ARE ART AUCTION ESTIMATES BIASED?

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JEL Classification: Z11; Z10

ABSTRACT

This paper considers whether pre-sale auction estimates are unbiased predictors of price when "no-sales" are considered utilizing a newly constructed sample of over 500 works by eight early 20th century American artists. Unbiased pre-sale auction estimates in predicting price, while expected, are generally not supported in previous work, but these studies (excepting one) do not include no-sales in the calculations. In order to study the question we employ a standard approach that uses an inverse Mills ration arising from a sample selection probit, as suggested by Heckman (1979) to correct for selection bias. We find that controlling for selection bias, pre-sale auction estimates appear to be biased downward and we offer possible reasons for this result.

We are grateful to Dr. Marilyn Laufer and to Mr. Josh Griffen for their assistance with this paper.

1. Introduction

An interesting and growing area of economics relates to the many aspects of the art market. Most formal studies of these markets have been principally limited to use of auction data, supplemented of course by anecdotal materials, since data on gallery or other sales are not generally available.[1] Work related to rates of return and investment (Mei and Moses 2002), to supply side effects including "death effects" on art prices (Ekelund, Ressler and Watson 2000; Itaya and Ursprung 2007; Ursprung and Wiermann 2008), to auction estimates and realized prices (Ekelund, Ressler and Watson 1998; Ashenfelter and Graddy 2003; McAndrew, Smith and Thompson 2012) to values related to "types" of artists (Galenson and Weinberg 2000, 2001; Ginsburgh and Weyers 2006) have all served to answer questions or pose new problems and questions in this interesting area applying economics to culture.

The purpose of this paper is to use a newly constructed sample of over 500 works by eight early 20th century American artists to consider whether pre-sale auction estimates are unbiased predictors of price. Ashenfelter (1989) and Milgrom and Weber (1982), for example, argue that pre-sale auction estimates are unbiased in predicting price in art and other markets. In efficient and competitive auction markets we would expect these results.[2] Few empirical studies, however, support this theoretical result. These empirical studies find consistent biases in pre-sale auction house estimates as predictors of art prices. But they, too, are subject to criticism since they generally have not considered the potential impact of "no sales" on their empirical findings.

An important step (and the only exception to the best of our knowledge) in estimating bias by inclusion of "no-sales" has been made by McAndrew, Smith and

Thompson (2012). They use a procedure that imputes prices of paintings that did not sell and then analyze the full (that is, imputed and market) price distribution. They conclude that previous findings of bias may have been a statistical artifact, that is, previous evidence of bias may be the result of eliminating "no sales" from the sample. The present paper employs a more standard approach by using an inverse Mills ratio arising from a sample selection probit estimate, as suggested by Heckman (1979), to correct for sample selection bias.[3] We find that even after controlling for selection bias, pre-sale auction estimates appear to be biased downward.

In addition, we address this question with a unique sample of data. While the literature has seen some focus on American Art, all of it has been either related to a massive coterie of international artists that includes American artists assigned to particular genres (Renneboog and Spaenjers 2012) or to paired sets of observations in order to determine art investment outcomes (Agnello and Pierce 1996; Mei and Moses 2002; 2005). No study has segmented a defined group of representative American artists for study. We focus in the present paper on a particular set of American artists called "the Eight" who, at the beginning of the last century banned together in reaction to the conservative attitudes of the art establishment personified by the National Academy of Design in New York City.

In an initial section we describe our data set, its relevance, and the methodology used in the calculation of bias in art auction estimates. Next we discuss bias correction for no sales as well as why the potential discovery of bias is important and why it might exist. Our statistical study of bias in auctions using our sample follows as does the conclusion of our analysis.

2. Data and Methodology

The eight artists collected in our data set are Robert Henri, the leader and teacher, (1865-1929), Arthur B. Davies (1862-1928), William Glackens (1870-1938), Ernest Lawson (1873-1939), George Luks (1867-1933), Maurice Prendergast (1858-1924), Everett Shinn (1876-1953) and John Sloan (1871-1951). They banned together in 1908 to create their own exhibition (under the direction of Henri) at the MacBeth Gallery in New York. They were "the embodiment of artistic individuality" (Kennedy 2009: 13) – one which included singularly different styles and approaches – and showed their work together for only 5 years.[4] Despite these artists' diversity, they are sometimes identified with the "Ashcan school" since some of them at times were attracted to scenes of social realism.[5]

