Buying Beauty: On Prices and Returns in the Art Market

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Abstract: This paper investigates the price determinants and investment performance of art. We apply a hedonic regression analysis to a new data set of over one million auction transactions of paintings and works on paper. Based on the resulting price index, we conclude that art has appreciated in value by a moderate 3.97% per year, in real U.S. dollar terms, between 1957 and 2007. This is a performance similar to that of corporate bonds – at much higher risk. A repeat-sales regression on a subset of the data demonstrates the robustness of our index. Next, quantile regressions document larger price appreciations in higher price brackets. We also find variation in historical returns across mediums and movements. Finally, we show that both high-income consumer confidence and art market sentiment forecast art price trends.

Key words: art; auctions; hedonic regressions; investments; repeat-sales regressions; sentiment.

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I. Introduction

Stories about the baffling amounts of money paid for first-tier art frequently entertain newspaper readers around the world. Yet, high prices do not necessarily imply high returns. Consider, for example, Claude Monet's "Dans la Prairie", the star lot of the Impressionist and Modern Art Evening Sale at Christie's London in February 2009. The canvas changed owners for the substantial sum of 10 million British Pound (GBP), and was the top seller in an auction that, according to the Wall Street Journal (2009), "showed that there's plenty of life" in the Impressionist and Modern sector. However, the same painting had been sold twice before in recent history – in June 1988 at Sotheby's London for 14.3 million GBP, and in November 1999 at Sotheby's New York for 15.4 million U.S. dollars (USD). By any standard, the rate of return on the Monet was dismal.

Nevertheless, the growth in the number of multi-million dollar sales, the expansion of the global population of high-net-worth individuals, and the increasing need for portfolio diversification have all brought increased attention to art as an investment in recent years. In turn, the belief in art as a viable alternative asset class has led to the creation of several art funds – not all very successful (Horowitz, 2011) – and art market advisory services which cater to affluent individuals who consider investing in art. The Wall Street Journal (2010) recently reported that almost 8% of total wealth is held in so-called "passion investments": art, musical instruments, wine, jewelry, antiques, etc. Of all such luxury assets, art is the most likely to be acquired for its potential appreciation in value (Capgemini, 2010).

There is a growing academic literature on art investments, but previous studies have utilized relatively small data sets of sales (pairs) at the high end of the market. The resulting indices are prone to a number of estimation issues and selection biases (cf. Section II). The current paper therefore uses a comprehensive new data set of nearly 1.1 million auction sales to re-examine the price formation and returns in the art market, over a period from 1957 to 2007.

We perform a hedonic regression analysis which relates transaction prices to a wide range of value-determining characteristics and year effects. Our results show that artist reputation, attribution, signs of authenticity, medium, size, topic, and the timing and location of the sale are significantly correlated with price levels. Based on the regression coefficients on the year dummies in our model, we can build a price index that controls for time variation in the composition of the market (and corrects for changes in price dispersion). We find that constant-quality art prices increased by a moderate 3.97% in real USD terms on a yearly basis over the 1957-2007 period. Between 1982 and 2007, the geometric average annual real return is 5.19%. For the second half of the twentieth century, our estimates are substantially below those reported by Goetzmann (1993) and Mei and Moses (2002).

Our baseline hedonic index proves robust to alternative specifications and estimation methods. For example, allowing for time variation in the hedonic coefficients does not materially affect our results.

Importantly, also applying a repeat-sales regression to a subset of our sample leads to nearly identical return estimates for the 1982-2007 period. Quantile regressions over the same time frame show that historical rates of appreciation vary across the price distribution; the annualized real return at the 95th percentile is almost 5 percentage points higher than the return at the 5th percentile. In line with this finding, but in contrast to previous research (and to what the Monet example may suggest), we do not find that portfolios of masterpieces underperform the rest of the market. Moreover, a "value" strategy, in which one focuses on important but relatively less expensive artists, has outperformed our baseline index by 1.6 percentage points on an annualized basis. Next, we show that oil paintings and post-war movements have outperformed other art over the last few decades.

Overall, the risk-return profile of art has been inferior to that of financial assets, even before transaction costs, especially in the second half of our time frame. However, art has outperformed other physical assets, such as gold, commodities, and real estate. While we find a low correlation between changes in the art price index and same-year equity returns, the correlation with lagged equity returns is substantially higher.

Finally, we examine the determinants of art market returns. We find evidence that (lagged) equity market returns and changes in high-income consumer confidence predict art returns, highlighting the importance of luxury consumption demand. However, we document that also a novel art buyer sentiment measure (based on volume and buy-in rates at high-profile auctions, and on media reports) forecasts price changes. This suggests that time-varying optimism about the potential of 'art as an investment' can partially explain the existence of art market cycles.

II. Literature on art returns

Researchers have used different methodologies to calculate the financial returns on art investments, starting from public auction records.[1] Stein (1977) considers the auctioned objects in each year as a random sample of the underlying stock of art (by deceased artists), and constructs an index based on the yearly average transaction price. Baumol (1986) and Frey and Pommerehne (1989) calculate the geometric mean return on works that sold at least twice during the considered time frame. Unfortunately, however, these simple methods do not enable the construction of a price index that adjusts for variations in quality. Most recent studies have therefore used either repeat-sales regressions or hedonic regressions to measure the price movements of art and other infrequently traded assets (e.g., real estate).

Repeat-sales regressions (RSR) explicitly control for differences in quality between works by only considering items that have been sold at least twice. The method uses purchase and sale price pairs to

[1] Art is not only sold at auction, but also privately, for example through dealers. Total turnover in the art and antiques market is roughly split equally between the two transaction types (McAndrew, 2010). However, it is generally accepted that auction prices set a benchmark also used in the private market.

estimate the average return of a portfolio of assets in each time period. Pesando (1993), Goetzmann (1993), Mei and Moses (2002), and Pesando and Shum (2008), among others, have applied the methodology to art investments. There are three problems with existing RSR studies. First, since art objects trade very infrequently (and resales can be hard to identify), only considering repeated transactions decimates any data set to a relatively small number of observations. For example, Mei and Moses (2002) include 4,896 sales pairs over a period of 125 years; Goetzmann et al. (2011) use even fewer sales pairs, although their focus is not on the resulting price index itself. Meese and Wallace (1997) show that the use of such small databases renders RSR estimators sensitive to influential observations. Second, most repeat-sales studies suffer from selection issues. For example, the sample used by Mei and Moses (2002) includes sales pairs with a first transaction anywhere in the world, but a resale at Sotheby's or Christie's New York – arguably the most expensive sales rooms in the world. Moreover, the initial purchase is identified using the provenance entries in the New York sales catalogues; this information could be more likely to be included when a high price is expected. An index estimated based upon such a sample may thus be biased upwards. Other studies, including Goetzmann (1993), have utilized repeat-sales information from the so-called "Reitlinger data" – books with auction price data until the 1960s – of which is well known that they are incomplete and focus disproportionately on famous artists (Guerzoni, 1995). Third, even abstracting from the issues just outlined, items which trade twice may in general not be representative for the overall population of art works.

Hedonic regressions control for quality changes in the transacted goods by attributing implicit prices to their "utility-bearing characteristics" (Rosen, 1974). In the often-used time-dummy variant of the hedonic pricing methodology, all available transaction data are pooled, and prices are regressed on a set of value-determining attributes and one or more time dummies. Under the assumption that all omitted characteristics are orthogonal to those included (Meese and Wallace, 1997),[2] the coefficients on the time dummies account for constant-quality price trends over the sample period. Since no information is thrown away prior to the estimation, hedonic regressions make efficient use of available data, and may therefore give more reliable estimates of price indices than RSR. Not surprisingly, one of the key difficulties is the choice of hedonic characteristics (Ashenfelter and Graddy, 2003). Observable and easily quantifiable features such as size, medium, and the location of sale are frequently used (Anderson, 1974; Buelens and Ginsburgh, 1993; Chanel et al., 1996; Agnello and Pierce, 1996), but the number of hedonic variables often remains relatively limited. The literature has failed to systematically include variables that measure reputation or the strength of attribution, an important price-determining factor for Old Masters (Robertson, 2005). Also, just like in studies using RSR, the utilized samples have been relatively small and selective. Research has been based

[2] Although there are omitted variables in every model, hedonic pricing is particularly suitable for luxury consumption goods markets, in which a limited number of key characteristics often determine the willingness to pay for an item (e.g., the 4 Cs of a diamond). In any case, Butler (1982) argues that the omitted variable bias is often negligible; "approximate correctness can be achieved with significantly fewer characteristics than is generally supposed".

either on the problematic (and old) Reitlinger data mentioned before (Buelens and Ginsburgh, 1993; Chanel et al., 1996), or on samples of art from one country (Agnello and Pierce, 1996; Renneboog and Van Houtte, 2002; Higgs and Worthington, 2005).

The estimated returns on art vary with data, methodology, and the time period under consideration (Ashenfelter and Graddy, 2003). With respect to paintings, the two most influential repeat-sales studies report relatively high real returns over the second half of the twentieth century. Goetzmann (1993) calculates an average annual real appreciation of 3.8% between 1850 and 1986, but with a "long and strong" bull market, in which annualized returns average around 15%, since 1940. Mei and Moses (2002) reports a real return of 4.9% over the period 1875-1999, but a higher annualized return estimate of 8.2% after 1950. (For prints, Pesando and Shum (2008) report much lower returns over the period 1977-2004.) In general, studies that use hedonic regressions have found somewhat lower returns, but to date no exhaustive hedonic analysis has been undertaken.

