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ON RETURNS AND RISK IN ART AUCTION MARKETS**

By

Yuexin Li, Marshall X. Ma,
Luc Renneboog

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Yuexin Li, Marshall Xiaoyin Ma, and Luc Renneboog*

ABSTRACT

We study price determinants and investment performance of art using a vast sample of transactions worldwide over the past 60 years. We focus on paintings and drawings, which have appreciated at a real (nominal) annual return of 2.49% (6.24%). Higher art returns are reached for paintings at the high end of the price distribution, oil paintings, more recent art movements, and transactions by reputable auction houses. The risk–return trade-off of paintings underperforms that of other passion investments. Paintings’ Sharpe ratios are below those of stocks, bonds, and gold but outperform those of commodities and real estate. Investments in paintings enter the optimal investment portfolio.

Keywords: auction; art investment; cultural economics; hedonic pricing model; repeat sales model.

JEL Code: D44, G20, G11, Z11

* Yuexin Li: yuexinli@ruc.edu.cn, School of Applied Economics, Renmin University of China, Beijing, 100872, China; Marshall Xiaoyin Ma: Ant Group, China, and Erasmus University, maxy@uvt.nl; Luc Renneboog: Luc.Renneboog@uvt.nl, Department of Finance, Tilburg University, Koopmans Building, Room 623, PO Box 90153, 5000 LE Tilburg, the Netherlands. Corresponding author: Yuexin Li. Yuexin Li gratefully acknowledges support from the Fundamental Research Funds for the Central Universities, and the Research Funds of Renmin University of China.

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ABSTRACT

We study price determinants and investment performance of art using a vast sample of transactions worldwide over the past 60 years. We focus on paintings and drawings which have appreciated at a real (nominal) annual return of 2.49% (6.24%). Higher art returns are reached for paintings at the high end of the price distribution, oil paintings, more recent art movements, and transactions by reputable auction houses. The risk–return trade-off of paintings underperforms that of other passion investments. Paintings’ Sharpe ratios are below those of stocks, bonds, and gold but outperform those of commodities and real estate. Investments in paintings enter the optimal investment portfolio.

1. Introduction

The growth of art markets is driven by increasing art prices and demand. The underlying drivers of demand are economic development, wealth accumulation and concentration, income inequality, and the emergence of new art-buying audiences, such as the financial elite of developing economies, including China, Russia, and India. The modern art market has been growing rapidly. The market was dominated by European auction houses up to the 1950s but is now a global market with more than 30,000 auction houses worldwide that have auctioned artworks created by more than 150,000 artists over the past half-century. The increase in studies on art as an investment over the past 30 years gives evidence of increasing interest in the financial performance of the art market. The estimated value of art and collectables held by high-net-worth individuals is approximately USD 1.74 trillion (Deloitte and ArtTactic, 2019). Global art sales grew from USD 40 billion in 2009 to USD 67 billion in 2018, dipping to USD 64 billion in 2019. The COVID-19 pandemic reduced the global art auction value to USD 50 billion in 2020. The auction sector currently accounts for 42% of the value of global art sales, with dealers and galleries accounting for the remaining 58%. Online sales have grown significantly over the

past year and received a strong boost during the global pandemic, reaching a record high of USD 12.4 billion in 2020 (Art Basel and UBS, 2021).

New price records for art are being set constantly. The most striking example is of Leonardo da Vinci's *Salvator Mundi*, which was sold by Christie's for USD 450.3 million in November 2017 after 20 minutes of fierce bidding. This auction broke the previous world auction record for the most expensive painting sold, *Interchange* by Willem de Kooning, which sold for USD 300 million but held the record for only 14 months. In addition to the exorbitant amount of money paid for *Salvator Mundi*, the return was substantial, having previously been auctioned for a mere GBP 45 by Sotheby's London in 1958. Although doubts about the painting's authenticity persist, it was authenticated as a *bona fide* Leonardo da Vinci work at the beginning of the 21st century. Such exceptionally high prices and returns raise questions about whether investing in art generally yields superior returns, what determines the price of paintings, the risk–return trade-off in modern art markets, and whether art belongs in a diversified investment portfolio.

For this study, we collect almost three million auction transactions of paintings over 1957–2016 and apply several methods to calculate the price index series. In our hedonic pricing models, the variables include artist reputation, physical characteristics of the painting (e.g. size, medium, signed, and dated), provenance (pedigree, exhibition history, literature, and certification), and transaction characteristics (auction house [branch], seasonality, etc.). We verify the size of the returns derived from the price index using three-stage weighted least-squares repeat sales regressions, adjacent-period hedonic regressions, and quantile regressions. Our results show that artist reputation, attribution, authenticity (signed, dated), medium, size, topic, provenance information, and the timing and location of the sale all significantly affect hammer prices. The coefficients of the time dummies enable us to construct a price index. Constant-quality art prices increased annually by a moderate 2.49% (6.24%) in real (nominal) USD over 1957–2016. Our results are lower than those reported by Goetzmann (1993), Korteweg, Kräussl, and Verwijmeren (2016), Mei and Moses (2002), Renneboog and Spaenjers (2013), and Spaenjers, Goetzmann, and Mamonova (2015) but higher than those of Pesando (1993). An important reason is that Goetzmann (1993), Mei and Moses (2002), and Spaenjers et al. (2015) use selective samples comprising only higher-end artworks, and thus, are less representative of the entire

art market. To comprehend the price fluctuations in modern art auction markets, we examine the investment performance over different holding periods, including bubble and bust periods, as well as for various subsamples based on a stratification of price levels for samples based on the medium (oil and acrylic paintings, watercolours and gouaches, and drawings), art movements, transactions by auction house reputation, transactions categorised by artist nationality, art market segments (local vs. international), and paintings created in various phases of an artist's career cycle. We find that both returns and risk in the first three decades of our sample period (1957–1986) exceed those in the subsequent three decades (1987–2016). Returns and risk are also higher for oil and acrylic paintings than for watercolours and drawings, for more recent art movements (e.g. *Minimalism and Contemporary*, *Pop Art*, and *Abstract Expressionism*), auctions organised by the Big Four auction houses (Sotheby's, Christie's, Bonhams, and Phillips), transactions in the international art auction market, and paintings created in the last phase of an artist's career cycle.

Investments in paintings outperform alternative investments in sculptures but underperform investments in other types of collectables or passion goods such as investment-grade white diamonds, classic cars, premier cru (first growth) red Bordeaux wines, stamps, and fine violins. The return by unit of risk of art investments is lower than that of equities, corporate bonds, and gold, but exceeds that of global commodities and real estate in the United States (US). As the correlations between paintings on the one hand and stocks and bonds on the other are negative, we study whether investments in paintings contribute to optimal portfolio allocation. The academic finance literature has focused on art performance (Korteweg et al., 2016; Lovo & Spaenjers, 2018; Mei & Moses, 2002; Renneboog & Spaenjers, 2013); its financial and macro-economic market drivers, such as equity market evolution and income inequality (Goetzmann, Renneboog, & Spaenjers, 2011); sentiment and hype (Pénasse, Renneboog, & Spaenjers, 2014); gender bias (Adams, Kräussl, Navone, & Verwijmeren, 2021; Bocart, Gertsberg, & Pownall, 2021; Cameron, Goetzmann, & Nozari, 2019); the impact of colour (Ma, Noussair, & Renneboog, 2021); behavioural anomalies, such as anchoring (Beggs & Graddy, 2009; Graddy, Loewenstein, Mei, Moses, & Pownall, 2015); art market bubbles (Pénasse & Renneboog, 2021); and artists' death as a supply shock (Pénasse, Renneboog, & Scheinkman, 2021).

While an art investment is expected to yield a combination of a monetary return and unobservable emotional value (an aesthetic dividend derived from ownership rights), this study focuses only on the financial performance of art. In line with Ashenfelter and Graddy (2003), we note that the estimated returns on art vary with samples, the method to calculate price indices, and sample period. Early studies used simple estimation methods without controlling for variables capturing the quality of the artworks (Baumol, 1986; Frey & Pommerehne, 1989; Stein, 1977).¹ More recent studies use either hedonic regressions or repeat sales regressions to estimate the price movements of art and other illiquid assets (e.g. real estate). The benefit of hedonic models is that they control for quality changes in the transacted goods by attributing implicit prices to their utility-bearing characteristics. In the commonly used time-dummy variant of hedonic pricing models, all available transaction data are pooled and prices are regressed on a set of value-determining attributes, including time indicators. Under the assumption that all omitted characteristics are orthogonal to those included, the coefficients on the time dummies account for constant-quality price trends over the sample period (Meese & Wallace, 1997). Since no observations are discarded, hedonic regressions efficiently use available data, and therefore, may provide more reliable estimates of price indices than repeat sales regression. The repeat sales models explicitly control for variations in quality between works of art by only retaining resales, but this entails that only small samples are examined. Approximately 3% of artworks – even over long-time windows spanning decades –re-enter the auction market, and thus, constitute a pair of repeat sales.² Meese and Wallace (1997) argue that such small databases may misrepresent the market and show that repeat sales regression estimators are sensitive to influential observations. Furthermore, most repeat sales studies suffer from additional selection bias, usually induced by selecting transactions from the most expensive auction rooms in the world.³ Korteweg et al. (2016) provide a theoretical framework to correct for

¹ Stein (1977) considers the auctioned objects 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 timeframe.

² For example, Mei and Moses (2002) include 4,896 sales pairs over the period 1875–2000, and Goetzmann et al. (2011) use a sample of 1,336 repeated sales pairs over the period 1830–2007.

³ For instance, Mei and Moses' (2002) sample includes paintings with a first transaction anywhere in the world but a resale at Sotheby's or Christie's New York. Moreover, the initial purchase is identified using the entries in the New York sales catalogues. Many repeat sales studies also include the *Reitlinger Data*, which are books comprising auction price data from the 18th century until the 1950s, and are recognised as incomplete and biased,

sample selection when investing in illiquid assets that trade endogenously and show an asymmetric V-shaped relationship between sale probabilities and returns. Adjustment for the selection bias in a subsample of repeat sales leads to a reduction of annual nominal raw returns by 2.4 percentage points and more than halves the artworks' return by unit of risk. As such, the bias adjustment reduces the attractiveness of art as part of a broad investment portfolio but does not exclude a positive portfolio allocation to specific art schools or top-selling artists. Lovo and Spaenjers (2018) present an infinite-horizon model of endogenous trading in the art auction market and show that the upward bias in estimating the market value of an artwork based on transaction prices of comparable artworks can be corrected by studying repeat sales auction transactions with long holding periods.⁴

This study extends the previous literature in several ways. This study relies on a much larger data sample than prior works, comprising a large cross-section of tens of thousands of sales per year and a long time window spanning six decades. The sample also includes several bubbles, such as the 1980s bubble and the bubble triggered by the Great Recession that started in 2008. Furthermore, the sample includes a broad set of auctions, including those organised in emerging markets (e.g. China). The data enable us to perform detailed analyses on subsamples based on art movements and market segments. We also show a panoramic picture of the art market over the past 60 years and, in particular, provide insights into recent art market performance since the Great Recession (2008 onwards).

The rest of this paper proceeds as follows. Section 2 describes the methodology and data, Section 3 reports art price indices composed from the baseline model and by different categories. Section 4 reports the return and risk features of the art market. Section 5 concludes the study.

as the focus is disproportionately on famous artists (Guerzoni, 1995). Thus, an index estimated based on this sample may be biased upwards.

⁴ Biased prices may also arise because of prejudice: the demand for the oeuvre of female artists is low, and *ceteris paribus*, the gender discount in hammer prices amounts to 47.6% (Adams et al., 2021). The discount seems higher in countries with greater gender inequality. The authors show that this is gender bias because, in experiments, participants cannot guess the gender of an artist simply by looking at a painting. Thus, the authors conclude that women's art appears to sell for less because it is made by women. It should be noted that this result is contested by both Bocart et al. (2021) and Cameron et al. (2019).

2. Methodology and Data

2.1 Methodology

2.1.1 Hedonic Pricing Model

We use a hedonic pricing model with the natural logarithm of hammer prices (in real USD terms) as the dependent variable to investigate the effects of the hedonic variables (independent variables describing the art object and the transaction) on price.⁵ The main advantage of this type of model is that returns can be calculated using an index based on all observed transactions, and not just on repeat sales.

The basic specification is

$$\begin{aligned} \ln(\text{Price}_{kt}) = & \alpha + \sum_{m=1}^M \beta_m \text{Artist}_{mkt} + \sum_{p=1}^P \beta_p \text{Artwork}_{pkt} + \sum_{q=1}^Q \beta_q \text{Provenance}_{qkt} \\ & + \sum_{n=1}^N \beta_n \text{Transaction}_{nkt} + \sum_{t=1}^T \gamma_t D_{kt} + \varepsilon_{kt} \quad (1) \end{aligned}$$

where Price_{kt} represents the hammer price of art object k at time t ; Artist_{mkt} captures the artist-specific attributes m of item k at time t ; Artwork_{pkt} represents a set of artwork-specific attributes, such as physical characteristics or topics p ; Provenance_{qkt} stands for provenance-related attributes q ; and Transaction_{nkt} represents transaction-level attributes n , which include auction house (branch) and month of sale. The β -coefficients reflect the relative shadow prices of the corresponding characteristics. We detail the hedonic variables in the data section below. D_{kt} stands for the time indicator variables, the year in which the art object is offered for sale. The coefficients γ_t reflect the time trend, which can be used to construct the art price index. For each year t , we take

$$\Pi_t \equiv \exp(\hat{\gamma}_t) \times 100 \quad (2)$$

The index enables us to calculate the return of art for each year t as follows:

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

⁵ The Blouin database gives either the hammer prices or the premium price, which is the hammer price plus a commission averaging 15%, paid by the buyer. Given that the actual commission percentage is not available, we divide the premium price by 1.15 as an approximation of the hammer price. The hammer price is then deflated by US CPI, taking 2007 as the base year.

The index generated by Equation (2) may lead to overestimation of returns owing to the log-transformation of the dependent variable. If there is time-varying dispersion of prices, a correction method can be implemented (Renneboog & Spaenjers, 2013; Silver & Heravi, 2007; Triplett, 2004). Assuming that the hedonic regression residuals are normally distributed in each period, we define the ‘adjusted’ index, corrected for Jensen’s inequality, as follows:

$$\Pi_t^* \equiv \exp\left(\hat{\gamma}_t + \frac{1}{2}(\hat{\sigma}_t^2 - \hat{\sigma}_0^2)\right) \times 100 \quad (4)$$

where $\hat{\sigma}_t$ and $\hat{\sigma}_0$ are the estimated variances of the residuals (i.e. ε_t and ε_0) of observations in periods t and 0, respectively. The adjusted return estimate in year t is defined as follows:

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

An underlying assumption of Equation (1) is that the price impact of the hedonic variables is stable over the entire sample period. This means that, for example, tastes, preferences for specific topics, or paintings of a specific size are assumed to be constant. To allow for time-varying tastes (e.g. yearly or every five years), we also apply (as a robustness test) an adjacent-period hedonic model, as this accounts for time-varying hedonic shadow prices. Hence, we run separate hedonic regressions every two years and then chain-link the time dummies to create an art index.

