Art as an Investment: A New Perspective

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Abstract

In the last few decades, numerous articles have been written on the topic of art as an alternative investment. This paper adds to the literature by investigating the real returns on art. We show that the mostly used methodologies are inapplicable when accounting for transaction costs that can sum up to 40% of transactions' value. Based on the largest up-to-date database of repeat sales of fine art, we find that even after accounting for transaction costs, art seems to be a viable investment given its high Sharpe ratio, and low to negative correlation with other standard asset classes. However, we note that the returns on art have declined since the global financial crisis. We conclude that most of the attractiveness of art as an investment is highly driven by abnormal returns during earlier years.

Keywords: Art market; Alternative investments; Art Index; Transaction costs; Optimal Portfolio Allocation, Sample Selection

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1. Introduction

The potential of a value increase has become an important driving motive for collecting art. According to a recent report on art and finance, wealth managers indicate that 6% of their clients acquiring art do so for purely investment purpose. 72% of the remaining buy art for collecting purpose but with an investment view (Deloitte Luxembourg & ArtTactic, 2016).

Fine art has emerged as an alternative investment due to the high observed returns on some art segments, and the ability to use it as a hedge in portfolios as proposed by economic research (for example, see Pesando & Shum, 2008; Mei & Moses, 2002). Individuals as well as institutional investors are getting further engaged in the scene. The art market has been expanding considerably over years. Despite a yearly decline of 11% in total sales volume in 2016, the art market has seen a significant growth of 169% between 2002 and 2016, from USD 21.06 to 56.6 billion (Kinsella, 2017; Mc Andrew, 2012).

Given its market growth and usability as a financial asset, art has attracted academics to study its investment characteristics. Their main contributions have been devoted to analyzing the risk and return perspectives of art investments. Different studies arrived at diverse results ranging from suggesting art as a viable investment outperforming fixed income securities and as a valid mean of diversification to noting it as unfeasible investment even before accounting for additional costs and risk factors.

Korteweg et al. (2016) find that investing in a comprehensive portfolio of art is unappealing, but targeting a specific category may add value. Reeneboog & Spaenjers (2013) conclude that even without accounting for transaction costs, art is much less attractive than other financial assets. Mei & Moses (2002) find art to outperform fixed income securities. Buelens & Ginsburgh (1993) note that the returns for some art segments are significantly higher than the returns on bonds and stocks.

Similar to standard financial markets, participants in the public art market have to pay additional costs on their transactions. When comparing the returns of art as an alternative investment with those of another asset class, the exclusion of standard transaction costs, such as sales taxes, for each, can lead to comparable measures and reasonable conclusions. However, there are two distinctive additional transaction costs in public art markets that need to be treated differently: the buyer’s premium and seller’s commission.

Art auction firms use the English ascending auction format. When the highest bid is reached, and in case there is no preset price reserve, the lot is sold. The highest bid is known as the hammer price. In the past, buyers were required to pay this price plus any taxes and other service charges but with no commission directly linked to the purchase hammer price. The seller, on the other hand, had to pay the auction house, in addition to other related charges, a direct sale's commission unless there was a pre-arrangement. The typical rate was 10% (Ashenfelter & Graddy, 2003).

During the mid-1970s, auction firms introduced a direct commission on buying art. They referred to it as the "buyer's premium", which is a percentage of the hammer price. Following this introduction, successful bidders had to pay the premium price, which is the hammer price plus the newly introduced buyer's commission. The buyer's premium rate was initially flat and set at 10%. Since 1993, it has become structural in the major art auction companies, and is currently as high as 25% on relatively low priced fine art objects.

Given the significance of these special transaction costs, and without accounting for standard costs, the real return on art would be calculated as the difference between the price of the second sale minus the seller's commission (hammer price net of seller's fees), and price of the first sale plus the buyer's commission (premium price). In other words, an auction participant has to pay the final price plus the buyer's commission when she buys, while she receives the final price minus the seller commission when she sells. Using hammer prices for the two sales would inflate the perceived returns, and in similar manners, the same applies when using the premium prices.

Until now, however, there have been no studies that particularly examined the effect of including the additional special art related transaction costs on an art index, and therefore on the real potential of art as an investment. Previous studies have either used the hammer prices for the two sales of a pair, or the premium. This practice leads to an overestimation in the reported return figures. Korteweg et al. (2016), Renneboog & Spaenjers (2013), and Taylor & Coleman (2011) use hammer prices. Pesando (1993), Pesando & Shum (2008) and Campos & Barbosa (2009), on the other hand, use premium prices. While Goetzmann (1993) and Mei and Moses (2002) don't specify the price type used in their research, it appears that Mei and Moses (2005) use hammer prices.

The main two methods that have been used for studying art investment are the hedonic and repeated-sale regression frameworks. Through the former, some characteristics of an artwork are decomposed and given separate values. Thus, it allows to compare heterogeneous assets of the same class. The key benefit of this approach is that it enables the inclusion of large datasets in the analysis, whereas the main disadvantage is its limitations to the model specifications.

The repeated-sales regression, on the other hand, is superior to the hedonic price models in that it controls for all characteristics of an artwork as the prices of the same assets are tracked overtime. Its main disadvantage is that the resulting figures are based on a subset of only those assets that were repeatedly sold. That is, it omits the larger proportion of available data. Throughout various research, academics have relied on the repeat sales regression framework, where an art index is constructed using art objects that were repeatedly sold at auction.

In light of the wider suitability of repeated-sale regression, and in pursuance of resolving the shortfall of a small dataset, we have developed a significantly large dataset of repeat sales of fine art.

We have examined the description of millions of public art sales from numerous sources. Whenever we observed an artwork that was previously sold, we retrieved information related to the previous sale. The buyer's premium was introduced in 1975; as our main goal is to study the returns on art after accounting for transaction costs, we limit the sample period to 1976-2015. Our final sample includes 54,364 repeat sale pairs. This number excludes any duplicates that might have been present in earlier studies, where an artwork that sells in two time periods is considered to be two separate entries. We further elaborate on this point in the next section.

With the availability of a large dataset of repeated-sales, it would be optimal to use the seminal repeat sales methodology. Nevertheless, with the inclusion of art transaction costs, being the buyer's premium in our case, this framework cannot be applied. Under the repeat sales approach, the returns on art after accounting for transaction costs don't vary from those before.

If the repeated-sale framework regards an average log price in a given period, the special case of art additional relevant costs incurs, except for the base period, two different levels of prices,

and therefore, the average price at each period would be only considered. Thus, the returns on the art index after accounting for transaction costs wouldn't reflect the real returns, as they would be merely different from the returns on the art index that doesn't consider these costs. The annual return drops by only 0.5%.

This requires returning to simpler approaches in calculating art returns. Such application is not novel in the field. For instance, in his seminal 1986's work, Baumol used standard continuous compounding for calculating art returns; Frey & Pommerehne (1989) followed the same principles. Moreover, the simple average return on all artworks in a given year can be regarded in fact as the expected return for an art investor with a well-diversified portfolio of art objects.

We look at the real returns on art and compare them with those of other assets. We note that art has low to negative correlations with different assets. This suggests that it can be used as a mean of diversification in an investment portfolio. Additionally, we find that art outperforms many asset classes inclusive of equities. Including art in an optimal portfolio significantly increases the Sharpe ratio from 0.41 to 0.51. However, the high returns on art are largely driven by returns on earlier years in the selected period. Additionally, the number of second sales in these years is considerably lower than those in the succeeding years. Omitting these years either for the high perceived returns, or low frequency of observations cause a drop in art returns, and therefore leads to different asset allocation.

By limiting the sample period to 1991-2015, art loses its potential as an alternative investment and is excluded from the optimal portfolio. These results are confirmed by analyzing the returns on artworks of the 30 artists who have the highest frequency of repeat sales pairs in our sample.

This paper is outlined as follows. Section 2 describes the data and illustrates further on the buyer's premium. In section 3, we discuss the repeat sales index, and provide comparative analysis of the returns on this index with the standard returns. In section 4, we look at the optimal asset allocation for a portfolio comprising art. Section 5 concludes.

2. Data and Transaction costs

2.1. Repeat Sales Database

Information on private art transactions is hard to obtain due to their reserved nature but public auction data, on the other hand, is available. A repeated-sale is identified as an asset that was sold at least twice in different time periods[1]. We recognize a repeated-sale by looking at the provenance of an art object. The provenance of an artwork tells the history of its ownership transfers and acquisitions.

That is, if a painting that is selling at an auction today was sold previously at auction, its provenance, if available, will state details about the previous sale. Particularly, we can observe the previous auction house, date, and lot number. In many cases, additional details such as the buyer's name and selling price or status may be also reported.

The Blouin Art Sales Index (BASI) is the most comprehensive online database on art sales. Since 2008, they have started adding the description which includes the provenance into their records. However, such information is fully unavailable for previous years. Given its size dominance, BASI includes the most extensive list of fine art auction houses. Based on this list, and as a first step, we collected online data from different auction houses. We chose those auctions that have at least one sale with a viable provenance[2] for our purpose, i.e., a provenance that indicates a previous public sale. We looked at almost every auction house that has an available online database. For each auction house, we manually checked hundreds of random records of fine art. If there was at least one artwork with provenance, we concluded that the particular auction house generally includes provenance data; and therefore, we downloaded all available records from the given auction house.

Following this method, we collected data from 60 different auction houses that are located all over the world. The availability of past data differs among auction houses. While some provide long range of data that goes back to 1990, others provide only one or few years of historical records. Table A1 in the appendix provides a full list of the auction houses along

[1]If an artwork was sold more than twice, thrice for example, we consider it as two repeated-sale pairs. Including multiple repeated sales is not an issue as long as there is no overlap between the holding periods (Shiller, 1991).
[2] The availability of a provenance doesn't necessarily implies that the artwork was previously traded. For example, it could transferred to different owners through gifting or donations. A viable provenance includes previous sale(s).

with their respective total number of sales, and the dates of the earliest and latest entries. For the remaining of 2014 and 2015, for which we didn't collect the data directly from auctions' websites, we relied on the online dataset of BASI which is a collection of all sales conducted at hundreds of auction firms.

Christie's and Sotheby's, both established in the mid-18th century, have been the leading auctioneers in the art market. They auction the largest number of high quality fine artworks as well as the most expensive ones. In order to construct the most extensive database of repeated sales, we had to look at as many of their past auctions as possible, but the online availability of such is limited.

Thus, as a second step, we looked at hard copies of their historical auction catalogues for their different locations. We thoroughly read years of auction catalogues that are found in the archives of the National Art Library, British Library and Paul Mellon Centre for British Art Studies in London, and Rijks Museum Library in Amsterdam. Whenever we arrived at an artwork that has a valid provenance, i.e. was previously traded, we copied information related to the (1) auction detail, (2) artwork description, (3) price list if available, and (4) list of artists. With this step, we have covered fine art sales of Christie's and Sotheby's New York and London that go back to the year 1980. Although our main goal was to cover auction catalogues of Christie's and Sotheby's at New York and London, we had also looked at available past catalogues for some other various locations as well as different auction houses such as Bonhams, Phillips and Lawrence.

We searched millions of fine art public sale records. Whenever we arrived at a sale with a provenance stating details about a previous sale, we went back to this auction and retrieved the pricing information. Our main sources were online databases such as those provided by auction houses, and physical auction catalogues found at the libraries specified above.