III. Data and methodology

In this paper, we construct a price index for art using the hedonic regression methodology. As outlined before, the main advantage of this approach is that information on all observed transactions can be taken into account. Our model relates the natural logs of real USD prices to year dummies, while controlling for a wide range of hedonic characteristics:

$$\ln P_{kt} = \alpha + \sum_{m=1}^{M} \beta_m X_{mkt} + \sum_{t=1}^{T} \gamma_t D_{kt} + \varepsilon_{kt} \qquad (1),$$

where P_{kt} represents the price of art object k at time t, X_{mkt} is the value of characteristic m of item k at time t, and D_{kt} is a time dummy variable that takes the value one if object k is sold in period t (and zero otherwise). The coefficients β_m reflect the attribution of a relative shadow price to each of the m characteristics, while the antilogs of the coefficients γ_t can be used to construct an art price index that controls for time variation in the quality of art sold. The value of the hedonic index in year t is:

$$\Pi_t \equiv \exp(\gamma_t) * 100 \qquad (2),$$

with γ_0 set equal to 0 for the initial, left-out period. The return in year t is then:

$$r_t \equiv \frac{\Pi_t}{\Pi_{t-1}} - 1 \qquad (3).$$

However, a subtle (and often neglected) point is that such an index will track the geometric – not the arithmetic – mean of prices over time, due to the log transformation prior to the estimation. This is especially important for our estimation of returns if there is time variation in the heterogeneity-controlled dispersion in prices, i.e., the hedonic regression residuals (Silver and Heravi, 2007). If we assume that the

residuals of our hedonic regression are normally distributed in each period, with variance σ_t^2 in period *t*, then we can correct for this transformation bias by defining the corrected index values as follows (Triplett, 2004; Silver and Heravi, 2007):

$$\Pi_t^* \equiv \exp\left[\gamma_t + \frac{1}{2}(\sigma_t^2 - \sigma_0^2)\right] * 100 \quad (4).$$

The corrected return in year *t*, can then be defined as follows:

$$r_t^* \equiv \frac{\Pi_t^*}{\Pi_{t-1}^*} - 1 \quad (5).$$

We describe our data in subsection A. The hedonic variables that will be used in the estimation of Eq. (1) are presented in subsection B.

A. Data

We focus on the market for oil paintings and works on paper (i.e., watercolors and drawings), which account for a substantial proportion of all transactions – and about 85% of total turnover – in the art market (Artprice, 2006). We start by compiling a list of artists. This selection of artists has to be as exhaustive as possible, so as not to have a bias towards artists that are popular today, and therefore we consult several authoritative art history resources from different time periods. Our artist selection procedure, of which details can be found in Appendix A, culminates in a list of 10,442 artists. We classify 4,490 of those artists in at least one of the following art movements: Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; Minimalism & Contemporary.

We then collect data on all relevant sales by matching our list of names with all artists in the online database Art Sales Index [http://www.artinfo.com/artsalesindex]. This resource contains auction records for different types of art. Prices are hammer prices, exclusive of transaction costs. Historically, the Art Sales Index, just like many other databases, has not included buy-ins (i.e., items that do not reach the reserve price and remain unsold).

Although the first sales in the Art Sales Index date from the beginning of the 1920s, data are unavailable or sparse in many years until the second half of the 1950s. Therefore, we start our analysis in 1957, the first year for which we have more than 1,000 observations. (Unfortunately, however, for 1963 the data coverage is limited, with only some of the highest priced sales included.) The Art Sales Index only includes London sales until the late 1960s, but it has an exhaustive worldwide coverage afterwards. The most recent auction records available for this study are from the autumn auctions of 2007.

Our final data set consists of 1,088,709 sales; about 60% of these transactions concern oil paintings, with the remainder split roughly evenly between watercolors and drawings. The artist with the highest

numbers of sales (5,405) is Pablo Picasso. The magnitude of our database enables us to draw a complete picture of the price formation and the returns in the art market, in contrast to most previous studies which are based on more selective samples.

We translate all nominal prices in our data set to prices in year 2007 USD, using the CPI as a measure of inflation. In real terms, the most expensive transaction is 'Portrait du Dr. Gachet' by Vincent van Gogh, which sold for 75 million USD in May 1990 at Christie's New York. (In nominal prices, it is 'Garçon à la Pipe' by Pablo Picasso, which was auctioned off for 93 million USD in May 2004 at Sotheby's New York.) While such high-profile sales attract ample attention, the average price level is much lower. The mean (resp. median) sales price over all observations for 2007 is 159,354 USD (resp. 14,775 USD).

Goetzmann (1996) argues that survivorship could cause upward bias in the estimation of art returns, since artists who "fall from fashion" are typically not traded. The impact of this bias on our results may be rather small. First, as Goetzmann (1996) points out himself, the rate of artist obsolescence is relatively low. Second, in contrast to previous work, we do not require a work of art to trade twice and/or to sell at a large auction house. Our sample thus also includes many sales of less popular artists at smaller auction houses at any point in time (especially after 1970). Finally, pieces that are donated to museums after a substantial increase in an artist's fame – or items that are sold through private transactions in the early part of artists' careers – are not observed at auction either (Goetzmann, 1993; Mei and Moses, 2002), partially offsetting the upward bias. Nevertheless, our return estimate should probably still be considered as an upper bound on the rate of return (before transaction costs) realized by art investors over our time frame.

B. Variables

Our hedonic regressions include a number of variables that capture the characteristics of the artist, of the work, and of the sale. The descriptive statistics for these hedonic variables are presented in Table 1.

[Insert Table 1 about here]

First, in addition to artist dummies capturing each artist's uniqueness, we consider the following exogenous reputational measure:

> *Textbook dummy*. We manually check which of our artists were included in several editions of the classic art history textbook 'Gardner's Art Through the Ages' (1926, 1959, 1980, 1996, and 2004). In total, 652 of our artists are listed in at least one edition. The dummy variable TEXTBOOK equals one if the artist was featured in the edition of – or the last edition prior to – the year of sale.

Two other characteristics related to the artist's career are included in the late-twentieth-century movement-specific models (cf. Section IV.E), but not in our general models, as they could potentially pick up price differences between various eras or movements:

Exhibition dummy. The variable EXHIBITION equals one once the artist has been represented at Documenta in Kassel. Inclusion in this prestigious exhibition evidences an artist's rise to fame. In total, 680 of our artists were represented at one of the eleven exhibitions between 1955 and 2002.

Dead artist dummy. It is often assumed that prices for art works increase after the death of an artist. The dummy variable DECEASED, which equals one if the sale occurs subsequent to the artist's death, should capture this effect.

Second, we also consider a range of price-determining variables that capture the attribution and authenticity, the medium, the size, and the subject matter of the work of art:

Attribution dummies. Attribution can be an important factor influencing the price of art objects, especially of older works. Different levels of attribution are used in the auction world: ATTRIBUTED (to), STUDIO (of), CIRCLE (of), SCHOOL (of), AFTER, and (in the) STYLE (of). About 12% of the observations in our sample carry such an attribution.

Authenticity dummies. More than half of the art works is SIGNED, while about one third is DATED.

Medium dummies. We introduce dummies for the different medium categories: OIL, WATERCOLOR (including gouaches), and DRAWING.

Size. The height and width in inches are represented by HEIGHT and WIDTH (with squared values HEIGHT_2 and WIDTH_2). The average work has a height and a width of about 20 inches (51 cm).

Topic dummies. The subject matter can significantly affect the aesthetic appreciation of art objects. We therefore categorize the works in different topic groups based on the first word(s) of the title. We create eleven categories, based on the search strings listed in Appendix B: ABSTRACT, ANIMALS, LANDSCAPE, NUDE, PEOPLE, PORTRAIT, RELIGION, SELF-PORTRAIT, STILL_LIFE, UNTITLED, and URBAN. Furthermore, we create a dummy STUDY that equals one if the title contains the words "study" or "etude". The largest categories are portraits and landscapes.

Third, we include dummies that indicate the timing of the sale, and the reputation and location of the auction house:

Month dummies. Since important sales are often clustered in time, we include month dummies. The busiest months are May, June, November, and December.

Auction house dummies. We make a distinction between different fine art auction houses that have been important throughout our sample period. For Sotheby's and Christie's, we introduce dummy variables for their London, New York, and other sales (e.g., SOTH_LONDON, SOTH_NY, and SOTH_OTHER). Together, these two institutions are responsible for about half of all sales in our sample. For two other big British auction houses, Bonhams and Phillips, we make a distinction between their London sales rooms and other activities (e.g., BON_LONDON and BON_OTHER).

We also create two dummies to account for the sales by important European and American auction houses (AUCTION_EUROPEAN and AUCTION_AMERICAN) – see Appendix C.

IV. The returns on art

A. Baseline indices

Table 2 shows the parameter estimates of the hedonic variables for our baseline model. Eq. (1) is estimated using ordinary least squares (OLS) and the dependent variable is the natural log of the real price in USD. For 1,078,482 sales we have complete information on all hedonic characteristics presented in the previous section. Because of the very large number of observations, nearly all coefficients are statistically highly significant. Hence, we focus on economic significance as well: Table 2 shows the "price impact" of each hedonic variable, which can be proxied by taking the exponent of the coefficient, and subtracting one. It is important to note that the variables are in most cases picking up otherwise unobservable differences in quality, and that the regression coefficients thus reflect correlation instead of causality. For example, works sold at Sotheby's or Christie's mainly catch higher prices because of their high attractiveness, not necessarily because of auction house certification.

[Insert Table 2 about here]

Table 2 reveals that works are on average priced 13.5% higher after the inclusion of the artist in an important art history reference book. Also the strength of the attribution has an important effect on the price of an art object. Whenever an attribution dummy comes into play, the price level drops by more than 50%. Not surprisingly, larger discounts are recorded for works that are "in the style of" or "after" a master than for "attributed" or "studio" works. We also observe that signed and dated works carry higher prices: a signature increases the price by as much as 31% on average, while a date adds almost 19% in value. Works on paper are priced lower than oil paintings, and drawings are less valuable than watercolors. Furthermore, prices increase with size, up to the point that the work becomes too large, as indicated by the negative coefficients on the squared terms. Regarding the topic dummies, there are significant discounts associated with studies and portraits, while self-portraits trade at a premium. The coefficients on our month-of-the-year dummies confirm that the most expensive auctions are clustered at the ends of the spring and the autumn. Finally, the highest prices are paid at the main offices of Sotheby's and Christie's.