We apply quantile regressions to account for art-market segmentation as an additional robustness check. Segmentation may depend on price ranges, with the high-end art market being within the reach of high-wealth individuals. Collecting expensive pieces of art may signal social status (Mandel, 2009). Furthermore, tastes based on specific types of art (e.g. schools of art) may create demand-based segmentation. While ordinary least squares (OLS) regressions provide estimates for the conditional means only, quantile regressions can be particularly useful for characterising the entire distribution of the dependent variable (Koenker & Hallock, 2001; Scorcu & Zanola, 2011; Zietz, Zietz, & Sirmans, 2008). We run a quantile variant of our adjacent-period hedonic regression model every two years since 1957 for the following percentiles: 95th, 75th, 50th, 25th, and 5th. We split our sample into sub-periods to ensure that the quantile regression coefficients pick up variations in the valuation of hedonic attributes

across price brackets as well as time. The quantile hedonic price indices are then constructed by chain-linking the coefficients on the year dummies for the relevant quantiles.

2.1.2 Repeat Sales Model

Another method to obtain a return series is based on calculating the pairwise returns of repeat sales. The main advantage of this method is that it controls for the uniqueness of each work. To obtain the repeat sales returns, we retain resold paintings from the same artist (excluding the artworks with attribution ‘style’, ‘after’, ‘school’, ‘circle’, ‘studio’, and ‘attributed’), with the same title, size, and medium, and for which the signature and date are present. Identifying matches is not straightforward, as some artists give the same title to multiple paintings, and canvas sizes are often similar. To rule out false pairs, we verify the repeat sales by visually inspecting pictures of the paintings.⁶ In this way, we identify 63,430 repeat sale pairs in our sample. We calculate the returns based on hammer prices in USD from two adjacent auctions of the same painting.

We assume that the continuously compounded return for a certain painting i in period t , $r_{i,t}$, equals the continuously compounded return of a price index of art (μ_t) plus the error term $\eta_{i,t}$:

$$r_{i,t} = \mu_t + \eta_{i,t} \quad (6)$$

where μ_t can be regarded as the average return of paintings in the portfolio in period t . We use repeat sales data on individual paintings to estimate the price index μ_t over time intervals $t = 1, 2, \dots, T$. The return of individual painting i , r_i , can be expressed as the log of the sales price ($P_{i,s}$) divided by the buying price ($P_{i,b}$). In Equation (7), r_i can be rewritten as the sum of returns $r_{i,t}$ during the entire holding period from $b_i + 1$ to s_i where b_i and s_i stand for buy and sell dates, respectively:

$$r_i = \ln\left(\frac{P_{i,s}}{P_{i,b}}\right) = \sum_{t=b_i+1}^{s_i} r_{i,t} = \sum_{t=b_i+1}^{s_i} \mu_t + \sum_{t=b_i+1}^{s_i} \eta_{i,t} \quad (7)$$

⁶ We exclude all the repeated transactions with a holding period of less than half a year, as some of these repeat sales may be errors in the database. The return trip transaction costs are at least 20%, which may preclude quick reselling, and it usually takes several months before an item can be offered for sale by an auction house (one has to wait for the right auction and the auction house has to undertake a due diligence, include the item in the auction catalogue, and offer this catalogue to potential buyers approximately 4–6 weeks before the auction).

Consistent with Goetzmann (1993) and Mei and Moses (2002), we apply the three-stage estimation procedure developed by Case and Shiller (1987). In the first stage, we apply OLS and regress returns, $\ln\left(\frac{P_{i,s}}{P_{i,b}}\right)$, on a matrix (containing a row for each painting and a column for each holding time period) with dummy variables indicating the holding period of each painting. In the second stage, we regress the squared residuals from the first stage on the time span between sales and an intercept. We repeat the first-stage regression using weighted least-squares with the fitted squared residuals of the second stage as weights in the third stage. The coefficients we obtain in the third stage are the corresponding returns for each period.

2.1.3 Unsmoothing Risk

The year fixed-effects coefficients from Equation (1) yield an art market index. However, the true risk of the art market may be underestimated by the standard deviation of the appraisal-based index returns, because appraisers may lag the true value changes (a sort of ‘tyranny of past values’ phenomenon) (Geltner, 1991). Art as an investment is less liquid than financial assets, such as equities and bonds, due to the lack of a continuous auction market. Consequently, changing appraisals of art assets may depend on past prices and may take more time to affect prices. Therefore, the first differences in index levels may be autocorrelated. To adjust for appraisal smoothing of return series, we unsmooth the price-time series, as originally applied in the real estate literature (Dimson & Spaenjers, 2011; Geltner, 1993).

We use the adjusted index and unsmooth the adjusted returns (as defined in Subsection 2.1) to calculate the risk. If we assume that all items are reappraised at the end of each period, the observed (smoothed) return in period t , r_t^* , can be expressed as a weighted average of the true (unsmoothed) return in period t , r_t^u , and the smoothed return from the previous period, r_{t-1}^* (Geltner, 1993):

$$r_t^* = (1 - \alpha)r_t^u + \alpha r_{t-1}^* \quad (8)$$

The appraisal smoothing factor α is a fraction between 0 and 1, and is determined by the autocorrelation coefficient.⁷ Equation (8) can be inverted to obtain the unsmoothed return series R_t^u from the observed returns r_t^* and r_{t-1}^* :

$$r_t^u = \frac{r_t^* - \alpha r_{t-1}^*}{1 - \alpha} \quad (9)$$

We can then obtain the unsmoothed risk from the unsmoothed adjusted return series r_t^u .

2.2 Data

2.2.1 Data and Variables

Our analysis is based on auction data spanning six decades, starting from 1957 and covering sales by auction houses and art galleries from all over the world. We gather 2,874,652 auction records of ‘paintings’ (including oil and acrylic paintings, watercolours and gouaches, and drawings) created by 155,156 artists. These auction records from the Hislop Art Sales Index and the Blouin database reveal that 78.5% of the auctioned paintings were sold in auctions (2,257,485 observations of successful auction sales) and that the remainder was ‘bought in’ (21.5%). We also collect artist biographical information from Oxford Art Online (Grove Art, Oxford University Press) to cross-check artists’ nationality and birth year and to partition artists into art movements (if applicable). We categorise this information according to the following dimensions:

First, the set of $Artist_{mkt}$ variables comprises:

- *Artist*. Artist fixed effects account for artists’ reputations and other personal traits.
- *Deceased artist*. This dummy equals one for sales taking place after the artist’s death. Art prices and turnover may increase after the artist’s death (Pénasse et al., 2021).
- *Nationality*. We collect artists’ nationalities while allowing for multiple nationalities by the artist.

⁷ Assuming that the smoothed series follows an AR(1) process, we can set the coefficient α equal to the autocorrelation coefficient at lag 1. This newly constructed series then has a first-order autocorrelation close to zero. In our sample, the autocorrelation coefficient at lag 1 for the unadjusted index is 0.2827, and that for the adjusted index is 0.2923.

- *Art movement dummies*. Based on the art movement information from Oxford Art Online, we classify artists (if applicable) into 13 art movements: *Medieval and Renaissance; Baroque; Rococo; Neoclassicism; Romanticism; Realism; Impressionism and Symbolism; Fauvism and Expressionism; Cubism, Futurism, and Constructivism; Dada and Surrealism; Abstract Expressionism; Pop Art; Minimalism and Contemporary*. The left-out benchmark consists of unclassified artists⁸.

Second, a vector of price-determining variables ($Artwork_{pkt}$) captures the physical, attribution, authenticity, and topic characteristics of the painting:

- *Attribution*. As attribution uncertainty can lead to substantial price discounting, we generate an indicator variable capturing the existence of doubt about the identity of the painting's creator.⁹
- *Authenticity*. The dummy equals one if the auctioned painting contains physically identifiable markings, such as signatures, dates, or inscriptions that enhance the authenticity of the art object.
- *Medium*. We introduce dummies for oil and acrylic paintings, watercolours and gouaches, and drawings.
- *Size*. The height and width in centimetres are represented by *Height* and *Width*, and their quadratic forms are *height squared* and *width squared*, respectively.
- *Topic*. We categorise the works in different topic groups based on the keywords of the artworks' titles using textual analysis based on the six most important languages used in the art auction world.¹⁰ We retain 13 categories: *abstract, animals, landscape, seascape, urbanscape, nude, people, self-portrait, portrait, religion, still life, study, and other topics*. *Untitled* is the omitted benchmark in the regression.

Third, the vector $Provenance_{qkt}$ contains provenance information offered in the auction catalogue along its four dimensions (Li, Ma, & Renneboog, 2021):

⁸ For 64.5% of the sales sample, the artist cannot be classified as belonging to an art movement.

⁹ Different levels of attribution are used in the art auction world: attributed to, studio of, circle of, school of, after, and in the style or manner of. These variables are especially important for older styles (pre-20th century), such as old masters, *Baroque*, and *Rococo*.

¹⁰ These are English, Dutch, French, German, Italian, and Spanish.

- *Pedigree*. This variable equals one if there is textual information about the painting's pedigree (past ownership, previous sales information, etc.).
- *Literature*. This variable equals one if there is textual information about the literature covering the painting. Art-related literature includes scholarly articles, publications by art critics and experts, art catalogues, and *catalogue raisonné*.
- *Exhibition*. This variable equals one if there is textual information about the exhibition history of the painting.
- *Certification*. This variable equals one if there is textual information about the authentication, either in the form of a physical certificate or oral confirmation of past ownership.

Fourth, we include the vector $Transaction_{nkt}$, which stands for transaction-level attributes, such as the time (month) of the sale, and the reputation and location of the auction house:

- *Auction house (branch)*. We introduce auction house fixed effects for every auction house at the branch level and distinguish among different types of fine art auction houses based on reputation. For Sotheby's and for Christie's, we introduce dummy variables for their London, New York, and other salesrooms (e.g. Sotheby's London, Sotheby's New York, and Sotheby's Other Branches). Together, these two institutions account for more than 32% of all sales in our sample. For two other large reputable British auction houses, Bonhams and Phillips (B&P), we make a similar distinction between London, New York, and other salesrooms. We also pool medium-sized American and European auction houses (see Appendix I). Smaller auction houses around the world are the benchmark.
- *Month*. Important sales are often clustered in time, and the busiest periods are the spring and autumn auctions (May–June and November–December, respectively). January is the benchmark omitted from the analysis.
- *Year*. We include year fixed effects; the exponentials of the year's fixed-effect coefficients yield an art index.

2.2.2 Summary Statistics

Of the 2.3 million successful auction sales in our data set, 82% occurred after the artist's death (Table 1). The nominal average (median) hammer price is approximately USD 47,000 (USD 4,000). Artists born or working in France, the United Kingdom (UK), the US, Italy, Germany, Belgium, and the Netherlands, make up more than 70% of the sample, making these countries the top seedbeds for artists. *Baroque, Impressionism and Symbolism*, and *Fauvism and Expressionism* constitute the best-selling art movements in terms of transaction volume (number of sales). The average painting measures 56 cm in height and 58 cm in width. Of these, 65% are oil or acrylic paintings, 19% watercolours and gouaches, and 16% drawings. In relation to physical evidence confirming or supporting authenticity, 71% are signed, 35% of paintings are dated, and 13% are inscribed. There is doubt about the painting's authenticity for approximately 3% of the auctioned paintings and attribution induces a discounting factor relative to an undisputed painting. Meanwhile, 43% of paintings do not have a clear topic that can be determined using textual analysis of titles. The most common non-abstract topics are landscapes (16%) and scenes with people (11%). Concerning provenance, approximately 14% of paintings contain pedigree information, 5% of paintings were part of exhibitions, approximately 5% were covered in art-related literature (e.g. *catalogue raisonné*), and 2% were sold with certificates (either in a physical form or an oral confirmation by, e.g. the artist). The spring (May–June) and autumn (November–December) seasons each account for more than 25% of sales. Sotheby's and Christie's (S&C) are the most prominent auction houses and together account for 32% of the worldwide auction sales over the past six decades. Their London and New York salesrooms are the most important branches in terms of volume and price.

[Insert Table 1 about here]

3. Art Price Indices

3.1 Baseline Price Indices

In Table 2, we show the output of the baseline hedonic pricing model (Equation (1)) with the natural log of real USD hammer prices as the dependent variable. Columns (1) and (2) present the coefficients

and their standard deviations, and Column (3) shows the corresponding price impacts (calculated by taking the exponent of the coefficient and then subtracting one).

Artworks with attribution labels ('style', 'after', 'school', 'circle', 'studio', and 'attributed') are priced with large discounts ranging from 50% to 80%, which increase the larger the 'distance' from the original artist's work. For instance, a painting attributed to Rubens (whose attribution may still be in doubt) sells at a discount of 52% to an uncontested Rubens, while a *Baroque* painting from the 'school' of Rubens sells at a 74% discount to the original. Signed or dated paintings tend to sell at a premium (close to 20%) to paintings without any sign of authenticity. Oil and acrylic paintings as well as watercolours and gouaches are priced 235% and 57% higher, respectively, than drawings (the benchmark). 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. Additionally, artworks on portraits, studies, and nudes are traded at a discount, whereas, self-portraits, urbanscapes, seascapes, and still lifes command premiums ranging from 8% to 20% (over the benchmark category of paintings for which the topic could not be identified by title analysis). Paintings for which provenance information is provided in the auction catalogue are considered to be attested. The provenance dimensions, pedigree, exhibition, and literature yield an extra 36% to 56% premium, and paintings with certification information are sold for an additional 13%. The hedonic model also includes the topics of the paintings and reveals that artists' self-portraits fetch the highest prices, as these paintings render not only a specific style but also depict a view on the creators themselves, while the lowest prices are expectedly paid for studies. Table 2 confirms that Sotheby's and Christie's London and New York branches sell artworks with the highest prices on average. The most expensive auctions are clustered in spring (May–June) and autumn (November–December).

[Insert Table 2 about here]

Using the model in Table 2, we construct the baseline and adjusted hedonic price indices and returns (as discussed in Subsection 2.1.1). Figure 1 depicts the evolution of the baseline and adjusted hedonic indices as well as the repeat sales index from 1957. Two boom periods are clearly visible: 1985–1990 and 2002–2007. The annual increase in real prices exceeded 20% between 1986 and 1990.

Hiraki, Ito, Spieth, and Takezawa (2009) demonstrate that the Japanese real estate and equity bubble strongly affected international art prices in the second half of the 1980s, particularly impressionist paintings. More generally, French art was preferred by Japanese collectors. In the wake of the strong increase in prices for French art, the demand for art in general, including modern art, surged. The second art market bubble period coincided with the equity market increase that lasted until the Great Recession, which commenced in the second half of 2007. The magnitude of the art price increase during the second boom period was smaller than that of the first.

In the abovementioned hedonic models, the shadow prices of the physical characteristics are constrained to be stable over the sample period, and they may change over time. Accounting for changes in taste, we apply an adjacent-period model based on every two consecutive years and then chain-link the time coefficients. We find that the adjacent-year price index depicts price trends similar to those observed using the baseline and adjusted indices.¹¹ In summary, the annualised (adjusted for Jensen's inequality) arithmetic mean real returns and volatility based on the hedonic index models amount to 2.90% (2.49%) and 15.91% (16.21%), respectively. When using the adjacent-period method, the return and risk amount to 1.72% and 15.52%, respectively. The annual returns and volatility obtained by means of the repeat sale index, necessarily based on a much smaller sample and probably upward bias, amount to 3.97% and 21.67%, respectively.¹²

[Insert Figure 1 about here]

3.2 Quantile Price Indices

Art markets are segmented; they comprise a high-end market in which prices are only within the reach of high-wealth individuals, down to a low-end market in which art objects are auctioned for hammer prices of a few hundred US dollars. Price segmentation may affect the distribution of returns, as the shadow prices of hedonic characteristics may vary across the distribution of auction prices.

¹¹ See Online Appendix Figure OA.1.

¹² The baseline and adjusted price indices and the repeat sales index are given in Online Appendix Table OA.1, which also shows geometric returns of 1.69%, 1.22%, and 1.88%, respectively. The adjacent-period price indices (including the quantile indices) are presented in Online Appendix Table OA.2.

