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ABSTRACT

The failure of many paintings to sell in art auctions indicates the presence of reserve prices set by sellers. This paper examines the relationship between sale rates and price surprises over time in art auctions. Using data on contemporary and impressionist art, we show that while sale rates appear to have little relationship to current prices, there exists a strong positive relationship of sale rates to unexpected aggregate price changes, which is reminiscent of a Phillips curve. As a result, sale rates provide a useful quantity indicator of the strength of the art market. The data also indicate that sale rates revert to "normal" very quickly following a price surprise. We estimate an empirical model to measure normal sale rates. We also find evidence that the reserve price is set on average at about 70% of the auctioneer's low estimate, as published in the auction catalog.

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Sale Rates and Price Movements in Art Auctions

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While much attention has been given to studying price movements in the art market, little attention has been given to studying sale rates.[2] Because of the presence of sellers' reserve prices, not all items that are put up for sale are sold. The variability in sale rates provides a quantity signal that plays a large role in public discussions of the current state of the art market. In this regard art markets, where the products on sale display considerable heterogeneity, are similar to housing and labor markets, where quantity signals also play an important role in discussions of the state of the market. 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, shows how quantity signals are formed even in the purest form of auction market transaction.

Sellers of individual art works usually set a confidential 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 unexpected price movements. Unexpected price movements are defined as the average percentage difference between the sale price and the pre-sale estimate as produced by auction house experts and published in the

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[2] Studies of price movements in art markets include Baumol (1986), Pesando (1993) Goetzmann (1993), Barre, Docclo, and Ginsburgh (1996), and Mei and Moses (2002). Ashenfelter and Graddy (2003, 2006) provide a survey.

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 unexpected price movements have a strong visible relationship, despite the efforts of auctioneers to produce accurate estimates.

The confidential reserve price is commonly thought to be related to an auctioneer's pre-sale estimated price. Indeed, the convention in art auctions is that the reserve price is set at or below the auctioneer's low estimate. We use this relationship to interpret our graphical relationship between sale rates and unexpected price movements. Using a data set on contemporary art in which we have prices for sold items and high bids for unsold items, we estimate the average discount that the reserve is set below the low estimate. Our results indicate that the reserve price is set at about 70% of the low estimate, which is consistent with what little is known about reserve prices.

In section I of the paper we describe the auction market and summary statistics on sale rates, prices, and unexpected price movements. In section II we interpret the relationship between sale rates and unexpected price movements. In section III we use sale rates and unexpected price changes to estimate the relation between the auctioneer's observable low estimate and the seller's observable reserve price.

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 typically set confidential reserve prices, 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.[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. 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.

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[3] For a description of art auctions, please see Ashenfelter (1989), who shows that auctioneer's pre-sale price estimates are highly correlated with the prices of subsequently sold items.

Table 1: Summary Statistics

Year	Observations	No. of Auctions	Price (sold items)	High Bid (Unsold Items)	Average estimate	Sale rate
Impressionist Art						
1980-1984	4,585	79	87,275	-	78,475	0.707
1985-1989	9,403	130	287,285	-	206,160	0.749
1990-1994	7,583	114	400,202	-	437,829	0.612
1995-1999	11,976	141	340,141	-	253,927	0.693
2000-2004	8,443	124	326,189	-	288,791	0.686
2005-2007	6,647	63	384,117	-	340,459	0.773
Contemporary Art						
1982-1984	698	6	4,210	1,991	3,445	0.745
1985-1989	1,566	12	25,428	11,520	19,511	0.819
1990-1994	1,993	17	26,081	30,443	32,638	0.740

Table 1 presents summary statistics on the number of observations, the number of auctions, the average prices for sold items, the high bids for unsold items in the contemporary art dataset, the average of the high and low pre-sale estimates, and the sale rates for 5 year periods. There are many more impressionist art auctions than contemporary art auctions because of the way the data sets were constructed. The sale rate is largely stationary over these five year intervals in both datasets. [4] The average sale rate over the entire 27 year period is 69.8% for impressionist art, while it is 77% for contemporary art for the period 1982-1994. For comparison the impressionist art sale rate is 68.5% over the same 1982-94 period, suggesting the "normal" sale rate is higher for contemporary than impressionist art.

[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.