After controlling for duplicates[3], our final dataset consists of 73,176 pairs. Since we are interested in analyzing the effect of including transaction costs, we limit the period and choose

[3] A duplicate occurs when we locate a pair that was sold in *t* and *t-1*, and then locate a more recent sale of the same artwork at *t+1*. This can be problematic when there is a change in title or artist's attribution between *t* and *t+1*. Without controlling for this, there would be amplification in the total number of repeat sales pairs and errors in the reported figures. We also account for duplicates when the provenance doesn't include a recent previous sale.

only pairs that were sold between 1976 and 2015; that is, after the inception of buyer's premium. This leaves us with 54,364 sale pairs of 50,576 unique artworks out of which 47,087 were repeatedly sold twice during the sample period, 3,213 were sold thrice, 255 were sold four times, 19 were sold five times, and only 2 were sold 6 consecutive times[4].

Our sample includes repeated sales of artworks created by 12,538 different artists. Pablo Picasso has the highest number of 687 repeat sales' pairs, followed by Andy Warhol with 451, and Piere-Auguste Renoir with 384. Table A2 in the appendix provides a list of the top 30 artists with the maximum number of repeat sales in our sample. It also reports the respective number of unique artworks and average prices.

The artwork with the highest value in our sample is Picasso's painting "Les Femmes d'Alger (Version 'O')" that was publicly sold for the first time at Christie's New York on the 10th of November 1997 for a premium price of USD 31 million (USD 29 million hammer), before it was sold again at the same auction house on the 11th of May 2015 for a premium price of USD 179 million (USD 160 million hammer) generating a real annual logarithmic return of 9.21%[5]. Table A3 in the appendix shows the 10 most expensive artworks in our sample. All the 20 first and second sales were conducted at Christie's and Sotheby's mainly in their New York premises. This clearly indicates the dominance of these auctioneers in the ultra-high quality public fine art market. In nominal USD terms, the total paid value for these transactions sum up to 0.93 billion.

The average hammer price across all sales is USD 215,000, while the average premium price is USD 246,000[6]. Table A4 in the appendix provides a list of auction houses with the highest number of sales in our sample along with the average USD prices. The sales at Christie's and Sotheby's at their various locations comprise 80% of the total[7].

[4] An artwork might have more repeated sales' frequency, but the other non-considered sales don't fall in our sample period. We only consider public sales after 1975. For example, Henri Le Sidaner's "Le Café du port" was repeatedly sold 6 times at auction. Since the first sale occurred at Christie's London in 1973, we omit this entry from our sample.

[5] This painting still holds the record for the highest price ever paid at auction.

[6] These numbers stand for all unique first and second sales which count to 104,945.

[7] This is strictly due to the availability of repeated sales pairs. We have analyzed all sales of various auction houses in the last 10 years, and whenever we arrived at a transaction with previous public sale, we retrieved its information. The majority of repeated sales' transactions were at Christie's and Sotheby's. This is not surprising given their power in the public art market.

Figure 1 below shows the distribution of sales in each year of the defined period. The number of second sales increases in time because it is the base for looking up a pair, and information related to more recent transactions is readily accessible. Additionally, the art market has seen a considerable growth in the last years as noted earlier.

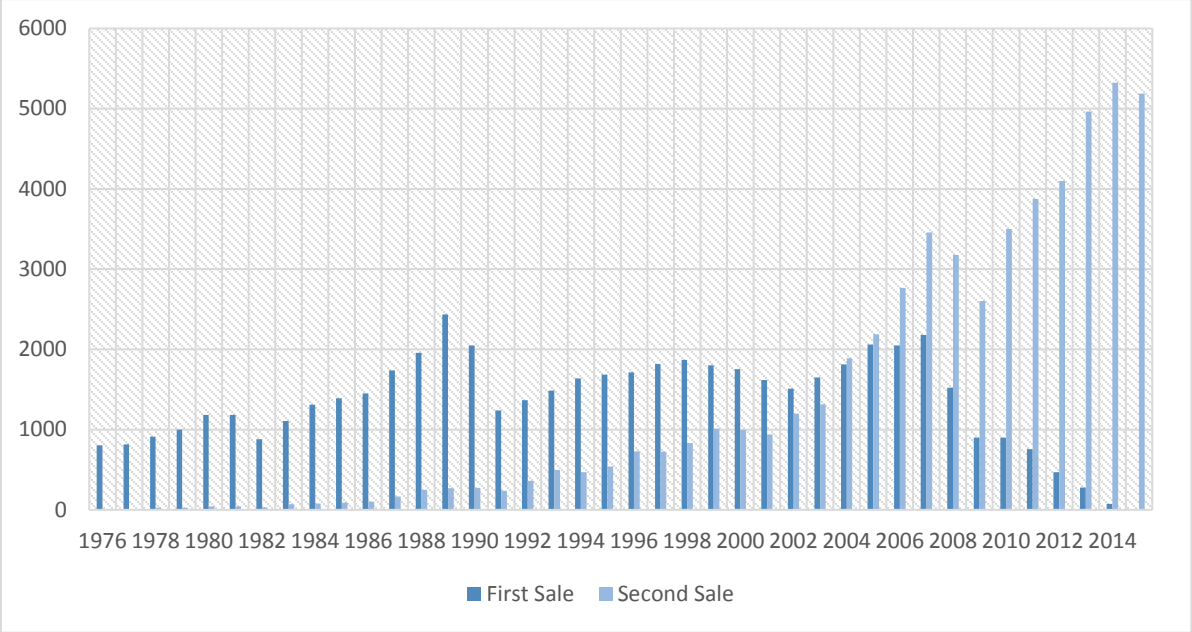

Figure 1. Distribution of first and second sales
This figure depicts the number of first and second sales in our sample. Normally, the number of first sales decreases in time, where the number of second sales raises in time. This is because the dataset was formed using more recent auction catalogues.

The number of first sales, on the other hand, declines sharply in the last few years of the sample period; this is related to the holding duration. Since 2009, it dropped below 1,000. Only 76 first sales occurred in 2014. Normally, it is zero in 2015 as we don't include pairs for which the first and second sales occurred during the same year in our sample.

2.2 Accounting for transaction costs

To our knowledge, there has been no studies that examined the effect on art returns after accounting for transaction costs[8][9]. As it is observable, and given its high significance, we ought to consider the buyer's premium when studying the investment perspective of art[10].

In September 1975, the world's two leading auction houses, Christie's and Sotheby's introduced a standard buyer's fee under the name of buyer's premium[11]. In the following years, auction firms around the globe followed the lead and have also started charging buyers with the same type of commission. (Reif, 1982)

As Table A5 in the appendix shows, since its inception, auction firms have been increasing the buyer's premium rate. For instance, the rates at Christie's and Sotheby's have been generally increasing since their inception. Until 1993, the rates were flat. For example, between 1978 and 1992, Christie's New York had been charging buyers' with a 10% flat rate. In March 1993, they introduced a new structural rate of 15% on sales up to USD 50,000 and 10% for any amount over this level. Since 1993, rates have been increasing but the format remained structural. Currently, Christie's New York buyer's premium rate is 25% on sales up to USD 150,000, 20% on USD 150,001 to USD 3 million, and 12% for above.

The inclusion of buyer's premium charges substantially affect the perceived returns. In fact, the sellers' commission which had been generally estimated at 10% does also affect the returns. However, referring to the published seller's commission rates, Jeff Pilkington, archive researcher at Christie's, states that "and these of course are not definitive as the rate was

[8] Burton & Jacobsen (2001) notes that the inclusion of some transaction costs, being seller's commission, insurance and storage costs diminishes the annual return on wine as a collectible. They consider the general effect but they don't examine how exactly this would alter the index and its respective returns.

[9] Dimson & Spaenjers (2011) assume 25% total transaction cost for collectible stamps. They directly incorporate this percentage on the index returns. This, in turn, becomes a study on the observed returns with the length of the holding period, and not the actual transaction costs' adjusted returns. Additionally, they apply the transaction cost to the index throughout the whole period starting 1900 to 2008, whereas the buyer's premium which is the highest commission on the transaction value was only incepted in the mid-1970s.

[10] In a way, the difference in premium and hammer prices might be seen as equivalent to the bid-ask spread for traded equity. However, art returns are always compared to an index which constitutes highly traded stocks for which the spread is fairly low. In any case, the mean bid-ask spread using monthly closing for all NYSE traded stocks with price above USD 5 is 1.83% for the period between January 1993 and December 2002 (Fang & Peress, 2009).

[11] The main reason behind the inception of buyer's premium was to increase the revenues without pulling away sellers by increasing the commission charged to them. "…as the salerooms cut sellers' rates in competition for exceptional works on offer, the buyer's premium has become a more important source of revenue." (Gleadell, 2007)

negotiable on an individual basis depending on the value of the consignment, and this information is of course confidential." Pilkington (2014), because "sellers can negotiate deals when it comes to the commission they pay the auction house; buyers can't" (Salmon, 2011).

Ashenfelter and Graddy (2003) presume that while the buyer's premium is usually not discussed and paid by the buyer, the seller's commission is often negotiated, and in some cases, the seller doesn't only have to pay no commission but is also guaranteed with minimum sale price.

We agree with this assumption because in its simplest form, the identity of the buyer of an artwork in an auction is not certain due to the bidding process. Thus, it would be odd that the buyer's premium is discussed beforehand. The seller or the agent acting on her behalf, on the other hand, is always known. Hence, negotiations for the payable commission is normally possible. Among other factors, such arrangements would depend on the relation between the auction house and seller, and the quantity and quality of artwork(s) put into sale.

The sellers and buyers might also need to pay additional charges for shipping, marketing and/or other services. These amounts are not standard and clearly unobservable. We can make the same assumption regarding the seller's commission for the reason explained above. Buyer's premium, however, is standard and observable. For this reason, we think it is reasonable to consider it when studying art as an investment.

To calculate the buyer's premium for each transaction, we obtained the rate structures for various auction firms. Sales at Christie's and Sotheby's in New York and London account for the majority of fine art sales in our sample; thus, we acquired their rates since its inception. For the remaining auction houses, we were able to retrieve the structure for recent years. For older years, we used the rates at Christie's New York as a proxy after converting the local currency to USD if the sale was conducted outside the United States.

Table A6 in the appendix provides the buyer's premium rates at Sotheby's and Christie's in their main locations in New York and London. In order to further generate revenues without discouraging sellers by raising the commission charged to them[12], the rates have been

[12] It is important to note that the buyer's premium could be shifted to sellers (for example, see Ashenfelter, 1989). That is, knowing that they have to pay a premium on the final price, buyers might reduce their highest bids by an equivalent percentage. In this case, the sellers implicitly contribute to the payment of the buyer's premium.

increasing over the years[13]. Initially, the rates were set at 10% flat rate. Figure 2 depicts the buyer's premium paid on a USD 150K auction sale at Christie's and Sotheby's New York between 1980 and 2015. In 1993, both auction firms have changed the rate to a structural format, where buyers of relatively lower priced fine art items are charged with higher commission. For example, by the end of 2002, at Christie's and Sotheby's New York, the rates were 19.5% for the first USD 100,000 and 10% for amounts over. That is, a buyer of a painting with a hammer price of USD 50,000 would have to pay 19.5% in commission, whereas a buyer of USD 500,000 painting would pay 12% (19.5% on 100K, and 10% on 400K).