This sample of 20th century American artists provides an interesting subject for study and we have constructed a data set of more than 2500 observations of these artists' work.[6] A data set was assembled of auction observations between 1987 and 2008 from Askart.com in order to study economic aspects of the artists – aspects that have concerned researchers in the economics of the arts -- comprising the Eight.[7] We began by examining a sample of 2568 paintings offered at auction during that period [Henri (395); Davies (358); Shinn (438); Glackens (313); Lawson (317); Luks (265); Sloan (212) and Prendergast (262)]. Data on the title of the piece, date of auction, low and high auction house estimates on the piece, height and width of the piece, media (for example, oil, watercolor, and so on), on whether the piece was signed by the artist, and the "price" of the piece at auction were recorded as available. Not all of these data were available for all paintings. After deleting all paintings having incomplete data from the sample, a "complete data sample" of 557 paintings remained. Of these, 422 were actually sold at auction [Henri (83); Davies (22); Shinn (217); Glackens (28); Lawson (28); Luks (44); Sloan (87) and Prendergast (49)] and 135 were "no sales," or "bought in". We employ the 557 and 422 samples in the statistical analyses to follow.

One important issue must be addressed before turning to our statistical analysis, and that is how we measure the "price" of the painting. Each painting sold at auction actually has three prices: The price received by the seller, the price at which the auctioneer "hammers down" the sale (hammer price), and the price paid by the buyer (premium price). While there is typically a commission paid by the seller to the auction house, its magnitude is usually subject to bargaining between the participants so that it is not public information. Thus, we have no information on the price received by the seller. Regarding the other two prices, it is important to distinguish hammer price from what we term "premium price." The premium price is the hammer price plus a percentage of the hammer price paid by the buyer. When our data source (Askart.com) reports "price" it is most often reported as "premium price." Thus there is a need to adjust our data for the buyer's premium in order to obtain the hammer price. While there are several hundred auction houses in the United States, the two largest are Christie's and Sotheby's. At these houses premiums are virtually identical (see Table 1). Other auction houses have followed these premiums over time, but, in general, charge somewhat lower premiums for art sales. Sotheby's and Christie's, sell in national and international markets while these other houses typically sell in regional markets.[8] Since paintings of The Eight would generally be expected to appeal to a national market, we feel comfortable in using the auction house commission schedule shown in Table I to reconcile hammer prices and premium prices for our data set.

[Table 1 here]

We reconcile these two prices as follows: As noted above, Askart.com typically provides premium prices. However, for 28 of the 422 paintings in our sample that sold, Askart.com provided hammer prices. For these 28 paintings we “grossed up” the hammer to the premium price using the fee schedule in Table 1. When we obtained a price variable, all of whose observations were premium prices, we creates a second price variable, hammer price, by discounting the premium prices according the fee schedule in Table 1.[9] It is of more than passing interest that the buyer’s premiums at the two auction houses closely follow one another. Such behavior was, in fact, the subject of antitrust action in the United States (Ashenfelter and Graddy 2005), but that is not at issue here. At issue is that the data has been adjusted so as to represent two prices – the hammer price and the premium price by the means described above. Again our primary focus addresses the popular question of whether there is systematic bias in auction house estimates of hammer prices for art -- tests that account for "no-sales" where artworks do not meet the sellers reserve and are "bought in." While others (for example, Angelo and Pierce (1996), Beggs and Graddy (1997), Ekelund, Ressler, and Watson (1998), and Ashenfelter and Graddy (2002)), have addressed this question with alternative data sets, the impact of "no sales," where art works are "bought in" because they do not meet the seller's reserve, have not been taken into account.

3. Are Auction Estimates Biased?

Important pieces of information available to potential buyers prior to a typical art auction are the low and high price estimates that the auction house places on the value of each painting. The low estimate (L) is related to – and some say, is determined by – the seller's reservation price; certainly, the seller's reservation price cannot exceed the auction house's low estimate. (It is commonly believed that the typical reservation price is set at 70-75 percent of the low estimate). The upper estimate (U) can be viewed as the price that the painting could reasonably be expected to fetch in a lively auction. Note that L is not a floor price (a seller may set her reservation price on a particular painting at zero), nor is U a ceiling price (a vigorous, highly contested auction of a popular piece would be expected to fetch prices in excess of U); they simply establish the bounds of an expected price as determined by an art expert at the auction house, in consultation with the seller. Thus if one wants a single measure of the auction house's assessment (AV) of the price at which a painting will sell, the natural measure is the arithmetic mean of L and U, that is,