Based on the coefficients on the time dummies and the variance of residuals in each period, we construct both an uncorrected art price index Π, and a price index Π^* that corrects for log transformation bias. The results are reported in Table 3; the price levels in 1957 are standardized to 100. As mentioned before, the coverage of the data is very selective for the year 1963, so we geometrically interpolate index values for that year. (Previous studies showed very small price movements in 1963.) Table 3 indicates that the index values have high statistical precision. In most cases, the standard deviation on the regression coefficient is

around 0.03, which implies tight confidence intervals around each index value. Figure 1 graphically depicts the evolution of the indices over our time frame, and compares them to the evolution of deflated average and median prices in our data set.

[Insert Table 3 and Figure 1 about here]

The corrected price index in Figure 1 illustrates that, in boom periods, prices can increase very fast: they more than tripled in real terms between 1982 and 1990. The yearly increase in prices between 1985 and 1990 exceeded 23%. However, prices also rapidly decreased after 1990, and no large changes in price levels occurred between the mid-1990s and the first years of the 2000s. In the most recent art boom period of 2002-2007, the annual real price appreciation averaged 13.65%.

The figure documents that an index based on average or median prices would overestimate the volatility of prices, because of the lack of control for quality differences over time. Indeed, a key contribution of this paper is to disentangle changes in market composition from those in heterogeneity-controlled price levels. At the same time, however, the average and median series serve as a check on the order of magnitude of the overall price appreciation (at least over the last two-three decades, when the coverage of the data set is no longer expanding notably). Figure 1 also illustrates the quantitative importance of the correction for the log transformation; while the end-of-period index values are very similar, we observe marked deviations between Π and Π^* over some periods.

Annualized (i.e., geometric average) returns are reported in Panel A of Table 4. We focus on the corrected price index. On average, art has appreciated at a yearly real rate of 3.97% between 1957 and 2007. Over the last 25 years, the geometric mean real return is somewhat higher (5.19%). The nominal equivalents (not reported), obtained by correcting the index for the year-to-year changes in the CPI series, are 8.21% (1957-2007) and 8.47% (1982-2007). These numbers are substantially below the return estimates reported in Goetzmann (1993) or Mei and Moses (2002) for the periods in common. For example, over the period 1957-1999, Mei and Moses (2002) report an annualized nominal return of 12.81%, while our index appreciated by 7.59% on an annual basis – a difference of over 5%.

[Insert Table 4 about here]

Table 4 also reports standard deviations of the time series of annual returns. For our corrected index, the standard deviation over the full time frame is slightly above 15%. However, we will later note that this number still underestimates the true riskiness of art investments (cf. Section V).

B. Robustness checks

We now check the quantitative robustness of our baseline results. First, we repeat our analysis using a number of different set-ups: (i) excluding the topic dummies (as these may capture the subject matter rather imprecisely), (ii) excluding the more than 5,000 artists with fewer than 100 sales (as these artists are less

liquid), and (iii) excluding Minimalism & Contemporary art (as selection and survivorship issues may be more of a concern for more recent artists). Panel B of Table 4 shows the uncorrected real return estimates for 1957-2007 and 1982-2007, which can be compared to the performance of price index Π, as shown in Panel A. Our estimates do not change substantially, with annualized price appreciations over the period 1957-2007 that differ by less than 0.05% from those reported earlier.

Second, a potential problem with the hedonic approach is that coefficients are constrained to be stable across the whole sample window. This is a strong assumption as shadow prices of hedonic characteristics (i.e., tastes) may change over time. An adjacent-period model can mitigate this problem: by dividing the sample in subperiods, it enables the hedonic coefficients to fluctuate (Triplett, 2004). We apply this method to our data set by performing a separate hedonic regression for every two consecutive years since 1982 (and then chain-linking our returns). We restrict our analysis to the second half of our time frame, because the methodology would underestimate the returns over the full time frame due to the expansion of coverage by the database over the first 20-25 years. The adjacent-year model generates an uncorrected return estimate (4.60%) that is very similar to the one we obtained from the pooled data, lending further support to our benchmark index.

Third, the main advantage of RSR is that is controls for the uniqueness of each work. Also, in contrast to a hedonic price index, it can be thought of as an investable index, at least in theory. Unfortunately, our data set does not uniquely identify each artwork – let alone each repeated sale. Yet, we aim to identify multiple transactions of the same item indirectly. We consider two items as being identical if they are from the same artist (not from a pupil or follower), have the same dimensions, carry the same title (but not "Untitled" or "Composition"), are of the same medium, and do not differ with respect to the presence of a signature or date. Strikingly, this reduces the data set from 1.1 million individual transactions to 30,611 'repeat sales' with a holding period of at least a year. For similar reasons as before – an RSR over the full sample would underestimate average returns because of the focus on higher-priced items in the first half of our time frame – we look at the 21,846 transactions between 1982 and 2007. (This number compares favorably to the size of the databases used in previous repeat-sales studies.) In line with Goetzmann (1993) and Mei and Moses (2002), we apply a three-stage estimation procedure on our sample of repeat sales, based on Case and Shiller (1987). In a first step, we regress returns on a matrix (containing a row for each item and a column for each time period) with dummy variables indicating the holding period of each item, using OLS. In a second stage, we regress the squared residuals from the first step on an intercept and the time between sales. In a third step, we redo the RSR, using weighted least squares, with the fitted squared residuals as weights. The last line of Panel B of Table 4 shows that, over the time frame under consideration, the RSR implies an average annual increase in the geometric mean price of 4.56%, compared to 4.55% for the (uncorrected)

hedonic regression index.[3] The standard deviation is only slightly higher than before. The correlation between the repeat-sales returns and the hedonic returns (not reported) is 0.98.

C. Quantile regressions

Despite some work on the "masterpiece effect" – which examines the question whether more expensive art out- or underperforms the overall market (e.g., Pesando, 1993; Mei and Moses, 2002) – prior literature has not systematically explored the potential variation of returns across price brackets. This is surprising, given that the art market is likely to be segmented for a number of reasons. First, art is indivisible, and therefore small investors are generally not able to invest in higher-end works. Second, wealthy individuals may be less tempted to buy in the lower-end of the market, where works do not signal the same social status (Mandel, 2009). Third, the more expensive parts of the market may be more prone to speculation. The distribution of returns may thus be skewed over and above a potential masterpiece effect. In such a setting, quantile regressions may be particularly useful (Zietz et al., 2008; Scorcu and Zanola, 2011). While OLS regressions provide estimates for the conditional means only, non-linear quantile regressions can characterize the entire distribution of the dependent variable (Koenker and Hallock, 2001).

We estimate price trends for the percentiles 0.95, 0.75, 0.50, 0.25, and 0.05, using the adjacent-year set-up outlined before. (We split our sample in subperiods to avoid that the hedonic coefficients measure variation in premiums or discounts across time rather than across price brackets). We denote the price indices by Q95, Q75, etc. We show the results, again since 1982, in Panel C of Table 4 and in Figure 2. An interesting pattern emerges. The low performance of Q05 is particularly striking: it has an annual growth rate of only 1.35%, compared with 4.91% for Q50 (i.e., the constant-quality median price level). Over the last 25 years, prices have gone up more in the higher price brackets. For example, for Q95, we record an annualized return of 6.32%. Paired-sample t-tests on the return series (not reported) show that the difference in (arithmetic) average return between Q05 and any of the other quantile series is statistically significant at the 0.05 level. The outperformance of the higher quantiles is mainly due to strong price rises in times of increasing demand for art. This finding seems in line with "superstar economics".[4] The higher

[3] As with the hedonic regression, the RSR implies an index that is related to the geometric mean price in each period. Goetzmann (1992) proposes to correct for log transformation bias by adding half of the cross-sectional variance of the returns in each period to the estimated coefficient, where this variance is estimated in the second step of the Case-Shiller method. However, Goetzmann and Peng (2002) argue that the nature of the bias due to the log transformation is generally not uniform through time. There is also a danger of misspecification of the error structure (Meese and Wallace, 1997) which may lead to an overestimation of the relevant correction term. Since we are mainly interested in testing the robustness of our baseline index to a change in methodology, we compare the pre-correction indices to each other; they should give similar results.

[4] In Rosen (1981), a small number of superstars earn large amounts of money, and increases in demand make the earnings distribution ever more skewed. A condition is that there is "imperfect substitution among quality

average growth and higher volatility of the upper price range can also be associated with increases in both income inequality (Goetzmann et al., 2011) and the income cyclicality of high-income households (Parker and Vissing-Jorgensen, 2010), although we do not formally test these hypotheses in this paper (because of lack of a sufficiently long time series). In contrast, at first sight, the results seem at odds with the finding of Mei and Moses (2002) that masterpieces underperform – an issue that we turn to next.

[Insert Figure 2 about here]

D. The performance of "masterpiece" and "value" portfolios

The quantile regression results shows that prices have generally gone up more for high-value items. To further examine the profitability and riskiness of buying high-end art, we estimate the historical performance of two different investment strategies, based on our repeat-sales data. First, we consider a "masterpiece" strategy: we 'buy' in year *t* all auctioned works by the 100 artists that were most expensive over years *t-1* and *t-2* (as measured by an adjacent-period hedonic regression model over those years). This strategy comes close to how other authors have examined the masterpiece effect, although we do not select works endogenously on realized transaction prices. Second, we implement a "value" strategy: we buy in year *t* all observed works by the 100 least expensive artists over *t-1* and *t-2* that were nevertheless included in the art history textbook described earlier at the start of year *t-2*. Such a strategy could exploit fluctuations in taste, or a lag in appreciation by the market relative to the recognition of the artist's art-historical significance. (Of course, the items included in this portfolio are in general still expensive compared to the overall sales distribution.) In both cases, we apply the RSR methodology to estimate returns; in other words, we 'sell' whenever the owner sold in practice. The results are shown in Panel D of Table 4, and compared to our earlier constructed RSR index in Figure 3.