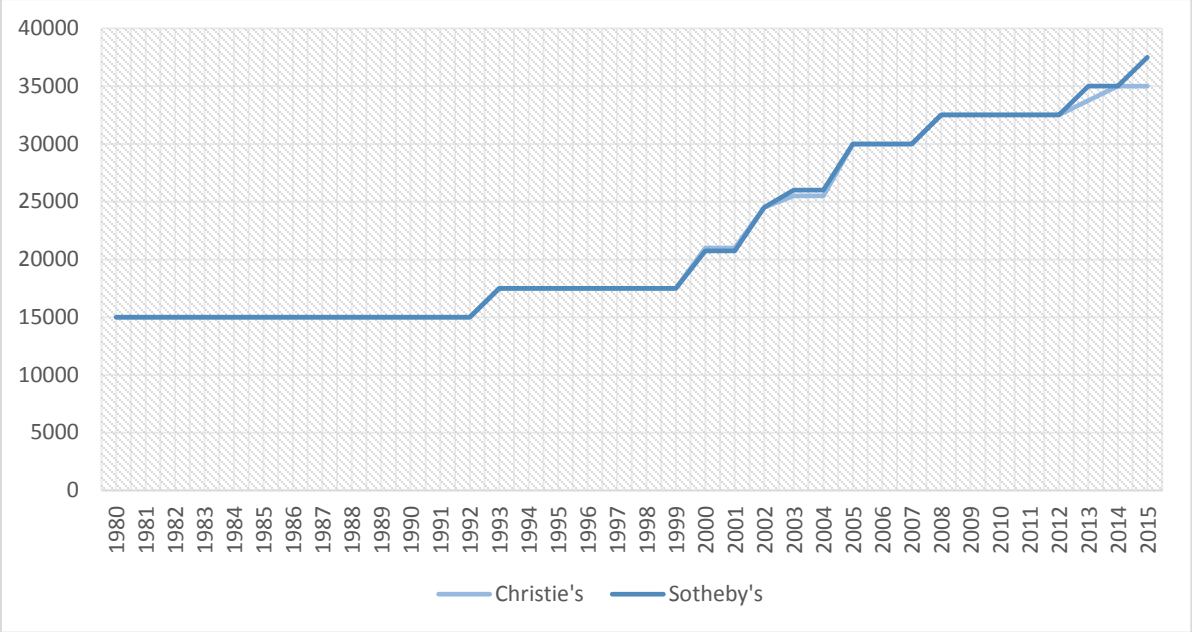

Figure 2. Christie's and Sotheby's buyer's premium
This figure displays the buyer's premium on a USD 150K sale at Christie's and Sotheby's New York on the 30th of June of each year from 1980 to 2015. The rates are almost indistinguishable. Actually, until the year 2000, the rates were identical[14]. Even afterward, there was no real deviation in buyer's charges between the two auction houses.

Additionally, the increase in buyer's premium might not be beneficial to auction houses; "a rise in buyers' premia at Sotheby's, a publically traded company, has reduced revenues and profits below their potential in the absence of such increases." (Anderson, et al., 2015)

[13] The only exception is when Christie's London decreased the rate from 10% to 8% in 1982, before raising it again to 10% in 1986.

[14] In 2000, Christie's and Sotheby's agreed to an amount of USD 512M to settle the price fixing scheme, where both auction houses were sued for colluding and fixing prices for buyers and sellers. (O'Connell, 2000)

For the minority of older sales included in our sample and for which we don't have the exact buyer's premium, we believe that using the time varying buyer's premium rates of Christie's New York to be a valid approximation. Additionally, there is no significant difference in the rates charged at different auction houses. Table A6 in the appendix shows the rates at various auction houses around the globe by the end of 2015.

An observer could think that it could be advantageous for a different auction house to attract buyers by charging them with low to no commission. This might not be the case. "We were strongly opposed to raising the premium," said Christopher Weston, the chairman of Phillips. "In 1975, when our competitors first introduced the buyer's premium, we held out for three years and eight months. It ended up helping everyone except Phillips." (Vogel, 1993)

With both the hammer and premium prices, in the next section, we carry on meaningful analysis on the data and illustrate on the difference among each price treatment.

3. A repeated-sale index

3.1. The model

In 1963, Bailey, Muth and Norse introduced the pioneering framework of repeated-sale regression. The basic idea was to create an index for real estate (heterogeneous assets) that is based on houses that were sold more than once during a sample period. To construct the index, the log price difference between the second and first sale is presumed to be equal to the difference between the period-respective unknown log indexes plus an iid error term.

Through a standard ordinary least square (OLS) regression, the unknown indexes are calculated by regressing the log price difference on a set of time dummy variables, one for each time period. The value of the independent variables is -1 if the first sale took place in the corresponding period, +1 for the second sale and 0 otherwise[15]. The log index is then estimated as the coefficients of the regression (Bailey, et al., 1963).[16]

After the seminal work of Bailey et al. (1963), various extensions to the standard framework have been suggested. Probably, the proposition of Case-Shiller is the second major milestone

[15] The dummy variables can be treated differently. It can take the value of +1 for the periods after the first sale and up until the second, and 0 otherwise. This method shows the index level relative the previous period.
[16] The log index for the base period is set to 0.

in the repeated-sale regression framework. In 1987, Case and Shiller proposed an extension that assumes a non-constant variance of the random component. They suggested that this variance is related to the timespan between sales (Case & Shiller, 1987).

To account for heteroscedasticity in the error terms, they proposed a three step generalized least square (GLS) regression[17]. In the first step, the procedure of Bailey et al. (1963) is followed exactly. In the second stage, the squared residuals from the first stage are regressed on respective holding periods plus a constant. In the last stage, the first step is repeated; however, the dependent variable becomes the log price difference divided by the square root of the fitted value from the second stage.

The Case-Shiller index and its extensions have been considered to be a reliable measure for tracking the performance in the real estate industry. For example, "the S&P CoreLogic Case-Shiller Home Price Indices are the leading measures of U.S. residential real estate prices" (S&P Case-Shiller, n.d.).

As the index is based on repeated-sales, adding sales in new-recent periods requires revision to the index. Revisions in both of the above procedures require re-estimating the coefficients. This is because the new sale is the second of a pair, while the first was completed in an earlier period, and the index is calculated as the best fit for all periods. Thus, new sales add to the available information on all periods. Technically speaking, with today's technology, revisions can be carried through a simple straight-forward exercise.

As a first step, we follow the standard Bailey et al. (1963) procedure. We estimate the coefficients of the indexes through an OLS regression in the following manner[18]:

$$r_{i,t} = \sum_{t=1}^{T} \beta^t D_i^t + \mu_i^t \qquad (1)$$

$$r_{i,t} = \ln\left(\frac{P_t^i}{P_{t0}^i}\right) \qquad (2)$$

D_i^t is a dummy variable that takes the value of -1 if the dummy corresponds to the first sale, +1 if it corresponds to the second sale, and 0 otherwise. We set the coefficient of the base

[17] Some studies concluded that there is no evidence for heteroscedasticity, i.e., the residuals wouldn't increase in the holding period (for example, see Jansen, et al., 2008)

[18] This is standard OLS regression: $\beta = (D'D)^{-1}D'r$, where *D* is the dummy matrix and *r* is the vector of returns.

year, 1976, to 0. P_t^i is the price of the second sale of artwork *i* at time *t*, P_{t0}^i is the price of the first sale, and μ_i^t is a random error component.

To form the index, we divide the anti-log of the estimated coefficients by the coefficient of the base year:

$$Index_t = \frac{\exp(\beta^t)}{\exp(\beta^0)} \qquad (3)$$

As the coefficient of the base year is 0, (3) reduces to $\exp(\beta^t)$.

Art indices that are constructed using hammer or premium prices are definitely indicative, and represent the movement in art markets. We construct an index under each of the three price treatments. In the first case, we consider the premium prices for the first and second sales. In the second case, we consider the hammer prices for both. In the third, we consider the real life scenario, and regard the hammer price for the second sale, and the premium price for the first.

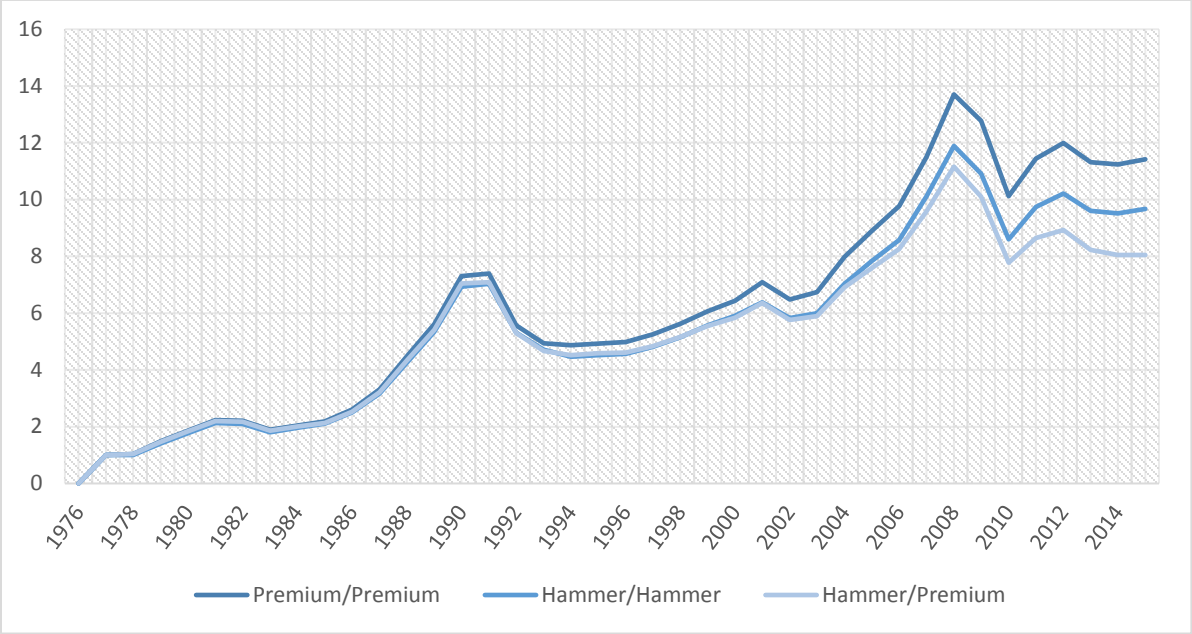

Figure 3. Repeat sales indices
This figure displays the repeat sales indices following the methodology of Baily et al. (1963). The index in 1976 (base year) is 1 (coefficient is 0). The difference in index levels under each of the three different pricing schemes inclines in time. Up until 1990, there is no observable difference.

Figure 3 above depicts the three indices. As expected, all indices follow the same pattern. Accounting for transaction costs results in the lowest levels, and this shows clearly in later

years of the period. However, the difference among the yearly return under each of the three cases is not substantial.

Table 1 illustrates the descriptive statistics for each of the three cases. As anticipated, considering premium prices in index construction results in the highest annual mean return. Its difference with the real return, nevertheless, is negligible. Most of the previous studies on art investment that are based on repeated sales samples use hammer prices. If we rely on the standard repeat sales framework, accounting for transaction costs in the special case of public art markets by using the hammer prices for the second sales and premium prices for the first wouldn't yield any difference as the results are fairly similar. There is only 0.5% difference in the average annual return after accounting for transaction costs.

Table 1. Descriptive Statistics for the three indices
This table reports the investment performance of the art index using Baily et al. (1963) methodology. Although the return on the real art index is lower than the other cases, there is no real difference between the return on the transaction costs adjusted index and the return on the other two. The standard deviation is normally similar under each case.