Consequently, we calculate the risk and return across price segments using quantile regressions. This approach is useful when the conditional distribution of the dependent variable is not symmetric. We estimate an adjacent-period quantile regression for every two years over the time window 1957–2016 for the 95th, 75th, 50th, 25th, and 5th percentiles. We use adjacent sub-periods to ensure that the quantile regression coefficients pick up variations in valuing hedonic attributes across price levels rather than across time. We then chain-link the coefficients on the time dummies for each quantile to obtain a price index by price-based market segments. Figure 2 shows that there have been large dispersions in art returns by price segment since 1957. However, we observe that returns are higher in the high-end market. The annual arithmetic real return at the 95th percentile amounts to 2.23%, whereas this return at the lowest end of the market (5th percentile) is 1.46%.¹³ The risk across percentiles is rather stable; for the 5th percentile, it is even higher (at 16.54%) than that of the 95th percentile (15.93%). The prices at higher percentiles increase more during boom periods. For example, during the mid-1980s, prices at the 95th percentile increased by approximately 241%, while those at the 5th percentile increased by approximately 182%. During the early-1990s bust, the market dropped by about half across all percentiles, for example, by 46% at the 5th percentile, 47% at the 50th percentile, and 48% at the 95th percentile.

[Insert Figure 2 about here]

3.3 Art Medium

Our sample of ‘paintings’, the name assigned for simplicity, comprises three subsamples based on the medium: (i) oil and acrylic paintings, (ii) watercolours and gouaches, and (iii) drawings. Market segmentation based on mediums may be related to price segmentation, as drawings are considerably cheaper than oils but may also be segmented by collectors’ preferences and specialisations. Therefore, we create a price index for each subsample by estimating the base model (Equation (1)). Figure 3 depicts the three price indices and reveals that the oil paintings, watercolours, and drawings follow similar price patterns from 1957 to 2000. Prices increase from 1957 to 1973, the year in which they level off and

¹³ See Online Appendix Table OA.2.

subsequently decline by one-third. A substantial price recovery commences in the second half of the 1980s, prices triple (in real terms) for each index, followed by a crash of approximately 50% in 1990–1991. From 2001 to 2007, the prices of oil paintings almost double, but by comparison, the prices of watercolours increase by only 44%, and the price level of drawings remains rather flat. From 2008 to 2016, the prices of oil paintings reduce to a level below that of 2001 (a decline of approximately 50%). The trend is also downward for watercolours and drawings, but less so than for oils.¹⁴

[Insert Figure 3 about here]

3.4 Art Movements

We match and classify artists into 13 major movements in art history based on the biography information from Oxford Art Online: (1) *Medieval and Renaissance*, (2) *Baroque*, (3) *Rococo*, (4) *Neoclassicism*, (5) *Romanticism*, (6) *Realism*, (7) *Impressionism and Symbolism*, (8) *Fauvism and Expressionism*, (9) *Cubism, Futurism, and Constructivism*, (10) *Dada and Surrealism*, (11) *Abstract Expressionism*, (12) *Pop Art*, and (13) *Minimalism and Contemporary*. We use the base model (Equation (1)) and apply it to each art movement. The models explain the price variation well for the movements that started in the second half of the 19th century (*Impressionism and Symbolism; Fauvism and Expressionism; Cubism, Futurism, and Constructivism; Dada and Surrealism; Abstract Expressionism; Pop Art; Minimalism and Contemporary*) as the R-squared surpasses 70%. However, for early movements (*Medieval and Renaissance, Baroque, Rococo, and Neoclassicism*), the price variation is explained by approximately 55%.¹⁵ We plot the price indices by movement, as shown in Figure 4. For presentation, we combine art movements into five clusters¹⁶ and set the initial index value of the *Medieval and Renaissance, Baroque, and Rococo* cluster to 100 in 1957. The initial index values

¹⁴ In Figure 3, we set the oil painting index in 1957 to 100 and the initial index values of watercolour and drawings are normalised based on the 5-year average price from 1957 to 1961 compared to oil paintings. Figure OA.3 in Online Appendix shows the price indices of the paintings by medium after setting the price level of 1957 as 100 for each subsample.

¹⁵ As the relative notoriety of art movements may differ, we select the 20 most famous artists for each movement by price impact (magnitude of artists' coefficients by movement), and the results are qualitatively similar (not tabulated but the results are available upon request).

¹⁶ These are (1) *Medieval and Renaissance, Baroque, Rococo*, (2) *Neoclassicism, Romanticism, Realism*, (3) *Impressionism and Symbolism, Fauvism and Expressionism, Cubism, Futurism, and Constructivism, Dada and Surrealism*, and (5) *Abstract Expressionism, Pop Art, Minimalism and Contemporary*.

of other art movement clusters are normalised by the average prices of the period from 1957 to 1961 in comparison with the group of *Medieval and Renaissance*, *Baroque*, and *Rococo*. Figure 4 shows that *Impressionism and Symbolism* had the highest price level from 1957 to the mid-2000s, and the art movements *Abstract Expressionism*, *Pop Art*, and *Minimalism and Contemporary* reach a similar price level. We also note that the most recent art movements experienced the most substantial price increases during the boom of the 1980s.¹⁷

[Insert Figure 4 about here]

We investigate whether a price premium arises for paintings originating from a country where the art movement originated or reached notoriety. For instance, although impressionist painters were active in all European countries, the art movement is most strongly connoted to France. Similarly, the most important production centre of *Baroque* paintings is the Low Countries (currently, Belgium and the Netherlands), with – initially – Flanders dominating the production of paintings (the Antwerp of Rubens, Van Dyck, and Jordaens) (De Marchi & Van Miegroet, 2006), and subsequently, the Netherlands (with Rembrandt) (Schama, 1999) and Spain (e.g. Carravaggio, Velasquez). Our hedonic model includes the interaction terms of artists' nationalities and art movements. We consult the art history database Grove Art Online to identify artists' countries of origin, which we define as an artist's birth country or country of residence (for living artists).¹⁸ We replace the artist fixed effects by artist nationality dummies in each of the hedonic models estimated by art movement. We find price premiums for paintings created by artists originating from France and Germany for *Medieval and Renaissance* artworks; from the Low Countries and Spain for *Baroque* artworks; from Italy and Spain for *Rococo*; from France and Italy for *Neoclassicism*; from France, Spain, and Russia for *Romantic* artworks; from France and Italy for *Realism*; from France and Spain for *Impressionism and Symbolism*; from Germany, Spain, and Russia for *Fauvism and Expressionism*; from Germany, Russia, and the UK for *Cubism, Futurism, and*

¹⁷ Figure OA.4 in Online Appendix changes the perspective when we set the initial value of each art movement cluster in the 1957 as 100. This figure shows that the price levels are similar across different movements. The prices of *Abstract Expressionism*, *Pop Art*, and *Minimalism and Contemporary* increase significantly more from the 1980s and are more volatile during boom–bust periods.

¹⁸ In some cases, an artist is allocated to two countries. For example, Picasso was Spanish (and strongly affected by the culture of his youth) but spent most of his adult life in France.

Constructivism; from Belgium, Italy, and Spain for *Dada and Surrealism*; and from the US and France for *Pop Art*. Most of the recognition of an art movement in prices by country of origin does not come as a surprise: *Baroque* artworks of the Low Countries are priced higher, as are Italian and Spanish *Rococo*, French *Neoclassicism* artworks and (social) *Realism*, French *Impressionism*, German *Expressionism*, Russian *Constructivism*, Belgian *Surrealism*, and American *Pop Art* artworks.¹⁹

3.5 Art Market Geography

While the oldest auction houses originated in the UK and continental Europe, auction houses internationally dispersed toward new art-buying audiences, such as those in the US. If art markets are efficient and the law of one price applies, the prices in different markets should converge (Mei & Moses, 2002; Pesando, 1993), although high transaction costs and differences in the supply of art objects across markets can impose barriers to arbitrage. Based on the location of auction houses, we recognise three main auction markets: (1) the UK, (2) the US, and (3) continental Europe. Figure 5 shows the price trends for the British, American, and continental European markets from 1970. The initial index value for UK sales in 1970 is set at 100, and the initial index values for the US and Europe sales are normalised by the average prices from 1970 to 1974 relative to those of the UK. Figure 5 shows that the price levels of the British and American markets are almost identical before the early 1990s. The two markets reached the same price level during the first bubble period in the mid-1980s, whereas prices of the British market reached a higher peak during the second bubble period in the mid-2000s. Over the whole sample period, British and American markets were the largest markets, whereas the continental European markets were more subdued and experienced lower price volatility.²⁰

[Insert Figure 5 about here]

¹⁹ Details are presented in Online Appendix Table OA.3.

²⁰ In Online Appendix Figure OA.5, we change the perspective and set the price in 1957 at 100 for each market such that one can more easily compare growth. This figure shows that the strongest average price growth since 1970 is realised for the UK market and that US and continental Europe price increases run in parallel.

3.6 Auction House Type

We compare the price evolution of the paintings sold at famous versus lesser-known auction houses (and their branches) and at large, medium-sized, and small auction houses. As the data prior to the 1970s are biased toward the UK, we create subsamples from this year. We partition auction houses into (1) Sotheby's and Christie's (S&C), (2) Bonhams and Phillips (B&P), (3) important European auction houses, (4) important American auction houses, and (5) other small worldwide auction houses. S&C have gained worldwide notoriety over the past 250 years, attracting the most expensive art objects and catering to an art-buying audience by means of many branches worldwide. B&P focus on similar art collectors and auction artworks from a broad range of art categories with some specialisation in modern and contemporary art. The coefficients of the basic hedonic variables for each auction house subsample are consistent with the baseline results.²¹ One interesting variation is that the *Certification* variable is not significant for auctions by S&C and B&P, while it is for other types of auction houses. This finding suggests that the reputation of the most famous auction houses implicitly substitutes for an explicit certification of artworks.

Figure 6 shows the price trends, which evolve similarly across auction house types over the period 1970 to 1995. During the first bubble period, the prices hammered at the top auction houses, such as S&C and B&P, tripled, an increase in line with those of the (a) important European and (b) American auction houses and (c) smaller auction houses. However, prices hammered in the top auction houses declined by only 60% when the bubble burst in 1990, whereas the increase in the price level of art auctioned by less reputable auction houses during the boom period was entirely undone (in real terms) by 1995. The start of the second bubble became most visible in the prices of the B&P auctions in 2001 and was initiated by modern and contemporary art sales. The strong upward price trends accelerated in the other auction houses by 2003 and peaked in 2007, just prior to the commencement of the Great Recession. Figure 6 also shows that the price levels (in real terms) by auction house type (except top auction houses) are lower in 2016 than almost half a century before. By contrast, the average price level

²¹ The results are not tabulated but are available upon request.

of paintings sold by S&C (B&P) in 2016 was in real terms about double (triple) of the price level of 1970.²²

[Insert Figure 6 about here]

3.7 Artist Nationality

The styles of artists are often influenced by the cultures the artists grew up in or experienced later in life. Therefore, the artworks created in different countries may reveal the histories and cultures of these countries. Therefore, we investigate the price trends and levels of paintings created by artists from the (historically) main art-producing regions.

Figure 7 shows the art price indices of British, American, French, Italian, and Dutch and Belgian artists since 1957. The initial index value for British artists was set at 100 in 1957, and the initial index values of artworks made by artists of other nationalities are normalised by the average prices from 1957 to 1961 relative to the British index. We find that artworks of different origins still have similar price trends over the sample period.²³ French art reached the highest price levels in the bubble period of the mid-1980s; French, Italian, and Dutch and Belgian artworks reached top prices in the mid-2000 bubble period and outperformed British and American art. One possible explanation is that the major auction markets are concentrated in the UK and the US, and only the highest-quality art from other countries reaches the major auction houses in these markets (David, Li, Oosterlinck, & Renneboog, 2021).

[Insert Figure 7 about here]

3.8 Local and International Markets

Renneboog and Spaenjers (2015) suggest that art demand is geographically segmented in local art markets and an international art market for the most expensive art objects. Local artists may be known and appreciated by local collectors. Furthermore, local art may be important in building regional or

²² Online Appendix Figure OA.6 shows the price levels by auction house type whereby the initial index value for S&C is set at 100 in 1970, and the initial index values for other auction houses are normalised by the average prices from 1970 to 1974 relative to S&C.

²³ The figure of price trends (the initial index values are all set at 100 in 1957) is in Online Appendix Figure OA.7.

national cultural identities. Paintings with landscapes, urbanscapes, and historical scenes may add a dimension to the work that may be more appreciated by local buyers and create a home bias in demand. As there may be a close connection between the country of sale and the artist's nationality, we calculate price indices by the location of the auction house.

As we intend to investigate the average price trends and levels of local and international markets, we use three definitions for local and international markets. (1) A local market comprises the sales of work of an artist whose nationality coincides with the country of the sale; (2) Since the top auction houses are located in the UK and the US, it is unclear whether a British (American) artist's work sold in the UK (US) is driven by home bias in demand or if the artwork's quality reaches international auction criteria for sale in these particular auction markets. To avoid possible confusion between home bias and international quality, we exclude British and American artists from our analysis as a robustness check. (3) As the London and New York branches of S&C are the most renowned auction rooms, there is a high probability that pieces of art expected to reach very high prices end up being auctioned there. Therefore, we define the international auction market as the lots auctioned at Sotheby's London, Sotheby's New York, Christie's London, or Christie's New York.

Figure 8a shows the price trends of local and international markets (according to the first definition in the above paragraph) since 1957. Although both markets experience similar trends, the gap between international and local markets has widened since the first art bubble at the end of the 1980s. Investors in international art would have tripled their investments in real terms over the past half century, whereas their investment in local art would have only doubled. Since the price distribution of art is skewed and the highest prices are concentrated in the UK and the US auction houses, we do not know whether the works of art by British and American artists that are sold in the UK and the US can be considered as belonging to the local or international art market. Therefore, we exclude British and American artists from our analysis in our second market segmentation definition. Hence, we expect the gap between local and international markets to widen under this definition, which is shown in Figure 8b. In the third market segmentation definition, we redefine the international market as sales through the London and New York branches of S&C. We observe in Figure 8c that both markets experience similar price trends,

that the price level in the international market is about three to five times higher than that of the local markets, and that the price gap widens over time.²⁴

[Insert Figures 8a, b, and c about here]

3.9 Artists' Career Cycles

Artists' best work may be created in the early or late periods of their careers. Artists may be 'old masters' when skills needed to create a masterpiece only mature later in life, but some artists may be young geniuses with creativity spiking early in their artistic career. For example, experimental old masters, such as Michelangelo, Rembrandt, and Cézanne, worked by trial and error and gradually worked towards a climax in artistic quality, which they produced later in life. By contrast, conceptual innovators and young geniuses, such as Vermeer, van Gogh, and Picasso, made sudden breakthroughs at a young age (Galenson, 2011).

Thus, we examine whether the art market's valuation of paintings depends on the life cycle of artistic creativity. We classify the artist's career cycle for deceased artists into three subsamples by relative age of the artists: (1) early, (2) middle, and (3) late. The auctioned lots are defined as follows: (1) Early age paintings were created in the first third of the career phase (after the age of 18 years); (2) Middle artworks were created during the middle third of the career phase; and (3) Late artworks were created during the last third of the career phase.²⁵ Figure 9a shows that the paintings created in the later periods of artistic careers reached the highest price levels in the auction markets. Conditional on the index difference based on initial price levels, Figure 9b shows that paintings created in the last part of an artist's career are, on average, sold at a premium and outperform earlier artworks.

