square and cublic terms
Ind Price 2-5	Individually priced slaves sold in groups of 2 to 5
Ind Price 6-9	Individually priced slaves sold in groups of 6 to 9
Ind Price 10-	Individually priced slaves sold in groups of 10 and above
Group Price 2-5	slaves sold in groups 2-5 with one price
Group Price 6-9	slaves sold in groups 6-9 with one price
Group Price 10-	slaves sold in groups 10 and above with one price

Table 10: Regression Results

Complete Parameter Estimates from Equations E1, E1b, E2, E2b

	Estimate from			
	E1	E1b	E2	E2b
Intercept		-31.32		0.445***
		(225.1)		(0.075)
Cash	-1.314e1	-12.93	0.004	0.005
	(1.478e1)	(14.8)	(0.018)	(0.018)
Credit.Period	8.750***	8.774***	0.013***	0.013***
	(1.222)	(1.223)	(0.001)	(0.001)
MColor	10.53	10.64	0.025	0.025
	(14.68)	(14.69)	(0.018)	(0.018)
FColor	3.199e1***	3.160e1***	0.042***	0.042***
	(13.1)	(13.1)	(0.016)	(0.016)
Orphan	-1.551e2***	-1.531e2***	-2.358e-1***	-0.237***
	(60.24)	(60.31)	(0.075)	(0.075)
Orphan.Male	63.82	61.42	0.066	0.067
	(81.99)	(82.09)	(0.1028)	(0.103)
Guar	1.564e2***	1.575e2***	1.920e-1***	0.191***
	(12.17)	(12.17)	(0.015)	(0.015)
HOCC	6.028e1***	5.930e1***	0.061***	0.062***
	(20.7)	(20.72)	(0.026)	(0.026)
Ind.Price.2.5	7.267e1***	2.769e1***	-0.004	-0.003
	(43.49)	(14.49)	(0.047)	(0.016)
Ind.Price.6.9	1.180e2***	21.14	0.048	0.047***
	(69.95)	(21.9)	(0.075)	(0.022)
Ind.Price.10	1.810e2***	38.39	0.046	0.065***
	(81.35)	(29.23)	(0.086)	(0.026)
Group.Price.2.5	-1.816e2***	-2.117e2***	-2.027e-1***	-0.201***
	(43.04)	(20.82)	(0.047)	(0.025)
Group.Price.6.9	-2.737e2***	-3.333e2***	-4.431e-1***	-0.445***
	(88.27)	(60.34)	(0.1011)	(0.074)
Group.Price.10	-5.892e2***	-7.269e2***	-9.311e-1***	-0.911***
	(113.9)	(80.6)	(0.1319)	(0.102)
Family	-32.43	-25.66	0.006	0.004
	(28.98)	(28.9)	(0.034)	(0.034)
Louisiana	-6.409e1***	-6.459e1***	-0.046***	-0.046***
	(17.71)	(17.71)	(0.021)	(0.021)
New.South	-7.031e1***	-7.220e1***	-0.088***	-0.088***