Index	Observations	Arithmetic Mean	St. Dev	R-Squared	adjusted R
Premium/Premium	54,364	6.21%	13.71%	0.281	0.280
Hammer/Hammer	54,364	5.79%	13.70%	0.260	0.259
Hammer/Premium	54,364	5.27%	14.01%	0.280	0.280

The influential extension of Case-Shiller doesn't directly account for the holding duration, but it assumes that the gap period affects the random error term in the regression model. In order to compare the result of Case-Shiller with the standard method, we construct the indices using their 3-steps GLS procedure.

The first step is already completed through the implementation of Bailey et al (1963) method. In the second step, we regress the squared residuals from first step on the respective holding period plus a constant:

$$\check{\mu}_i^{t^2} = c + \gamma HP \qquad (4)$$

In the last step, we re-estimate the index coefficients in the same manner as in step 1, but we divide each observation by the square root of the fitted value from the second stage[19]. The return (dependent variable) becomes:

$$r_{i,t} = \frac{ln\left(\frac{P_t^i}{P_{t0}^i}\right)}{\sqrt{\bar{\mu}_i^t}} \qquad (5)$$

In line with previous studies[20], the index coefficients for this 3-steps procedure are almost perfectly correlated with the first procedure (>99%). Nonetheless, following this second approach leads to the same results. The difference in average and yearly returns is irrelevant under any of the three methods.

3.2. Analysis

Under the repeated sales methodology, the annual returns are indifferent whether we account for transaction costs or not. This requires returning to traditional approaches in order to elaborate further on the matter. The continuous compounded returns are significantly different after accounting for transaction costs.

Figure 3 illustrates the difference in the standard average returns[21] when considering the hammer prices for both the first and second sales, premium prices for both, and the hammer price for the second sale (sell) and premium price for the first (buy). The last case accounts for transaction costs.

Considering premium prices for both sales yield the highest average return because premium rates have been increasing over years as can be noted in Figure 2 above[22]; the buyer's premium commission which is added to the same hammer price of USD 150K is increasing in time. Considering hammer prices for both yield slightly lower average return. Accounting for

[19] This is a standard GLS regression with the weights being the square root of the fitted values form stage 2: $\tilde{\beta} = (D'W^{-1}D)^{-1}D'W^{-1}r$

[20] For example, see Nagaraja et al. (2014).

[21] Returns are standard continuous compounded: $y_t = y_0 e^{r(t-t_o)} \Rightarrow r = \frac{1}{n}\sum_1^n ln(\frac{P_t^i}{P_{t_0}^i})/t - t_0$

[22] If the hammer price is used for the first sale, and premium for the second, there would be an even more upward bias, and the returns would be the highest. This could be the case if the dataset includes one of the two prices for each artwork. That is, some artworks have only premium prices while others have the hammer. This may be partially solved in hedonic regression frameworks by controlling for the price type in the model; for example, see Bocart & Hafner (2015).

transaction costs, on the other hand, leads to a significant drop. There is a considerable difference in the return on art when taking buyer's premium into account. For example, the difference between the second and third cases is 0.5%, while it is about 2.4% in the case of standard averages (10% vs 97% difference). Normally, there is no difference in the standard deviation under the three cases.

Indeed, the inclusion of the hefty transaction costs when studying art returns should lead to changes in the reported results. A 25% charge on top of the final price is part of the purchase price. It comes to no surprise that these amounts should be highly regarded whenever studying the investment perspective of art. With their inclusion, the observed returns get closer to the exact real figures.

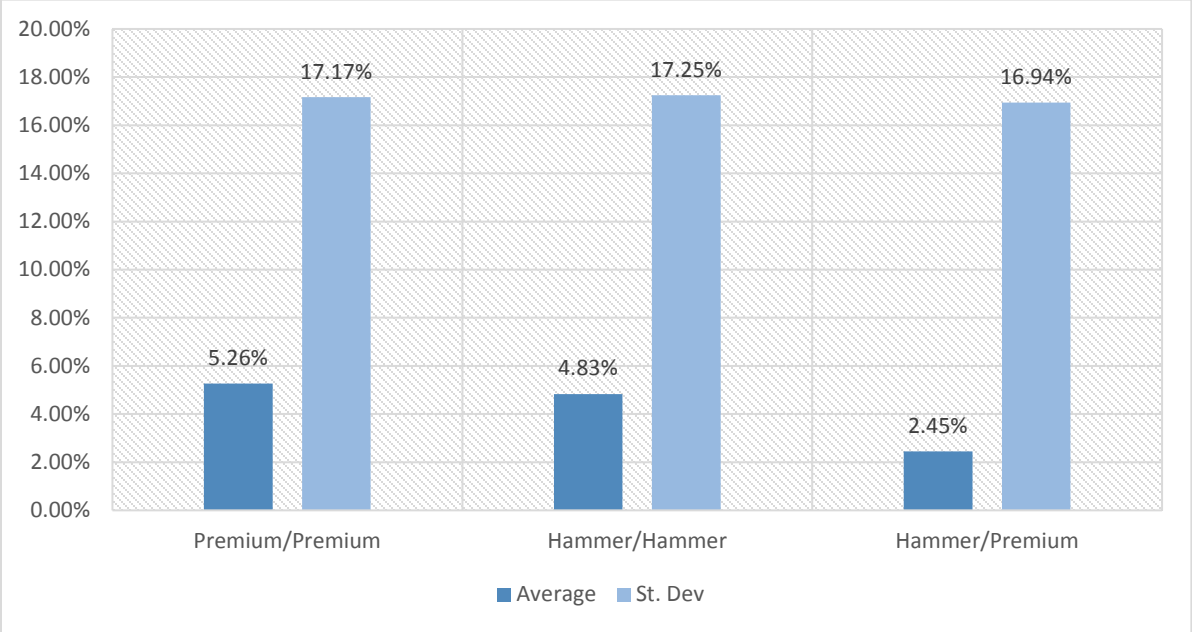

Figure 4. Mean return and standard deviation
This figure reports the average return and standard deviation on the art portfolio in our sample when considering different price consideration. The real return, i.e. the transaction cost adjusted return, is significantly lower than the other two. The standard deviation is similar under the three cases.

Accounting for transaction costs definitely yield lower returns. The difference in returns, however, should decrease in the length of the holding periods. The average holding period in our sample is 13 years[23]. The maximum holding period of 39 years is for an artwork whose

[23] The holding period is the number of years between the first and second sales. We round the difference to the nearest number.

first sale was in 1976, the base period in our sample, and second sale in 2015. The holding period with the highest frequency of 2,983 repeat sales pairs is 4 years. After 4 years, the number of pairs declines in the increase of the holding period. Only small portion was sold over the longest holding periods.

Figure 5 below depicts the average return per each holding period. The transaction cost adjusted return, buying at premium price and selling at hammer, is adversely related to the length of the holding period. Nevertheless, after accounting for the additional cost, the return is always – as it should be – lower than the other two. Additionally, as explained before, the return for premium/premium prices is consistently the highest.

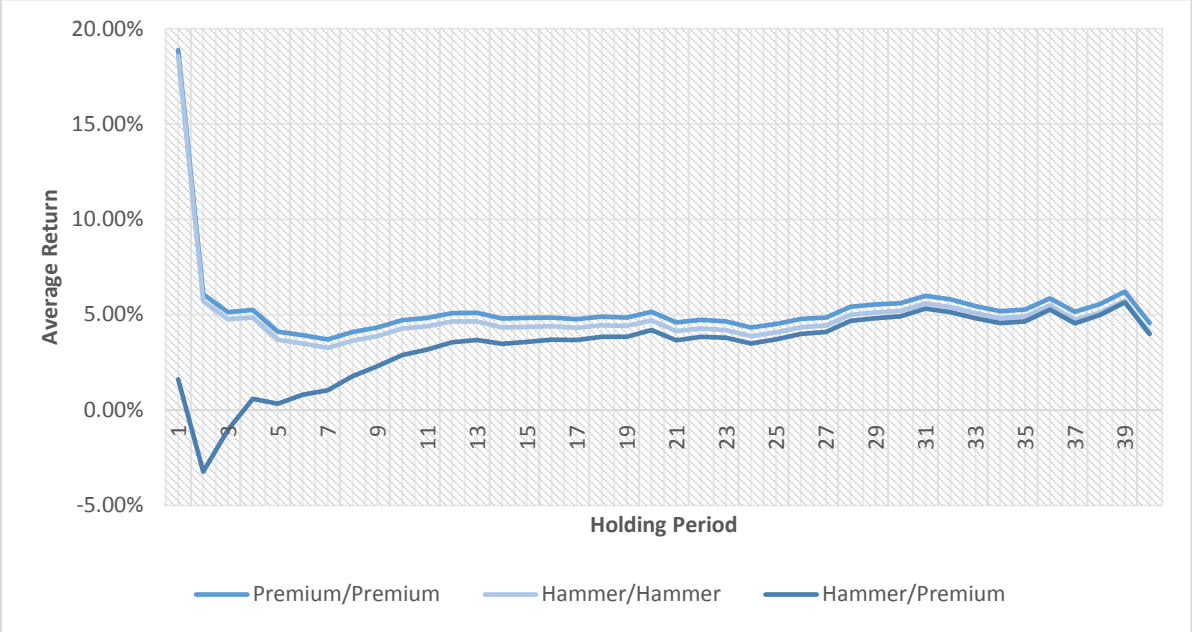

Figure 5. Average return per holding period
This figure shows the average return per holding period. The difference between the average return between the case where we account for the transaction cost being the buyer's premium in our example, and the case where we don't, decreases over longer holding periods

To set a meaningful base line for comparing the real returns with those of the index, we calculate the return on art for each year separately in the following standard continuous compounding manner[24]:

[24] If we calculate the simple annual price appreciation $\frac{1}{n}\sum_{j=1}^{39}\left(P_y^i/P_j^i\right)^{\frac{1}{j}}-1$ instead, the yearly returns become higher.

$$r_y = \frac{1}{n}\sum_{j=1}^{39} \frac{ln\left(\frac{P_y^i}{P_j^i}\right)}{j} \qquad (6)$$

That is, in each year, we calculate the return on art as the average log return on all artworks that were sold for the second time during that year, and for the first time during previous years. To put it differently, the return in a given year is the average annual return of all artworks that were purchased in the past and sold during the year.

Figure 6 shows the difference in the year-to-year returns under each of the pricing scheme. When accounting for transaction costs, the returns are clearly lower in each year[25]. An observer would anticipate such figures as the artwork's sale price (second sale) is net of buyer's commission, while the purchase price (first sale) includes the buyer's premium.