[Insert Figures 9 a and b here]

²⁴ While Figures 8a, b, and c show the price trends, Online Appendix Figures OA.8a, b, and c show the evolution of international and local market price levels, taking into account the price differences at the starting point in 1970.

²⁵ It should be noted that this classification may suffer from the impact of early death; an artist who died before the age of 50 years does not have a late-career phase. Therefore, we redefined the life cycle based on the absolute age at which the artist created the painting: (1) below or equal to 30 years; (2) above 30 years and below or equal to 50 years; and (3) above 50 years. We document that the evolution of the price levels of paintings created at an artist's different age ranges follows similar patterns, although the long-term return of early work is lower than paintings created when the artist was above 30 years old.

We further examine the career cycle by art movement. For some early art movements in which skill matters more than others, the artist needs a lifetime of practice, and the best works are produced in the career-end phase. However, young talent seems to be appreciated more in more recent movements in which no prior skills are needed (e.g. the drip art of Jackson Pollock). Our sample confirms the hypothesis that works in the late-career phase in early movements appreciate more, while in recent movements, the works in the early career phase appreciate more.²⁶

4. Returns and Risk of the Art Market

4.1 An Overview of Returns and Risk

An overview of art returns and risk is presented in Table 3. Panel A reports the annualised (geometric and arithmetic) nominal and real returns from the hedonic pricing model, as well as the real returns from the repeat sales model for different holding periods: (1) 60 years (1958–2016); (2) the first three decades of our sample window (1958–1986); (3) the last three decades (1987–2016); (4) the bubble periods (1985–1990 and 2003–2007); and (5) the bust periods (1991–1995 and 2008–2010). We document that the nominal arithmetic (geometric) mean return over the entire 60-year period amounts to 6.24% (5.00%). Accounting for inflation, the arithmetic (geometric) mean real return is 2.49% (1.22%). By limiting the sample to paintings that repeatedly came to the auction market, we obtain a repeat sales real arithmetic (geometric) return of 3.97% (1.88%). The annual nominal (real) arithmetic returns in the first three decades are notable at 11.05% (6.23%). By marked contrast, the annual nominal (real) art returns over the most recent three decades disappoint at merely 1.26% (-1.38%). This period, which includes two boom periods as well as busts, continued to show decreasing returns after the art price collapse of 2008. Focusing on the bubble periods, we observe a high annualised return of 18.10% nominally and 13.90% in real terms for 1985–1990 and nominal returns of 9.22% and real returns of 6.16% for 2003–2007. In the bust periods, the art annualised returns are all negative: -2.17% (nominal) and -5.11% (real) for 1991–1995; -2.40% (nominal) and -3.81% (real) for 2008–2010. Panel B reports return matrices with varying starting and ending years by holding period. Within each matrix subpanel,

²⁶ The results are not tabulated but the tables are available upon request.

the column year denotes that the holding period starts on 1 January of that year, and the row year denotes that the holding period ends on 31 December of that year. Holding the starting year constant, we observe a declining trend of art returns beyond the 1980s for each starting year, and the recent holding period yields negative real returns. Panel C reports the volatility of art returns in both base-case and unsmoothed forms. The latter approach is meant to correct the underestimation of the standard deviation of the appraisal-based index returns, as changing appraisals of art assets may depend on past prices and may take more time to affect prices (Geltner, 1993). Over the 1958–2016 period, the standard deviation of unsmoothed art returns in real terms amounts to 21.73% (higher than the 16.21% calculated from the base-case returns series). The volatility in nominal terms is similar in size. We also observe that the volatility in the first three decades of our sample is about one-third larger than that of the past three decades.

To put our risk–return results into perspective, we focus on Goetzmann (1993), Korteweg et al. (2016), Mei and Moses (2002), and Pesando (1993), who use the repeat sale regression method to compute index returns, and Renneboog and Spaenjers (2013), who report hedonic index returns. Our returns are close to those reported by Renneboog and Spaenjers (2013), who show annualised real returns of 3.97% with volatility of 15.21%, by Spaenjers et al. (2015), who document an annualised real return of 3.40% with volatility of 15.20% for repeat sales over the period 1900–2013, by Mei and Moses (2002), who disclose an annualised real return of 4.90% for repeat sales over the period 1875–1999 with volatility of 42.80%, and by Korteweg et al. (2016), who correct for sample selection and report an annualised real return of 6.30% in the 1960–2013 period with volatility of 11.40%. The differences in volatility largely depend on the sample sizes. Goetzmann (1993) documents that the annualised real return is 17.50% with volatility of 52.80% from 1900 to 1986, but the sample consists of a selective set of paintings at the high-end market. Pesando (1993) reports much lower annualised real returns (of 1.51%) for 1977–1992 with volatility of 19.94% but limits the analysis to prints (which differ from paintings in that there are many repeat sales of prints from one original etching on a copper plate, woodblock, or litho).

[Insert Table 3 about here]

4.2 Art Returns by Subsample

We examine annualised real returns by art market segments and art schools (as in Subsections 3.2 to 3.9): (1) price levels; (2) art mediums; (3) art movements; (4) art market locations; (5) auction house types; (6) artist nationalities; (7) local vs. international market segmentation; and (8) artist career cycles.

We document in Panel A of Table 4 a hierarchy in terms of real returns (Sharpe ratios) by price level segment. The high-end art auction market – at the 95th percentile – yields an arithmetic average real return of 2.23% (0.09), whereas the low-end art auction market – at the 5th percentile – yields only 1.46% (0.04) over 60 years from 1957 to 2016. We note an almost monotonic positive relationship between returns and price levels.

Among the three common types of art media for paintings, oil and acrylic paintings generate the highest annualised real return (3.39%) followed by watercolours and gouaches (2.50%) and drawings (2.10%) (Panel B of Table 4).

Over the same period, more recent art movements obtain higher returns. For instance, *Minimalism and Contemporary* art has an impressive 12.88% annualised real return (Panel C of Table 4). *Pop Art* (7.93%), *Neoclassicism* artworks (7.48%), and *Abstract Expressionism* artworks (5.28%) follow in the hierarchy of annualised returns over this 60-year period. The Sharpe ratio is highest for *Minimalism and Contemporary* art (0.26), followed by *Neoclassicism* (0.20), *Dada and Surrealism* (0.20), *Cubism, Futurism, and Constructivism* (0.19), *Abstract Expressionism* (0.18), *Pop Art* (0.18), and *Rococo* (0.15). Over the last 30 years, art returns have been disappointing, especially since the bursting of the second bubble and the Great Recession; only *Minimalism and Contemporary*, *Pop Art*, *Abstract Expressionism* and *Cubism, Futurism, and Constructivism* artworks realise real returns significantly above zero. When we further divide our sample into bubbles (1985–1990 and 2003–2007) and bust periods (1991–1995 and 2008–2010), we find that especially in the last bust period 2008–2010, *Pop Art* and *Abstract Expressionism* artworks perform well, continuing to yield positive annualised real returns (5.43% and 1.32%, respectively).²⁷

²⁷ See Panel C of Appendix II.

We study returns in the major geographical art markets: the UK, the US, and continental Europe (of which we further select the French and German markets). Paintings sold in the UK reached the highest real returns (3.26%) in the 1970–2016 period whereas real returns obtained in the US and continental Europe are rather meagre (Panel D of Table 4).

To analyse the impact of auction house reputation (and turnover), we examine the returns of paintings sold by (1) Sotheby's and Christie's (S&C), (2) Bonhams & Phillips (B&P), (3) important American auction houses, (4) important European auction houses, and (5) other small worldwide auction houses. We find that B&P generate the highest real returns (4.14%) in the period 1970–2016 across all auction house types owing to the strong performance of modern and contemporary art (Panel E of Table 4).

Paintings sold through S&C generate real annual returns of 2.9%. We also study the return effects by artist nationality. The paintings of most artists generate between 3% and 5%, with work by Russian artists (7.3%) noticeably positive and British artists (2.9%) noticeably negative (Panel F of Table 4).

We use three definitions of geographic market segments to distinguish between local and international auction markets. (1) A sale is local when the artist's nationality coincides with the country of the sale. (2) As the international market is located in the UK and the US, we exclude British and American artists from the model and retain all other nationalities such that we can distinguish local and international (British or American) sales. (3) We consider only sales in the London and New York City branches of S&C as the international art market, because the best pieces of art worldwide often end up there. Irrespective of the above definitions of local vs. international market segments, we find that paintings sold in the international auction market significantly outperform those of local auction markets in terms of returns and Sharpe ratios (Panel G of Table 4).

Finally, we test whether the time of the creation of a painting affects returns by situating the creation of a painting within an artist's career cycle. We find that, for deceased artists, artworks created in the last third of their career cycle perform best in the secondary market, with an annualised real return of 4.08% (Panel H of Table 4).

[Insert Table 4 about here]

4.3 Comparison with Financial Assets and Other Alternative Investments

We compare investing in paintings with other alternative investments (e.g. sculptures, classic cars, premier cru Bordeaux wines, investment-grade white diamonds, and stamps), and financial assets (equities, government bonds, corporate bonds, gold, and real estate).²⁸ Panels A and B of Table 5 report the risk–return trade-off, and Panel C reports the pairwise correlations of the returns of paintings and the other asset classes. Because of data availability for some alternative investment classes (which were typically hand-collected by the authors of the relevant studies), we cannot match those sample periods to our own.²⁹ Furthermore, our sample of paintings is much larger than that of the other alternative investments. Consequently, a comparison of the alternative investment classes should be made with caution. Among the alternative investment assets, paintings (2.49%) outperform sculptures (1.11%) but lag the returns of classic cars and violins (3.69% and 3.68%, respectively) (Panel A). Premier cru (first growth) red Bordeaux wines, stamps, and white diamonds yield significantly higher real returns (9.74%, 5.60%, and 5.23%, respectively). The Sharpe ratio (excess return, or real return minus real risk-free rate, divided by the standard deviation) for paintings amounts to 0.10, which is higher than that for sculptures (0.02) but lower than that for other alternative assets. For stamps, red Bordeaux wines, classic cars, white diamonds, and fine violins, the Sharpe ratios are 0.27, 0.38, 0.39, 0.51, and 0.17, respectively (but the abovementioned caveats related to sample periods and sizes should be kept in mind). In terms of return co-movements, painting returns are strongly correlated with sculptures (0.69) and white

²⁸ Stamp returns (from 1958–2008) are calculated from Dimson and Spaenjers (2011); red Bordeaux wine returns (1958–2012) are calculated from Dimson, Rousseau, and Spaenjers (2015); classic car returns (1999–2016) are calculated from Laurs and Renneboog (2019); sculpture returns (1986–2013) are calculated from Vosilov (2015); white diamond returns (2000–2012) are from Renneboog and Spaenjers (2012) and Renneboog (2013); and violin returns (1981–2009) are from Graddy and Margolis (2011). Real returns of the S&P 500, FTSE 100, Global Government Bond (using 10-year bonds from the countries of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, South Africa, Spain, Sweden, the UK, and the US, and weighted by GDP), Dow Jones Corporate Bond, US AAA 10-year Corporate Bond, Goldman Sachs Commodity (a composite index of 24 commodity sector returns, representing an unleveraged, long-only investment in commodity futures that is broadly diversified across the spectrum of commodities), and LME Gold are calculated based on Global Financial Data. US housing real returns are from Shiller (2016). T-bill rates are downloaded from the Federal Reserve Bank of St. Louis and are a proxy for the risk-free rate.

²⁹ For the assets with longer sample periods than that of this study on paintings (e.g. stamps series are available from 1900 to 2008), we use only the sample period starting from 1958 (when the starting year is earlier than 1958) and ending in 2016 (in case the end year is after 2016).

diamonds (0.70), but not with stamps (-0.02), red Bordeaux wines (0.01), classic cars (0.19), and violins (0.04) (Panel C).

Turning to traditional financial assets in Panel B of Table 5, for the period 1958–2016, we find that the (British and American) stock markets significantly outperform the art market for paintings in terms of return by unit of risk (Sharpe ratio). Likewise, the returns of corporate bond and global government bond real returns are at least 50 basis points higher than those of auctioned paintings, but bonds' risk is about one-third lower than that of the market for paintings, such that the Sharpe ratios of bonds significantly outperform those of auctioned paintings. Gold investments also yield higher real returns than paintings; the latter perform better than investments in global commodities and US housing over the long run. The Sharpe ratio of paintings (0.10) is lower than that of S&P 500 stocks (0.42), FTSE 100 stocks (0.19), global government bonds (0.30), Dow Jones corporate bonds (0.43), and gold (0.15), but higher than that of global commodities (0.03) and US housing (-0.03).

We further divide our sample into two periods of 30 years (1958–1986; 1987–2016) and recalculate the real returns, nominal returns, risk, and Sharpe ratios (Panel B of Table 5). In the first 30 years of 1958–1986, the real return of paintings amounts to 6.23%, which is similar to that of stocks (S&P 500 6.71% and FTSE 100 6.68%) and gold (6.93%). The art market for paintings significantly outperforms global government bond markets, corporate bonds, commodities, gold, and US housing in terms of Sharpe ratios. However, in the second period (1987–2016), investors in paintings incur negative real returns (-1.38%) or meagre nominal returns of 1.26%, with the art market underperforming all other financial markets.

In terms of return correlations, paintings' returns are significantly correlated with those of global commodities (0.40) and gold (0.32), and are negatively correlated with those of Dow Jones corporate bonds (-0.23), S&P 500 stocks (-0.11), and global government bonds (-0.10) (Panel C of Table 5), which demonstrates that paintings have diversification potential when included in investment portfolios.

To test the potential role of paintings in the optimisation of portfolio allocation comprising traditional financial assets, namely, equity, bonds, gold, and real estate, we perform a mean-variance analysis by including and excluding paintings in optimal portfolios (Panel D [1958–2016], Panel E [1958–1986], and Panel F [1987–2016] in Table 5). For the whole sample window, the inclusion of

paintings in the investment universe generates portfolio Sharpe ratios that outperform those of portfolios based on an investment excluding art (Panel D). For example, the optimal Sharpe ratio is 0.44 of a portfolio that includes S&P 500 stocks and global government bonds, but after adding paintings in this portfolio, the Sharpe ratio increases to 0.47. When other assets, such as corporate bonds, treasury bills, and gold, are gradually added to the portfolio, the conclusion holds that a portfolio including paintings has a higher Sharpe ratio than one without. When we consider all eight asset classes in an investment pool (S&P 500 stocks, global government bonds, Dow Jones corporate bonds, treasury bills, gold, US housing, global commodities, and paintings), the optimal portfolio weights are 47.2% for Dow Jones corporate bonds, 26.7% for S&P 500 stocks, and 16.7% for gold, with paintings entering the portfolio with a weight of 9.5%. The Sharpe ratio of this optimal portfolio is 0.60. However, given paintings' low Sharpe ratio (0.10), it may be surprising that paintings enter with a positive weight in an optimal portfolio comprising equities and bonds. Still, the negative correlation of paintings with both equities and bonds, and hence, their negative beta with respect to the market portfolio, ensures that they enter the optimal portfolio and offer substantial alpha under the Capital Asset Pricing Model (CAPM) assumption.

Panels E and F of Table 5 present the optimal portfolio allocation results of financial assets and paintings by sub-period. Over the sub-period 1958–1986 (Panel E), the optimal portfolio comprises 33.0% of S&P 500 stocks, 27.2% of Dow Jones corporate bonds, 16.5% of gold, and 23.3% of paintings; thus, paintings enter with a much higher weight than for the full period of 1958–2016 (Panel D). However, paintings almost disappear from the optimal portfolio in the post-1987 sample (Panel F), which is explained by the negative real returns that investing in paintings generates over this period (although the correlations of paintings with other financial assets in the post-1987 period remain similar to those in the pre-1987 period³⁰). Only a very small portion of the optimal portfolio consists of paintings (0.04%) in the period 1987–2016; with the remainder of the investment in Dow Jones corporate bonds (73.9%), US housing (15.0%), S&P 500 stocks (6.7%), global commodities (3.5%), and gold (0.9%).