[Insert Figure 3 about here]

We find no evidence of underperformance of a "masterpiece" strategy, which is not inconsistent with our quantile regressions, but stands in contrast to Mei and Moses (2002).[5] The described strategy yields an annualized growth in price levels of 4.81%, compared to 4.56% for our earlier constructed RSR index. The

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differentiated goods". This is certainly the case in the art market: ten mediocre works do not add up to a single masterpiece. In a recent paper, Gyourko et al. (2006) rely on superstar economics to rationalize why the gap in house prices between "superstar cities" and less attractive locations keeps increasing over time; the authors note that "living in a superstar city is like owning a luxury good".

[5] Mei and Moses (2002) and Ashenfelter and Graddy (2003) argue that idiosyncratic overbidding and mean reversion could be one explanation for the seemingly negative effect in studies that identify masterpieces based on transaction prices. Goetzmann (1996) provides an alternative explanation: if only larger auction houses are taken into account, expensive items that drop in value are more likely to be included in the sample than lesser-quality works that underperform. Of course, the relative performance of masterpieces may also vary over time, for example if it depends on evolutions in aggregate demand or the income distribution (cf. supra).

"masterpiece" strategy realized strikingly high returns in the boom in the late 1980s (when indeed "blue chip" art was very much in favor), but lost much in the subsequent bust. For the "value" strategy, we record an annualized return of 6.16%; it has performed notably well since the mid-2000s. Both high-end strategies thus have end-of-period index values above those for the overall sample, although the outperformance is not statistically significant at the traditional levels. The (unreported) p-value of a t-test on the difference between the "value" returns and the benchmark returns is 0.14.

E. Indices per medium and per movement

We now return to our baseline hedonic model and repeat the hedonic regression analysis on three complementary subsamples of our data set: oil paintings, watercolors, and drawings. The coefficients on the hedonic variables (not reported) are in line with the previous results. Although the trends are similar across the different types of art, we find faster price increases for oil paintings. In real terms, watercolors and drawings were on average still priced lower in 2007 than in 1989 and 1990. Panel E of Table 4 reports the (corrected) returns over the different time frames. Over the last half century, prices for oil paintings have appreciated at a yearly average real rate of 4.63%, while watercolors and drawings have increased by 3.67% and 2.51% annually. Oil paintings have strongly and significantly outperformed works on paper in the second half of our time frame – a finding that is related to the discrepancies in returns between price categories reported before. The lower performance of art items other than paintings is also consistent with Pesando and Shum (2008), who find an average real return on prints of 1.51% between 1977 and 2004.

Finally, we run a separate hedonic regression for each movement, based on the classification of each artist. We add the variables EXHIBITION and DECEASED to the models for the three most recent art movements (Abstract Expressionism, Pop, and Minimalism & Contemporary). Most artists of these movements have been active over our time frame, which will enable a correct measurement of exhibition and death effects. We find that EXHIBITION is significantly positive in the Abstract Expressionism and Minimalism & Contemporary set-ups; in the latter model we also observe a clearly positive death effect (not reported). In general, the results on the other hedonic characteristics are in line with the earlier findings, although there is some variation in the coefficients on the topic dummies (e.g., a premium is paid for nudes only in Pop) and on the auction house dummies (e.g., auctions at the large continental European houses generate premiums for the earliest art movements). The average yearly real returns for the different art movements since 1957 and since 1982 are also reported in Panel E of Table 4. Since 1957, the indices have increased by between 2.57% and 6.32% on average per year. Between 1982 and 2007, only the post-war art movements Abstract Expressionism, Pop, and Minimalism & Contemporary have shown real price appreciations of more than 7% per annum, on average. However, the standard deviations show that these movements have also been the more volatile ones. Romanticism, Realism, Impressionism & Symbolism,

and Fauvism & Expressionism record mean appreciations of less than 5% over the same time frame. The indices for three art movements from different time periods (Rococo; Cubism, Futurism & Constructivism; and Pop) are plotted in Figure 4 from 1982 onwards. The figure confirms that a post-war art movement like Pop has been more profitable – the outperformance is statistically significant at the 0.05 level – but is also more risky.

[Insert Figure 4 about here]

V. Comparison of investment performance and correlation with other asset classes

We want to compare the performance of art investments to that of other assets. However, we first need to address the underestimation of risk by our hedonic indices. Since our methodology aggregates sales information per calendar year, our returns will suffer from spurious first-order autocorrelation and have understated standard deviations. We can unsmooth our baseline index Π*, a technique originated in the real estate literature, but later also applied to collectibles (e.g., Campbell, 2008; Dimson and Spaenjers, 2011). Based on Working (1960), we can calculate that taking a yearly average of daily prices induces spurious first-order serial correlation in the hedonic coefficients of about 0.25. We therefore re-estimate our standard deviations, removing this spurious autocorrelation from the return series. Over the period 1957-2007, the standard deviation of our desmoothed art index is now equal to 19.05% (instead of 15.21%). Over the second quarter century, the standard deviation rises less sharply, from 15.31% to 18.04%.[6]

We collect data from Global Financial Data on indices measuring total returns on U.S. T-bills, 10-year U.S. government bonds, Dow Jones corporate bonds, the GFD global index for government bonds, S&P 500 stocks, the GFD world index for equity, gold prices, and the CRB commodity price index. We borrow data on residential real estate prices in the U.S. from Shiller (2009); unfortunately, commercial real estate price indices have only been available for shorter time periods. Panel A of Table 5 shows the average yearly real returns and volatilities calculated over the periods 1957-2007 and 1982-2007. The same table also presents the ex-post (arithmetic) Sharpe ratios, using the returns on T-bills as the risk-free rate.

[Insert Table 5 about here]

Over the longer time frame, the art index clearly underperforms stocks. The S&P 500 and the GFD global equity index have appreciated at average real rates of 6.63% and 6.34%, respectively, while our art index increased by 3.97% annually over the same period. The reward-to-variability, as measured by the Sharpe ratio, is higher for stocks and corporate bonds than for art. The art index has a higher average return

[6] Even these new numbers are still a lower estimate of the true riskiness of art investments, for two reasons. First, the standard deviations reported here refer to the aggregate art market; Panel D of Table 4 made clear that the volatility of most art portfolios is likely to be higher. Second, our analysis does not take into account buy-ins. If reserve prices in the art market follow recent sales prices, this implies a return measurement bias when the market reverses (Goetzmann and Peng, 2006): returns may be underestimated (resp. overestimated) in boom (resp. bust) periods.

since 1957 than both government bond indices, but the Sharpe ratios only surpasses that of U.S. government bonds. Nevertheless, compared to the other tangible assets in Table 5 (gold, commodities, and real estate), art does relatively well. Over the shorter time frame (since 1982), the risk-return profile of art only compares favorably to that of other real asset classes.

Our comparison does not take into account differences in transaction costs, which are high for art investments. For most of our time frame, auction houses charged buyer's premiums and seller's commissions of around 10% (Pesando, 1993; Ashenfelter and Graddy, 2003). However, in recent years, while important consignors have sometimes been able to obtain lower commission rates, the buyer's premium has grown to around 25% for many smaller purchases. The large transaction costs emphasize the need for long holding periods in collectibles markets (Dimson and Spaenjers, 2011). Moreover, art buyers have to take into account storage and insurance costs.

We now turn to the correlations between the asset categories. Panel B of Table 5 shows the correlation matrix of real returns for the 1957-2007 time frame. The correlations between our art index on the one hand and the gold, commodity, and real estate price indices on the other are 0.30 or higher. In contrast, we find very little comovement between art and financial assets. Yet, additional (unreported) analysis shows correlations of art returns with lagged equity returns of 0.34 (S&P stocks) and 0.55 (global stocks). This suggests that wealth effects may drive art prices – something we examine in more depth in the next section.

VI. Explaining the returns on art

Art is ultimately a durable luxury consumption good, and consumption indeed seems to dominate the art purchase decision for a representative agent (Mandel, 2010). The fundamental value of a work of art can thus be thought of as the present value of all future flows of consumption services. Since supply is inelastic, the market price of these consumption flows will be determined by the strength of demand in each period. The importance of investment income for wealthy households, together with the discretionary nature of luxury consumption, may then induce positive correlation between art prices and financial asset values (Aït-Sahalia et al., 2004). Previous literature (e.g., Hiraki et al., 2009; Goetzmann et al., 2011) has indeed found a strong relation between stock prices and art prices. In line with this work, in column (1) of Table 6, we regress our art returns on same-year and lagged global stock market returns over the period 1981-2007. Below each coefficient, we report Newey-West standard errors that control for heteroskedasticity and autocorrelation up to two lags. Adjusted R-squareds are reported at the bottom. The results confirm that stock returns significantly affect art price growth rates.[7]

[7] In unreported analysis, we also control for changes in top incomes (using updated U.S. data from Piketty and Saez (2003), available from Emmanuel Saez' webpage), real interest rates, and equity market sentiment (Baker and Wurgler, 2006), but this does not materially change our results.

[Insert Table 6 about here]

To further examine the role of consumer demand, we add in column (2) a variable that measures whether high-income (upper third) consumers think it is a good time to purchase "major household items". (Ludvigson (2004) notes that "there is some evidence that consumer confidence surveys reflect expectations of income and non-stock market wealth growth".) The information is taken from the University of Michigan's Survey of Consumers, and we use the data for December of the previous year. The measure has been standardized to have zero mean and unit variance. We find that consumer sentiment strongly significantly affects art returns. We also see an increase in adjusted R-squared from 0.33 to 0.49.