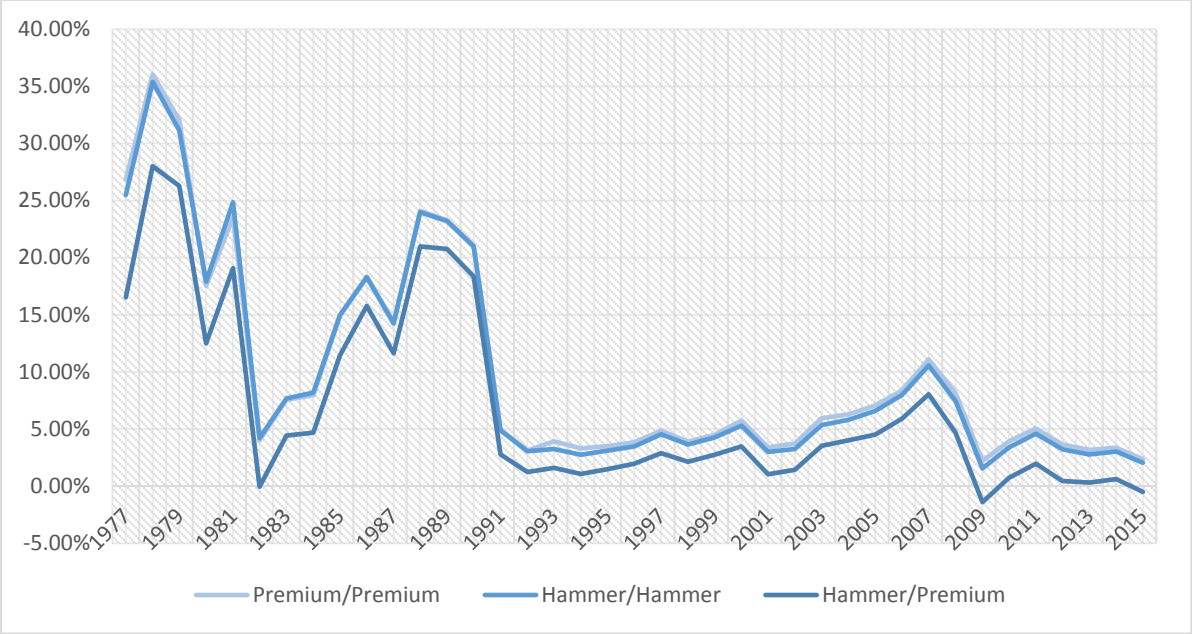

Figure 6. Difference in real standard returns on yearly basis
This figure shows the average standard continuous compounded returns on art in each year of the period 1977-2015 under each of the three pricing cases. The transaction cost adjusted return is substantially lower than the other two in each year irrespective of the holding periods.

[25] A reader needs not to confuse the real returns of each year in Figure 6 with the returns of holding periods illustrated in Figure 5.

The real returns as per our calculations are the closest to the returns an art investor would obtain in the real world. On the other hand, the difference in the annual returns of the repeated sales art index under each of the three cases as illustrated in Figure 7 below is negligible. Thus, if the repeated sales methodology is applied, accounting for transaction costs becomes of no importance. This doesn't mean that such costs don't affect the observed returns, but instead, we can note that this framework can't be applied[26].

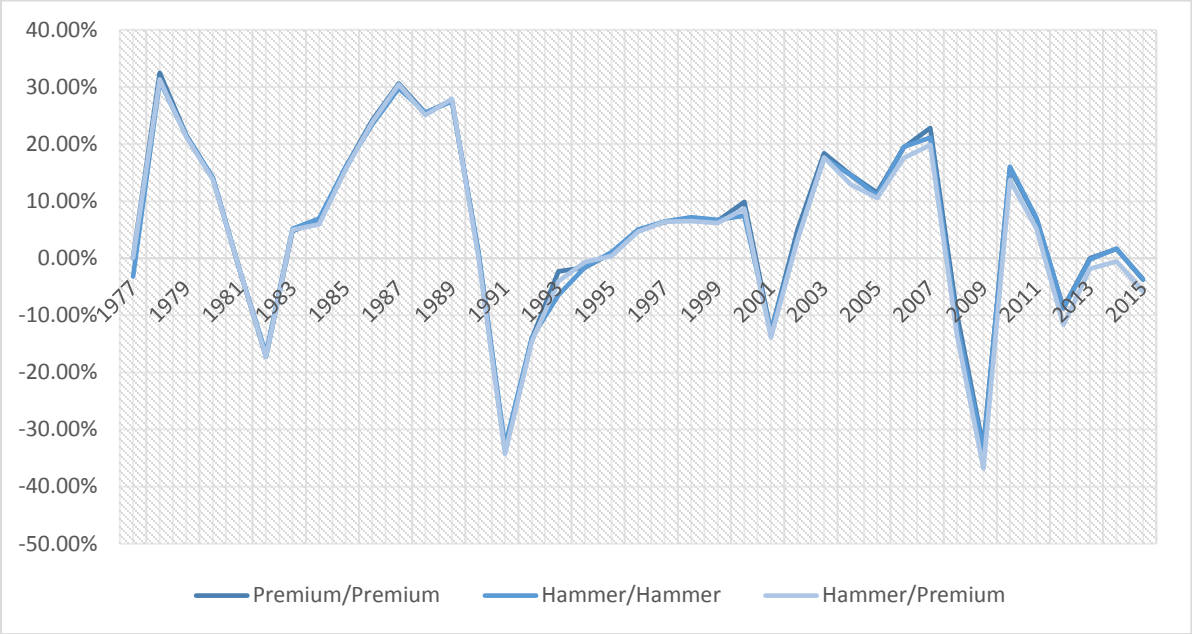

Figure 7. Difference in the index returns on yearly basis (Case-Shiller)
This figure shows the annual return on the art index constructed using the Case & Shiller (1987) 3-steps methodology. The returns are similar under each of the three pricing cases. This clearly indicates that this method is not suitable for an art index when accounting for transaction costs.

Although the standard repeated-sale method requires an OLS regression to approximate the coefficients, the estimates of the mean logged price indices are the weighted averages of the arithmetic mean log price relative to all assets in a given period (Wang & Zorn, 1997).

The fact that accounting for art's transaction requires two levels of prices in each time period makes the repeated-sale framework impractical[27]. Consider the simple case of an artwork

[26] It is important to note that we can't control for the price type in the regression model. The standard as well the extended methods solely estimate the index coefficients at each time period through the observed returns. A hybrid model can't be specified as unlike in the hedonic framework where each artwork has either hammer or premium price, each observation (repeat sale pair return) relies on both.
[27] Hedonic models, on the other hand, can't explicitly account for transaction costs as they require one price of each asset at a given time period.

which was sold thrice at t_1, t_2 and t_3. As explained before, we treat these sales as two independent pairs.

For the first pair, the first and second sale values at t_1 and t_2 are the premium and hammer prices respectively. For the second pair, the first and second sale values at t_2 and t_3 are the premium and hammer prices respectively. That is, we have two values at t_2; for one pair, it is the hammer and for the other, it is the premium. As the index estimates the coefficients of each year by considering all its sales, an average would be regarded, and this in turn wouldn't reflect the transaction costs.

4. Optimal Portfolio Allocation

In this section, we determine the optimal portfolio allocation. We assume that investors seek a diversified portfolio that includes various assets and a risk free instrument. We allow the addition of the art portfolio to this index. We calculate the annual art returns as in (6). We choose the third case where we account for transaction costs. That is, we consider the premium price for the first sale (buy), and the hammer price for the second (sell).

Figure 8 below shows the average return on all artworks sold at a given year along with the quantity. We acknowledge the fact that the number of sales at the beginning of the period is small relative to the subsequent years. Clearly, the returns for these early years are also high. This can lead to upward bias in the aggregated average return as each year is given an equal weight. This bias, however, is present in all earlier research that includes the same sample period. For example, similar to the art index in Figure 6, the repeat sales art indices of Mei & Moses (2002) and Renneboog & Spaenjers (2013) show an extreme sharp increase in the index levels during the same period.

If we omit these years and consider only the period 1991 up until 2015, the average return would simply drop, and so does the standard deviation[28]. We further illustrate on the effect of this sample selection when we construct the optimal portfolio.

[28] If we limit the time period in our sample to 1991-2015, the average annual return drops to 2.3%, while the standard deviation decreases to 2.1%.

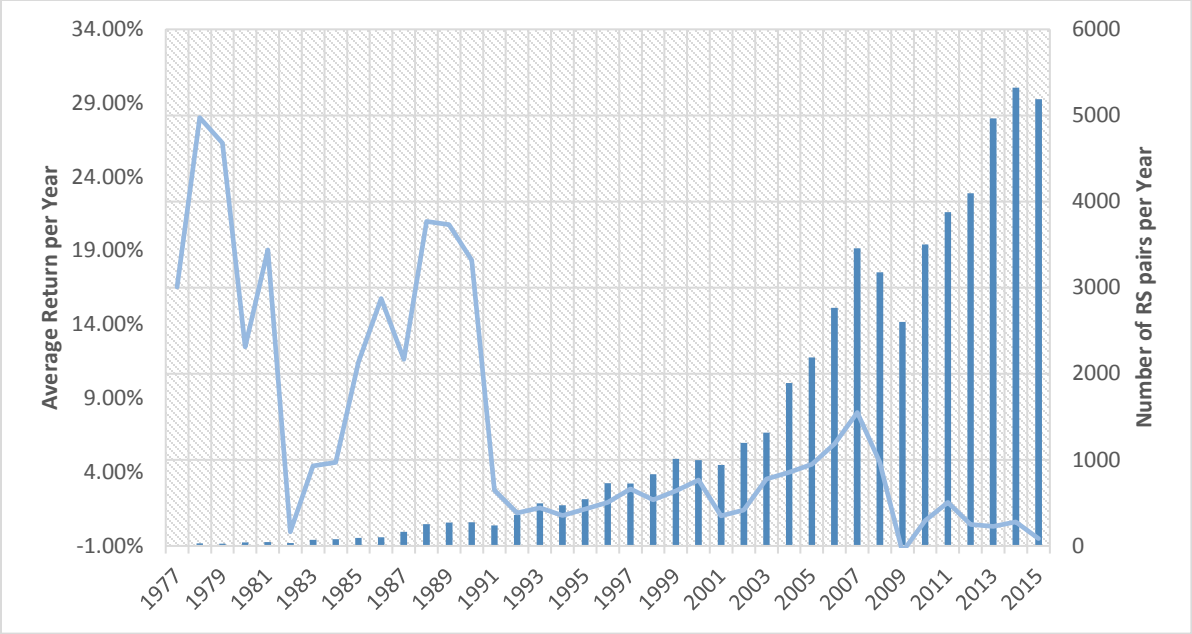

Figure 8. Average annual returns and number of RS pairs
This figure displays the average continuous compounded annual return alongside with the number of repeat sales pairs in each year[29].

On different case, to analyze the potential of art investment, we construct a portfolio of different asset classes. In addition to a global stocks portfolio that is defined as MSCI World, we include commodities represented by S&P GSCI, corporate bonds represented by Merrill Lynch Corporate Master Index, real estate represented by World-DS REITs, and gold represented by gold price index. We retrieve the data from Thomson Reuters Datastream. We use the logarithmic annual returns $\ln(\frac{P_t}{P_{t-1}})$ for the period 1976 to 2015. Table 2 depicts the descriptive statistics of returns for all asset classes.

Similar to equity, the average annual return on art is the highest after real estate. Given its lower volatility, it yields the second highest Sharpe ratio after corporate bonds. The highest return on art of 28% was achieved in 1978. The only year in which art had seen a real negative return was 2009 due to the global financial crisis (-1.4%). For comparison, during the same period, in 2008, there was a sharp loss of more than 50% in the MSCI World, while art provided a positive return of 4.7%. Since 2008, art returns have declined compared to previous years. To 2015, the art market portfolio has seen a negative return of -0.5%.

[29] This is the number of second sales in Figure 1; i.e. the number of observed returns in a given year.

These figures, which stand for the overall art market, promote art as a viable investment class. With this in mind, an investor with a selected number of diversified artworks in her portfolio would expect equivalent returns. From a diversification point of view, art has low to negative correlation with the other asset classes.