continued on next page

Complete Parameter Estimates from Equations E1, E1b, E2, E2b

	Estimate from			
	E1	E1b	E2	E2b
	(19.31)	(19.31)	(0.023)	(0.023)
Southeast	25.36	23.44	-0.034	-0.034
	(30.89)	(30.93)	(0.038)	(0.038)
Border.States	-6.995e1***	-7.331e1***	-1.014e-1***	-0.099***
	(19.21)	(19.17)	(0.023)	(0.023)
Old.South	-4.431	-8.587	-0.052***	-0.052***
	(15.41)	(15.33)	(0.017)	(0.017)
Out.Of.State	8.416e1***	8.238e1***	0.093***	0.091***
	(17.79)	(17.8)	(0.019)	(0.019)
Unknown	-4.843e1***	-4.959e1***	-0.056***	-0.056***
	(10.86)	(10.86)	(0.013)	(0.013)
Age.M	5.792e1***	5.776e1***	0.069***	0.068***
	(5.406)	(5.41)	(0.007)	(0.007)
Age.F	2.331e1***	2.251e1***	0.013***	0.014***
	(6.258)	(6.259)	(0.008)	(0.008)
Male	-1.977e2***	-2.038e2***	-3.674e-1***	-0.362***
	(82.18)	(82.21)	(0.1025)	(0.102)
HOCCM	-8.912e1***	-8.878e1***	-1.039e-1***	-0.103***
	(44.67)	(44.72)	(0.055)	(0.055)
Skill	3.077e2***	3.141e2***	3.403e-1***	0.341***
	(33.56)	(33.54)	(0.042)	(0.042)
No. Kids	1.195e2***	1.186e2***	1.501e-1***	0.151***
	(5.827)	(5.829)	(0.007)	(0.007)
Int Paid	1.401e+03***	1.407e+03***	1.812***	1.833***
	(315.6)	(316)	(0.3695)	(0.369)
Age.M2	-1.539***	-1.533***	-0.002***	-0.002***
	(0.1922)	(0.1924)	(2.36e-4)	(2.362e04)
Age.M3	0.009***	0.009***	9.99e-6***	9.92e-6***
	(0.002)	(0.002)	(2.594e-6)	(2.593e-6)
Age.F2	-4.068e-1***	-3.803e-1***	1.112e-4	9.97e-5
	(0.2218)	(0.2219)	(2.761e-4)	(2.759e-04)
Age.F3	-0.001	-0.001	-8.33e-6***	-8.22e-6***
	(0.002)	(0.002)	(3.068e-6)	(3.065e-6)
Year & year-month	+	+	–	–
Adj. R^2	0.786	0.606	0.705	0.352

Significance codes: '***':1%, '**':5%, '*':10%

Table 11: Regression Results

Complete Parameter Estimates from Equations E3 and E3b

	Estimate from			
	E3		E3b	
	β_X	$\beta_{X\,30}$	β_X	$\beta_{X\,30}$
Intercept			191.9	
			(235.2)	( )
Terms Cash	-13.96	-29.95	-14.84	-28.82
	(23.156)	(19.38)	(23.18)	(19.37)
Credit.Period	1.054e+01***	5.080***	1.054e+01***	5.197***
	(1.678)	(1.784)	(1.68)	(1.785)
MColor	11.61	-0.8032	13.23	-0.9971
	(26.93)	(17.2)	(26.96)	(17.22)
FColor	38.59	3.182e+01***	38.69	3.110e+01***
	(26.81)	(14.8)	(26.84)	(14.8)
Orphan	-120.9	-1.530e2***	-114.6	-1.505e2***
	(113)	(70.31)	(113.1)	(70.4)
Orphan.Male	61.96	59.38	52.81	59.03
	(146.8)	(97.34)	(147)	(97.47)
Guar	1.600e2***	1.560e2***	1.601e2***	1.579e2***
	(23.95)	(13.91)	(23.98)	(13.91)
HOCC	8.966e1***	4.268e1***	8.689e1***	4.190e1***
	(39.67)	(23.79)	(39.71)	(23.82)
Ind.Price.2.5	17.83	8.758e1***	-24.94	3.635e1***
	(51.99)	(43.46)	(30.25)	(16.3)
Ind.Price.6.9	-11.74	1.693e2***	-1.056e2***	6.199e1***
	(78.27)	(70.73)	(42.86)	(25.23)
Ind.Price.10	145.2	1.874e2***	14.25	33.73
	(100.1)	(82.21)	(67.05)	(32.3)
Group.Price.2.5	-73.35	-2.736e2***	-1.022e2***	-3.123e2***
	(48.28)	(47.06)	(28.36)	(30.3)
Group.Price.6.9	-2.446e2***	-2.333e2***	-2.939e2***	-3.289e2***
	(100.9)	(115.1)	(76.93)	(96.65)
Group.Price.10	-255	-7.558e2***	-3.440e2***	-9.258e2***
	(162.6)	(128)	(142.2)	(97.62)
Family	43.77	-7.335e1***	53.93	-6.940e1***
	(48.37)	(36.22)	(48.29)	(36.25)
Louisiana	-27.28	-9.453e1***	-25.66	-9.613e1***

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Complete Parameter Estimates from Equations E3 and E3b