³⁰ The pairwise correlation coefficients for art, other alternative investments, and financial assets by sub-period are reported in Online Appendix Table OA.4.

Panels G and H of Table 5 exhibit the optimal portfolio allocations of investments within art schools. Panel G presents the results of all artists by school, whereas Panel H considers only the works by the top 20 artists by art school (the masterpieces or investments in ‘blue-chip’ paintings). We start with the portfolio allocation of a collector who invests in a broad index of the oldest art movements (*Medieval and Renaissance* and *Baroque*) and gradually expands the collection toward more recent art schools. Panel G shows that more recent art schools can play a positive and substantial role in art portfolio investment: the optimal allocation when considering all art schools consists of 36.3% in *Minimalism and Contemporary*, 33.7% in *Neoclassicism*, 26.6% in *Abstract Expressionism*, 3.5% in *Rococo*, and nothing in other schools. Panel H limits the sample to works by the top 20 artists by school.³¹ The results show that paintings by artists from earlier schools also perform well within a portfolio context: the optimal portfolio comprises investments of 24.4% in *Abstract Expressionism*, 22.0% in *Neoclassicism*, 21.2% in *Medieval and Renaissance*, 14.8% in *Minimalism and Contemporary*, 7.0% in *Baroque*, 6.9% in *Pop Art*, and 3.7% in *Romanticism*. The results suggest that recent schools dominate portfolio allocation, with a weight of 62.9% (*Minimalism and Contemporary* and *Abstract Expressionism*). Our optimal ‘blue-chip’ paintings’ portfolio is more diversified than an optimal art portfolio based on an investment universe comprising all paintings of the 13 art movements.

[Insert Table 5 about here]

4.4 Transaction Costs and Sources of Risks

It should be emphasised that the results for all asset classes are based on raw returns. As transaction costs vary substantially across asset classes, they should not be ignored when trading off the attractiveness of investing in specific assets. For art, in particular, transaction costs are high: auction houses charge a ‘premium’ to the buyer and a ‘commission’ to the seller such that for an average auction transaction, a round trip costs approximately 25% of the hammer price. Additionally, costs related to insurance and storage and induced by taxes may further lower art returns. Consequently, the above conclusions on the risk–return trade-off and the diversification potential of art in investment portfolios

³¹ The top 20 artists in each school are obtained from the top rankings of coefficients of the artist fixed effects in the hedonic regression; we then construct the price index (return) series for the sample of these selected top artists.

should be interpreted with caution. While the transaction costs for investors holding art for a generation could be bearable when smoothed over the holding period, the net annual art returns for investors with a short investment horizon turn considerably unfavourable relative to those of more liquid financial assets.

Before addressing the question as to what justified the high transaction costs paid to art market intermediaries, let us consider the characteristics of art objects/markets.

First, except for the market for prints or photographs, art objects offered for sale are usually *unique* pieces, the value of which is determined by the characteristics of the art object (e.g. topic, style, colour, medium, and artist reputation). However, individual investors could pay more than their private valuation of the art object because of the resale option value, which is the possibility that another interested party would offer an even valuation in the future. As such, the resale option value is affected by various demand factors, such as the (fluctuation in the) concentration of wealth in the economy, income inequality, the equity market evolution, or changes in the size of the art-collecting audience, following, for instance, the emergence of new types of buyers. In contrast to the case of standardised liquid financial assets, pinpointing the fundamental value of an art object is not feasible, because art objects cannot be related to a stream of future cash flows (given the absence of a rental market for art) and there are no clear ways in which the discount rate of investing in art is affected by demand shocks (given that buyers' identities are not disclosed). Second, the art market is *opaque* and *illiquid*, in contrast to the considerable amount of information generated about corporations with traded equity and debt. Prices may also be slow to reflect changing valuations, because the lack of *short selling* induces delays in incorporating negative information into prices. Furthermore, a decision to sell a painting may take long to be executed as the right type of auction might not be available for a specific type of art object. Third, there is no unified art trading floor; the secondary art market comprises thousands of intermediaries (auction houses, dealers) worldwide and is *unregulated*. Fourth, a problem in the art world is also that fakes and forgeries are occasionally discovered, which may be particularly important for modernist art. This erodes trust, reduces market participation, and leads to lower valuations (Bocart & Oosterlinck, 2011).

High transaction costs could, to some extent, be rationalised because the art market intermediaries provide specific services to deal with the abovementioned market inefficiencies. Intermediaries, such as auction houses, actively search for sellers to build an auction that includes some objects that they expect to generate great interest. To do so, they invest time in knowing the collections of potential sellers and contact potential buyers directly. For a wider audience, auction catalogues are made available four to six weeks before the auction. This involves an auction house investing in photographing the art objects, printing and distributing the catalogues, and marketing the art (which involves displaying objects, sometimes in various auction house branches). In the auction catalogue, experts from (or on behalf of) the auction house collect provenance information and make price estimates. This goes hand in hand with a thorough check of the authenticity of the art objects to avoid selling fakes or forgeries. The transaction costs also include an insurance premium for the buyers, because in the event they have purchased a forgery, the auction house takes the object back. The auction house then faces the loss of the commission and reputational loss (and potentially messy lawsuits when the seller does not want to return the sales price or pleads joint responsibility for offering a forged painting). As such, transaction costs reflect the price of expert valuation and reliable provenance research, creating trust in this unregulated market.

In addition to the characteristics of art objects and their markets, as discussed above, there are additional differences with other financial assets.³² First, art serves a dual purpose for the investor, as it combines both investment characteristics and consumption features that yield an aesthetic dividend in the form of ownership rights (the enjoyment that owning art can generate) and, in some cases, a ‘conspicuous consumption’ dividend (the utility that investors experience when they show off their art purchases to enhance their social status (Mandel, 2009)). These various functions of art – investment, consumption good, and status object – augment the heterogeneity in the beliefs about the value of a piece of art (Lovo & Spaenjers, 2018; Pénasse et al., 2021). This heterogeneity in beliefs is further

³² In contrast to the equity and bond markets, few investment funds focus on art. Pownall (2014) classifies three types of risks when indirectly investing in art (using art funds): operational risk of the fund (e.g. lack of regulation and opaque nature of any information on investments); the overall market risk; and the liquidity risk (a forced sale in bad times can result in a big loss). These risks may explain why there have been so many failures in the art fund industry.

enhanced by several demand factors that can also be regarded as the underlying risk factors of the art market, including (i) changes in taste (possibly gradually induced by changes in the composition of the art-buying audience); (ii) sentiment, fads, and hype (Pénasse et al., 2014); and (iii) financial shocks to equity returns, the personal income of the wealthiest part of the population, and income inequality.³³ Our results support the notion that equity market movements precede those of the art market.³⁴ Regarding the third demand factor, Goetzmann et al. (2011) find cointegrating relationships between top incomes and art prices, which supports the Veblenian view of art as an instrument of social competition among the rich. If art is bought as a source of pleasure, the investor can consume non-pecuniary dividends to justify the relatively low financial returns of art. Likewise, in most cases, the returns of art investments are too low for investors not to derive substantial aesthetic (intangible) returns from art ownership. A shock to both the demand and supply sides of the art market could be induced by political and economic turmoil, such as war and recession (David et al., 2021). Pénasse et al. (2021) show the effects of supply shocks at the level of the individual artists (premature death of artists) on prices and sales of the deceased.

Considering the time-varying heterogeneity of beliefs by art market participants about the value of art objects and the impact of financial, economic, and political shocks, pricing art is a more complex and less tangible process than price formation in traditional financial markets.

5. Conclusion

We studied the return and risk characteristics of investments in ‘paintings’ (broadly defined as oil and acrylic paintings, watercolours and gouaches, and drawings) via art auction markets over the past 60 years. We applied several methods to estimate the real returns and risk: (i) hedonic pricing models (which include artist reputation, and characteristics of the paintings, provenance, auction houses, and transactions), which yield an annualised arithmetic real (nominal) return of 2.49% (6.24%); (ii) hedonic

³³ From the participants’ perspective, Christopherson (2014) characterises art market risks as (i) property risks (which relate directly to the nature of the individual items bought and sold); (ii) legal and regulatory issues (which govern the market and market processes); and (iii) financial and market risks (including the state of the market in response to the wider economic environment, external regulatory factors, and the structure of the market in terms of its participants and processes).

³⁴ The results are not tabulated but the tables are available upon request.

quantile regressions whereby the difference between paintings in the high-end and low-end markets amounts to 52.74% with a real return of 1.46% for the cheapest art segment and 2.23% for the most expensive art; (iii) an adjacent-period hedonic model which generates real annual returns of 1.72%; and (iv) a three-stage weighted least-squares repeat sales regression, yielding a real annual return of 3.97%. The unsmoothed volatility of real (nominal) returns amounts to 21.73% (21.88%). We split our sample into two 3-decade periods and find much higher annual real (nominal) returns of 6.23% (11.05%) and unsmoothed volatility of 24.62% over the first three decades (starting in 1957), compared to the most recent ones (starting in 1987), which yield a real (nominal) return of -1.38% (1.26%) and unsmoothed volatility of 17.41%.

The high-end art market experiences higher returns than the low-end market, but also has higher volatility. Returns vary significantly across art schools. For instance, investing in *Minimalism and Contemporary* art yielded an attractive 17.70% annualised real return (over the past 60 years). Other recent art movements also generate high annual real returns, such as *Pop Art* (9.00%), *Neoclassicism* (7.48%), and *Abstract Expressionism* (6.22%), whose performance was more resilient in the financial crisis of 2008–2010.

In terms of the geographical location of art markets, paintings sold in the UK generated higher returns than those sold in the US or continental Europe. The auction houses where the highest returns were made were Bonhams and Phillips (which mainly focus on modern and contemporary art and generated a real annual return of 4.14%), followed by S&C (2.91%). Returns of paintings sold in international auction markets performed better than those sold in local markets. For deceased artists, late artworks, defined as those created in the last third of an artist's career, yielded higher annual real returns than paintings created in earlier phases of the artist's career cycle.

Paintings on average did not outperform alternative investments in the world of passion investments or collectables in terms of real returns or Sharpe ratios. As such, comparisons were hindered by the research having different sample sizes and, more importantly, being executed over different sample periods. Hence, the following conclusions require a strong caveat: investing in paintings outperforms alternative investments in sculptures, but is outperformed by investments in other types of collectables or passion goods, such as investment-grade white diamonds, classic cars, premier cru Bordeaux wines,

stamps, and fine violins. Compared to traditional financial assets (stocks, bonds, gold, commodities, and real estate) held over the (very) long run, paintings' Sharpe ratio is below that of stocks, government bonds, and gold but higher than that of commodities and real estate.

The returns of paintings exhibit a negative correlation with those of equities and bonds, such that the art's investment diversification potential makes art enter an optimal investment portfolio with a positive weight. The results show that optimal portfolios for which paintings belong to the investment universe maximise the Sharpe ratio compared to optimal portfolios that exclude paintings. When we consider eight assets in the investment universe (S&P 500 stocks, global government bonds, Dow Jones corporate bonds, treasury bills, gold, US housing, global commodities, and paintings), the optimal portfolio investment comprised 47.2% for Dow Jones corporate bonds, 26.7% for S&P 500 stocks, and 16.7% for gold, with paintings entering the portfolio with a weight of 9.5%. The sub-period results show that during 1958–1986, the optimal portfolio comprised 23.3% paintings, while paintings almost disappeared from the optimal portfolio in the post-1987 sample, which can be explained by the negative real returns of paintings over this period.

References

- Adams, R. B., Kräussl, R., Navone, M., & Verwijmeren, P. (2021). Gendered prices. *The Review of Financial Studies*, 34(8), 3789–3839.
- Art Basel, & UBS. (2021). The art market 2021. The Art Basel and UBS Global Art Market Report.
- Ashenfelter, O., & Graddy, K. (2003). Auctions and the price of art. *Journal of Economic Literature*, 41(3), 763–787.
- Baumol, W. J. (1986). Unnatural value: Or art investment as floating crap game. *The American Economic Review*, 76(2), 10–14.
- Beggs, A., & Graddy, K. (2009). Anchoring effects: Evidence from art auctions. *The American Economic Review*, 99(3), 1027–1039.
- Bocart, F., & Oosterlinck, K. (2011). Discoveries of fakes: Their impact on the art market. *Economics Letters*, 113(2), 124–126.
- Bocart, F. Y., Gertsberg, M., & Pownall, R. A. (2021). An empirical analysis of price differences for male and female artists in the global art market. *Journal of Cultural Economics*. <https://doi.org/10.1007/s10824-020-09403-2>
- Cameron, L., Goetzmann, W. N., & Nozari, M. (2019). Art and gender: Market bias or selection bias? *Journal of Cultural Economics*, 43(2), 279–307.
- Case, K. E., & Shiller, R. J. (1987). Prices of single-family homes since 1970: New indexes for four cities. *New England Economic Review*, September, 45–56.
- Christopherson, T. (2014). Art market risk and complexity: An insider's view. In A. M. Dempster (Ed.), *Risk and uncertainty in the art world* (pp. 47–66). London, New Delhi, New York, Sydney: Bloomsbury.
- David, G., Li, Y., Oosterlinck, K. & Renneboog, L. (2021). Art in times of crisis (CentER Discussion Paper No. 2021-026). Tilburg University. Available at <https://ssrn.com/abstract=3929327>
- Deloitte, & ArtTactic. (2019). Art & Finance Report 2019.
- De Marchi, N., & Van Mieghroet, H. J. (2006). The Antwerp-Mechelen production and export complex. In A. Golahny, & M. M. Mochizuki (Eds.), *In his milieu: Essays on Netherlandish art in memory of John Michael Montias* (pp. 133–147). Amsterdam: Amsterdam University Press.
- Dimson, E., Rousseau, P. L., & Spaenjers, C. (2015). The price of wine. *Journal of Financial Economics*, 118(2), 431–449.
- Dimson, E., & Spaenjers, C. (2011). Ex post: The investment performance of collectible stamps. *Journal of Financial Economics*, 100(2), 443–458.
- Frey, B., & Pommerehne, W. (1989). *Muses and markets: Explorations in the economics of the arts*. Oxford: Basil Blackwell.
- Galenson, D. W. (2011). *Old masters and young geniuses: The two life cycles of artistic creativity*. Princeton, New Jersey: Princeton University Press.
- Geltner, D. (1991). Smoothing in appraisal-based returns. *The Journal of Real Estate Finance and Economics*, 4(3), 327–345.
- Geltner, D. (1993). Estimating market values from appraised values without assuming an efficient market. *Journal of Real Estate Research*, 8(3), 325–345.
- Goetzmann, W. N. (1993). Accounting for taste: Art and the financial markets over three centuries. *The American Economic Review*, 83(5), 1370–1376.
- Goetzmann, W. N., Renneboog, L., & Spaenjers, C. (2011). Art and money. *The American Economic Review*, 101, 222–226.
- Graddy, K., Loewenstein, L., Mei, J., Moses, M., & Pownall, R. (2015). Empirical evidence of anchoring and loss aversion from art auctions. Working paper No. 73, Brandeis University.
- Graddy, K., & Margolis, P. E. (2011). Fiddling with value: Violins as an investment? *Economic Inquiry*, 49(4), 1083–1097.
- Guerzoni, G. (1995). Reflections on historical series of art prices: Reitlinger's data revisited. *Journal of Cultural Economics*, 19, 251–260.
- Hiraki, T., Ito, A., Spieth, D. A., & Takezawa, N. (2009). How did Japanese investments influence international art prices? *Journal of Financial and Quantitative Analysis*, 44(6), 1489–1514.