As depicted in Table 2, art is negatively correlated with corporate bonds and real estate. The correlation coefficient of art with global equity is 6%. This level of correlation suggests that art can indeed serve as a mean of diversification as suggested by earlier research studies. Moreover, the art market portfolio yielded positive returns during the 2008 crisis while most of the other asset classes experienced considerable losses.

Table 2 Descriptive statistics of portfolio elements
This table provides the descriptive statistics for each of the asset classes in the diversified portfolio. The return on real estate is the highest, while investing in commodities yields the lowest returns. Importantly, accompanied with lower volatility, the Sharpe ratio of an art portfolio is significantly high. This table also shows the correlation matrix for the various asset classes. The art portfolio is negatively correlated with corporate bonds and real estate. Additionally, its correlation with the stock index is considerably low. This may suggest the diversification benefit of including a wide art portfolio in an investor's investment choice.

	Art	**Global Stock**	**Corp. Bonds**	**Commodities**	**Real Estate**	**Gold**
Obs.	39	39	39	39	39	39
Avg. Return	0.068	0.069	0.076	0.047	0.109	0.053
Median	0.035	0.119	0.080	0.099	0.150	0.031
Maximum	0.280	0.330	0.304	0.404	0.606	0.844
Minimum	-0.014	-0.546	-0.071	-0.625	-0.644	-0.388
Std. Deviation	0.080	0.172	0.076	0.247	0.259	0.211
Sharpe Ratio	0.261	0.127	0.372	-0.004	0.237	0.025

Correlation Matrix

	Art	**Global Stock**	**Corp. Bonds**	**Commodities**	**Real Estate**	**Gold**
Art	1.000					
Global Stock	0.063	1.000				
Corp. Bonds	-0.192	0.308	1.000			
Commodities	0.321	0.310	0.117	1.000		
Real Estate	-0.046	0.598	0.476	0.227	1.000	
Gold	0.288	0.082	-0.081	0.308	0.110	1.000

To investigate further on these correlation figures, we regress art returns on the market returns using standard Capital Asset Pricing Model (CAPM):

$$R_{i,t} - r_f = \alpha_i + \beta_i\left(R_{m,t} - r_f\right) + \varepsilon_{i,t} \quad (7)$$

We use the 3-months US treasury bills as a proxy for the risk free asset, and the MSCI World Index as the market return. Table 3 below shows the estimates of our regression. The Beta coefficient of the market risk premium with respect to art is very low compared to other asset classes. Additionally, the R-squared is 0, which means that the independent variable being the market risk premium provides no explanation for art returns. This emphasizes the validity of using art as a mean of diversification as the returns on art are not related/correlated to/with stock returns. In line with the standard CAPM beta, the upside and downside risk coefficients represented by β+ and β- are negative for art. If β- represents the relation between art and equity when the latter only experiences negative returns, its negative value suggests that art can serve as a good alternative investment in bad times.

Table 3. CAPM regression results
This table shows the standard CAPM regression results. The coefficient of the model in the case of art is very low. This adds to the correlation coefficient of art with the stock index, and further suggest the diversification benefit of art. This table also reports the downside and upside risk calculated through regressing the assets' returns over the risk free rate on the market risk premium when the market experiences only negative/positive returns.

	Art	Corporate Bonds	S&P GSCI	REITS	Gold
Intercept	0.02	0.03	-0.01	0.04	0.00
Beta	0.03	0.14	0.45	0.90	0.10
R-Squared	0.00	0.10	0.10	0.36	0.01
Standard Error	0.08	0.07	0.24	0.21	0.21
Observations	39.00	39.00	39.00	39.00	39.00
β+	-0.02	0.23	-0.63	0.31	-0.77
β-	-0.03	0.13	0.48	1.14	-0.25

To the final step, we construct the optimal portfolio. Table 4 below depicts the results. Over the whole sample, the unconditional inclusion of art in an asset portfolio significantly increases the Sharpe ratio by 9 points from 0.41 to 0.51 by allocating a considerable weight of 43% to art. This is due to the high average annual return and moderate volatility of art, and its low to negative correlation with other asset classes. If we to include a risk free asset in the

portfolio, only an investor with risk aversion coefficient equal to 10 would invest 2% in risk free assets[30].

However, if we limit the sample period to 1991-2015, art becomes unattractive. The unconditional optimal portfolio doesn't allocate any weight to art. This indicates that the sample period plays a significant role in the identification of art as an alternative asset class. This is also documented by earlier studies. Baumol (1986) found the annual compounded rate of return on art to be 0.55% even without accounting for transaction costs. Buelens & Ginsburgh (1993) revisited his findings, and noticed that, by considering sub-periods and schools, paintings can offer large returns during large time intervals. Their main motive was to understand whether the unreported high returns on art in the 1980s were in line with those over the last centuries. That is, the abnormal returns that we document in this study, and which are reflected in all earlier studies that consider the returns of the 1980s.

Korteweg et al. (2016) also find "some suggestive evidence that a strategy targeted at certain styles or at top-selling artists may be optimally included in an investment portfolio of art, stocks, bonds, real estate, and commodities."

As a robustness check, we choose a sub-sample and calculate the average annual returns on artworks by the top 30 artists who have the highest frequency of repeat sales pairs in our sample as listed in Table A2 in the Appendix. The optimal portfolio allocation analysis for this sub sample is reported in Table A7 in the appendix. The total number of repeat sales pairs by these artists is 6,778 of 6,005 unique artworks.

The average annual return of 11% for these 30 artists over the period 1977-2015 is much higher than the return on the overall pairs. Nevertheless, in line with our initial analysis on the whole sample, it drops down to 3% when considering only 1991-2015. Over the whole period, an optimal portfolio would allocate 32% to art, while for post-1990, art becomes an unattractive investment.

[30] We use the average annual rate on the U.S. 3-month treasury bills.

Table 4. Optimal portfolio allocation
This table shows the tangency weights of the optimal portfolio over the whole sample and for the sub-sample 1991-2015. Overall, when we allow art to be included in the portfolio, it is given a considerable 43% weight, and the Sharpe ratio significantly increases from 0.4 to 0.5. This result is based on that art has on itself a high Sharpe ratio, and low to negative correlation with the other asset classes. However, omitting the earlier years, leads to totally different perspective. If we consider the returns on art between 1991 and 2015 only, no weight would be given to art in an unconditional optimal portfolio.

	1976-2015				**1991-2015**			
	Benchmark	-	$\gamma = 2$	$\gamma = 10$	Benchmark	-	$\gamma = 2$	$\gamma = 10$
Art	-	0.431	0.431	0.424	-	0.000	0.000	0.000
Global Stock	0.153	0.000	0.000	0.000	0.034	0.034	0.034	0.033
Corporate Bonds	0.780	0.543	0.543	0.533	0.966	0.966	0.966	0.941
Commodities	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Real Estate	0.048	0.025	0.025	0.025	0.000	0.000	0.000	0.000
Gold	0.020	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Treasury	-	-	0.000	0.018	-	-	0.000	0.026
Return	0.076	0.074	0.074	0.073	0.067	0.067	0.067	0.066
St. Dev	0.069	0.051	0.051	0.050	0.065	0.065	0.065	0.063
Sharpe Ratio	0.412	0.505	0.505	0.495	0.633	0.633	0.633	0.616

5. Conclusion

In this paper, we studied the investment perspective of art. To arrive at reliable results and more meaningful analysis, we have developed the most extensive database of repeat sales pairs of fine art. This is the largest database available up to date.

We have taken one step further and considered the real auction prices of every transaction. To our knowledge, we are the first to more accurately account for observed transaction costs. Accounting for the buyer's premium, which is the most significant factor in fine art auction sales' commission and can be as high as 25% of the transaction value, requires two levels of prices at each period. This makes the seminal and widely used repeat sales methodology, which would usually be the most appealing to use with a repeat sales database, impractical. It yields no important difference between the annual logarithmic return of the repeat sales index before and after accounting for transaction costs.

With this in mind, we went back to the standard methods in calculating the return on investment. This is a particularly normal choice with the availability of a large dataset. The nominal average annual return on art is similar to other financial assets, while its Sharpe ratio is noticeably higher. These figures alongside with the low to negative correlation of art with other investment classes makes it an attractive choice of investment. We find art to be a valid mean of diversification. Including art in a diversified portfolio raises the Sharpe ratio by 10 points from 0.41 to 0.51. The desirability of art as an investment, however, is driven by abnormal returns in the early years of the sample period.

We exclude the 1980s during which art has seen very high returns, and limit our sample period to 1991-2015. Following this approach, art becomes an unattractive choice of investment. No weight would be allocated to art in an optimal portfolio. These results are confirmed by selecting a sub sample of artworks created by the top 30 artists with the highest frequency of repeat sales pairs in our sample.

References

Anderson, S., Ekelund, R., Jackson, J. & Tollison, R., 2015. Are auction revenues affected by rising art buyers' premia? The case of early American art. *Applied Economics*, 47(14), pp. 1389-1400.

Ashenfelter, O., 1989. How Auctions Work for Wine and Art. *Journal of Economic Perspective*, 3(3), pp. 23-26.

Ashenfelter, O. & Graddy, K., 2003. Auctions and the Price of Art.. *Journal of Economic Literature*, 41(3), pp. 763-787.

Bailey, M., Muth, R. & Nourse, H., 1963. A Regression Method for Real Estate Price Index Construction. *Journal of the American Statistical Association*, 58(304), pp. 933-942.

Baumol, W., 1986. Unnatural Value: Or Art Investment as Floating Crap Game. *The American Economic Review*, 76(2), pp. 10-14.

Bocart, F. & Hafner, C., 2015. Volatility of Price Indices for Heterogeneous Goods with Applications to the Fine Art Market. *Journal of Applied Econometrics*, 30(2), pp. 291-312.

Buelens, N. & Ginsburgh, V., 1993. Revisiting Baumol's "art as floating crap game'. *European Economic Review*, 37(7), pp. 1351-1371.

Burton, B. & Jacobsen, J., 2001. The Rate of Return on Investment in Wine. *Economic Inquiry*, July, 39(3), pp. 337-350.

Campos, N. & Barbosa, R. L., 2009. Paintings and numbers: an econometric investigation of sales rates, prices, and returns in Latin American art auctions. *Oxford Economic Papers*, 61(1), pp. 28-51.

Case, K. & Shiller, R., 1987. Prices of single-family homes since 1970: new indexes for four cities. *New England Economic Review*, 9.pp. 45-56.

Christie's, n.d. *Financial Information: Buying at Christie's.* [Online]
Available at: http://www.christies.com/buying-services/buying-guide/financial-information/
[Accessed 29 March 2019].

Deloitte Luxembourg & ArtTactic, 2016. *Art & Finance Report*, s.l.: s.n.

Dimson, E. & Spaenjers, C., 2011. Ex post: The investment performance of collectible stamps. *Journal of Financial Economics*, 100(2), pp. 443-458.

Fang, L. & Peress, J., 2009. Media Coverage and the Cross-section. *THE JOURNAL OF FINANCE*, October, 64(5), pp. 2023-2052.

Frey, B. & Pommerehne, W., 1989. *Muses and Markets: Explorations in the Economics of the Arts*. Oxford: Basil Blackwell.

Gleadell, C., 2007. *http://www.artnews.com/2007/09/18/auction-buyers-decry-new-hike-in-auction-premiums/.* [Online]

Available at: http://www.artnews.com/2007/09/18/auction-buyers-decry-new-hike-in-auction-premiums/
[Accessed 18 April 2017].