The results in columns (1) and (2) of Table 6 highlight the importance of consumption demand. However, they cannot fully explain the pattern of art markets booms and busts that we have witnessed over the last decades. This may be because the fundamental value of art, as defined before, is hard to grasp. Combined with the impossibility of short-selling, this uncertainty implies a potential role for art buyer sentiment, which could be defined as unjustified optimism (or pessimism) about future resale values. Furthermore, because auctions are held infrequently, sentiment may only slowly exert pressure on observed aggregate price levels. We thus expect high sentiment to be followed by price appreciations – at least in the short run – rather than by low returns as is the case in more liquid financial asset markets (Baker and Wurgler, 2006).

We propose three proxies for art buyer sentiment which can be measured by the end of each year (so that they can be related to price levels in the year starting immediately after). A first factor is the year-on-year change in fourth-quarter sales volume at Sotheby's and Christie's (London). Baker and Stein (2004) argue that in markets with short-sale constraints liquidity can proxy for sentiment. Moreover, they suggest that the "liquidity-as-sentiment approach" is particularly relevant for "real" asset markets. Our second variable equals the rate of items sold (and thus not bought in) at the Impressionist and/or Modern art evening auctions in the Fall of each year (since 1980) in New York. These high-profile auctions are considered a barometer for the market, and buy-ins at these sales are widely commented upon in the press. We proxy for the sales rates by dividing the number of observed transactions by the maximum lot number for each auction. For our third proxy, we turn to the historical archives of The Economist. We look up all articles dated between 1980 and 2006 which mention "art market", "art prices", or "art auctions". We read each article to verify that it is indeed about the state of the art market, or about art investment. We then analyze the content of each of the 56 selected articles using a software package called General Inquirer. General Inquirer counts the number of words belonging to certain categories in a text, and is also used by Tetlock (2007) in his analysis of Wall Street Journal columns. In each year, our measure of sentiment is the relative use of "positive outlook" versus "negative outlook" words in the latest article of the year, using the built-in dictionaries of the software.

Our main sentiment measure is then the first principal component of these three sentiment proxies (which have positive pairwise correlations of between 0.3 and 0.4). Applying a principal components procedure reduces the idiosyncratic noise in each individual measure (Baker and Wurgler, 2006). We show the evolution of our standardized sentiment measure since 1980 in Figure 5. Sentiment was negative in the early 1980s, 1990s, and 2000s, and generally positive in the second half of the 1980s and the mid-2000s.

[Insert Figure 5 about here]

In column (3) of Table 6, we regress the returns on art on the lagged sentiment measure, controlling for same-year and lagged global equity returns and the lagged consumer confidence measure, over the period 1981-2007. The lagged stock return variable is still positive but loses significance at the traditional levels. In line with expectations, we find a positive impact of art market sentiment that is statistically significant at the 0.05 level. This strongly suggests that time-varying optimism about art investment impacts art pricing. Unreported analysis shows that Pop and Minimalism & Contemporary art, which may be harder to value, are more sensitive to changes in art buyer sentiment.

VII. Conclusion

Many collectors are acutely attuned to the financial value of their assets (Burton and Jacobsen, 1999). Moreover, investors are increasingly turning to collectibles markets to diversify their portfolios. This underlines the importance of an accurate measure of the financial returns to art. Therefore, in this paper, we have investigated the price determinants and historical investment performance of art, by applying an extensive hedonic regression framework to a data set of more than one million paintings and works on paper. Our hedonic art price index indicates that art prices have increased by a moderate 3.97%, annually, in real USD terms between 1957 and 2007. This return estimate is lower than that reported in previous papers that used smaller samples of high-quality paintings sold at top auction houses. During art market booms, however, prices can skyrocket. For example, between 2002 and 2007, our index shows a real return of 13.65% per year. We also document larger price appreciations at the upper end of the market, and variation in average returns across mediums and movements. In general, art's risk-return profile is much less attractive than that of financial assets, even before transaction costs. Finally, regression results show that art price cycles are determined by both luxury consumption demand and variation in art market sentiment.

Appendix A – Compilation of list of artists

We start by consulting Grove Art Online [http://www.oxfordartonline.com], a database published by Oxford University Press that contains all articles of the 34-volume 'The Dictionary of Art' (1996) as well as 'The Oxford Companion to Western Art' (2001). We select all 9,775 individual artists from the categories 'graphic arts', 'painting and drawing', and 'printmaking'. We subsequently expand our set of artists by means of another online database, Artcyclopedia [http://www.artcyclopedia.com]. This raises the number of artists to 10,211.

We then compose a list of thirteen art movements: Medieval & Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism & Symbolism; Fauvism & Expressionism; Cubism, Futurism & Constructivism; Dada & Surrealism; Abstract Expressionism; Pop; and Minimalism & Contemporary. When possible, we classify our artists into one of these categories, based on the 'Styles and Cultures' from Grove Art Online and 'Art Movements' of Artcyclopedia. We can put 4,132 artists into at least one art movement.

Next, we expand our data set in two more ways, to correct for the possible underrepresentation of modern and contemporary art. We compare the index of the influential book 'Modern Art' (Britt, 1989) to our data set and add 62 modern artists to our list (with classification). The book also enables us to assign another 87 artists not yet classified to a specific art movement. Next, in order to have a representative and up-to-date sample of contemporary artists, we consult Wikipedia [http://en.wikipedia.org/wiki/List_of_contemporary_artists] in April 2008. We can add 169 artists, bringing our list to 10,442 artists in total; 40 other artists can now be classified in Minimalism & Contemporary.

Finally, we check for pseudonyms and different spellings of all artists' names.

Appendix B – Titles and topics

We use the first word(s) of the title to classify works in topic categories. Most titles in our database are in English, but we also include French keywords in our analysis. We avoid search strings that can be used in different contexts. Sometimes we only search for titles no longer than one word or in which the word is followed by a space (e.g., "cat_") to avoid misclassifications due to longer words with identical first characters (e.g., "catholic").

These are the topic categories, along with their search strings: ABSTRACT ("abstract", "composition"), ANIMALS ("horse", "cheval", "chevaux", "cow_", "cows", "vache", "cattle", "cat_", "cats", "chat_ ", "dog_", "dogs", "chien", "sheep", "mouton", "bird", "oiseau"), LANDSCAPE ("landscape", "country landscape", "coastal landscape", "paysage", "seascape", "sea_", "mer_", "mountain", "river", "riviere", "lake", "lac_", "valley", "vallee"), NUDE ("nude", "nu_", "nue_"), PEOPLE ("people", "personnage", "family", "famille", "boy", "garcon", "girl", "fille", "man_", "men_", "homme", "woman", "women", "femme", "child", "enfant", "couple", "mother", "mere_", "father", "pere_", "lady", "dame"), PORTRAIT ("portrait"), RELIGION ("jesus", "christ_", "apostle", "ange_", "angel", "saint_", "madonna", "holy_", "mary magdalene", "annunciation", "annonciation", "adoration", "adam and eve", "adam et eve", "crucifixion", "last supper"), SELF-PORTRAIT ("self-portrait", "self portrait", "auto-portrait", "autoportrait"), STILL_LIFE ("still life", "nature morte", "bouquet"), UNTITLED ("untitled", "sans titre"), URBAN ("city", "ville", "town", "village", "street", "rue", "market", "marche", "harbour", "port_", "paris", "london", "londres", "new york", "amsterdam", "rome_", "venice", "venise").

Appendix C – Important European and American auction houses

The AUCTION_EUROPEAN category includes all sales by: Lyon & Turnbull (Scotland), Francis Briest / Artcurial Briest (France), Ader, Picard & Tajan / Ader & Tajan / Tajan (France), Bruun Rasmussen (Denmark), Dorotheum (Austria), Koller (Switzerland), Lempertz (Germany), Neumeister (Germany), Finarte (Italy), Bukowskis (Sweden), Stockholms Auktionsverk (Sweden). The AUCTION_AMERICAN category includes all sales by: Butterfields (until 2002), Swann Auction Galleries, Skinner, Doyle New York, Freeman's, Leslie Hindman.

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Table 1 – Descriptive statistics hedonic variables

Table 1 displays the descriptive statistics for the hedonic variables used in this study. TEXTBOOK is a dummy variable that equals one if the artist was included in the last edition of 'Gardner's Art Through the Ages' (1926, 1959, 1980, 1996, or 2004) prior to the sale. EXHIBITION is a dummy variable that equals one once the artist has exhibited at the Documenta art exhibition in Kassel, Germany. DECEASED equals one in case the artist is dead at the time of the sale. The attribution dummies ATTRIBUTED, STUDIO, CIRCLE, SCHOOL, AFTER, and STYLE equal one if the auction catalogue identifies the work as being "attributed to" the artist, from the "studio" of that artist, from the "circle" of the artist, from the artist's "school", "after" the artist, or "in the style of" the artist, respectively. The authenticity dummies SIGNED and DATED take the value of one if the work carries a signature of the artist or is dated, respectively. The medium dummies OIL, WATERCOLOR, and DRAWING indicate whether the work is an oil painting, a watercolor (or a gouache), or another work on paper. The variables HEIGHT and WIDTH measure the height and the width of the work in inches. The topic dummies are based on the first word(s) of the title of the work (cf. Appendix B). The month dummies indicate the month of the sale. The auction house dummies SOTH_LONDON, SOTH_NY, SOTH_OTHER, CHR_LONDON, CHR_NY, CHR_OTHER, BON_LONDON, BON_OTHER, PHIL_LONDON, and PHIL_OTHER equal one if the sale takes place at Sotheby's London, Sotheby's New York, another branch of Sotheby's, Christie's London, Christie's New York, another branch of Christie's, Bonhams London, another office of Bonhams, Phillips London, or another sales room of Phillips, respectively. AUCTION_EUROPEAN and AUCTION_AMERICAN are dummy variables that equal one if the sale takes place at a large Continental European or a large American auction house, respectively (cf. Appendix C). For each variable, we report the number of observations (N), the mean, and the standard deviation (S.D.). For dummy variables, we also show the number of zeros and ones.