	Estimate from			
	E3		E3b	
	β_X	$\beta_{X\,30}$	β_X	$\beta_{X\,30}$
	(27.72)	(22.75)	(27.74)	(22.75)
New.South	-1.194e2***	-5.154e1***	-1.256e2***	-5.153e1***
	(38.33)	(22.02)	(38.33)	(22.04)
Southeast	-39.31	53.47	-37.35	49.15
	(46.44)	(40.89)	(46.5)	(40.89)
Border.States	-1.305e2***	-33.68	-1.299e2***	-4.064e1***
	(30.74)	(24.68)	(30.77)	(24.61)
Old.South	-4.792e1***	21.81	-5.067e1***	17.04
	(24.48)	(19.62)	(24.49)	(19.51)
Out.Of.State	36.16	7.835e1***	36.8	7.630e1***
	(80.03)	(18.5)	(80.13)	(18.51)
Unknown	-7.525e1***	-3.094e1***	-7.341e1***	-3.370e1***
	(19.61)	(12.93)	(19.62)	(12.9)
Age.M	4.047e1***	7.224e1***	4.025e1***	7.232e1***
	(8.912)	(6.867)	(8.923)	(6.872)
Age.F	-3.917	3.828e1***	-5.235	3.835e1***
	(10.15)	(7.92)	(10.16)	(7.922)
Male	-2.724e2***	-21.4	-2.807e2***	-32.09
	(129.5)	(274.7)	(129.7)	(275)
HOCCM	-1.811e2***	-34.14	-1.794e2***	-34.97
	(78.98)	(53.24)	(79.08)	(53.3)
Skill	3.070e2***	3.052e2***	3.152e2***	3.104e2***
	(61.46)	(39.31)	(61.47)	(39.31)
No. Kids	1.267e2***	1.229e2***	1.255e2***	1.225e2***
	(11.35)	(6.869)	(11.35)	(6.882)
Int Paid	-3079	1.183e+03***	-3110	1.214e3***
	(2893)	(348.1)	(2897)	(348.4)
Age.M2	-9.820e-1***	-2.002***	-9.733e-1***	-2.003***
	(0.3348)	(0.2365)	(0.3352)	(0.2367)
Age.M3	0.005	0.013***	0.005	0.013***
	(0.004)	(0.003)	(0.004)	(0.003)
Age.F2	0.5937	-9.762e-1***	6.427e-1***	-9.799e-1***
	(0.3647)	(0.2783)	(0.3648)	(0.2785)
Age.F3	-0.011***	0.005	-0.011***	0.005
	(0.004)	(0.003)	(0.004)	(0.003)
Female.1830		179.2		170.4
		(277.9)		(278.2)
Adj. R^2	0.794		0.619	

Significance codes: '***':1%, '**':5%, '*':10%, Year and year-month dummies included.

Table 12: Regression Results

Complete Parameter Estimates from Equations E4 and E4b

Estimate from				
	E4		E4b	
	β_X	$\beta_{X\,30}$	β_X	$\beta_{X\,30}$
Intercept			6.255e-1***	
			(1.15e-1)	
Terms Cash	-5.149e-2	-0.002	-0.051***	-0.001
	(0.027))	(0.023)	(0.027)	(0.023)
Credit.Period	0.015***	0.006***	0.015***	0.006***
	(0.002)	(0.002)	(0.002)	(0.002)
MColor	0.056***	-0.002	0.059***	-0.002
	(0.032)	(0.022)	(0.032)	(0.022)
FColor	0.057***	0.043***	0.057***	0.043***
	(0.031)	(0.018)	(0.031)	(0.018)
Orphan	-3.358e-1***	-1.632e-1***	-3.276e-1***	-1.661e-1***
	(1.36e-1)	(0.087)	(1.36e-1)	(0.087)
Orphan.Male	1.19e-1	0.037	1.14e-1	0.039
	(1.81e-1)	(1.22e-1)	(1.81e-1)	(1.22e-1)
Guar	2.547e-1***	1.634e-1***	2.563e-1***	1.626e-1***
	(0.027)	(0.017)	(0.027)	(0.017)
HOCC	1.594e-1***	0.021	1.588e-1***	0.02
	(0.048)	(0.029)	(0.048)	(0.029)
Ind.Price.2.5	-1.520e-1***	0.042	-1.445e-1***	0.045***
	(0.054)	(0.048)	(0.032)	(0.019)
Ind.Price.6.9	-0.029	0.067	-0.017	0.069***
	(0.079)	(0.076)	(0.038)	(0.027)
Ind.Price.10	1.22e-1	0.051	1.505e-1***	0.059***
	(0.094)	(0.086)	(0.051)	(0.029)
Group.Price.2.5	-1.351e-1***	-2.903e-1***	-1.284e-1***	-2.877e-1***
	(0.052)	(0.054)	(0.033)	(0.037)
Group.Price.6.9	-4.915e-1***	-4.357e-1***	-4.799e-1***	-4.351e-1***
	(1.13e-1)	(1.40e-1)	(0.092)	(1.22e-1)
Group.Price.10	-4.928e-1***	-1.098***	-4.713e-1***	-1.076***
	(1.92e-1)	(1.49e-1)	(1.73e-1)	(1.24e-1)
Family	1.901e-1***	-1.019e-1***	1.885e-1***	-1.023e-1***
	(0.057)	(0.042)	(0.057)	(0.042)
Louisiana	-0.028	-0.077***	-0.03	-0.076***
	(0.03)	(0.028)	(0.03)	(0.028)