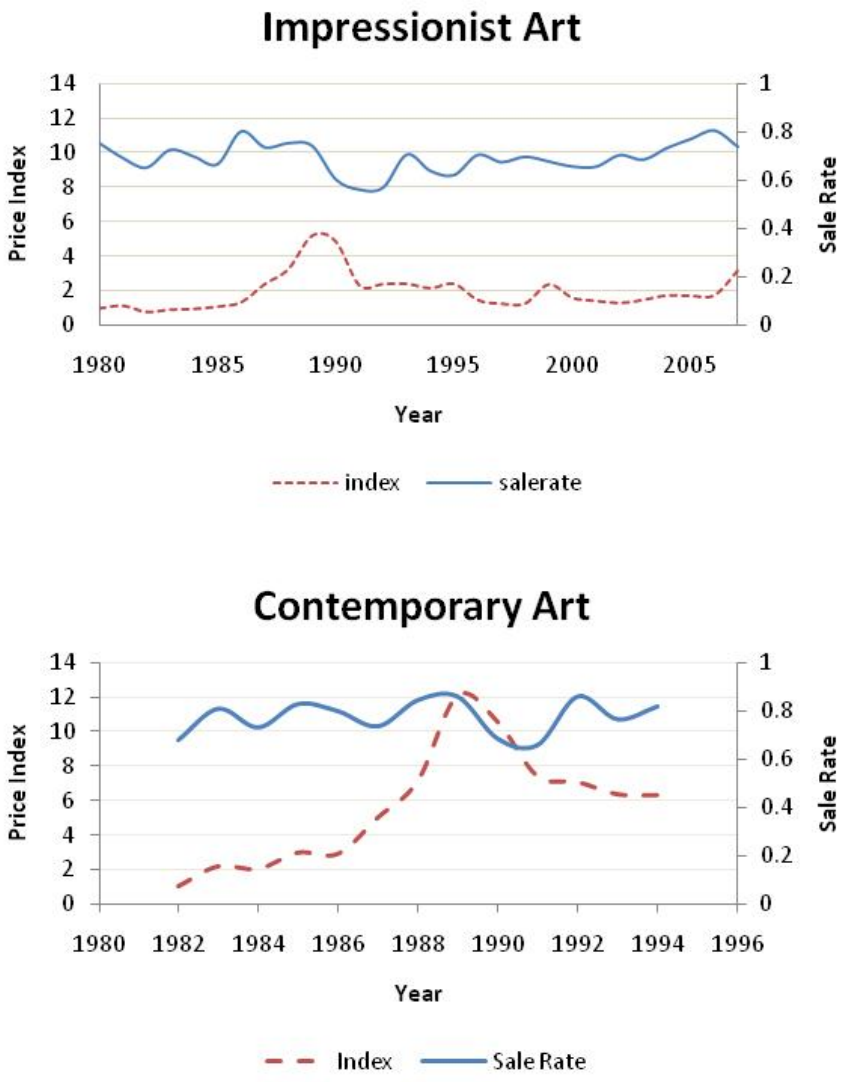

Figure 1: Sale Rates and Price Indices

Figures 1 present's sale rates and a yearly hedonic price index plotted over time and demonstrates that these sale-rates fluctuate around a stable level, with no consistent correlation with an index of prices[5]. The correlation of yearly sale rates with the current impressionist index is -.24, and the correlation of yearly sale rates with the current contemporary index is .26. There is a higher correlation of the lagged price indices with sale

[5] The impressionist art index is constructed by regressing log prices on 57 artist dummies, log height, log width, and 27 year dummies. 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, whether or not the painting was subject to VAT, and 13 year dummies.

rates: for impressionist art the correlation is -.60 and for Contemporary Art the correlation is -.58. During the 1989 crash, in both datasets prices and sale rates fell. The negative correlations with the lagged yearly price index suggests that price surprises, or "price shocks," might be driving sale rates. We have a very good measure of price shocks on an item by item basis because of the pre-sale estimates placed on items by experts at the auction houses.

In Figure 2 below, we plot the buy-in rate (which is calculated as one minus the sale rate) against the price shock, by auction, for both impressionist and contemporary art. Price shocks are calculated as the ratio of the sale price to the average estimate minus one for each painting, and then averaged over each auction. For contemporary art, we separate the unexpected shock for sold items from the unexpected shock for unsold items (using the high bid price in place of a sold price). As would be expected, the price shock for unsold items is consistently negative.

