Sale Rates and Price Shocks in Art Auctions

Orley Ashenfelter, Princeton University
  e-mail:c6789@princeton.edu
  telephone:609-258-4040
  fax:609-258-2907

Kathryn Graddy, Brandeis University
  (corresponding author)
  e-mail: kgraddy@brandeis.edu
  telephone: 781-736-8616
  fax:781-736-2269

session title: Economics of the Arts
  session co-chairs: Jiangping Mei and Michael Moses
  Discussants: Cedric Ceulema
    Benjamin Mandel
    Marie Conolly Pray
    Bruce Weinburg

September 2010

Draft Document
Sale Rates and Price Shocks

Orley Ashenfelter and Kathryn Graddy

While much attention has been given to studying price movements in the art market, little attention has been given to studying sale rates. Because of the unique characteristic of auction markets, namely the presence of sellers’ reserve prices, not all items that are put up for sale are sold. An understanding of sale rates, as measured by the number of items that actually change hands as a proportion of items that are put up for sale, are crucial to an understanding of the art market.

Sellers of individual items will set a secret reserve price, and if the bidding does not reach this level, the items will go unsold. An item that has not been sold may be put up for sale at a later auction, sold elsewhere, or taken off the market. We begin our study by looking in detail at sale rates, prices and price shocks. Price shocks are defined as the average percentage difference between the sale price and the pre-sale estimate as published in the pre-sale catalogue. We show that sale rates have shown no discernible trend or consistent correlations with current price levels, but that sale rates and price shocks have a

---

1 Industrial Relations Section, Princeton University, Firestone Library Princeton, New Jersey 08544, c6789@princeton.edu; Department of Economics and International Business School, Brandeis University, 415 South Street, Waltham, MA 02454. The authors would like to thank Jiangping Mei, Mike Moses and Margaret Stevens for useful comments on an early draft of this paper. The authors would also like to thank Ly Tran and Huong Nguyen for their research assistance.

strong visible relationship.

The secret reserve price in an art auction is commonly thought of in art auctions as having a relationship to the low estimate. Indeed, the convention in art auctions is that the reserve price is set at or below the low estimate. We use this relationship to interpret our graphical relationship between sale rates and price shocks. Using a data set on contemporary art in which we have prices for sold items and high bids for unsold items, we can estimate the average discount rate below the low estimate which the reserve price is set under our above assumptions. Our estimates show that the reserve price is set at about 70% of the low estimate, which is consistent with what is known about reserve price.

This paper proceeds as follows. In section I we describe the auction market and look at summary statistics on sale rates, prices and price shocks. In section II we interpret the relationship between sale rates and price shocks. In section III we apply our understanding of sale rates and unexpected price changes to estimate the average amount below the low estimate that sellers set their reserve prices, and we conclude our analysis in section IV.

I. Sale Rates and Prices in Art Auctions

Art auctions are ascending price auctions, where the bidding starts out low and the auctioneer subsequently calls out higher and higher prices. When the bidding stops, the item is said to be “knocked down” or “hammered down”, and the final price is the “hammer price.” Not all items that have been put up for sale and “knocked down” have been sold. Sellers of individual items will set a secret reserve price, and if the bidding does not reach this level, the items will go unsold. Auctioneers say that an unsold item has been “bought-in.”

Prior to the sale, a pre-sale catalogue is published which includes high and low estimates of the art work to be auctioned. The auction house does not publish, and indeed is very secretive about, the seller’s reserve price for the work of art. The auction houses
observe an unwritten rule of setting the secret reserve price at or below the low estimate.\textsuperscript{3}

Our first dataset consists of objects sold in auctions of impressionist art at Christie's and Sotheby's in London and New York. For the period 1980 to 1990, the dataset on impressionist and modern art auctions was constructed by Orley Ashenfelter and Andrew Richardson by looking through public price lists and auction catalogues from Christie's and Sotheby's. For the period 1990 to July of 2007, the dataset was constructed by Kathryn Graddy with the help of Ly Tran and Huong Nguyen by using a combination of Hislop's art sales index database and the ARTNET database. Our dataset includes sales of 58 selected impressionist and modern artists that took place at Christie’s and Sotheby’s auction houses in London and New York. The artists in this sample were selected because their art is well represented at auction.