$$AV = \frac{L+U}{2} \tag{1}$$

It follows that the requirement for auction house's assessment to be an unbiased estimate of the hammer price (P) of a painting is that the expected value of the hammer price equal the value assessed by the auction house

$$E[P] = AV = \frac{L+U}{2} \tag{2}$$

A number of investigators have addressed the question of whether the auction house's assessment is an unbiased estimator of hammer price from both theoretical and empirical perspectives. As noted in our introductory remarks, in theory, based on the structure of the typical art auction and the incentives of the participants, the unbiasedness property should hold [see Milgrom and Weber (1982) or Ashenfelter (1989)]. Unfortunately, the empirical analysis of the question produces mixed results. Agnello and Pierce (1996), Beggs and Graddy (1997), Ekelund, Ressler, and Watson (1998), and Ashenfelter and Graddy (2002) find that auction house estimates systematically understate hammer prices, while Mei and Moses (2005) find the opposite (at least for masterpiece-type paintings).[10] These papers are quite diverse: The paintings analyzed range from French impressionists to Mexican artists, and the empirical techniques employed range from simple analysis of descriptive statistics, to correlation analysis, to regression and probit analysis. But these empirical studies have a common statistical flaw; they ignore no-sales.

No-sales typically make up 25%-33% of the samples employed in many of the above studies.[11] The problem with excluding these paintings from the sample and dealing only with ones that were actually purchased is that the excluded works may not be a random draw from the population of paintings; hence the remaining paintings cannot be viewed as arising from a random sample and therefore can lead to misleading inferences.

A recent study by McAndrew, Smith and Thompson (2012) provide some evidence that the bias findings of the above studies could well be attributable to sample selection bias. These authors analyze a sample of 4174 French impressionist paintings offered at auction between 1985 and 2001. They address the left censoring problem implied by no-sales using an ingenious four step statistical procedure which allows them to impute prices that the no-sale paintings would have received had they been sold based on the distribution of the (hammer) prices of the paintings that were sold. Using this complete distribution of prices, they test for the presence of bias and find none. In addition, they replicated the procedure employed in prior studies using a censored version of their sample (that is, using only sold paintings' hammer prices) and found "convincing" evidence of bias. Thus it is entirely possible that prior findings of bias were statistical artifacts attributable to the failure to take no-sales into account.

Clearly, the problem of left censoring of a sample of art auction prices due to no-sales must be addressed for any statistical analysis of such prices to be believable. McAndrew, Smith, and Thompson have developed a novel approach for dealing with the problem of "no sales." Our approach differs in that it does not statistically analyze a price vector in the manner of McAndrew, Smith and Thompson where some of the elements are market determined prices while others are estimates (whose stochastic properties are not obvious) arising from some multi-stage statistical process.

We utilize an alternative, well-known and well-accepted procedure available for dealing with this type of sample selection problem in regression analysis. Heckman (1979) showed that bias in least squares estimates due to sample selection could be eliminated by adding an inverse Mills ratio (based on the probability of each respective observation being included in the sample) to the model as an additional explanatory variable. This procedure is the one which we will use to analyze the question of whether auction house estimates are unbiased predictors of actual hammer prices of paintings of The Eight sold between 1987 and 2008.

The model we employ to empirically investigate the possibility of this type of assessment bias is in sympathy with but a bit more general than those employed in prior studies. We begin by assuming that we can summarize the relationship between the hammer prices of, say n, paintings sold at auction (P_i, i=1,…,n) and the auction house's estimate of the sales price (AV_i, i=1,…,n) of those paintings by the following general relationship

$$P_i = \theta(AV_i)^{\lambda} \bullet \exp(\varepsilon_i) \quad i = 1, \ldots, n \qquad (3)$$

where θ and λ are unknown parameters and ε is a stochastic disturbance term. This formulation allows us to test for two types of potential bias: what we call multiplicative bias, measured by θ, and what we call proportional bias, measured by λ. These interpretations require some explanation.

First note that if θ = λ = 1 and E[ε] = 0, then AV would be an unbiased estimator for P, that is,

$$E[P_i] = AV_i \quad i = 1, \ldots, n \qquad (4)$$

as noted above. Thus a test of the joint null hypothesis θ = λ = 1 is a test of whether AV is an unbiased estimate of P. Now assume for a moment that λ=1 but $\theta \neq 1$, so that

$$E[P_i] = \theta AV_i \qquad (5)$$

Thus if θ>1 (θ<1), AV understates (overstates) P on average by a factor of |θ-1|%. Note that this percentage does not change with the level of AV.[12] Since θ is a multiplicative factor in our model, we call this type of over or understatement "multiplicative bias". This type of bias (or an additive bias which can always be transformed to an "on average" multiplicative bias) is the one typically considered in prior studies.