	N	Mean	S.D.	0	1
Artist characteristics					
TEXTBOOK	1,088,709	0.1218	0.3271	956,096	132,613
EXHIBITION	1,088,709	0.2118	0.4086	858,118	230,591
DECEASED	1,088,709	0.8810	0.3238	992,796	95,913
Work characteristics					
Attribution dummies					
ATTRIBUTED	1,088,709	0.0435	0.2040	1,041,361	47,348
STUDIO	1,088,709	0.0051	0.0716	1,083,104	5,605
CIRCLE	1,088,709	0.0229	0.1496	1,063,778	24,931
SCHOOL	1,088,709	0.0065	0.0802	1,081,663	7,046
AFTER	1,088,709	0.0101	0.1002	1,077,668	11,041
STYLE	1,088,709	0.0288	0.1671	1,057,407	31,302
Authenticity dummies					
SIGNED	1,088,709	0.5900	0.4918	446,375	642,334
DATED	1,088,709	0.3292	0.4699	730,275	358,434
Medium dummies					
OIL	1,088,709	0.6025	0.4894	432,813	655,896
WATERCOLOR	1,088,709	0.1739	0.3790	899,358	189,351
DRAWING	1,088,709	0.2236	0.4167	845,247	243,462
Size variables					
HEIGHT	1,078,702	20.6597	14.8467		
WIDTH	1,078,549	21.5984	15.8748		
Topic dummies					
STUDY	1,088,709	0.0152	0.1225	1,072,127	16,582
ABSTRACT	1,088,709	0.0255	0.1576	1,060,960	27,749
ANIMALS	1,088,709	0.0108	0.1033	1,076,970	11,739
LANDSCAPE	1,088,709	0.0430	0.2028	1,041,934	46,775
NUDE	1,088,709	0.0082	0.0903	1,079,757	8,952
PEOPLE	1,088,709	0.0377	0.1906	1,047,628	41,081
PORTRAIT	1,088,709	0.0619	0.2410	1,021,273	67,436

RELIGION	1,088,709	0.0161	0.1257	1,071,234	17,475
SELF-PORTRAIT	1,088,709	0.0030	0.0544	1,085,479	3,230
STILL_LIFE	1,088,709	0.0244	0.1543	1,062,130	26,579
UNTITLED	1,088,709	0.0287	0.1670	1,057,438	31,271
URBAN	1,088,709	0.0137	0.1164	1,073,761	14,948
Sale characteristics					
Month dummies					
JANUARY	1,088,709	0.0287	0.1670	1,057,438	31,271
FEBRUARY	1,088,709	0.0450	0.2074	1,039,667	49,042
MARCH	1,088,709	0.0916	0.2884	989,021	99,688
APRIL	1,088,709	0.0862	0.2807	994,864	93,845
MAY	1,088,709	0.1358	0.3426	940,857	147,852
JUNE	1,088,709	0.1389	0.3459	937,442	151,267
JULY	1,088,709	0.0547	0.2275	1,029,109	59,600
AUGUST	1,088,709	0.0132	0.1141	1,074,345	14,364
SEPTEMBER	1,088,709	0.0325	0.1773	1,053,329	35,380
OCTOBER	1,088,709	0.0904	0.2868	990,270	98,439
NOVEMBER	1,088,709	0.1674	0.3733	906,483	182,226
DECEMBER	1,088,709	0.1155	0.3196	962,974	125,735
Auction house dummies					
SOTH_LONDON	1,088,709	0.1220	0.3273	955,868	132,841
SOTH_NY	1,088,709	0.0868	0.2816	994,167	94,542
SOTH_OTHER	1,088,709	0.0553	0.2285	1,028,541	60,168
CHR_LONDON	1,088,709	0.0945	0.2925	985,848	102,861
CHR_NY	1,088,709	0.0621	0.2413	1,021,149	67,560
CHR_OTHER	1,088,709	0.0711	0.2570	1,011,321	77,388
BON_LONDON	1,088,709	0.0106	0.1023	1,077,189	11,520
BON_OTHER	1,088,709	0.0058	0.0759	1,082,400	6,309
PHIL_LONDON	1,088,709	0.0151	0.1220	1,072,251	16,458
PHIL_OTHER	1,088,709	0.0093	0.0960	1,078,571	10,138
AUCTION_EUROPEAN	1,088,709	0.1364	0.3432	940,173	148,536
AUCTION_AMERICAN	1,088,709	0.0189	0.1361	1,068,160	20,549

Table 2 – Baseline hedonic regression results

Table 2 presents the baseline hedonic regression results. Eq. (1) is estimated using OLS. The dependent variable is the natural log of the price in year 2007 USD. The descriptive statistics for the independent variables are shown in Table 1. For each variable, we report the coefficient (β), the standard deviation (S.D.), and the price impact (i.e., the exponent of the coefficient minus one). The number of observations (N) and the R-squared (R2) are presented at the bottom of the table.

	β	**S.D.**	**exp(β) - 1**
Year dummies	[included]		
Artist characteristics			
Artist dummies	[included]		
TEXTBOOK	0.1263	0.0065	13.46%
Work characteristics			
Attribution dummies			
ATTRIBUTED	-0.7365	0.0050	-52.12%
STUDIO	-0.7977	0.0134	-54.96%
CIRCLE	-1.0490	0.0068	-64.97%
SCHOOL	-1.4152	0.0120	-75.71%
AFTER	-1.8850	0.0104	-84.82%
STYLE	-1.5688	0.0064	-79.17%
Authenticity dummies			
SIGNED	0.2703	0.0027	31.04%
DATED	0.1706	0.0026	18.60%
Medium dummies			
OIL	[left out]		
WATERCOLOR	-0.7144	0.0033	-51.05%
DRAWING	-1.1005	0.0030	-66.73%
Size variables			
HEIGHT	0.0205	0.0002	2.07%
WIDTH	0.0250	0.0002	2.53%
HEIGHT_2	-0.0001	0.0000	-0.01%
WIDTH_2	-0.0001	0.0000	-0.01%
Topic dummies			
STUDY	-0.2049	0.0078	-18.53%
ABSTRACT	-0.0780	0.0068	-7.50%
ANIMALS	-0.1703	0.0094	-15.66%
LANDSCAPE	-0.1320	0.0048	-12.37%
NUDE	-0.1645	0.0105	-15.17%
PEOPLE	-0.0372	0.0050	-3.65%
PORTRAIT	-0.2278	0.0050	-20.37%
RELIGION	-0.1114	0.0082	-10.54%
SELF-PORTRAIT	0.1202	0.0171	12.77%
STILL_LIFE	0.0410	0.0067	4.18%
UNTITLED	-0.1639	0.0065	-15.12%
URBAN	0.0409	0.0081	4.17%
Sale characteristics			
Month dummies			
JANUARY	[left out]		
FEBRUARY	-0.1209	0.0072	-11.39%
MARCH	0.0318	0.0065	3.23%
APRIL	0.0859	0.0065	8.97%
MAY	0.1325	0.0062	14.16%
JUNE	0.1430	0.0063	15.37%
JULY	0.0843	0.0070	8.80%
AUGUST	-0.0629	0.0101	-6.09%
SEPTEMBER	-0.1599	0.0077	-14.78%

OCTOBER	0.0007	0.0065	0.07%
NOVEMBER	0.1821	0.0061	19.98%
DECEMBER	0.1517	0.0064	16.38%
Auction house dummies			
SOTH_LONDON	0.6324	0.0037	88.22%
SOTH_NY	0.7195	0.0041	105.35%
SOTH_OTHER	0.3107	0.0046	36.44%
CHR_LONDON	0.6468	0.0039	90.94%
CHR_NY	0.6685	0.0046	95.12%
CHR_OTHER	0.1540	0.0042	16.65%
BON_LONDON	0.1180	0.0094	12.52%
BON_OTHER	-0.1193	0.0125	-11.24%
PHIL_LONDON	0.2170	0.0079	24.23%
PHIL_OTHER	0.1164	0.0099	12.35%
AUCTION_EUROPEAN	0.1308	0.0033	13.98%
AUCTION_AMERICAN	-0.0968	0.0074	-9.22%
N	1,078,482		
R2	0.6411		

Table 3 – Baseline art price indices and art returns

Table 3 presents the art price indices and returns for the baseline hedonic regression model detailed in Table 2. For each year, we report the dummy coefficient (γ), the standard deviation (S.D.), the variance of the residuals (σ^2), the uncorrected price index and return (Π and r), and the price index and return that are corrected for changes in price dispersion over time (Π^* and r^*) (cf. Section III). Index values for 1963 are geometrically interpolated.