The figures below show a strong relationship between buy-in rates and price shocks. A regression of the buy-in rate on the price shock for sold items for impressionist art yields a slope coefficient of -0.345 and a standard error of just 0.029. A regression of the buy-in rate on the price shock for sold items for contemporary art yields a slope coefficient of -0.322 with a standard error of 0.050. The slope of the relationship is steeper for unsold items at -0.759, but with a standard error of 0.399 it is not significantly different from the slope for sold items.

This strong observed correlation between unexpected price shocks and our measure of volume –the sale rate—is suggestive of a Phillips curve. Mortensen (1970) sets out an elegant model of reservation price determination in a labor market context and uses it to explain the nature of a Phillips Curve. With art, one can think of the buy-in rate as the unemployment rate for paintings. An unexpected positive price shock raises the sale rate

because more owners of paintings receive price offers above their reservation price.

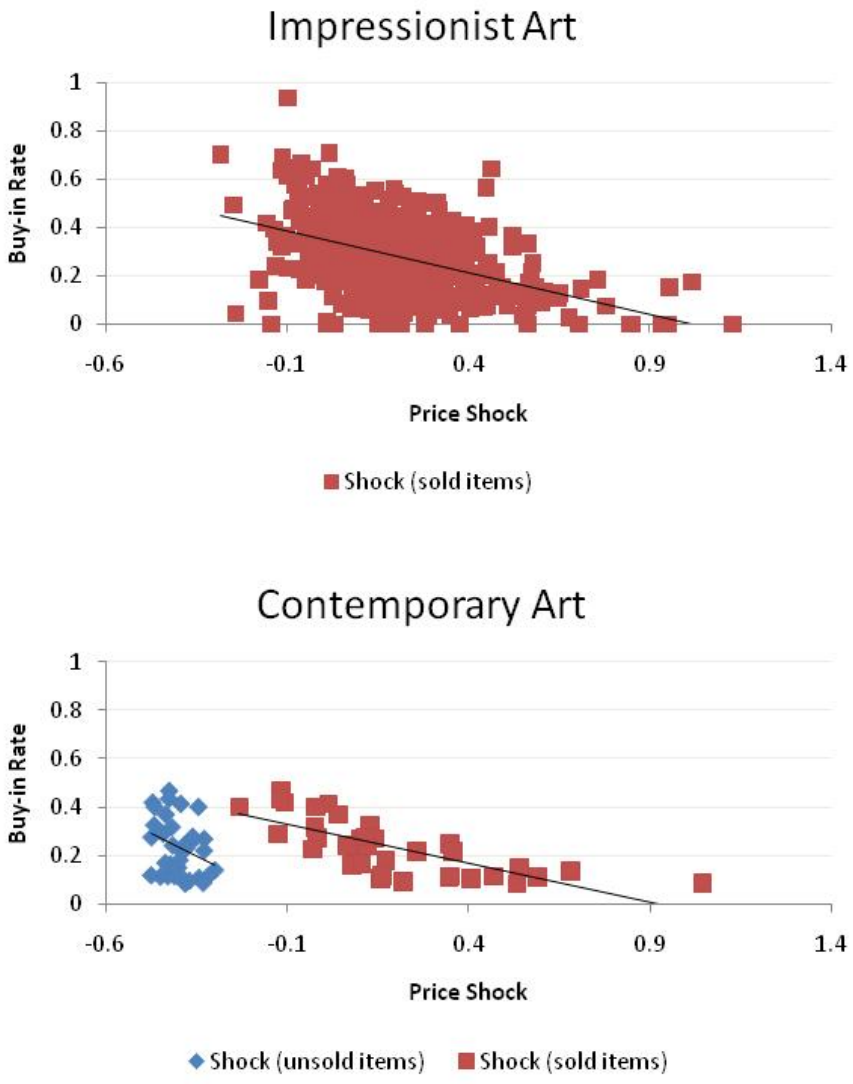

Figure 2: Buy-in Rates and Price Shocks

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

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, R_{it}, which is both item specific and time specific, is related to each low estimate, LE_{it}, by an

individual reserve factor, θ_{it}, where $R_{it}= \theta_{it}LE_{it}$.[6]