Our second dataset on contemporary art was constructed by Kathryn Graddy and includes all sales of contemporary art at Christie’s auction house on King Street in London between 1982 and 1994. The data were gathered from the archives of Christie’s auction house, and for each item, the observable characteristics were hand-copied from the pre-sale catalogues. The information on whether or not a lot is sold and the final bid from 1988 onwards was taken primarily from Christie’s internal property system. Before 1988, many of the lots were missing from the internal system. An assistant in the archives department said that after a certain period of time, some of the lots are deleted from the system, for no predictable reason. From December 1982 through December 1987, we had access to the auctioneer’s books and were able to track the missing items in that manner. For this dataset, we have observations both on the sale price for sold items and on the high bid for unsold items, as reported in Christie’s internal property system.

\textsuperscript{3} For a description of art auctions, please see Ashenfelter (1989).
Table 1: Summary Statistics

<table>
<thead>
<tr>
<th>Year</th>
<th>Observations</th>
<th>No. of Auctions</th>
<th>Price High Bid (sold items)</th>
<th>High Bid (Unsold Items)</th>
<th>Average Sale rate (Unsold Items)</th>
<th>Average Sale rate estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impressionist Art</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1980-1984</td>
<td>4,585</td>
<td>79</td>
<td>87,275</td>
<td>-</td>
<td>78,475</td>
<td>0.707</td>
</tr>
<tr>
<td>1985-1989</td>
<td>9,403</td>
<td>130</td>
<td>287,285</td>
<td>-</td>
<td>206,160</td>
<td>0.749</td>
</tr>
<tr>
<td>1990-1994</td>
<td>7,583</td>
<td>114</td>
<td>400,202</td>
<td>-</td>
<td>437,829</td>
<td>0.612</td>
</tr>
<tr>
<td>1995-1999</td>
<td>11,976</td>
<td>141</td>
<td>340,141</td>
<td>-</td>
<td>253,927</td>
<td>0.693</td>
</tr>
<tr>
<td>2000-2004</td>
<td>8,443</td>
<td>124</td>
<td>326,189</td>
<td>-</td>
<td>288,791</td>
<td>0.686</td>
</tr>
<tr>
<td>2005-2007</td>
<td>6,647</td>
<td>63</td>
<td>384,117</td>
<td>-</td>
<td>340,459</td>
<td>0.773</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Observations</th>
<th>No. of Auctions</th>
<th>Price High Bid (sold items)</th>
<th>High Bid (Unsold Items)</th>
<th>Average Sale rate (Unsold Items)</th>
<th>Average Sale rate estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Contemporary Art</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1982-1984</td>
<td>709</td>
<td>6</td>
<td>4,210</td>
<td>2,269</td>
<td>3,490</td>
<td>0.732</td>
</tr>
<tr>
<td>1985-1989</td>
<td>1,581</td>
<td>12</td>
<td>25,428</td>
<td>12,829</td>
<td>19,671</td>
<td>0.811</td>
</tr>
<tr>
<td>1990-1994</td>
<td>2,009</td>
<td>17</td>
<td>28,377</td>
<td>34,780</td>
<td>36,702</td>
<td>0.724</td>
</tr>
</tbody>
</table>

Table 1 presents summary statistics on number of observations, number of auctions, average prices for sold items, high bids for unsold items in the contemporary art dataset, average estimates, and sale rates for 5 year periods. There are many more impressionist art auctions than contemporary art auctions because of the way the data was constructed. Impressionist art is a lot more expensive than contemporary art, and finally, it is interesting that during the period 1990-1994 it appears to be the high value items that did not sell in the contemporary art auctions. The sale rate appears to be largely stationary in both datasets.  