- Koenker, R., & Hallock, K. (2001). Quantile regression. *Journal of Economic Perspectives*, 15(4), 143–156.
- Korteweg, A., Kräussl, R., & Verwijmeren, P. (2016). Does it pay to invest in art? A selection-corrected returns perspective. *The Review of Financial Studies*, 29(4), 1007–1038.
- Laurs, D., & Renneboog, L. (2019). My kingdom for a horse (or a classic car). *Journal of International Financial Markets, Institutions and Money*, 58, 184–207.
- Li, Y., Ma, M., & Renneboog, L. (2021). In art we trust (CentER Discussion Paper No. 2021-016). Tilburg University. Available at <https://ssrn.com/abstract=3871007>
- Lovo, S., & Spaenjers, C. (2018). A model of trading in the art market. *American Economic Review*, 108(3), 744–774.
- Ma, M., Noussair, C., & Renneboog, L. (2021). Colors, emotions, and the auction value of paintings. *European Economic Review*. <https://doi.org/10.1016/j.euroecorev.2021.104004>
- Mandel, B. (2009). Art as an investment and conspicuous consumption good. *The American Economic Review*, 99(4), 1653–1663.
- Meese, R., & Wallace, N. (1997). The construction of residential housing price indices: A comparison of repeat-sales, hedonic-regression, and hybrid approaches. *Journal of Real Estate Finance and Economics*, 14(1), 51–73.
- Mei, J., & Moses, M. (2002). Art as an investment and the underperformance of masterpieces. *American Economic Review*, 92(5), 1656–1668.
- Pénasse, J., & Renneboog, L. (2021). Speculative trading and bubbles: Evidence from the art market. *Management Science*. <https://doi.org/10.1287/mnsc.2021.4088>
- Pénasse, J., Renneboog, L., & Scheinkman, J. A. (2021). When a master dies: Speculation and asset float. *The Review of Financial Studies*, 34(8), 3840–3879.
- Pénasse, J., Renneboog, L., & Spaenjers, C. (2014). Sentiment and art prices. *Economic Letters*, 122(3), 432–434.
- Pesando, J. E. (1993). Art as an investment: The market for modern prints. *The American Economic Review*, 83(5), 1075–1089.
- Pownall, R. A. (2014). Art price risk, emotional and aesthetic value. In A. M. Dempster (Ed.), *Risk and uncertainty in the art world* (pp. 165–185). London, New Delhi, New York, Sydney: Bloomsbury.
- Renneboog, L. (2013). The returns on investment grade diamonds (CentER Discussion Paper Series No. 2013-025). Tilburg University. Available at <https://ssrn.com/abstract=2251791>
- Renneboog, L., & Spaenjers, C. (2012). Hard assets: The returns on rare diamonds and gems. *Finance Research Letters*, 9(4), 220–230.
- Renneboog, L., & Spaenjers, C. (2013). Buying beauty: On prices and returns in the art market. *Management Science*, 59(1), 36–53.
- Renneboog, L., & Spaenjers, C. (2015). Investment returns and economic fundamentals in international art markets. In O. Velthuis, & S. Baia-Curioni (Eds.), *Cosmopolitan canvases: The globalization of markets for contemporary art* (pp. 129–146). Oxford University Press.
- Schama, S. (1999). *Rembrandt's eyes*. New York: Alfred A. Knopf.
- Scorcu, A., & Zanola, R. (2011). The ‘right’ price for collectibles: A quantile hedonic regression investigation of Picasso paintings. *Journal of Alternative Investments*, 14(2), 89–99.
- Shiller, R. J. (2016). *Irrational exuberance* (3rd ed.). Princeton, New Jersey: Princeton University Press.
- Silver, M., & Heravi, S. (2007). Why elementary price index number formulas differ: Evidence on price dispersion. *Journal of Econometrics*, 140(2), 874–883.
- Spaenjers, C., Goetzmann, W. N., & Mamonova, E. (2015). The economics of aesthetics and record prices for art since 1701. *Explorations in Economic History*, 57, 79–94.
- Stein, J. (1977). The monetary appreciation of paintings. *Journal of Political Economy*, 85(5), 1021–1036.
- Triplett, J. (2004). Handbook on hedonic indexes and quality adjustments in price indexes. OECD Science, Technology and Industry Working Papers 2004/9.
- Vosilov, R. (2015). Sculpture as an alternative investment: An analysis of price dynamics between sculpture and equity and bond markets. *The Journal of Alternative Investments*, 17(4), 21–45.
- Zietz, J., Zietz, E., & Sirmans, G. (2008). Determinants of house prices: A quantile regression approach. *Journal of Real Estate Finance and Economics*, 37(4), 317–333.

Table 1 – Descriptive Statistics of Hedonic Variables

This table presents the descriptive statistics of the hedonic variables (related to the successful auction sales). *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*, *Dated*, and *Inscribed* take the value of one if the work carries a signature of the artist or is dated, inscribed, respectively. The medium dummies *Oil*, *Watercolour*, and *Drawing* indicate whether the work is an oil painting, a watercolour, or a drawing. The variables *Height* and *Width* measure the height and the width in centimetres. The month dummies indicate the month of the sale. The auction house (branch) dummies capture sales at *Sotheby’s London*, *Sotheby’s New York*, *Sotheby’s Other Branches*, *Christie’s London*, *Christie’s New York*, *Christie’s Other Branches*, *Bonhams London*, *Bonhams Other Branches*, *Phillips London*, and *Phillips New York*. The paintings are also classified according to art movement. It should be noted that these percentages do not add up to 100% because some artists do not belong to an art movement. *Important European AH* and *Important American AH* are dummy variables that equal one if the sale takes place at a large continental European or American auction house, respectively (see Appendix I). *Pedigree*, *Exhibition*, *Literature*, and *Certification* equal one if the auction catalogue artworks have any information on these provenance dimensions. The real hammer prices are deflated to 2007 USD. We report the number of observations (N), mean, and standard deviation (S.D.). For dummy variables, we show the number of cases whereby the variable takes the value one.

Variable	N	Mean	S.D.	Equal to One
Artist Characteristics				
Deceased	2,257,485	0.82	0.38	1,857,210
<i>Nationality</i>				
American	2,257,485	11.73%	32.17%	264,742
Belgian	2,257,485	4.97%	21.72%	112,089
British	2,257,485	12.12%	32.63%	273,513
Dutch	2,257,485	5.78%	23.33%	130,405
French	2,257,485	19.14%	39.34%	432,037
German	2,257,485	7.33%	26.06%	165,411
Italian	2,257,485	10.02%	30.02%	226,163
Spanish	2,257,485	2.13%	14.43%	48,046
Russian	2,257,485	2.72%	16.28%	61,480
<i>Art movement</i>				
Medieval & Renaissance	2,257,485	2.61%	15.93%	36,182
Baroque	2,257,485	10.28%	30.37%	142,783
Rococo	2,257,485	2.52%	15.68%	35,030
Neoclassicism	2,257,485	1.12%	10.51%	15,508
Romanticism	2,257,485	3.67%	18.81%	50,983
Realism	2,257,485	5.36%	22.52%	74,421
Impressionism & Symbolism	2,257,485	8.52%	27.91%	118,240
Fauvism & Expressionism	2,257,485	6.59%	24.80%	91,456
Cubism, Futurism, & Constructivism	2,257,485	4.53%	20.80%	62,939
Dada & Surrealism	2,257,485	4.60%	20.95%	63,904
Abstract Expressionism	2,257,485	3.61%	18.65%	50,105
Pop Art	2,257,485	1.98%	13.95%	27,556
Minimalism & Contemporary	2,257,485	2.28%	14.93%	31,669
Artwork Characteristics				
<i>Attribution</i>				
Attributed	2,257,485	3.27%	17.79%	73,867
Studio	2,257,485	0.30%	5.48%	6,805
Circle	2,257,485	1.20%	10.88%	27,062
School	2,257,485	0.32%	5.65%	7,227
After	2,257,485	0.58%	7.59%	13,082
Style	2,257,485	1.40%	11.75%	31,635
<i>Authenticity</i>				
Signed	2,257,485	70.55%	45.58%	1,592,667
Dated	2,257,485	35.32%	47.80%	797,356
Inscribed	2,257,485	13.16%	33.81%	297,166
<i>Medium</i>				

Variable	N	Mean	S.D.	Equal to One
Oil	2,257,485	64.48%	47.86%	1,455,655
Watercolour	2,257,485	19.17%	39.37%	432,832
Drawing	2,257,485	16.35%	36.98%	368,998
<i>Size</i>				
Height (cm)	2,247,673	56.3	45.9	N/A
Width (cm)	2,242,967	58.4	50.3	N/A
<i>Topic</i>				
Abstract	2,257,485	2.60%	15.92%	58,733
Animals	2,257,485	4.81%	21.41%	108,673
Landscape	2,257,485	15.54%	36.22%	350,714
Seascape	2,257,485	4.24%	20.15%	95,758
Urbanscape	2,257,485	8.34%	27.64%	188,220
Nude	2,257,485	1.68%	12.84%	37,876
People	2,257,485	10.69%	30.90%	241,365
Self Portrait	2,257,485	0.37%	6.11%	8,452
Portrait	2,257,485	4.99%	21.77%	112,584
Religion	2,257,485	2.87%	16.70%	64,800
Still Life	2,257,485	5.68%	23.15%	128,315
Study	2,257,485	1.67%	12.80%	37,642
Other Topic	2,257,485	42.81%	49.48%	966,463
Provenance Characteristics				
Pedigree	2,257,485	14.02%	34.72%	316,551
Exhibition	2,257,485	4.50%	20.72%	101,486
Literature	2,257,485	4.73%	21.23%	106,787
Certification	2,257,485	2.15%	14.50%	48,496
Transaction Characteristics				
<i>Auction House</i>				
Sotheby's London	2,257,485	7.04%	25.58%	158,862
Sotheby's New York	2,257,485	5.46%	22.71%	123,162
Sotheby's Other Branches	2,257,485	3.83%	19.20%	86,495
Christie's London	2,257,485	5.40%	22.59%	121,798
Christie's New York	2,257,485	4.03%	19.66%	90,890
Christie's Other Branches	2,257,485	6.89%	25.33%	155,573
Bonhams London	2,257,485	0.88%	9.33%	19,808
Bonhams Other Branches	2,257,485	2.46%	15.49%	55,552
Phillips London	2,257,485	0.88%	9.32%	19,767
Phillips New York	2,257,485	0.35%	5.92%	7,936
Important American AH	2,257,485	2.57%	15.84%	58,114
Important European AH	2,257,485	11.61%	32.03%	262,038
<i>Month</i>				
January	2,257,485	3.46%	18.27%	78,029
February	2,257,485	5.04%	21.88%	113,784
March	2,257,485	9.00%	28.62%	203,170
April	2,257,485	8.23%	27.49%	185,847
May	2,257,485	12.65%	33.24%	285,551
June	2,257,485	13.12%	33.76%	296,150
July	2,257,485	4.89%	21.57%	110,421
August	2,257,485	1.80%	13.30%	40,657
September	2,257,485	5.14%	22.09%	116,093
October	2,257,485	9.36%	29.13%	211,310
November	2,257,485	15.63%	36.32%	352,903
December	2,257,485	11.68%	32.11%	263,570
Hammer Price				
Variable	N	Mean	S.D.	Median
Nominal in USD	2,227,674	46,696	543,362	3952
Real in USD	2,227,674	53117	564607	5133

Table 2 – Baseline Hedonic Regression

This table presents the baseline hedonic regression results. Model (1) is estimated using OLS. The dependent variable is the natural log of hammer price (in 2007 USD). Column (1) reports the coefficients of the pricing model; Column (2) reports the standard errors (in parentheses), which are clustered at auction branch level; and Column (3) presents the price impact (i.e. the exponent of the estimated coefficient minus one). *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Dept. Var.: Ln(Price)	(1) Coefficient	(2) Standard Error	(3) Price Impact
Artist Characteristics			
Deceased	0.1361***	(0.0216)	14.58%
Artwork Characteristics			
<i>Attribution</i>			
Attributed	-0.7343***	(0.0322)	-52.02%
Studio	-0.7227***	(0.0543)	-51.46%
Circle	-0.9934***	(0.0592)	-62.97%
School	-1.3643***	(0.1116)	-74.45%
After	-1.7525***	(0.0684)	-82.67%
Style	-1.5497***	(0.0637)	-78.77%
<i>Authenticity</i>			
Signed	0.1787***	(0.0189)	19.57%
Dated	0.1721***	(0.0075)	18.78%
Inscribed	-0.0083	(0.0096)	-0.83%
<i>Medium</i>			
Oil	1.2089***	(0.0175)	235.01%
Watercolour	0.4498***	(0.0159)	56.80%
<i>Size</i>			
Height	0.0060***	(0.0002)	0.60%
Width	0.0054***	(0.0002)	0.54%
Height Squared ($\times 10^{-4}$)	-0.0073***	(0.0008)	-0.01%
Width Squared ($\times 10^{-4}$)	-0.0059***	(0.0009)	-0.01%
<i>Topic</i>			
Abstract	0.0087	(0.0200)	0.87%
Animals	-0.0133	(0.0199)	-1.32%
Landscape	0.0327	(0.0295)	3.32%
Seascape	0.0850***	(0.0190)	8.87%
Urbanscape	0.1357***	(0.0161)	14.53%
Nude	-0.0739***	(0.0209)	-7.12%
People	0.0246	(0.0159)	2.49%
Self Portrait	0.1894***	(0.0289)	20.85%
Portrait	-0.1518***	(0.0161)	-14.08%
Religion	0.0098	(0.0227)	0.98%
Still Life	0.1025***	(0.0238)	10.79%
Study	-0.1606***	(0.0153)	-14.84%
Other Topic	0.1025***	(0.0254)	10.78%
Provenance Characteristics			
Pedigree	0.3138***	(0.0181)	36.86%
Exhibition	0.4037***	(0.0130)	49.74%
Literature	0.4453***	(0.0139)	56.08%
Certification	0.1226***	(0.0304)	13.03%
Transaction Characteristics			
<i>Auction House</i>			
Sotheby's London	0.6529***	(0.0259)	92.11%
Sotheby's New York	0.6690***	(0.0353)	95.25%
Sotheby's Other Branches	0.3495***	(0.0401)	41.84%
Christie's London	0.6423***	(0.0271)	90.08%
Christie's New York	0.5163***	(0.0291)	67.60%
Christie's Other Branches	0.2057***	(0.0623)	22.84%
Bonhams London	0.3121***	(0.0279)	36.63%
Bonhams Other Branches	-0.0185	(0.0674)	-1.83%

Dept. Var.: Ln(Price)	(1) Coefficient	(2) Standard Error	(3) Price Impact
Phillips London	0.2326***	(0.0249)	26.19%
Phillips New York	0.3160***	(0.0269)	37.16%
Important American AH	-0.1225***	(0.0335)	-11.53%
Important European AH	0.1593***	(0.0343)	17.27%
<i>Month</i>			
February	-0.0558	(0.0634)	-5.43%
March	0.0522	(0.0661)	5.36%
April	0.1127**	(0.0554)	11.93%
May	0.1840***	(0.0318)	20.20%
June	0.1469**	(0.0736)	15.82%
July	0.0895	(0.0862)	9.36%
August	-0.0336	(0.0640)	-3.30%
September	-0.0785	(0.0658)	-7.54%
October	0.0299	(0.0559)	3.04%
November	0.1741***	(0.0443)	19.02%
December	0.1477**	(0.0644)	15.92%
Artist FE	Yes		
Year FE	Yes		
# of Obs.	2,163,281		
Adj. R-squared	0.7211		

Table 3 – Art Returns and Risk

This table provides an overview of art returns and risk based on auction prices (in 2007 USD). Panel A reports annualised geometric and arithmetic nominal returns, real returns, and repeat sale real returns. The nominal returns are calculated by means of the adjusted nominal hedonic indices (see Subsection 2.1.1). Annualised real returns are calculated similarly but the auction prices are deflated using 2007 USD. The repeat sale real returns are calculated via Equation (7) are based on inflation-corrected auction prices (in 2007 USD). Panel B reports four subpanels of return matrixes comprising annualised nominal and real returns. The column year denotes the starting year (from 1 January) of the holding period and the row denotes the ending year (until 31 December). Panel C reports the (unsmoothed) volatility (for the unsmoothing methodology, see Equation (9)) of nominal and real returns as well as the volatility of repeat sale real returns.