Year	γ	S.D.	σ^2	Π	r	Π^*	r^*
1957			1.1789	100.00		100.00	
1958	-0.0817	0.0402	1.1144	92.16	-7.84%	89.23	-10.77%
1959	0.2102	0.0384	1.2183	123.39	33.89%	125.85	41.03%
1960	0.2275	0.0380	1.1131	125.55	1.75%	121.48	-3.47%
1961	0.3014	0.0382	1.1805	135.18	7.67%	135.28	11.36%
1962	0.3327	0.0353	1.1744	139.47	3.18%	139.16	2.86%
1963	-	-	-	140.72	0.89%	140.61	1.04%
1964	0.3505	0.0355	1.1803	141.97	0.89%	142.07	1.04%
1965	0.5273	0.0338	1.1770	169.44	19.35%	169.27	19.15%
1966	0.6390	0.0345	0.9487	189.45	11.81%	168.85	-0.25%
1967	0.7044	0.0347	0.9466	202.26	6.76%	180.07	6.65%
1968	0.8423	0.0334	1.0564	232.17	14.79%	218.37	21.27%
1969	0.8716	0.0335	1.0208	239.08	2.98%	220.90	1.16%
1970	0.7773	0.0325	0.9335	217.57	-9.00%	192.44	-12.88%
1971	0.9410	0.0312	0.9100	256.25	17.78%	224.01	16.40%
1972	1.1224	0.0308	1.0856	307.22	19.89%	293.22	30.89%
1973	1.3932	0.0304	0.9249	402.77	31.10%	354.73	20.98%
1974	1.2909	0.0303	0.9030	363.61	-9.72%	316.75	-10.71%
1975	1.0670	0.0304	0.8847	290.66	-20.06%	250.89	-20.79%
1976	0.9606	0.0301	0.8685	261.31	-10.10%	223.75	-10.82%
1977	0.9581	0.0300	0.8779	260.68	-0.24%	224.25	0.22%
1978	1.0943	0.0300	0.8710	298.69	14.58%	256.07	14.19%
1979	1.1720	0.0299	0.8397	322.86	8.09%	272.49	6.41%
1980	1.1763	0.0299	0.8148	324.22	0.42%	270.26	-0.82%
1981	1.0436	0.0299	0.8329	283.94	-12.43%	238.83	-11.63%
1982	0.8652	0.0300	0.8095	237.56	-16.34%	197.49	-17.31%
1983	0.8888	0.0299	0.8137	243.21	2.38%	202.62	2.60%
1984	0.9058	0.0298	0.8711	247.40	1.72%	212.10	4.68%
1985	0.9976	0.0298	0.8566	271.17	9.61%	230.80	8.82%
1986	1.2319	0.0298	0.8567	342.76	26.40%	291.75	26.40%
1987	1.5505	0.0297	0.8845	471.38	37.53%	406.86	39.46%
1988	1.7498	0.0297	0.8662	575.35	22.06%	492.07	20.94%
1989	1.9651	0.0296	0.9220	713.58	24.03%	627.57	27.54%
1990	2.0252	0.0297	0.9227	757.79	6.20%	666.68	6.23%
1991	1.6356	0.0298	0.7791	513.24	-32.27%	420.25	-36.96%
1992	1.5304	0.0298	0.7576	462.02	-9.98%	374.26	-10.95%
1993	1.3661	0.0298	0.7699	392.01	-15.15%	319.51	-14.63%
1994	1.3595	0.0297	0.8066	389.41	-0.66%	323.27	1.18%
1995	1.3727	0.0297	0.8103	394.58	1.33%	328.17	1.52%
1996	1.3678	0.0297	0.7994	392.66	-0.49%	324.78	-1.03%
1997	1.3676	0.0297	0.8437	392.60	-0.02%	332.02	2.23%
1998	1.3954	0.0297	0.8626	403.65	2.82%	344.60	3.79%
1999	1.4458	0.0297	0.8745	424.54	5.17%	364.60	5.80%
2000	1.4157	0.0297	0.9165	411.94	-2.97%	361.28	-0.91%
2001	1.3539	0.0297	0.9354	387.26	-5.99%	342.86	-5.10%
2002	1.4276	0.0297	0.9354	416.88	7.65%	369.08	7.65%
2003	1.5405	0.0297	0.8974	466.69	11.95%	405.40	9.84%
2004	1.6462	0.0297	0.9214	518.74	11.15%	456.07	12.50%
2005	1.6691	0.0296	0.9769	530.76	2.32%	479.76	5.19%
2006	1.7724	0.0296	1.0711	588.51	10.88%	557.62	16.23%
2007	1.9786	0.0299	1.1133	723.27	22.90%	699.91	25.52%

Table 4 – Annualized returns for baseline indices, robustness checks, and extensions

Panel A of Table 4 presents the annualized (i.e., geometric average) returns and standard deviations (S.D.) over the periods 1957-2007 and 1982-2007 for the baseline art price indices detailed in Table 3. It also shows the number of observations (N) included in the estimation. Panel B shows the results for a number of robustness checks (cf. Section IV.B). Panel C repeats the adjacent-period hedonic model using quantile regressions (cf. Section IV.C). Panel D presents the RSR results for two different trading strategies (cf. Section IV.D). Panel E shows the return estimates (corrected for changes in price dispersion over time) for the different mediums and movements considered in this study (cf. Section IV.E).

		Real returns			
	N	1957-2007		1982-2007	
		Mean	S.D.	Mean	S.D.
Panel A: Baseline indices					
Art price index Π	1,078,482	4.04%	16.68%	4.55%	14.39%
Art price index Π*	1,078,482	3.97%	15.21%	5.19%	15.31%
Panel B: Robustness checks (compare to Π)					
Drop topic dummies	1,078,482	4.02%	14.05%	4.53%	14.39%
Exclude artists < 100 sales	935,736	4.04%	14.26%	4.57%	14.69%
Exclude Min. & Cont.	1,059,010	4.00%	13.95%	4.48%	14.26%
Adjacent-period model	-	-	-	4.60%	13.62%
Repeat-sales regression (RSR)	21,846 (x2)	-	-	4.56%	15.79%
Panel C: Quantile regressions					
Q95	862,290	-	-	6.32%	18.99%
Q75	862,290	-	-	5.77%	16.54%
Q50	862,290	-	-	4.91%	15.11%
Q25	862,290	-	-	3.89%	13.84%
Q05	862,290	-	-	1.35%	12.57%
Panel D: Trading strategies (compare to RSR)					
"Masterpiece" strategy	1,467 (x2)	-	-	4.81%	22.08%
"Value" strategy	727 (x2)	-	-	6.16%	20.99%
Panel E: Indices per medium and per movement					
Oil	650,563	4.63%	14.69%	5.73%	15.39%
Watercolor	187,612	3.67%	16.38%	3.96%	14.79%
Drawing	240,307	2.51%	20.64%	4.37%	15.22%
Medieval & Renaissance	30,806	3.01%	27.13%	6.44%	19.59%
Baroque	124,617	4.76%	17.69%	5.82%	12.57%
Rococo	30,292	3.69%	25.42%	5.03%	12.15%
Neoclassicism	12,601	6.32%	45.93%	5.36%	22.45%
Romanticism	41,897	4.28%	17.34%	4.79%	15.24%
Realism	60,820	2.57%	21.42%	4.16%	15.46%
Impressionism & Symbolism	95,829	4.10%	24.01%	4.55%	16.70%
Fauvism & Expressionism	73,543	3.72%	22.84%	4.90%	18.36%
Cubism, Futurism & Constr.	49,056	5.53%	22.40%	6.01%	20.55%
Dada & Surrealism	49,697	5.85%	32.32%	5.58%	19.42%
Abstract Expressionism	35,960	-	-	7.78%	21.91%
Pop	18,924	-	-	10.35%	29.33%
Minimalism & Contemporary	19,472	-	-	7.07%	23.68%

Table 5 – Art versus other assets

Panel A of Table 5 displays the geometric mean real returns on art and other assets since 1957 and since 1982. The real returns on art are based on our corrected price index Π^*, and are shown in Table 3. The return data for the financial assets, gold, and commodities come from Global Financial data. Data for U.S. real estate come from Shiller (2009). The panel also includes the standard deviation (S.D.) of the returns, and the arithmetic Sharpe ratio (i.e., the arithmetic average excess return divided by its standard deviation). The standard deviations for art are based on a desmoothed return series (cf. Section V). The return on T-bills is used as a proxy for the risk-free rate. Panel B shows the pairwise correlations between the returns since 1957. Correlation coefficients that are significantly different from zero at the 0.05 level are displayed in bold.

Panel A: Comparison of investment performance

	Real returns					
	1957-2007			1982-2007		
	Mean	S.D.	Sharpe	Mean	S.D.	Sharpe
Art	3.97%	19.05%	0.2000	5.19%	18.04%	0.2725
T-bills	1.39%	2.11%	N.A.	1.99%	1.88%	N.A.
U.S. government bonds	2.68%	10.56%	0.1853	5.77%	9.87%	0.4503
DJ corporate bonds	3.97%	9.74%	0.3443	6.81%	7.69%	0.7256
Global government bonds	3.07%	8.19%	0.2641	5.98%	7.53%	0.5717
S&P 500 stocks	6.63%	16.54%	0.4106	9.33%	15.34%	0.5707
Global stocks	6.34%	16.16%	0.3953	8.91%	16.76%	0.5039
Gold	2.35%	24.19%	0.1285	-0.89%	14.80%	-0.1171
Commodities	3.03%	11.40%	0.1780	2.06%	10.28%	0.0511
U.S. real estate	1.06%	4.06%	-0.0548	2.41%	4.73%	0.0902

Panel B: Correlations of returns

	Art	T-bills	U.S. government bonds	DJ corporate bonds	Global government bonds	S&P 500 stocks	Global stocks	Gold	Commodities	U.S. real estate
Art	1.00									
T-bills	0.01	1.00								
U.S. government bonds	-0.20	**0.56**	1.00							
DJ corporate bonds	-0.17	**0.58**	**0.90**	1.00						
Global government bonds	-0.10	**0.46**	**0.88**	**0.89**	1.00					
S&P 500 stocks	-0.03	**0.34**	**0.27**	**0.39**	**0.33**	1.00				
Global stocks	0.20	**0.28**	0.18	**0.32**	**0.33**	**0.88**	1.00			
Gold	**0.30**	**-0.54**	-0.18	-0.28	-0.13	-0.28	-0.15	1.00		
Commodities	**0.44**	**-0.41**	-0.26	-0.25	-0.25	-0.15	-0.07	**0.55**	1.00	
U.S. real estate	**0.39**	-0.24	-0.13	-0.13	-0.07	-0.15	0.02	0.24	0.16	1.00

Table 6 – Explaining the returns on art

Table 6 presents the results of a linear regression of art returns on a number of independent variables, over the period 1981-2007. Below each coefficient, we report Newey-West standard errors that control for heteroskedasticity and autocorrelation up to two lags. The real returns on art are based on our corrected price index Π^*, and are shown in Table 3. Model (1) only includes same-year and lagged global stock returns, from Global Financial Data, as independent variables. Column (2) adds (lagged and standardized) data from the University of Michigan's Survey of Consumers on the attitude of high-income (upper third) consumers with respect to the purchase of "major household items". Model (3) adds a newly constructed (lagged and standardized) art market sentiment measure, based on volume and buy-in rates at high-profile auctions, and on media reports (cf. Section VI). The number of observations (N) and the adjusted R-squared (R2) are presented at the bottom of the table.