Goetzmann, W., 1993. Accounting for taste: Art and the financial markets over three centuries. *The American Economic Review,* 83(5), pp. 1370-1376.

Jansen, S. et al., 2008. Developing a House Price Index for The Netherlands: A Practical Application of Weighted Repeat Sales. *The Journal of Real Estate Finance and Economics,* August, 37(2), pp. 163-186.

Kinsella, E., 2017. *The Key Findings of Art Basel's 2017 Global Art Market Report.* [Online]
Available at: https://news.artnet.com/market/key-findings-art-basel-ubs-report-899525

Korteweg, A., Kräussl, R. & Verwijmeren, P., 2016. Does it Pay to Invest in Art? A Selection-Corrected Returns Perspective. *Review of Financial Studies,* 29(4), pp. 1007-1038.

Mc Andrew, C., 2012. *The International Art Market in 2011,* Helvoirt: The European Fine Art Foundation.

Mei, J. & Moses, M., 2002. Art as an Investment and the Underperformance of Masterpieces. *The American Economic Review,* 92(5), pp. 1656-1668.

Mei, J. & Moses, M., 2005. Beautiful Asset: Art as Investment. *Journal of Investment Consulting,* 7(2), pp. 45-51.

Nagaraja, C., Brown, L. & Wachter, S., 2014. Repeat Sales House Price Index Methodology. *Journal of Real Estate Literature,* 22(1), pp. 23-46.

O'Connell, V., 2000. *Christie's, Sotheby's Agree to Pay $512 Million Collusion Settlement.* [Online]
Available at: https://www.wsj.com/articles/SB969829620926708015
[Accessed 12 April 2017].

Pesando, J., 1993. Art as an Investment: The Market for Modern Prints. *The American Economic Review,* 12, 83(5), pp. 1075-1089.

Pesando, J. & Shum, P., 2008. The Auction Market for Modern Prints: Confirmations, Contradictions, and New Puzzles. *Economic Inquiry,* April, 46(2), pp. 149-159.

Pilkington, J., 2014. *Personal Communication.* s.l.:s.n.

Reif, R., 1982. *AUCTIONS; Buyer's fees, end of a battle.*. [Online]
Available at: http://www.nytimes.com/1982/09/03/arts/auctions-buyer-s-fees-end-of-a-battle.html

Reitlinger, G. R., 1961. *The Economics of Taste: The Rise and Fall of Picture Prices, 1760-1960.* London: Barrie and Rockliff.

Renneboog, L. & Spaenjers, C., 2013. Buying Beauty: On Prices and Returns in the Art Market. *Management Science,* 59(1), pp. 36-53.

S&P Case-Shiller, n.d. *S&P CORELOGIC CASE-SHILLER HOME PRICE INDICES.* [Online] Available at: http://us.spindices.com/index-family/real-estate/sp-corelogic-case-shiller

Salmon, F., 2011. *Why you can't always trust auction results.* [Online] Available at: http://blogs.reuters.com/felix-salmon/2011/11/21/why-you-cant-always-trust-auction-results/ [Accessed 4 April 2017].

Shiller, R., 1991. Arithmetic Repeat Sales Price Estimators. *Journal of Housing Economics,* February, 1(1), pp. 110-126.

Taylor, D. & Coleman, L., 2011. Price determinants of Aboriginal art, and its role as an alternative asset class. *Journal of Banking & Finance,* 35(6), pp. 1519-1529.

Vogel, C., 1993. *The Art Market.* [Online] Available at: http://www.nytimes.com/1993/03/05/arts/the-art-market.html?pagewanted=all [Accessed 20 April 2017].

Wang, F. & Zorn, P., 1997. Estimating House Price Growth with Repeat Sales Data: What's the Aim of the Game?. *Journal of Housing Economics,* June, 6(2), pp. 93-118.

Appendix

Table A1. Online art data

This table shows the total number of art sales collected from auction houses' online databases. It also shows the location as well as the dates of the earliest entry and latest. The totals represent all sales and not only those with viable provenance. Christie's has the most extensive online dataset with more than 3.3 million records over the longest period among all auction firms. Their first entry dates back to January 1989.

Auction House Name	Location	#Artworks	Start Date	End Date
Christie's	Multi-Locations	3,371,755	10-Jan-89	19-Dec-13
Bonhams	Multi-Locations	2,323,226	07-Jan-03	18-Dec-13
Lawsons	Australia	921,886	04-Sep-00	07-Mar-14
Sotheby's	Multi-Locations	914,423	16-Oct-98	13-Feb-14
Skinners	United States	465,092	13-Jan-01	19-Dec-13
Doyle New York	United States	307,106	12-Jan-00	11-Mar-14
Tajan	France	254,397	17-Nov-03	06-Feb-14
Tennants	United Kingdom	210,620	20-Nov-08	10-May-14
Leslie Hidman	United States	193,658	14-Nov-04	29-Apr-14
Lombrail Teucquam	France	176,678	07-Jul-02	16-Dec-13
Eldreds	United States	166,928	19-Nov-99	02-May-14
ArtCurial	France	164,908	29-Oct-06	16-Apr-14
Millon & Associes	France	154,939	30-Jan-06	19-Dec-13
Freemans	United States	152,966	08-Sep-00	17-Dec-13
Wolly and Wallis	United Kingdom	142,842	26-Jan-05	11-Dec-13
Koller Auctionen	Switzerland	124,194	16-Nov-03	20-May-14
Groz & Delettrez	France	123,648	05-Jun-04	18-Dec-13
Sloans & Kenyon	United States	108,131	31-May-03	03-May-14
Lyon & Turnbull	United Kingdom	102,024	14-Dec-99	07-May-14
Versailles Encheres	France	87,107	09-Apr-00	27-Apr-14
Neal	United States	82,400	22-Feb-02	22-Nov-13
Cornettede Saint Cyr	France	79,440	24-Apr-08	16-Dec-13
Vanderkindere	Belgium	68,451	19-Mar-02	18-Jun-14
Webbs	New Zealand	66,943	22-Jul-08	31-Mar-14
Ader	France	66,456	20-Feb-08	18-Dec-13
Waddingtons	Canada	63,601	10-Jan-07	11-Dec-13
Nagel Auktionen	Germany	60,170	10-Dec-94	05-Dec-12
Stephan Wiltz & Co	South Africa	54,086	30-Jul-07	14-May-14
Stockholms Auktionverts	Sweden	51,871	29-Nov-05	28-Apr-14
Bukowskis	Sweden	51,643	15-Sep-09	10-Mar-14
James & Julia	United States	49,026	20-Apr-02	04-Feb-14
Pandolfini	Italy	47,056	11-Dec-00	27-May-14
Lempertz	Germany	40,992	20-Nov-08	24-May-14
EricPillon	France	40,816	16-Mar-08	15-Dec-13
Hodgins	Canada	38,659	13-Mar-06	04-May-14

Heritage Auctions	United States	38,019	10-Mar-03	21-Feb-14
Leonard Joel	Australia	38,004	16-Oct-11	17-Apr-14
Ketterer Kunst	Germany	37,277	28-Mar-03	07-Dec-13
Boisgirard Paris	France	36,379	19-Dec-07	20-Dec-13
Weschlers	United States	33,922	18-Nov-03	09-May-14
Piasa	France	30,704	22-Jun-11	18-Dec-13
James Adams	Ireland	27,357	03-Mar-09	10-Dec-13
Van Hams	Germany	26,938	01-Dec-11	29-Jan-14
Fischer	United States	26,322	16-Oct-10	10-Apr-14
Phillips	Multi-Locations	22,906	13-Oct-06	21-Nov-13
Chevau Leger	France	21,819	19-Feb-04	27-Feb-11
Boisgirard Nice	France	21,590	12-Sep-07	12-Apr-14
Agra English	Poland	18,179	23-Sep-90	23-Mar-14
Auktionshaus Stahl	Germany	17,063	01-Apr-10	01-May-14
Whyte's	Ireland	16,961	08-Mar-00	25-Nov-13
Faresti Art	Italy	12,115	26-Mar-10	31-May-14
Agra Polish	Poland	10,856	23-Sep-90	23-Mar-14
MacDougalls	United Kingdom	8,329	30-Nov-04	27-Nov-13
John Moran	United States	7,933	20-Jul-10	10-Dec-13
Thierry Lannon	France	7,661	16-May-04	19-Jun-14
International Art Centre	New Zealand	7,362	18-Nov-10	10-Apr-14
Shannon's	United States	7,087	19-Jun-98	24-Oct-13
Deutscher and hackett	Australia	6,257	10-May-07	26-Mar-14
Deveres	Ireland	3,307	03-Oct-11	13-Apr-14
Menzies	Australia	3,174	24-Sep-08	31-Oct-13
Total	-	11,815,659	-	-

Table A2. Artists with the highest number of repeat sales

This table provides a list of the artists with the highest number of repeated sales in our sample in ascending order. It also lists the number of repeated sale pairs per each artist as well as the number of unique artworks that were repeatedly sold. The average hammer price along with the average premium price per each artist is also reported.

Rank	Artist	# RS pairs	# Unique Artworks	Avg. Hammer	Avg. Premium
1	Pablo Picasso	687	608	1,212,271	1,370,009
2	Andy Warhol	451	398	1,252,516	1,426,459
3	Pierre-Auguste Renoir	384	344	702,586	790,779
4	Marc Chagall	342	305	478,433	548,024
5	Alexander Calder	269	245	347,160	405,940
6	Maurice de Vlaminck	244	224	314,399	354,373
7	Fernand Leger	236	205	505,769	579,362
8	Edgar Degas	223	197	959,018	1,080,593
9	Raul Dufy	214	182	112,647	130,545
10	Henri Matisse	209	191	1,066,413	1,203,389
11	Camille Pissarro	208	182	538,144	610,131
12	Eugene Boudin	208	183	89,974	103,682
13	Jean Dubuffet	203	186	295,630	341,823
14	Maurice Utrillo	202	184	94,514	109,553
15	Joan Miro	199	178	884,377	1,004,939
16	Claude Monet	198	156	3,310,482	3,703,959
17	Henry Moore	190	174	334,003	383,460
18	Kees van Dongen	190	172	434,991	496,162
19	Salvador Dali	187	167	308,577	352,816
20	Louis Valtat	184	169	41,887	49,682
21	Jean-Michel Basquiat	167	136	1,404,105	1,604,303
22	Edouard Vuillard	160	131	221,471	251,738
23	Henri Lebasque	158	144	84,592	98,516
24	Auguste Rodin	154	134	364,020	419,442
25	Paul Klee	154	126	240,304	276,404
26	Sam Francis	154	142	153,217	178,682
27	Laurence Stephen Lowry	152	143	302,242	351,649
28	Paul Signac	152	129	480,113	547,545
29	Pierre Bonnard	152	137	385,475	438,372
30	Max Ernst	147	133	289,654	335,161
	Total/Average	**6,778**	**6,005**	**573,633**	**651,583**

Table A3. Most expensive artworks

This table shows the ten most expensive artworks in our sample as per the second sale of a pair in nominal USD terms. All these artworks were auctioned at Christie's and Sotheby's mainly in their New York premises. This clearly shows the dominance of these two auctioneers in the high quality fine art auction market. As can be noticed, two sales out of these 20 were conducted before 1976. These are first sales and in value terms, we ought to include the highest values of the second sales. It is important to note, however, that these two artworks aren't included in the final sample of 54,364 repeat sales' pairs.