Panel A: Annualised Nominal, Real, and Repeat Sale Real Returns

<i>Holding Period</i>	Arithmetic Mean Return			Geometric Mean Return		
	Nominal	Real	Repeat Sale	Nominal	Real	Repeat Sale
1958–2016	6.24%	2.49%	3.97%	5.00%	1.22%	1.88%
1958–1986	11.05%	6.23%	7.88%	9.76%	4.78%	4.79%
1987–2016	1.26%	-1.38%	-0.08%	0.29%	-2.34%	-1.04%
<i>Bubble Period</i>						
1985–1990	18.10%	13.90%	12.97%	14.53%	10.24%	9.32%
2003–2007	9.22%	6.16%	5.18%	8.72%	5.68%	4.37%
<i>Bust Period</i>						
1991–1995	-2.17%	-5.11%	-5.02%	-2.40%	-5.35%	-5.44%
2008–2010	-2.40%	-3.81%	-2.09%	-3.24%	-4.81%	-2.48%

Panel B: Art Returns by Holding Period

Nominal Return: Arithmetic Mean						
Till ↓ / From →	1958	1968	1978	1988	1998	2008
1968	10.58%					
1978	10.60%	12.50%				
1988	12.22%	13.99%	16.79%			
1998	8.30%	8.29%	7.23%	1.42%		
2008	7.56%	7.38%	6.36%	2.80%	3.89%	
2016	6.24%	5.81%	4.57%	1.26%	1.13%	-5.89%
Nominal Return: Geometric Mean						
Till ↓ / From →	1958	1968	1978	1988	1998	2008
1968	9.25%					
1978	9.27%	11.15%				
1988	10.91%	12.70%	15.76%			
1998	6.85%	6.78%	5.73%	-0.08%		
2008	6.25%	6.06%	5.12%	1.65%	3.27%	
2016	5.00%	4.58%	3.44%	0.29%	0.58%	-6.25%
Real Return: Arithmetic Mean						
Till ↓ / From →	1958	1968	1978	1988	1998	2008
1968	8.33%					
1978	6.42%	6.39%				
1988	7.40%	7.83%	10.28%			
1998	3.93%	3.13%	2.33%	-1.84%		
2008	3.48%	2.77%	2.11%	-0.26%	1.21%	
2016	2.49%	1.68%	0.86%	-1.38%	-1.03%	-7.48%
Real Return: Geometric Mean						
Till ↓ / From →	1958	1968	1978	1988	1998	2008
1968	7.04%					
1978	5.02%	4.86%				
1988	5.94%	6.26%	8.92%			
1998	2.40%	1.53%	0.79%	-3.33%		
2008	2.11%	1.38%	0.84%	-1.41%	0.58%	
2016	1.22%	0.42%	-0.27%	-2.34%	-1.58%	-7.91%

Panel C: Art Return Volatility

Volatility of:	1958–2016	1958–1986	1987–2016
Nominal Return	16.32%	17.16%	14.00%
Unsmoothed Nominal Return	21.88%	24.13%	17.72%
Real Return	16.21%	17.79%	13.63%
Unsmoothed Real Return	21.73%	24.62%	17.41%
Repeat Sale Real Return	21.67%	26.93%	13.71%

Table 4 – Real Art Returns by Subsample and Holding Period

This table presents annualised real art returns calculated by means of hedonic indices, for various subsamples and holding periods. The subsamples are split by price level (to enable quantile regressions); by art medium; by art movement; by auction market location; by auction houses type; by artist nationalities; by market segment (local vs. international market); and by artist career cycle. Regarding the holding period returns, the starting year commences on 1 January and the end year ends on 31 December. The Sharpe ratio is calculated as excess real return (arithmetic mean real returns minus real risk-free rate) divided by the standard deviation of returns. T-bill rates from the Federal Reserve Bank of St. Louis are a proxy for the risk-free rate.

	Arithmetic Mean Real Returns			Geometric Mean Real Returns			Sharpe Ratio
	1958–2016	1958–1986	1987–2016	1958–2016	1958–1986	1987–2016	1958–2016
Panel A: Price Levels (Quantile regressions)							
Price Quantile 5% (cheapest)	1.46%	4.21%	-1.38%	0.10%	2.23%	-2.06%	0.0355
Price Quantile 25%	1.58%	4.36%	-1.30%	0.32%	2.63%	-2.01%	0.0443
Price Quantile 50%	1.72%	4.56%	-1.23%	0.53%	3.00%	-1.97%	0.0543
Price Quantile 75%	1.92%	4.87%	-1.14%	0.74%	3.39%	-1.93%	0.0672
Price Quantile 95% (most expensive)	2.23%	5.39%	-1.03%	1.00%	3.87%	-1.88%	0.0852
Panel B: Mediums (Hedonic Pricing)							
Oil painting	3.39%	7.27%	-0.63%	2.12%	5.89%	-1.65%	0.1516
Watercolour	2.50%	6.15%	-1.27%	1.41%	4.83%	-2.01%	0.1068
Drawing	2.10%	5.55%	-1.48%	0.38%	3.03%	-2.29%	0.0649
Panel C: Art Movements (Hedonic Pricing)							
Medieval & Renaissance	3.32%	6.23%	0.31%	1.41%	3.55%	-0.76%	0.1244
Baroque	3.42%	7.60%	-0.90%	2.00%	5.68%	-1.67%	0.1432
Rococo	4.40%	9.01%	-0.37%	2.04%	5.52%	-1.44%	0.1458
Neoclassicism	7.48%	16.51%	-1.87%	3.14%	9.42%	-2.98%	0.1990
Romanticism	3.35%	7.97%	-1.43%	1.78%	5.88%	-2.30%	0.1304
Realism	3.20%	7.83%	-1.58%	0.57%	3.68%	-2.55%	0.0998
Impressionism & Symbolism	3.47%	8.62%	-1.85%	1.60%	6.12%	-2.86%	0.1280
Fauvism & Expressionism	3.68%	8.56%	-1.37%	1.76%	5.98%	-2.42%	0.1362
Cubism, Futurism, & Constructivism	4.74%	8.94%	0.39%	2.87%	6.90%	-1.14%	0.1894
Dada & Surrealism	5.32%	10.66%	-0.21%	3.08%	7.85%	-1.63%	0.1958
Abstract Expressionism	5.28%	8.43%	2.25%	2.63%	5.27%	0.14%	0.1819
Pop Art	7.93%	13.94%	3.17%	1.42%	3.39%	-0.12%	0.1809
Minimalism & Contemporary	12.88%	27.24%	2.98%	5.43%	12.33%	0.92%	0.2583

	Arithmetic Mean Real Returns			Geometric Mean Real Returns			Sharpe Ratio
	1970–2016		1987–2016	1970–2016		1987–2016	1970–2016
Panel D: Auction Market Location (Hedonic Pricing)							
UK	3.26%		1.11%	1.88%		0.03%	0.1471
US	0.72%		-0.96%	-0.60%		-2.06%	-0.0022
Continental Europe	0.20%		-2.06%	-0.99%		-3.02%	-0.0344
France	-0.13%		-2.84%	-1.78%		-4.14%	-0.0483
Germany	0.09%		-1.78%	-0.83%		-2.46%	-0.0463
Panel E: Auction House (Hedonic Pricing)							
Sotheby's & Christie's	2.91%		0.71%	1.67%		-0.30%	0.1317
Bonhams & Phillips	4.14%		3.02%	2.67%		1.80%	0.1871
Important American Auction House	-0.72%		-1.70%	-1.80%		-2.37%	-0.0965
Important European Auction House	0.58%		-1.65%	-0.64%		-2.63%	-0.0102
Other Small Worldwide Auction House	-0.11%		-2.33%	-1.39%		-3.28%	-0.0529
Panel F: Artist Nationalities (Hedonic Pricing)							
American	4.38%	8.46%	0.16%	2.25%	5.47%	-0.98%	0.1454
Belgian	3.38%	7.96%	-1.37%	1.93%	5.98%	-2.09%	0.1370
British	2.87%	5.76%	-0.13%	1.64%	4.21%	-0.94%	0.1243
Dutch	3.30%	7.99%	-1.54%	1.81%	5.93%	-2.28%	0.1328
Dutch & Belgian	3.31%	7.88%	-1.41%	1.92%	5.99%	-2.12%	0.1379
French	2.59%	7.21%	-2.18%	0.96%	5.37%	-3.40%	0.0930
German	3.76%	8.11%	-0.75%	1.98%	5.55%	-1.58%	0.1506
Italian	3.76%	7.62%	-0.24%	1.86%	5.10%	-1.39%	0.1421
Russian	7.31%	13.36%	1.05%	1.73%	4.66%	-1.22%	0.1754
Spanish	5.56%	10.76%	0.17%	2.20%	6.26%	-1.83%	0.1732

	Arithmetic Mean Real Returns			Geometric Mean Real Returns			Sharpe Ratio
Panel G: Market Segmentations (Local vs. International) (Hedonic Pricing)							
<i>Definition 1: Whole Sample, Local = 1 if Artist Nationality Matches Sale Country</i>							
	1958–2016	1958–1986	1987–2016	1958–2016	1958–1986	1987–2016	1958–2016
Local	2.37%	5.97%	-1.36%	1.31%	4.87%	-2.24%	0.1002
International	3.37%	7.22%	-0.61%	1.93%	5.47%	-1.61%	0.1415
<i>Definition 2: Since 1970, Excluding American and British Artists</i>							
	1970–2016		1987–2016	1970–2016		1987–2016	1970–2016
Local	0.25%		-1.88%	-0.97%		-2.86%	-0.0316
International	2.03%		-0.72%	0.83%		-1.69%	0.0793
<i>Definition 3: Since 1970, International = 1 if Auction Takes Place in Sotheby's or Christie's London or New York City</i>							
	1970–2016		1987–2016	1970–2016		1987–2016	1970–2016
Local	0.25%		-1.52%	-0.86%		-2.42%	-0.0329
International	3.44%		1.12%	2.03%		-0.09%	0.1555
Panel H: Artist Career Cycle (Hedonic Pricing)							
	1958–2016	1958–1986	1987–2016	1958–2016	1958–1986	1987–2016	1958–2016
Early	3.36%	6.77%	-0.17%	1.60%	4.56%	-1.39%	0.1275
Middle	3.57%	7.00%	0.03%	2.12%	5.45%	-1.20%	0.1531
Late	4.08%	7.59%	0.46%	2.60%	5.93%	-0.73%	0.1809

Table 5 – Comparison of Art Investment Performance with Other Alternative and Financial Assets

This table presents the comparison of the risk and returns of alternative investments, traditional financial assets, gold, and real estate. Panel A reports the real arithmetic mean, nominal arithmetic returns, return volatility (real), and Sharpe ratio (excess real returns divided by their standard deviation) of alternative investments. Panel B reports the risk–return characteristics of other financial assets. Panel C reports the pairwise correlation coefficients for art, other alternative investments and financial assets. Panel D presents the optimal portfolio allocation of financial assets and paintings within the period of 1958–2016, and Panel E (F) presents the optimal allocation results in sub-period 1958–1986 (1987–2016). Panel G and Panel H present the optimal portfolio allocations within art schools and movements, respectively. Stamp returns (1958–2008) are from Dimson and Spaenjers (2011); red Bordeaux wine returns (1958–2012) are from Dimson et al. (2015); classic car returns (1999–2016) are from Laurs and Renneboog (2019); sculpture returns (1986–2013) are from Vosilov (2015); white diamond returns (2000–2012) are from Renneboog and Spaenjers (2012) and Renneboog (2013); and violin returns (1981–2009) are from Graddy and Margolis (2011). Real returns of the S&P 500, FTSE 100, Global Government Bond (using 10-year bonds from the countries of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, South Africa, Spain, Sweden, the UK, and the US, and are weighted by GDP), Dow Jones Corporate Bond, US AAA 10-year Corporate Bond, Goldman Sachs Commodity (a composite index of 24 commodity sector returns, representing an unleveraged, long-only investment in commodity futures that is broadly diversified across the spectrum of commodities), and LME Gold are calculated based on Global Financial Data. US housing real returns are from Shiller (2016). T-bill rates downloaded from the Federal Reserve Bank of St. Louis and are a proxy for the risk-free rate. Numbers in bold in Panel C refer to statistical significance at the 5% level. SD stands for standard deviation.