The average sale rate over the entire period is 69.8% for impressionist art for the entire 27 year period and is 76% for contemporary art for the period 1982-1994. For impressionist art for the period 1982-1994 the average sale rate is 68.5%.

---

4 Price estimates for impressionist art are missing for 105 out of 651 auctions. 80 of 105 of these missing price estimates occur in the years 1992 to 1994.
Figure 1: Sale Rates and Price Indices

Figures 1 presents sale rates and a hedonic price index plotted over time and demonstrates that these sale-rates are indeed quite stable, with little correlation to a hedonic index of prices\(^5\). The correlation of the impressionist index to sales rates is -.13, and the correlation of contemporary art to sale rates is .0167. During the 1989 crash, in both datasets

\(^5\) The impressionist art index is constructed by regressing log prices on 57 artist dummies, log height, log width, and 27 year dummies and the contemporary art index is constructed by regressing log price on 119 artist dummies, log height, log width, 20 medium dummies, log of years since painting was constructed, and whether or not the painting was subject to VAT.
prices and sale rates fell.

Figure 2: Buy-in Rates and Price Shocks

In contrast to Figure 1, Figure 2 shows a strong relationship between price shocks and the buy-in rate (which is calculated as one minus the sale rate) for both impressionist and contemporary art. Price shocks are calculated as the sale price to average estimate ratio minus one for each painting, and then averaged over each auction. A regression of the buy-in rate on the price shock for impressionist art yields a slope coefficient of -0.345 and a standard error of just 0.029, and a slope coefficient of -.149 for contemporary art with a standard error of .0335438. The constant is 0.352 with a standard error of 0.008 for
impressionist art and .379 with a standard error of .035 for contemporary art.

This strong observed correlation between unexpected price shocks and our measure of volume—the sale rate—is suggestive of a Phillips curve. Mortensen (1970) used a labor market sequential search model to explain the Phillips curve. With art, one can think of the buy-in rate as the unemployment rate for paintings. An unexpected positive wage shock raises employment (the sale rate) because more workers (owners of paintings) receive wage (price) offers above their reservation wage (price).

II. An Empirical Explanation of the Relationship of Sale Rates to Price Shocks

Before the auction, the auction house publishes a range of estimates of the value of each item for sale, but does not reveal the reserve price, which by convention is at or below the low estimate. Consistent with the common perception in art auctions, each reserve price, which is both item specific and time specific, is related to each low estimate by an individual reserve factor, \( \theta_{it} \), where \( R_{it} = \theta_{it} E(p_{it}) \).

An item is sold if and only if \( p_{it} > R_{it} \rightarrow p_{it} > \theta_{it} E(p_{it}) \). Now define the price shock \( ps_{it} \) for that item as \( ps_{it} = \ln p_{it} - \ln E(p_{it}) \) and let \( y_{it} = 1 \) if the item is sold, \( y_{it} = 0 \) otherwise. Then, \( y_{it} = 1 \iff ps_{it} > \ln \theta_{it} \), where \( \theta_{it} \) is the reserve factor of the seller of item \( it \). Adding \( \nu_{it} = (ps_{it} - ps_{it}) \), where \( ps_{it} = \frac{1}{n_t} \sum_{i} ps_{it} \), \( (n_t \) is the number of items for sale during the time period \( t \) ) to each side of the above equation, we are left with

\[
y_{it} = 1 \iff ps_{it} > \ln \theta_{it} + \nu_{it}.
\]

As \( \nu_{it} \) is an item-specific deviations from an average price shock, we will assume that that \( \nu_{it} \sim \text{IN}(0, \sigma_{\nu}^2) \).