Dependent variable: real returns on art	(1)		(2)		(3)	
Same-year global stock returns	0.1751		0.1325		0.1184	
	(0.1050)		(0.0901)		(0.0987)	
Previous-year global stock returns	0.5396	**	0.4012	*	0.2976	
	(0.2534)		(0.1941)		(0.2066)	
High-income consumer confidence			0.0677	***	0.0554	**
			(0.0226)		(0.0231)	
Art market sentiment					0.0425	**
					(0.0175)	
N	27		27		27	
Adjusted R2	0.33		0.49		0.52	

Figure 1 – Hedonic price indices

Figure 1 presents the baseline art price indices detailed in Table 3. Π is the uncorrected price index, while Π^* corrects for changes in price dispersion over time. The figure also includes the average and median real price for each year in our data set.

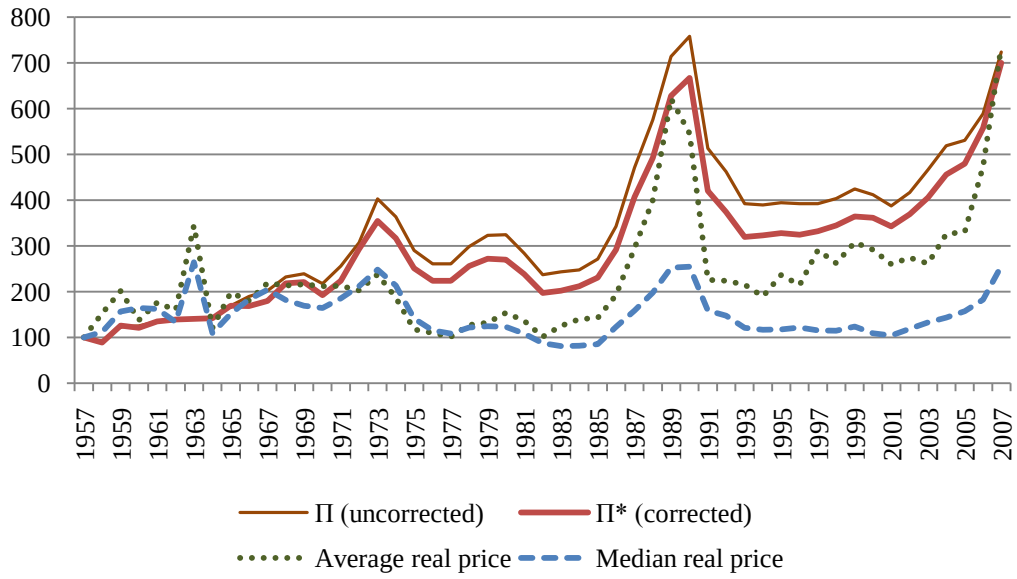

Figure 2 – Quantile regressions

Figure 2 presents the art price indices that result from repeating the adjacent-period hedonic model using quantile regressions (cf. Section IV.C).

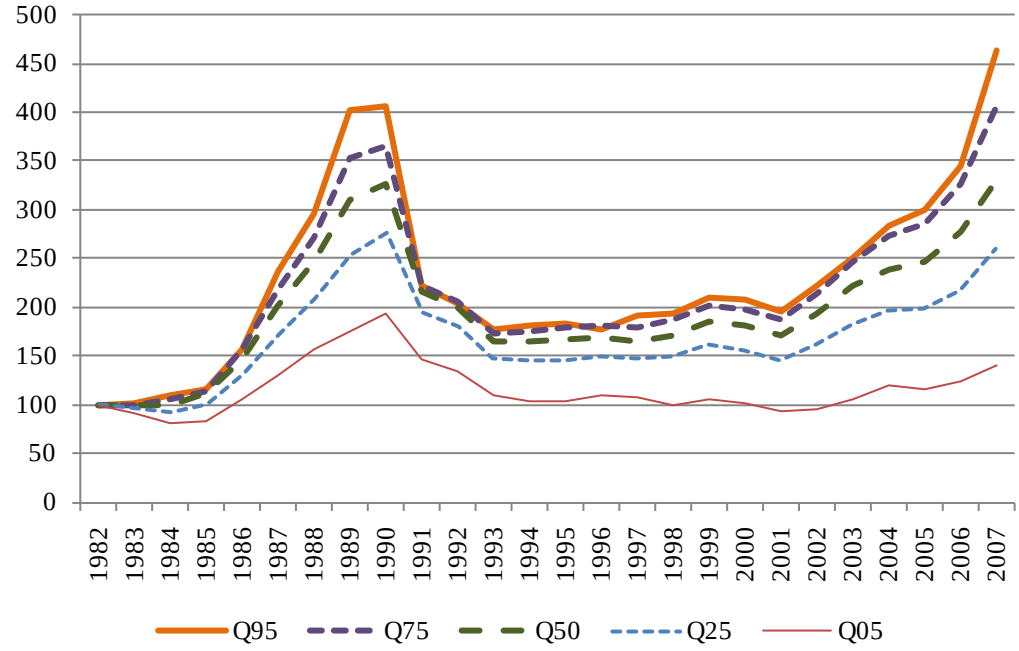

Figure 3 – Trading strategies

Figure 3 presents the index that results from applying an RSR to all item pairs that are considered to be repeated transactions (cf. Section IV.B), and the art price indices for a "masterpieces" and a "value" trading strategy (cf. Section IV.D).

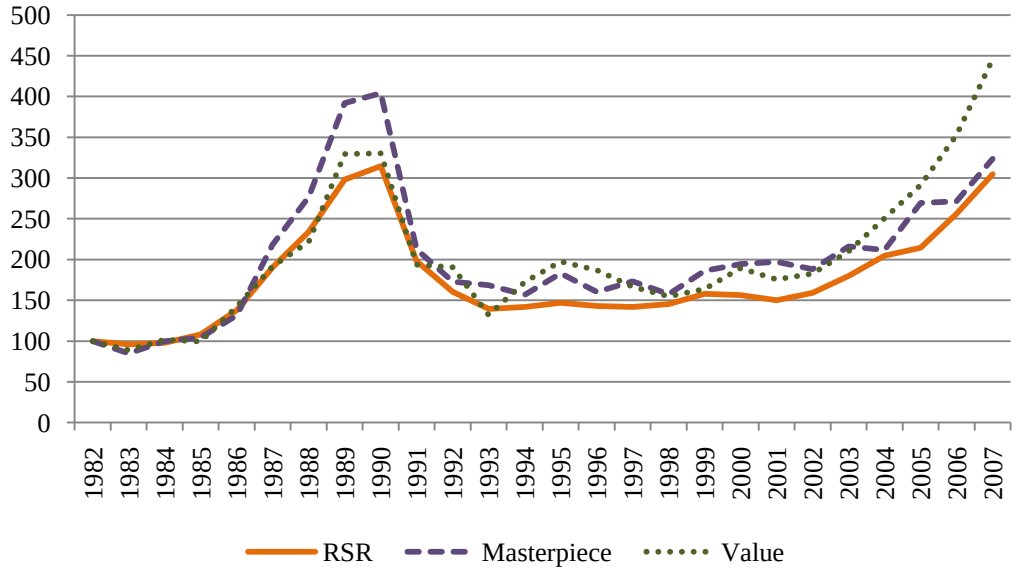

Figure 4 – Indices per movement

Figure 4 presents the (corrected) art price indices for three different movements: Rococo; Cubism, Futurism & Constructivism; and Pop (cf. Section IV.E).

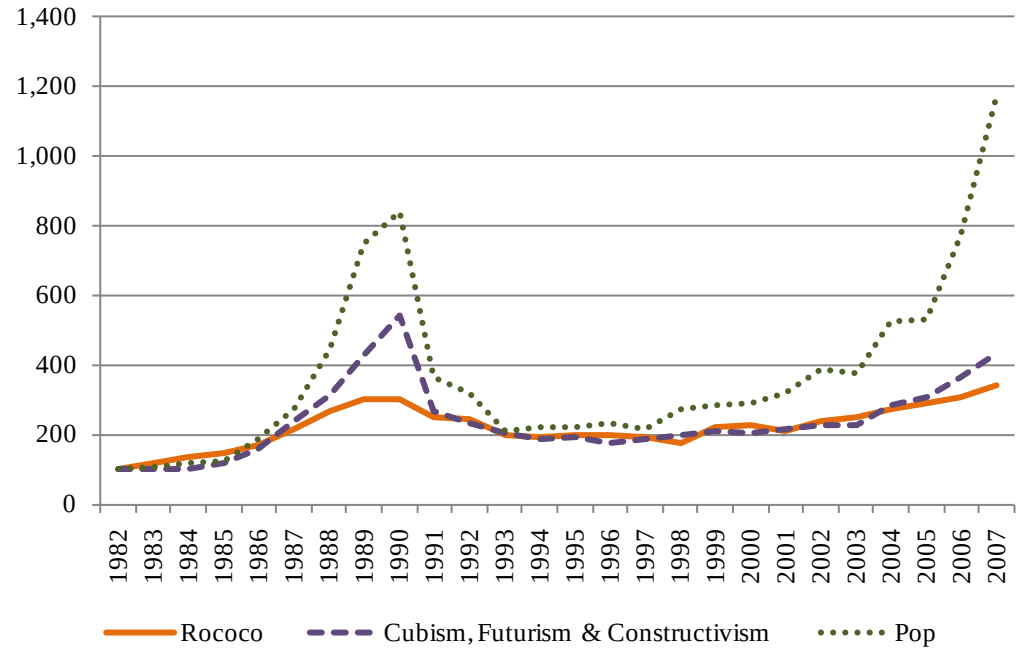

Figure 5 – Art market sentiment

Figure 5 presents the end-of-year values for the art market sentiment measure used in this study. It is based on volume and buy-in rates at high-profile auctions, and on media reports (cf. Section VI). It is standardized to have zero mean and unit variance.