Rank	Artist	Title	Medium	Date	Auction House	Lot	Hammer	Premium	Duration	Ann. Return
1	Pablo Picasso	Les femmes d'Alger…	oil on canvas	10-Nov-97	Christie's - New York	33	29,000,000	31,902,500	17.50	9.21%
				11-May-15	Christie's - New York	8	160,000,000	179,365,000		
2	Roy Lichtenstein	Nurse	oil and …	2-May-95	Sotheby's - New York	27	1,500,000	1,652,419	20.52	19.20%
				9-Nov-15	Christie's - New York	13	85,000,000	95,365,000		
3	Barnett Newman	Black Fire I	oil on canvas	24-Oct-74	Sotheby's - New York	544	95,000	95,000	39.55	16.87%
				13-May-14	Christie's - New York	34	75,000,000	84,165,000		
4	Francis Bacon	Three Studies …	oil on canvas	8-Feb-01	Christie's - London	13	4,046,840	4,456,944	13.26	20.98%
				13-May-14	Christie's - New York	20	72,000,000	80,805,000		
5	Claude Monet	Le bassin aux nymphéas	oil on canvas	5-May-71	Sotheby's - New York	41	320,000	320,000	37.14	14.58%
				24-Jun-08	Christie's - London	16	71,945,150	80,659,876		
6	Francis Bacon	Portrait of George…	oil on canvas	15-Nov-00	Christie's - New York	29	6,000,000	6,606,000	13.24	16.97%
				13-Feb-14	Christie's - London	10	62,540,080	70,182,112		
7	Amedeo Modigliani	NU ASSIS …	oil on canvas	11-Nov-99	Sotheby's - New York	125	15,250,000	16,777,500	10.98	11.84%
				2-Nov-10	Sotheby's - New York	7	61,500,000	68,962,500		
8	Pablo Picasso	La Gommeuse	oil on canvas	4-Dec-84	Sotheby's - London	23	1,568,450	1,725,295	30.92	11.48%
				5-Nov-15	Sotheby's - New York	26	60,000,000	67,450,000		
9	Vincent van Gogh	L'allée Des Alyscamps	oil on canvas	4-Nov-03	Christie's - New York	25	10,500,000	11,767,500	11.50	14.02%
				5-May-15	Sotheby's - New York	18	59,000,000	66,330,000		
10	Jackson Pollock	Number 19, 1948	enamel…	4-May-93	Christie's - New York	10	2,200,000	2,422,500	20.03	15.31%
				15-May-13	Christie's - New York	18	52,000,000	58,363,750		

Table A4. Auction houses

This table shows the top 30 auction houses with the maximum number of overall sales in our repeat sales samples. It also provides the average USD hammer and premium prices per each auction house. Clearly, the leading auctioneers Christie's and Sotheby's dominate the list.

Rank	Auction House	# Sales	Avg. Hammer	Avg. Premium
1	Christie's - London	20,266	181,034	207,770
2	Sotheby's - New York	18,416	333,677	381,005
3	Sotheby's - London	17,834	249,704	286,250
4	Christie's - New York	16,857	350,751	399,461
5	Christie's - Amsterdam	2,412	28,884	35,004
6	Bonhams - London	1,946	37,681	44,798
7	Christie's - Paris	1,541	138,715	163,152
8	Menzies - Sydney	1,220	63,911	78,287
9	Christie's - Hong Kong	1,096	238,090	282,489
10	Phillips - New York	1,036	360,637	416,205
11	Hotel Drouot - Paris	1,018	94,804	105,600
12	Phillips - London	907	121,452	142,251
13	Sotheby's - Hong Kong	825	289,285	342,724
14	Sotheby's - Paris	818	184,366	220,838
15	Sotheby's - Amsterdam	817	32,045	39,208
16	Sotheby's Parke Bernet - New York	609	30,090	32,695
17	Sotheby's - Melbourne	448	33,911	39,774
18	Bonhams - New York	431	25,061	30,751
19	Parke Bernet Galleries - New York	428	33,235	36,229
20	Tajan - Paris	397	88,411	99,693
21	Whyte's - Ireland	383	21,484	25,761
22	Stockholms Auktionsverk - Stockholm	381	29,664	35,602
23	Doyle New York - New York	376	29,788	34,551
24	Agra Art - Warsaw	368	9,714	10,618
25	Deutscher and Hackett - Melbourne	363	37,373	45,762
26	Heritage Auctions - Dallas	362	25,228	31,018
27	Dorotheum - Vienna	356	51,426	61,993
28	ArtCurial - Paris	325	44,109	53,934
29	Menzies - Melbourne	300	72,316	88,253
30	Christie's - Melbourne	269	25,764	30,036
	Total/Average	**92,805**	**108,754**	**126,724**

Table A5. Sotheby's and Christie's buyer's premium rates

This table shows the buyer's premium rates at Christie's and Sotheby's in their main locations in London and New York since the date of their inceptions and until the 31st of December 2015. Both auction houses introduced the buyer's premium first in London. When Christie's opened its offices in New York, it directly applied the buyer's commission. Sotheby's New York followed the next year. The rates at both firms were very similar throughout the years. With the exception that Christie's London decreased the rate in 1982 before increasing it again in 1986, the premium rates have been increasing.

	1-Sep-75	**1-May-78**	**1-Jan-79**	**1-Jan-82**	**1-Aug-86**	**1-Jan-93**	**1-Mar-93**
Sotheby's New York	-	-	10%	-	-	15% ≤ $50K; 10% > $50K	-
Sotheby's London	10%	-	-	-	-	15% ≤ £30K; 10% > £30K	-
Christie's New York	-	10%	-	-	-	-	15% ≤ $50K; 10% > $50K
Christie's London	10%	-	-	8%	10%	-	15% ≤ £30K; 10% > £30K

1-Mar-00	1-Apr-02	15-Apr-02	10-Jan-03	1-Mar-03	1-Jan-05	12-Jan-07	1-Feb-07	1-Sep-07
20% ≤ $15K; $15K < 15% ≤ $100K; 10% > $100K	19.5% ≤ $100K; 10% > $100K	-	20% ≤ $100K; 12% > $100K	-	20% ≤ $200K; 12% > $200K	20% ≤ $500K; 12% > $500K	-	25% ≤ $20K; $20K < 20% ≤ $500K; 12% > $500K
20% ≤ £10K; £10K < 15% ≤ £60K; 10% > £60K	19.5% ≤ £70K; 10% > £70K	-	20% ≤ £70K; 12% > £70K	-	20% ≤ £100K; 12% > £100K	20% ≤ £250K; 12% > £250K	-	25% ≤ £10K; £10K < 20% ≤ £250K; 12% > £250K
17.5% ≤ $80K; 10% > $80K	-	19.5% ≤ $100K; 10% > $100K	-	19.5% ≤ $100K; 12% > $100K	20% ≤ $200K; 12% > $200K	-	20% ≤ $500K; 12% > $500K	25% ≤ $20K; $20K < 20% ≤ $500K; 12% > $500K
17.5% ≤ £50K; 10% > £50K	-	19.5% ≤ £70K; 10% > £70K	-	19.5% ≤ £70K; 12% > £70K	20% ≤ £100K; 12% > £100K	-	20% ≤ £250K; 12% > £250K	25% ≤ £10K; £10K < 20% ≤ £250K; 12% > £250K

1-Jun-08	11-Mar-13	15-Mar-13	1-Oct-13	1-Feb-15
25% ≤ $50K; $50K < 20% ≤ $1M; 12% > $1M	-	25% ≤ $100K; $100K < 20% ≤ $2M; 12% > $2M	-	25% ≤ $200K; $200K < 20% ≤ $3M; 12% > $3M
25% ≤ £25K; £25K < 20% ≤ £500K; 12% > £500K	-	25% ≤ £50K; £50K < 20% ≤ £1M; 12% > £1M	-	25% ≤ £100K; £100K < 20% ≤ £1,8M; 12% > £1,8M
25% ≤ $50K; $50K < 20% ≤ $1M; 12% > $1M	25% ≤ $75K; $75K < 20% ≤ $1,5M; 12% > $1,5M	-	25% ≤ $100K; $100K < 20% ≤ $2M; 12% > $2M	-
25% ≤ £25K; £25K < 20% ≤ £500K; 12% > £500K	25% ≤ £37,500; £37,500 < 20% ≤ £750K; 12% > £750K	-	25% ≤ £50K; £50K < 20% ≤ £1M; 12% > £1M	-

Table A6. Buyer's premium rates for various auction houses

This table shows the buyer's premium rates for different auction houses in various locations on the 31st of December 2015. As can be noted, there is no significant difference among them. Actually, except for Sotheby's which we have their exact premium rates since their inceptions as provided before, all auction houses in the United States that are listed below have similar rates as those of Christie's New York. Thus, using Christie's New York premium rates for other auction houses only when unavailable does indeed serve as a good proxy.

Auction House	Location	Premium Rate	Exchange Rate /USD
Christie's	New York	25% ≤ $100K; $100K < 20% ≤ $2M; 12% > $2M	1.00
Sotheby's	New York	25% ≤ $200K; $200K < 20% ≤ $3M; 12% > $3M	1.00
Bonhams	New York	25% ≤ $100K; $100K < 20% ≤ $2M; 12% > $2M	1.00
Phillips	New York	25% ≤ $100K; $100K < 20% ≤ $2M; 12% > $2M	1.00
Doyle	New York	25% ≤ $100K; $100K < 20% ≤ $2M; 12% > $2M	1.00
Heritage Auctions	Texas	25% ≤ $100K; $100K < 20% ≤ $1M; 12% > $1M	1.00
Christie's	London	25% ≤ £50K; £50K < 20% ≤ £1M; 12% > £1M	0.68
Sotheby's	London	25% ≤ £100K; £100K < 20% ≤ £1.8M; 12% > £1.8M	0.68
Bukowskis	Sweden	18% ≤ SEK 1M; 12% > SEK 1M	1.00
Tajan	France	25% ≤ €30K; €30K < 20% ≤ €1,2M; 12% > €1,2M	0.92
Lempertz	Germany	24% ≤ €400K; 20% > €400K	0.92
Waddington's	Canada	20% ≤ C$50K; 20% > C$50K	1.39
Menzies	Australia	25% Flat rate	1.37
Poly Auction	Hong Kong	15% Flat rate	0.13

Table A7 Optimal asset allocation for 30 artists

This table shows the optimal asset allocation for the 30 artists with the highest number of repeat sales pairs in our sample as reported in Table A2. These results are in line with the main figures for the overall dataset. By limiting the sample period to post 1990, art becomes an unattractive investment.

	1977-2015				1991-2015			
	Benchmark	-	$\gamma = 2$	$\gamma = 10$	Benchmark	-	$\gamma = 2$	$\gamma = 10$
Art	-	0.319	0.319	0.258	-	0.000	0.000	0.000
Global Stock	0.170	0.000	0.000	0.000	0.034	0.034	0.034	0.033
Corporate Bonds	0.757	0.631	0.631	0.511	0.966	0.966	0.966	0.941
Commodities	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Real Estate	0.061	0.044	0.044	0.036	0.000	0.000	0.000	0.000
Gold	0.012	0.006	0.006	0.005	0.000	0.000	0.000	0.000
Treasury	-	-	0.000	0.190	-	-	0.000	0.026
Return	0.078	0.089	0.089	0.081	0.067	0.067	0.067	0.066
St. Dev	0.070	0.072	0.072	0.058	0.065	0.065	0.065	0.063
Sharpe Ratio	0.438	0.581	0.581	0.471	0.633	0.633	0.633	0.616