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Complete Parameter Estimates from Equations E4 and E4b

	Estimate from			
	E4		E4b	
	β_X	$\beta_{X\,30}$	β_X	$\beta_{X\,30}$
New.South	-1.486e-1***	-0.058***	-1.461e-1***	-0.059***
	(0.045)	(0.026)	(0.045)	(0.026)
Southeast	-1.107e-1***	-0.006	-1.110e-1***	-0.002
	(0.055)	(0.05)	(0.055)	(0.05)
Border.States	-1.813e-1***	-0.065***	-1.743e-1***	-0.063***
	(0.036)	(0.029)	(0.036)	(0.029)
Old.South	-0.066***	-0.041***	-0.064***	-0.041***
	(0.027)	(0.021)	(0.027)	(0.022)
Out.Of.State	0.073	0.086***	0.073	0.086***
	(0.087)	(0.02)	(0.087)	(0.02)
Unknown	-1.071e-1***	-0.030***	-1.078e-1***	-0.031***
	(0.022)	(0.015)	(0.022)	(0.015)
Age.Male	0.052***	0.088***	0.051***	0.087***
	(0.011)	(0.009)	(0.011)	(0.009)
Age.Female	-0.01	0.028***	-0.01	0.028***
	(0.012)	(0.01)	(0.012)	(0.01)
Male	-4.094e-1***	-6.941e-1***	-4.047e-1***	-6.731e-1***
	(1.55e-1)	(1.42e-1)	(1.55e-1)	(1.42e-1)
HOCCM	-2.784e-1***	-0.02	-2.817e-1***	-0.021
	(0.092)	(0.067)	(0.092)	(0.067)
Skill	3.293e-1***	3.336e-1***	3.264e-1***	3.359e-1***
	(0.072)	(0.05)	(0.072)	(0.05)
No. Kids	1.896e-1***	1.434e-1***	1.905e-1***	1.436e-1***
	(0.013)	(0.008)	(0.013)	(0.009)
Int Paid	-2.663	1.783***	-2.746	1.811***
	(3.621)	(4.09e-1)	(3.621)	(4.08e-1)
Age.M2	-0.001***	-0.002***	-0.001***	-0.002***
	(3.99e-4)	(2.93e-4)	(3.99e-4)	(2.93e-4)
Age.M3	4.198e-6	1.592e-5***	3.96e-6	1.59e-5***
	(4.57e-6)	(3.13e-6)	(4.57e-6)	(3.13e-6)
Age.F2	0.001***	-4.80e-4	0.001***	-4.92e-4
	(4.41e-4)	(3.48e-4)	(4.41e-4)	(3.48e-4)
Age.F3	-1.78e-5***	-1.90e-6	-1.76e-5***	-1.76e-6
	(4.91e-6)	(3.84e-6)	(4.91e-6)	(3.84e-6)
Female.1830		-2.833e-1***		-2.694e-1***
		(1.48e-1)		(1.48e-1)
Adj. R^2	0.720		0.3844	

Significance codes: '***':1%, '**':5%, '*':10% Year and year-month dummies not included.

Table 13: Geographical Origins of Raw Slaves Sales Data (Appendix)

Origin	Frequency
Place of origin is not given or inappropriate (eg., slaves of local origin)	3158
Delaware, District of Columbia, Maryland, Virginia, North and South Carolina,	562
Georgia, and Florida	126
Kentucky, Tennessee, and Missouri	284
Alabama, Texas, and Arkansas	242
Local (out of state seller in North)	49
Specific origin unknown but outside Louisiana	363

8 Appendix

8.1 Data Construction

The slave sale data set was filtered and cleaned in stages. We first started looking at the price, age, and sex recorded on the invoice. Group sales were kept in the sample as long as all information on all individual slaves in the group was present. There were 125 invoices that had missing price, age and or sex information. Some of these 125 observations were part of group sale invoices. In order to be consistent with estimating our models, we had to delete any observation that belonged to a transaction where one of the above variables for any slave was missing. In total, we deleted 225 (100 more observations due to group invoices) observations. The remaining observations amounted to 4784 records that had salvageable price, age and sex information. Since one of the primary interests of the paper was to estimate price differences conditional on the slaves' origin, we had to further filter the remaining 4784 records to salvage place of origin.