Alternatively, assume θ = 1 and $\lambda \neq 1$, so that

$$E[P_i] = (AV_i)^{\lambda} \qquad (6)$$

In this case P will increase more than proportionately, proportionately, or less than proportionately to AV as $\lambda \overset{>}{\underset{<}{=}} 1$. Unlike multiplicative bias, this type of bias changes as a percentage of the auction house estimates. In particular if λ>1 auction houses then to understate the value of "better" (that is, higher value) paintings by more in percentage terms than they do "lesser"(that is, lower value) paintings.[13] Since λ measures the percentage change in P attributable to a given percentage change in AV, we call this type of bias "proportional bias". Note the substantial and increasing bias when the traditional view would have concluded no bias since θ = 1. Finally note that if θ >1 and $\lambda > 1$, there is a consistent understatement of hammer prices by the auction house, and that understatement increases more than proportionately to increases in the estimated values of the paintings.

We now turn to the estimation of the magnitude of any extant biases in the auction houses' assessments of paintings of The Eight sold at auction during the period 1987 – 2008. We begin with the complete data sample of 557 paintings discussed earlier, 135 of which were no-sales. Since our analysis of bias will employ only data on those paintings which sold (n=422), we employ Heckman's sample selection correction to avoid biases due to nonrandom exclusion to the 135 no-sales. We further note that all dollar denominated variables that we analyze below (prices, assessed values, limits, and so on) are expressed in real, that is, price deflated, terms.

Estimating a probit model predicts the probability of each of the 557 paintings being sold. The dependent variable in the model was SOLD, whether the painting sold at auction (SOLD=1) or was a no-sale (SOLD=0). The explanatory variables included a constant term, the size of the painting in square inches, a dummy for whether or not the painting was signed SIGNED=1, if signed), the age of the artist when he painted the picture, the real (price deflated) value of the auction houses' high and low estimates, a set of four multi-year time period dummies, seven artist dummies, eight medium dummies, and a dummy variable for whether the auction took place during a recessionary period (DREC=1, if bought in a recession).[14] The Chi-square statistic for the model (χ^{2*} = 36.97) was statistically significant at the $\alpha = 0.10$ level, and the equation predicted over 98% of the paintings that sold correctly. If the predicted value for the ith painting from the probit equation is z_i, then the inverse Mills ratio (IMR) corresponding to that painting is

$$IMR_i = \frac{f(z_i)}{1 - F(z_i)} \tag{7}$$

where f(.) is the density and F(.) is the distribution function if the standard normal distribution evaluated at (.). We create this measure for all 557 observations and employ it (for the 422 sold paintings) as an explanatory variable in the regression analysis to follow.

The model we posited earlier, rewritten to include the IMR is

$$P_i = \theta(AV_i)^{\lambda} \bullet \exp(\gamma IMR + \varepsilon_i) \tag{8}$$

Taking logarithms of both sides, we find

$$\ln(P) = \beta_1 + \beta_2 \ln(AV) + \beta_3 IMR + \varepsilon \tag{9}$$

Observe that $\beta_1 = \ln(\theta)$, $\beta_2 = \lambda$, and $\beta_3 = \gamma$, so that the joint test for unbiasedness

H_0: θ = λ = 1, translates to the joint test H_0: $\beta_1 = 0$ and H_0: $\beta_2 = 1$. We estimate equation (10) by ordinary least squares (OLS) to test for whether price estimate implied by the auction house bounds is an unbiased estimate of the actual price paid for the painting.