An item is sold when $p_{it} > R_{it}$ *or* $p_{it} > \theta_{it} LE_{it}$, Now define the price shock ps_{it} for that item as $ps_{it} \equiv \ln p_{it} - \ln LE_{it}$ and let $y_{it} = 1$ if the item is sold, $y_{it} = 0$ otherwise. Then, $y_{it} = 1$ *when* $ps_{it} > \ln \theta_{it}$, where θ_{it} is the reserve factor of the seller of item *it*. We model the reserve factors for individual sellers as:

$$\ln \theta_{it} = \ln \bar{\theta} + u_{jt} + \omega_{it}$$

where $\bar{\theta}$ an "average" reserve factor is for all sellers, $u_{jt} \sim IN(0, \sigma_u^2)$ is a cluster effect. We allow paintings to be clustered by auction date *(t)*, artist *(j)*, and jointly by artist and auction date. $\omega_{it} \sim IN(0, \sigma_\omega^2)$ is an individual seller effect. Therefore,

$$y_{it} = 1 \quad \Leftrightarrow \quad ps_{it} > \ln \bar{\theta} + u_{jt} + \omega_{it}$$

Thus, we have a random effects probit model (REPM) specification, which we can use to estimate the average reserve factor $\bar{\theta}$ and the standard deviation σ_ω across sellers. In the special case of no auction/artist-specific reserve factor effects (u_{jt}=0) we have the standard Probit model for which:

$$\Pr[y_{it} = 1] = \Phi\left(\frac{ps_{it} - \ln \bar{\theta}}{\sigma_\omega} \right)$$

where Φ is the standard normal distribution function.

III. Estimation

In column 1 of Table 2 we present the standard probit estimates, and in columns 2-4 we present the random effects probit model (REPM) estimates. The coefficients are highly significant in all models, and the results for both the standard probit and the random-effects

[6] Ashenfelter, Graddy, and Stevens (2004) show that under certain assumptions, the seller has an optimal reserve price which is a constant proportion of the expected price. This proportion depends upon a seller's discount factor, the expected price growth of art, and the variance of the unexpected price shock.

probit indicate that the reserve price is on average 71% of the low estimate.[7] The estimates of the standard deviation across sellers, σ_ω, are also similar in the four models, ranging from 0.259 to 0.290. The intra-auction correlation (rho in column 2) equals 0.060 with an estimated error of 0.020, the intra-artist correlation (rho in column 3) equals 0.037 with a standard error of 0.030, and the intra-auction/artist correlation (rho in column 4) equals 0.231 with an estimated error of 0.052. Thus, in column 4, approximately 23% of the variance is attributable to the same artist within an auction.

Table 2: Sale Rates and Unexpected Price Shocks for Contemporary Art

	Probit	REPM (Auction)	REPM (Artist)	REPM (Artist & Auction)
$\ln P_{it}/LE_{it}$	3.397 (0.107)	3.490 (0.112)	3.452 (0.117)	3.859 (0.172)
constant	1.145 (0.036)	1.183 (0.057)	1.172 (0.044)	1.312 (0.060)
RE: auction SD		0.253 (0.045)		
RE: artist SD			0.194 (0.082)	
RE: artist & auction SD				0.548 (0.081)
rho		0.060 (0.020)	0.037 (0.030)	0.231 (0.052)
Log Likelihood	-1315	-1296	-1314	-1304
reserve factor (θ)	0.714	0.713	0.712	0.712
reserve factor SD (σ_ω)	0.294	0.286	0.290	0.259

Note: Standard errors in parentheses. There are 4257 observations in each regression.

How reasonable are our estimates of average reserve factor, $\bar{\theta}$? In the contemporary art dataset, out of 3295 sold items, 1263 items (or 38%) sold at or below the low estimate. In

[7] The coefficient on the constant in the probit model is equal to $\frac{-1}{\sigma_w}(\ln \bar{\theta})$ and the coefficient on the price shock is equal to $\frac{1}{\sigma_w}$

this sample, the mean price was 87% of the low estimate. The high bid for unsold items was on average 72% of the low estimate. In impressionist and modern art, 37% sold at or below the low estimate, and the mean price was 90% of the low estimate. 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% of the low estimate of $40,000,000.[8]

IV. Conclusion

Unexpected price movements regularly occur in art auctions, and these price shocks are highly correlated with art auction sale rates. The probability an item is sold in an auction depends upon how low the reserve price is set. In data on contemporary art auctions, we estimate the confidential reserve price to be set at approximately 70% of the low estimate. Our results explain why sale rates in art auctions are considered so significant to market observers: they indicate how aggregate prices are evolving.

[8] Using a very different method, McAndrew et. al. (2010) estimate that the reserve price is set at 73% of the low estimate.

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