Table 13 gives the geographical origin of the 4784 primary slaves on the invoices. Of the remaining slaves, 3158 were coded as 'Place of origin is not given, or inappropriate (eg., slaves of local origin)'. To account for and salvage as many slaves as possible, we proposed the following. If the place of origin is not known, we tracked it with two additional variables: the previous transaction of slave, and the origin of the seller. When these two variables matched up, we recorded the slave to have originated from the corresponding region. After applying this procedure, 305 more observations could not be saved because of place of origin. Of these 305 observations some belonged to group sales which led us to drop a total of 322 observations, leaving a data set with 4462 observations. These 4462 primary observations were split into 8 different regions; 'New Orleans', 'Louisiana', 'New South', 'Old South','Border States', and 'Unknown' but out of state. Table 2 gives the distribution of the final sample of slaves according to these regions. Table 14 gives the geographical distribution of the hiring transactions.

Table 14: Distribution of Slaves by geographical origin from the Slave Hire Data (Appendix)

State	Counts	Frequency
North Carolina	6356	33.18
Maryland	2369	12.37
Virginia	3353	17.50
South Carolina	6	0.03
Louisiana	186	0.97
Tennessee	6263	32.70
Georgia	467	2.44
Mississippi	155	0.81
Total	19155	100.00

Table 15: More Wald tests on regional dummies (Appendix)

	E3		E4		E3b		E4b	
	$\beta_R = 0$	$\beta_{R\,30} = 0$	$\beta_R = 0$	$\beta_{R\,30} = 0$	$\beta_R = 0$	$\beta_{R\,30} = 0$	$\beta_R = 0$	$\beta_{R\,30} = 0$
χ^2	23.87	54.79	33.83	48.69	24.66	54.09	31.72	49.10
df	6	6	6	6	6	6	6	6
p-value	5.5e-4	5.11e-10	7.25e-6	8.50e-9	3.94e-4	7.06e-10	1.85e-5	7.11e-9

Table 16: Comparing Deleted obs with Selected obs
- individually priced slaves (Appendix)

Samples	Statistics	Prices	Age
Deleted Sample, % female = 46.8 %	1st Quartile	400.0	17
	Median	560.0	22
	3rd Quartile	800.0	30
	Mean	642.1	24.54
	Std Dev.	342.35	11.11
	No. of obs.	225	
Selected Sample, % females = 52.0 %	1st Quartile	450.0	17
	Median	600.0	22
	3rd Quartile	800.0	30
	Mean	642.1	23.96
	Std Dev.	310.35	10.06
	No. of obs.	2516	

8.2 Testing for Structural Change

Table 15 considers more Wald tests for price variation over the two periods before and after 1830 (complementing the results in (6) discussed earlier). Here, we tested the null hypothesis of no regional price variation in each of the two periods separately in the specifications E3 and E4 which accounts for the structural break in 1830. Again, the test consistently rejects the hypothesis that there was no regional price variation. Hence, we conclude that slaves originating from different regions on average earn discounts relative to New Orleans.

8.3 Comparing Deleted observations and final selected sample

Our data construction resulted in deleting 225 observations from the initial slave sales sample generating a final sample of 4462 due to missing covariates. Since we are primarily interested in the price variation by geographical origin, there might be concern that the deleted observations are not random, but selected in some particular way. Figure 10 and Table 16 attempt to address these concerns. Figure 10 compares the histogram of prices and age for the deleted and selected sample. The histogram plots for both samples appear very similar. A simple Kolmogorov-Smirnov test of equality of the two densities fails to reject the null of equality. Table 16 compares some simple statistics of the deleted and final selected sample. The proportion of females in the final selected sample is slightly higher. The mean and quartiles for prices and age appears very close. We are reasonbly confident that our data construction process is not systematically deleting certain types of observations.

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