Now assume that the transaction price (P) is the hammer price (HP) and that the auction house estimate (AV) is given by the arithmetic mean of their upper and lower price estimates, as in equation (2) above. Using as a sample the 422 paintings of The Eight sold at auction in the 1987-2008 periods, we find

$$\begin{aligned} \ln(HP_i) &= 0.2287 + 1.0426\ln(AV_i) - 0.5774 IMR_i + e_i \\ &\quad (2.604) \quad (64.61) \qquad\quad (-3.219) \qquad\qquad (10) \\ R^2 &= 0.912 \qquad F^*(2,419) = 10.83 \end{aligned}$$

(The numbers in parenthesis are t statistics based on White's heteroscedasticity consistent standard errors.[15]) The results indicate that the individual null hypothesis $\beta_1 = 0$ can be rejected at the α=0.01 level and the individual null hypothesis $\beta_2 = 1$ can be rejected at the α=0.01 level [t=(1.0426-1)/.0155 = 2.75]. The F reported above refers to the joint test H_0: $\beta_1 = 0$ and H_0: $\beta_2 = 1$. The calculated F value is 10.83 indicating that unbiasedness in the auction house estimates can be rejected at the $\alpha = 0.01$ level [$F_c^{.01}(2,419)$=4.66]. Not only do we have strong evidence of bias, but our results allow us to dissect the bias into its various sources. Since the constant term is statistically greater than zero, θ must be greater than unity. Indeed, $\hat{\theta} = ati\log(b_1) = \exp(0.1824) = 1.200$, so that we estimate a significant multiplicative bias in the amount of 20% (i.e., $\hat{\theta}$ -1). Thus the auction house estimates tend to understate the hammer price of paintings sold at auction by 20% of their respective assessed values and that and that magnitude is consistent throughout the range of assessed values.

Similarly, since $\hat{\lambda}$ (= b_2) is statistically greater than unity, there is also a proportional understatement in the auction house estimates. Specifically, our results indicate that a 10% increase in the auction house's estimate will result in a 10.4% increase in hammer price. This magnitude at first seems quite small, but its effect can accumulate rather quickly, especially for expensive paintings. For example, a picture that the auction house assesses at $10,000 should have a hammer price of about $14,454, *ceteris paribus*, roughly a 45% understatement by the auction house. But a painting assessed at $100,000 should have a hammer price of about $158,489, *ceteris paribus*, roughly a 58% understatement. Taken together, these results suggest that auction houses consistently underestimate hammer prices and that understatement increases with their assessed value of the painting.[16]

The role played by the auction house commissions in determining the extent of the assessment bias must be evaluated. Since the buyer pays a commission to the auction house when she purchases a painting, she pays the premium price (PP). Thus, at least from the demand side, there is some reason to suspect that the extent of understatement may be affected by commissions. *A priori*, the direction of the effect is unclear: Since auction houses are in business to maximize profits (to the extent that increased understatement leads to higher prices and hence higher commissions) we might expect to find a greater degree of understatement associated with the relationship between premium price and assessed value than between hammer price and assessed value. Alternatively, since commissions (at least in blocks) tend to fall as a percentage of hammer price as hammer price increases, the extent of understatement (particularly proportional bias) may be less when considering full prices than when considering hammer prices. Thus the bias question with respect to premium price is an empirical one. To address this question, we repeat the prior analysis using premium price in lieu of hammer price. We find the following results:

$$\begin{aligned} &\ln(PP_i) = 0.2286 + 1.0271\ln(AV_i) - 0.3385IMR_i + e_i \\ &\qquad\quad (2.925) \quad (66.38) \qquad\quad (-2.039) \\ &R^2 = 0.922 \qquad F^*(2,419) = 8.79 \end{aligned} \tag{11}$$

(The numbers in parenthesis are t statistics based on White's heteroscedasticity consistent standard errors.)[17] Similar to the previous results, the constant term is statistically different from zero at the 1% level and the estimate of λ (that is, b_2) is statistically greater that unity at the 0.10 level [t=(1.027-1)/.0155 = 1.74]. The F statistic for the joint test is 8.79, so the null of unbiasedness can be rejected at α = 0.01 level [$F_c^{.01}(2,419)$=4.66]. These results imply $\hat{\theta} = ati\log(b_1) = \exp(0.2286) = 1.2568$ or about a 26% multiplicative bias, slightly higher than the 20% we arrived at using the hammer price, and $\hat{\lambda}$=1.027, about .0155 smaller than the estimate we obtained using the hammer price. It seems that the multiplicative bias is slightly larger and the proportional bias is slightly smaller than we found using the hammer price. All together however, these estimates are quire similar in magnitude and significance to their counterparts in the hammer price model. We conclude that including commissions in the painting's price amounts to incorporating several potentially offsetting effects on bias, and hence does not contribute much to our understanding of the extent of bias in auction house assessments.