Now consider the sale rate \( S_t \) over a time period \( t \), \( S_t = \frac{1}{n_t} \sum_{i} y_{it} \). Furthermore, let \( \ln \theta_{it} = \ln \bar{\theta} + \varepsilon_{it} \) and assume that any deviations for work \( i \) at time \( t \) from an average discount rate are idiosyncratic and thus \( \varepsilon_{it} \sim \text{IN}(0, \sigma_{\varepsilon}^2) \). We can now write
\[ y_t = 1 \Leftrightarrow ps_t > \ln \bar{\theta} + \varepsilon_t + v_t. \] The expected sale rate at auction \( t \), given the average price-shock and the average reserve factor of the sellers at the auction, is given by:

\[ E[S_t | ps_t, \bar{\theta}] = \Pr[y_t = 1 | ps_t, \bar{\theta}] = \Phi \left( \frac{ps_t - \ln \bar{\theta}}{\sigma_{z+v}} \right) \]  

(13)

This suggests the below relationship, which can now be estimated:

\[ \Phi^{-1}(S_t) = \frac{1}{\sigma_{z+v}} (ps_t - \ln \bar{\theta}) + \pi_t \]  

(14)

Here, the error term, \( \pi_t \), occurs because of replacement of \( E[S_t | ps_t, \bar{\theta}] \) by the observed sale rate, \( S_t \), and we assume that \( \pi_t \sim IN(0, \sigma^2_{\pi}) \).

### III. Estimation

Using the approach to estimation outlined above, we can now derive estimates for \( \sigma \) and \( \bar{\theta} \). Estimating \( \bar{\theta} \) is of special interest, since it tells us how far below the estimate, on average, the "secret" reserve is set. A believable estimate for \( \bar{\theta} \) also provides a check that the above expression is reasonable.

We estimate the ordinary least squares model

\[ Y_t = \alpha + \beta (\frac{1}{n} \sum_{i=1}^{n} \ln p_{it} - \ln \text{est}(p_{it})) + \pi_t \]

for the Contemporary art dataset, as we have high bids on unsold items. From equation 14 above, \( Y_t = \) the inverse normal of the sale rate, \( \alpha = \frac{-1}{\sigma_{z+v}} (\ln \bar{\theta}) \), \( \beta = \frac{1}{\sigma_{z+v}} \), and \( \pi_t \sim IN(0, \sigma^2_{\pi}) \). Intuitively, we can identify \( \bar{\theta} \) because we have observations on the sale price for items sold, and on the high bid for items that are unsold, along with estimated price. Our estimation consists of an ordinary least squares regression of the inverse normal of the yearly sale rate on the yearly price shocks. The R-squared for this regression is .77. The
coefficient on the price shock is 1.68 with a standard error of 0.16. The coefficient on the constant is 0.60 with a standard error of 0.03. These estimates yield a discount factor that is on average 0.70 below the low estimate.

How reasonable are our estimates of $\theta$? In the contemporary art dataset, our of 3295 sold items, 1263 items (or 38%) sold at or below the low estimate. In this sample, the mean percentage below the low estimate was 87%. The high bid for unsold items was on average 72% below the low estimate. In impressionist and modern art, 37% sold at or below the low estimate, and the mean percentage below the low estimate was 90%. The only evidence we could find on any actual reserve prices is contained in a book by Peter Watson that documents the selling of *Portrait of Dr. Gatchet*. For this picture, the secret reserve was $35,000,000, 87.5% below the low estimate of $40,000,000.$^6$

IV. Conclusion

From our regression equation above, we can identify three forces that act on the sale rate. First, the sale rate is decreasing as the variance in the price shocks across items within an auction increases and the sale rate is also decreasing in the variance in the discount factor across items. Secondly, the sale rate is increasing in the price shock for a particular auction. Finally, the sale rate is decreasing as the average discount factor increases.

These forces are all intuitive and raise the question as to what actually determines these underlying parameters, especially the reserve price. Studying the reserve price is a promising area for future research.

---

$^6$ In another context, McAfee, Quan, and Vincent (2000) construct a theoretical model and find that for real estate, the optimal reserve for buildings should be at least 75% of the appraised value, despite the Resolution Trust Corporation (RTC) and The Federal Deposit Insurance Corporation (FDIC) using reserve prices of between 50-70%.
References