As a final consideration, we turn to the stochastic properties of our model. While we have assumed that the disturbance term of our model is normally distributed, equations (4) and (9) make it clear that it is in fact log-normally distributed (that is, normally distributed in its logarithms). It follows that price and AV should also be considered to be log-normally distributed. McAndrew, Smith, and Thompson argue that in this case, the appropriate estimator for the auction house's assessed value is the geometric mean of assessed value limits, not the arithmetic mean; that is

$$\ln(AV1) = \frac{\ln U + \ln L}{2} \neq \ln\left[\frac{U+L}{2}\right] \tag{12}$$

We used the arithmetic mean for AV in the prior analysis; if we substitute the geometric mean of the limit values for AV) into the model explaining hammer prices, we find

$$\begin{aligned} \ln(HP_i) &= \underset{(2.880)}{0.2528} + \underset{(64.53)}{1.041}\ln(AV1_i) - \underset{(-3.189)}{0.5774}IMR_i + e_i \\ R^2 &= 0.912 \qquad F^*(2,419) = 11.70 \end{aligned} \tag{13}$$

(The numbers in parenthesis are t statistics based on White's heteroscedasticity consistent standard errors.)[18] These results are almost exactly those found for hammer prices when we proxied AV with the arithmetic mean of the limits. The constant term is statistically significant at the .01 level and implies a $\hat{\theta}$ value of 1.288, so that there is a 29% multiplicative understatement of hammer price by the auction houses' value estimates. $\hat{\lambda}$ is also statistically greater than unity (t = 2.565) implying a 3.9% proportional bias downward. The joint test also rejects the null of unbiasedness at the α=0.01 level. It appears that the only gain to employing the geometric mean of the limits in lieu of the (log of the) arithmetic mean is that the statistical results are somewhat stronger.

These results taken together clearly indicate that auction houses assessed value of paintings systematically understate the prices of paintings sold at auction, from both a multiplicative and proportional perspective. What incentive do auction houses have to follow this policy of consistent understatement when economic theory suggests that, in general, they have no incentive to do so? One explanation might lie in conservative forecasting. All economists are aware of the advantages of conservative forecasting: If a "low" forecast proves accurate, the obvious response is, "I told you things would not go well." But if things turn out better than forecast, all are pleased. This is the rationale proposed in a number of prior studies [see, for example, Ekelund, Ressler, and Watson (1998), or Angelo and Pierce (1996)]: if an owner receives a price for his work in excess of the amount he expected based on the auction house's estimate, he will be pleased and perhaps offer future paintings to the house for auction. Moreover, if prices are underestimated then reserve price, usually a percentage of the low estimate, will be lowered thus increasing the likelihood of a sale. There is, however, a demand side explanation as well. Auction houses are in business to sell paintings in order to collect both seller's and buyer's premiums. *Ceteris paribus*, the probability of selling any given painting increases with the number of bidders. *Ceteris paribus,* more buyers will bid on lower priced paintings than higher priced ones. Thus, by understating the value of the painting, the auction houses draw more bidders into the auction. From then on, auction dynamics may yield a higher selling price than would have resulted from fewer bidders. These two conjectures may help explain the theoretical anomaly that we observe in terms of auction house estimates (see additional discussion on this point in the concluding section).

4. Conclusions

Naturally, The Eight artists are simply a subset, but a distinct and representative subset, of early 20th century American artists. Their time was one of artistic turmoil and they were not the only group to reject traditionalism and, building on European forebears, attempting to construct an "American art." Using auction records for these artists, we investigated one central issue. Our study of auction house estimates reveals that, at least for the period under study, they consistently underestimate hammer prices for the works of The Eight and that the underestimate becomes greater with the value of the piece. This means that the actual hammer prices are consistently above the mean value of the estimates published in the auction catalogs. We have suggested that such a policy would appeal to buyers and also stimulate demanders to bid, but this policy may also be part of the overall policy of profit maximization.

Markets, given sufficient information, will tend to be efficient and we could assume that to be true of art markets. Buyer’s premiums would tend to fall to competitive levels, but such is not the case, suggesting some form of noncompetitive market. It is well known that Sotheby's and Christie’s auction houses do not compete on buyer's premia, a problem that involved the two houses in legal difficulties (Ashenfelter and Graddy 2005) in the past. It would appear from Table 1, such competition still does not exist, indicating a form of noncompetitive behavior. However, there *are* competitive margins on which these auction houses do compete. A standard seller's premium on art is 10 percent (in 2012), an amount that has fallen over time. Revenue enhancement has shifted through time from sellers to buyers in many auction houses, including the two major ones. This means that there is competition among auction houses on the sellers’ side of the market. Since it is in the interest of auction houses to obtain the best material for sale, the basis for revenues from sellers and buyers, negotiations on seller's commissions (and on "reserves") are made routinely. But a 10 percent seller's premium is only the published rate. Auction houses are willing to bargain with sellers of first-rate art and especially for collections of first-rate art in order to obtain quality pieces to auction. Some houses are even willing to guarantee a minimum return to a seller of the highest quality art, thereby sharing risk. (Outright purchase of prime pieces for later sale has also become a practice of the major houses). It may be that systematic under valuations gain added impetus from these considerations.

Thus, the general underestimate of mean hammer price found in auctions for The Eight artists may be viewed as and is consistent with an attempt to increase overall revenues. Sellers become more ready to sell when "surprised" by higher prices. Buyers are most "activated" to bid when they think a "bargain" will be arriving at auction. Given the level of any negotiated seller's premium, it is in the interest to sell as many works as possible (and to minimize seller's reserves) so as to maximize revenue.

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Endnotes

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[1]The inability to utilize gallery price data is not the only problem in the empirical study of art markets. Auction data naturally only records pieces of art that are in private hands or are being "deaccessioned" by museums. In the case of American art, many (most) of the highest quality pieces are and have been in museum collections for the past 100 years. Correlations between price and suggestions of quality of art at auction must take this fact into account.

[2] These results appear to be based upon the assumptions of a competitive market in auctions and on the fact that both buyers and sellers actually want unbiased pre-sale estimated prices. Either or both of these assumptions could be disproved in our test. The auction market may not be competitive and market participants, particularly sellers, may prefer downward bias in pre-sale estimates.

[3] The Heckman procedure has been used in a number of studies although not in connection with "no sales." Interesting investigations have been conducted, for example, on particular genres of paintings (symbolists in Collins, Scorcu and Zanola 2009) or on the impact of "fakes" (Bocart and Oosterlinck 2011).

[4]The Eight – by no means *all* of the *avant garde* were dissenters from the academic and received style of painting extolled by the National Academy's processes. The famous Armory Show in New York in 1913 combined an exhibition of American and European modernists (largely derived from European modernism. But despite their relatively short appearance as a defined group, collections of these particular eight artists are assembled a century later by collectors and museum curators (Kennedy 2009), making them a distinct but diverse subset of early 20th century American artists.

[5] And the subject matter of the eight painters could hardly be more diverse as aptly described by Milroy (1991:16): "Certainly George Luks, John Sloan, and Evertt Shinn made pictures of New York slums and trash-filled alleys. But William Glackens, Robert Henri, and Maurice

Prendergast preferred parks and avenues. Ernest Lawson found pure landscape, not social commentary, in Manhattan and the Bronx. Arthur Davies found dreams. Nor were Prendergast, Lawson, and Davies eccentric adjuncts to an "urban" core headed by Henri and Sloan, but rather equal members of a carefully assembled coalition." Each of these artists, within their own styles and approaches to art, embodied a uniquely "American" perspective (Glackens 1957; Perlman 1979; Homer 1988).

[6] The story of the birth of a uniquely American art in the first two decades of the 20th century is a long, complex and interesting tale, reported and analyzed in numerous sources. Our focus these artists should not obscure the rush of other currents of the time, including the aforementioned Armory Show exhibit of 1913, the promotions of modernist art (of individuals such as Arthur Dove, John Marin, Marsden Hartley and Georgia O'Keefe) by Joseph Stiglitz in his famous New York galleries and the Exhibition of Independent Artists in 1910. Modernism – broadly conceived as a rejection of traditionalist-academic art of the 19th century – was in the air. But we single out the Eight because their drive for a uniquely American art was perhaps the earliest, best organized and most "representative" of the new drive for independence from tradition and Euro-centric culture in the United States. See for example Wilmerding 1973; Goddard 1990 and Hughes 1997. One of the most useful surveys of early 20th century modernism in the U. S. is Baigell (1996: 192-241)

[7] Askart.com is an online art resource that specializes in American (and lately, other) art and artists.

[8] If, as seems likely, Sotheby's and Christie's are price leaders among US auction houses, one would expect the competitive fringe to price their services according to the fee schedule Sotheby's and Christie's set. One explanation as to why the other auction houses appear to set their fees a bit lower is that they draw on a smaller market than Sotheby's and Christie's (i.e., a regional or even local, as opposed to a national market.).

[9] For example, if the sale took place in 2004 and we know the hammer price was $10000, then the premium price is $12000 (= $10000*1.20). If instead, we know the premium price is $12,000, the hammer price would be $10,000 (= $12,000/1.20).

[10] While Mei and Moses (2002) do not consider "no sales", they also confine their attention to only high-end masterpiece auctions. If auction houses have an incentive to overestimate these paintings values in order to persuade potential buyers that they will indeed be bidding on masterpieces, then this alternative sample selection issue could account for Mei and Moses results.

[11]The eight artists we consider are representative of American artists of the period in terms of no sales. Twenty-four percent of The Eight auction pieces are no sales and we have calculated twenty-three percent no sales using another complete data set of five different American artists from approximately the same period. All data are available upon request from the authors.

[12] Thus if $\theta=1.2$ and the auction house estimates a painting's value at $1000, the hammer price would be expected to be $1200; but if the auction house estimates a painting's value at $10000, the hammer price would be expected to be $12000 – the percentage understatement is the same on both cases, 20%.

[13] For example, suppose $\lambda=1.035$, then an estimated $1000 painting would be expected to sell for $1273.50 [= $(1000)^{1.035}$], or a 27% understatement by the auction house; while one estimated at $10000 would be expected to sell for $13,804.00 [= $(10000)^{1.035}$], a 38% understatement.

[14] For the various sets of dummies: (a) Sloan was the omitted artist, (b) chalk was the omitted medium, and (c) the time dummies were grouped into two 5-year (1987-1991 and 1992-1996) and three 4-year periods (1997 – 2000, 2001-2004, and 2005-2008), constituting the five dummies in the set; the omitted period was 1987-1991. The NBER defines the recessions that took place during this period: June 1990 – March 1991, March 2001 – November 2001, and

December 2007 – December 2008. If the auction took place in any of these periods, DREC was defined to be unity; otherwise, zero.

[15] The Breusch-Pagan test for heteroscedasticity produces a $\chi^2(2)$ test statistic of 29.52, which is statistically significant at the .01 level. Heteroscedasticity is a problem; OLS coefficient estimates are unbiased and consistent, but their standard errors are inconsistently estimated by traditional OLS formulas. We solve this problem by employing White's recommended approach to compute heteroscedasticity consistent standard errors. The t ratios reported above are these standard errors divided into their corresponding coefficient estimates.

[16] It is worth noting that we also estimated the above model and the ones we subsequently consider by including artist and media dummies. This resulted in no marked change in the magnitude of crucial parameters or in their statistical significance. Furthermore all of the dummies were statistically insignificant at traditional levels in any of the models. We take this to mean that the auction houses' art experts take artist and media, as well as characteristics of the picture into account when formulating their assessments. In any event, these types of variables have no role in our bias analysis.

[17] The Breusch-Pagan test for heteroscedasticity produces a $\chi^2(2)$ test statistic of 28.12, which is statistically significant at the .01 level. Heteroscedasticity is a problem; OLS coefficient estimates are unbiased and consistent, but their standard errors are inconsistently estimated by traditional OLS formulas. We solve this problem by employing White's recommended approach to compute heteroscedasticity consistent standard errors. The t ratios reported above are these standard errors divided into their corresponding coefficient estimates.

[18] The Breusch-Pagan test for heteroscedasticity produces a $\chi^2(2)$ test statistic of 29.63, which is statistically significant at the .01 level. Heteroscedasticity is a problem; OLS estimates coefficient are unbiased and consistent, but their standard errors are inconsistently estimated by traditional OLS formulas. We solve this problem by employing White's recommended approach

to compute heteroscedasticity consistent standard errors. The t ratios reported above are these standard errors divided into their corresponding coefficient estimates.

TABLE 1: BUYER'S PREMIA AT SOTHEBY'S AND CHRISTIE'S, 1975-2011

1975-1992	1993 - 1999	2000 - 2003	2004	January 2005-September 2007	September 2007 - June 1, 2008	June 1, 2008 - 2011
10% all lots	15% up to $50,000 10% above $50,000	20% up to $10,000 15% between $15,000 And $100,000 10% above $100,000	20% up to $20,000 15% over $20,000	20% up to $200,000 12% above $200,000	25% up to $20,000 20% between $20,000 and $500,000 12% over $500,000	25% up to $50,000 20% between $50,000 and $1,000,000 12% over $1,000,000