Panel A: Comparison of Investment Performance of Alternative Investments

Asset Class	Paintings	Stamps	Red Bordeaux Wines	Classic cars	Sculptures	White Diamonds	Fine Violins
Period	1958–2016	1958–2008	1958–2012	1999–2016	1986–2013	2000–2012	1981–2009
Real Returns	2.49%	5.60%	9.74%	3.69%	1.11%	5.23%	3.68%
Nominal Returns	6.24%	12.00%	15.86%	5.95%	3.95%	7.82%	7.94%
Volatility (real)	16.21%	15.01%	23.12%	10.22%	15.01%	10.96%	9.54%
Sharpe Ratio (real)	0.10	0.27	0.38	0.39	0.02	0.51	0.17

Panel B: Comparison of Investment Performance of Other Financial Assets

Asset Class	Paintings	S&P 500 Stock	FTSE 100 Stock	Global Govt. Bond	Dow Jones Corp. Bond	US AAA 10-Yr Corp. Bond	Commodity	Gold	US Housing	T-Bill
Period	1958–2016	1958–2016	1979–2016	1958–2016	1958–2016	1958–2016	1970–2016	1958–2016	1958–2016	1958–2016
Real Returns	2.49%	7.84%	3.73%	2.98%	4.49%	3.81%	1.34%	4.25%	0.73%	0.87%
Nominal Returns	6.24%	11.72%	8.39%	6.74%	8.27%	7.57%	5.55%	8.39%	4.47%	4.62%
Volatility (real)	16.21%	16.82%	13.82%	7.76%	9.17%	8.00%	21.66%	21.44%	4.61%	2.17%
Sharpe Ratio (real)	0.10	0.42	0.19	0.30	0.43	0.42	0.03	0.15	-0.03	-
Period	1958–1986	1958–1986	1979–1986	1958–1986	1958–1986	1958–1986	1970–1986	1958–1986	1958–1986	1958–1986
Real Returns	6.23%	6.71%	6.68%	2.36%	3.64%	2.01%	-1.82%	6.93%	0.42%	1.20%
Nominal Returns	11.05%	11.62%	15.39%	7.15%	8.44%	6.77%	4.64%	12.55%	5.27%	6.05%
Volatility (real)	17.80%	16.83%	9.36%	9.08%	11.57%	9.43%	17.87%	26.34%	3.13%	2.43%
Sharpe Ratio (real)	0.28	0.34	0.47	0.15	0.24	0.10	-0.15	0.21	-0.20	-
Period	1987–2016	1987–2016	1987–2016	1987–2016	1987–2016	1987–2016	1987–2016	1987–2016	1987–2016	1987–2016
Real Returns	-1.38%	9.00%	2.82%	3.62%	5.37%	5.68%	3.31%	1.48%	1.05%	0.53%

Nominal Returns	1.26%	11.83%	6.22%	6.32%	8.09%	8.40%	6.12%	4.09%	3.65%	3.14%
Volatility (real)	13.63%	17.02%	14.95%	6.21%	5.84%	5.79%	23.79%	14.78%	5.80%	1.85%
Sharpe Ratio (real)	-0.14	0.50	0.15	0.49	0.82	0.92	0.11	0.06	0.08	-

Panel C: Pairwise Correlation of Art and Financial Assets (1958–2016; in Real Terms)

	Paintings	Stamps	Red Bordeaux Wines	Cars	Sculptures	White Diamonds	Violins	S&P 500 Stock	FTSE 100 Stock	Global Govt. Bond	Dow Jones Corp Bond	US AAA 10-Yr Corp. Bond	Commodity	Gold	US Housing	T-Bill
Paintings	1															
Stamps	-0.02	1														
Red Bordeaux Wines	0.01	-0.04	1													
Classic cars	0.19	0.21	0.09	1												
Sculptures	0.69	-0.17	0.19	0.17	1											
White Diamonds	0.70	-0.09	0.01	0.53	0.45	1										
Violins	0.04	-0.05	0.32	0.21	0.06	-0.45	1									
S&P 500 Stock	-0.11	-0.24	0.14	-0.03	0.18	0.05	-0.08	1								
FTSE 100 Stock	-0.03	-0.38	0.25	-0.03	0.23	0.17	-0.09	0.83	1							
Global Govt. Bond	-0.10	-0.35	-0.02	-0.23	0.10	-0.23	-0.09	0.33	0.24	1						
Dow Jones Corporate Bond	-0.23	-0.30	0.10	-0.52	-0.10	-0.85	-0.06	0.37	0.31	0.87	1					
US AAA 10-Yr Corporate Bond	-0.21	-0.32	0.03	-0.22	-0.20	-0.13	-0.18	0.22	0.10	0.80	0.89	1				
Goldman Sachs Commodity	0.40	-0.03	0.27	-0.02	0.38	0.04	0.02	-0.04	0.21	-0.10	-0.17	-0.32	1			
Gold	0.32	0.31	-0.03	-0.23	0.24	0.35	-0.04	-0.25	-0.11	-0.10	-0.24	-0.28	0.45	1		
US Housing	0.09	0.08	0.12	0.26	0.21	-0.15	-0.12	0.17	0.19	0.11	0.05	0.05	0.03	-0.11	1	
T-Bill	0.03	-0.49	0.13	-0.06	-0.03	0.12	-0.05	0.22	0.22	0.43	0.49	0.54	-0.31	-0.48	-0.03	1

Panel D: Optimal Portfolio Allocations of Financial Assets (Including and Excluding Paintings; 1958–2016)

	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings
Paintings	-	18.35%	-	19.17%	-	19.17%	-	9.53%	-	9.53%	-	9.53%
S&P 500 Stock	52.84%	42.51%	37.77%	28.13%	37.77%	28.13%	29.89%	26.68%	29.89%	26.68%	29.89%	26.68%
Global Govn. Bond	47.16%	39.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dow Jones Corp. Bond	-	-	62.23%	52.70%	62.23%	52.70%	49.37%	47.21%	49.37%	47.21%	49.37%	47.21%
T-Bill	-	-	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Gold	-	-	-	-	-	-	20.74%	16.58%	20.74%	16.58%	20.74%	16.58%
US Housing	-	-	-	-	-	-	-	-	0.00%	0.00%	0.00%	0.00%
Commodity	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
Real Portfolio Returns	5.55%	4.96%	5.75%	5.05%	5.75%	5.05%	5.44%	5.15%	5.44%	5.15%	5.44%	5.15%
Real Portfolio SD	10.59%	8.72%	9.89%	7.81%	9.89%	7.81%	7.78%	7.14%	7.78%	7.14%	7.78%	7.14%
Return-Risk Ratio (real)	0.5237	0.5685	0.5818	0.6461	0.5818	0.6461	0.6993	0.7214	0.6993	0.7214	0.6993	0.7214
Shape Ratio (real)	0.4416	0.4688	0.4939	0.5348	0.4939	0.5348	0.5876	0.5997	0.5876	0.5997	0.5876	0.5997

Panel E: Optimal Portfolio Allocations of Financial Assets (Including and Excluding Paintings; 1958–1986)

	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings
Paintings	-	43.04%	-	38.67%	-	38.67%	-	23.28%	-	23.28%	-	23.28%
S&P 500 Stock	94.53%	49.20%	69.06%	36.00%	69.06%	36.00%	41.86%	33.04%	41.86%	33.04%	41.86%	33.04%
Global Govn. Bond	5.47%	7.76%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dow Jones Corp. Bond	-	-	30.94%	25.33%	30.94%	25.33%	30.29%	27.18%	30.29%	27.18%	30.29%	27.18%
T-Bill	-	-	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Gold	-	-	-	-	-	-	27.85%	16.50%	27.85%	16.50%	27.85%	16.50%
US Housing	-	-	-	-	-	-	-	-	0.00%	0.00%	0.00%	0.00%
Commodity	-	-	-	-	-	-	-	-	-	-	0.00%	0.00%
Real Portfolio Return	6.48%	6.17%	5.76%	5.75%	5.76%	5.75%	5.84%	5.80%	5.84%	5.80%	5.84%	5.80%
Real Portfolio SD	15.82%	10.50%	13.29%	9.25%	13.29%	9.25%	9.43%	8.35%	9.43%	8.35%	9.43%	8.35%
Return-Risk Ratio (real)	0.4093	0.5874	0.4336	0.6216	0.4336	0.6216	0.6196	0.6950	0.6196	0.6950	0.6196	0.6950
Shape Ratio (real)	0.3337	0.4736	0.3437	0.4923	0.3437	0.4923	0.4929	0.5518	0.4929	0.5518	0.4929	0.5518

Panel F: Optimal Portfolio Allocations of Financial Assets (Including and Excluding Paintings; 1987–2016)

	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings	Without Paintings	With Paintings
Paintings	-	0.00%	-	3.52%	-	3.52%	-	2.97%	-	1.86%	-	0.04%
S&P 500 Stock	26.73%	26.73%	11.03%	10.32%	11.03%	10.32%	11.45%	10.78%	7.68%	7.42%	6.67%	6.67%
Global Govn. Bond	73.27%	73.27%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Dow Jones Corp. Bond	-	-	88.97%	86.16%	88.97%	86.16%	85.20%	83.51%	71.36%	70.90%	73.95%	73.94%
T-Bill	-	-	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Gold	-	-	-	-	-	-	3.35%	2.74%	3.78%	3.39%	0.86%	0.86%
US Housing	-	-	-	-	-	-	-	-	17.18%	16.44%	14.98%	14.97%
Commodity	-	-	-	-	-	-	-	-	-	-	3.53%	3.52%
Real Portfolio Return	5.06%	5.06%	5.77%	5.50%	5.77%	5.50%	5.65%	5.45%	4.76%	4.67%	4.86%	4.85%
Real Portfolio SD	7.20%	7.20%	5.94%	5.62%	5.94%	5.62%	5.79%	5.55%	4.68%	4.58%	4.74%	4.74%
Return-Risk Ratio (real)	0.7027	0.7027	0.9714	0.9793	0.9714	0.9793	0.9766	0.9827	1.0157	1.0195	1.0246	1.0246
Shape Ratio (real)	0.6288	0.6288	0.8817	0.8847	0.8817	0.8847	0.8847	0.8867	0.9021	0.9033	0.9123	0.9123

Panel G: Optimal Portfolio Allocations by Art Schools

	Art Schools (1958–2016)											
Medieval & Renaissance	22.17%	13.63%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Baroque	77.83%	44.82%	11.61%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Rococo	-	41.56%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	3.45%
Neoclassicism	-	-	88.39%	62.51%	63.49%	56.87%	55.74%	39.42%	38.89%	45.33%	45.94%	33.67%
Romanticism	-	-	-	37.49%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Realism	-	-	-	-	36.51%	17.77%	17.00%	13.12%	12.83%	0.00%	0.00%	0.00%
Impressionism & Symbolism	-	-	-	-	-	25.36%	20.43%	5.59%	5.77%	0.00%	0.00%	0.00%
Fauvism & Expressionism	-	-	-	-	-	-	6.83%	0.00%	0.00%	0.00%	0.00%	0.00%
Cubism, Futurism, & Constructivism	-	-	-	-	-	-	-	41.87%	37.91%	0.00%	0.00%	0.00%
Dada & Surrealism	-	-	-	-	-	-	-	-	4.60%	0.00%	0.00%	0.00%
Abstract Expressionism	-	-	-	-	-	-	-	-	-	54.67%	33.55%	26.56%
Pop Art	-	-	-	-	-	-	-	-	-	-	20.52%	0.00%
Minimalism & Contemporary	-	-	-	-	-	-	-	-	-	-	-	36.32%
Real Portfolio Return	3.40%	3.81%	7.01%	5.93%	5.92%	5.70%	5.67%	5.55%	5.56%	6.28%	6.84%	8.75%
Real Portfolio SD	17.19%	18.90%	30.50%	24.29%	23.46%	22.24%	22.10%	20.62%	20.68%	22.02%	23.55%	25.48%
Return-Risk Ratio (real)	0.1977	0.2018	0.2298	0.2441	0.2522	0.2563	0.2567	0.2690	0.2689	0.2852	0.2903	0.3436
Sharpe Ratio (real)	0.1471	0.1558	0.2013	0.2083	0.2152	0.2173	0.2174	0.2269	0.2269	0.2457	0.2533	0.3094

Panel H: Optimal Allocations by Top Artists in Art Schools

	Top Artists by Art Schools (1958–2016)											
Medieval & Renaissance	41.71%	40.48%	34.85%	27.40%	27.40%	27.40%	26.55%	26.55%	25.65%	25.37%	23.02%	21.16%
Baroque	58.29%	52.54%	26.60%	17.15%	17.15%	17.15%	15.02%	15.02%	14.40%	8.14%	9.12%	7.01%
Rococo	-	6.98%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Neoclassicism	-	-	38.55%	30.72%	30.72%	30.72%	29.45%	29.45%	29.04%	24.47%	24.02%	22.03%
Romanticism	-	-	-	24.73%	24.73%	24.73%	22.15%	22.15%	21.20%	11.77%	13.44%	3.72%
Realism	-	-	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Impressionism & Symbolism	-	-	-	-	-	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Fauvism & Expressionism	-	-	-	-	-	-	6.83%	6.83%	4.60%	4.40%	0.00%	0.00%
Cubism, Futurism, & Constructivism	-	-	-	-	-	-	-	0.00%	0.00%	0.00%	0.00%	0.00%
Dada & Surrealism	-	-	-	-	-	-	-	-	5.10%	0.00%	0.00%	0.00%
Abstract Expressionism	-	-	-	-	-	-	-	-	-	25.83%	19.71%	24.40%
Pop Art	-	-	-	-	-	-	-	-	-	-	10.70%	6.89%
Minimalism & Contemporary	-	-	-	-	-	-	-	-	-	-	-	14.79%
Real Portfolio Return	13.82%	13.69%	14.45%	12.84%	12.84%	12.84%	12.66%	12.66%	12.48%	13.01%	13.10%	14.64%
Real Portfolio SD	37.76%	37.34%	35.18%	29.99%	29.99%	29.99%	29.46%	29.46%	28.99%	29.06%	28.49%	31.08%
Return-Risk Ratio (real)	0.3661	0.3667	0.4108	0.4283	0.4283	0.4283	0.4296	0.4296	0.4303	0.4476	0.4599	0.4712
Sharpe Ratio (real)	0.3431	0.3434	0.3861	0.3993	0.3993	0.3993	0.4001	0.4001	0.4003	0.4177	0.4294	0.4432

Figure 1 – Baseline Price Real Indices

This figure presents the baseline and adjusted hedonic, and repeat sales price indices since 1957 detailed in Online Appendix Table OA.1. The initial index values are set at 100 in 1957 for all three indices (see Equations (1)–(5) in Subsection 2.1.1).

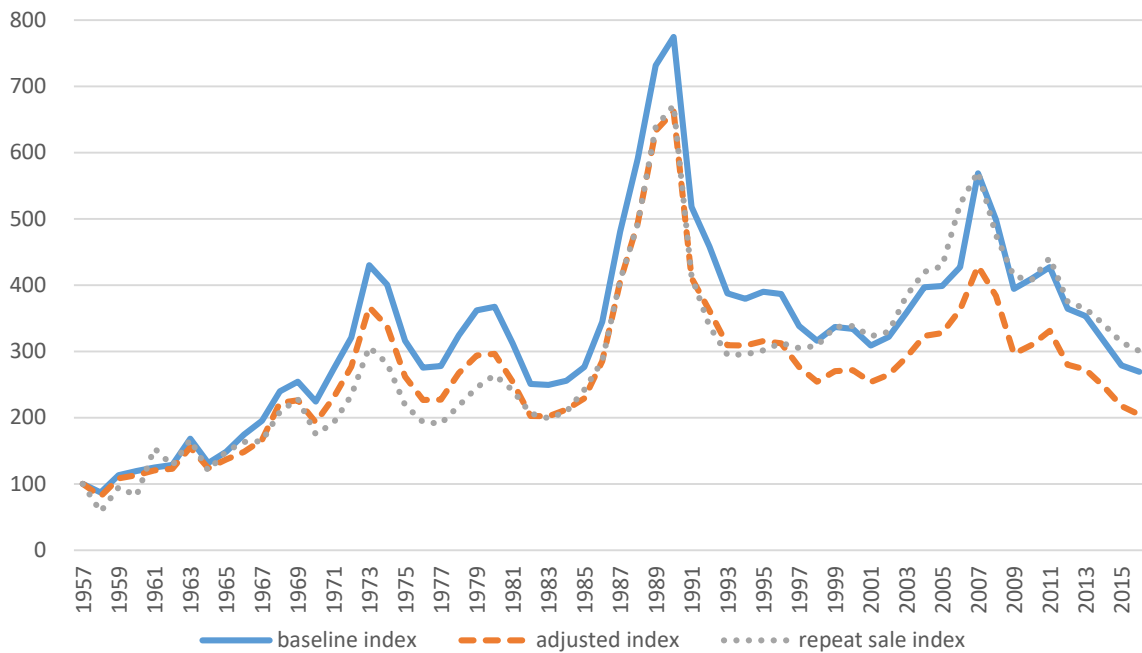


Figure 2 – Quantile Price Indices (Price Levels)

This figure presents the art price indices since 1957 that result from the quantile regressions for the percentiles 95th, 75th, 50th, 25th, and 5th. We run a quantile variant of our adjacent-period hedonic regression model for every 2-year period since 1957 for the following percentiles: 95th, 75th, 50th, 25th, and 5th. The quantile hedonic price indices are then constructed by chain-linking the coefficients on the year dummies for the relevant quantiles (for details, see Online Appendix Table OA.2). The Q95 index value in 1957 is set at 100; the initial index values of Q05, Q25, Q50, and Q75 indices are normalised based on the 5-year average percentiles from 1957 to 1961 relative to Q95 index. The price trend figure of which the initial index values are set at 100 in 1957 for all groups is presented in Online Appendix Figure OA.2.

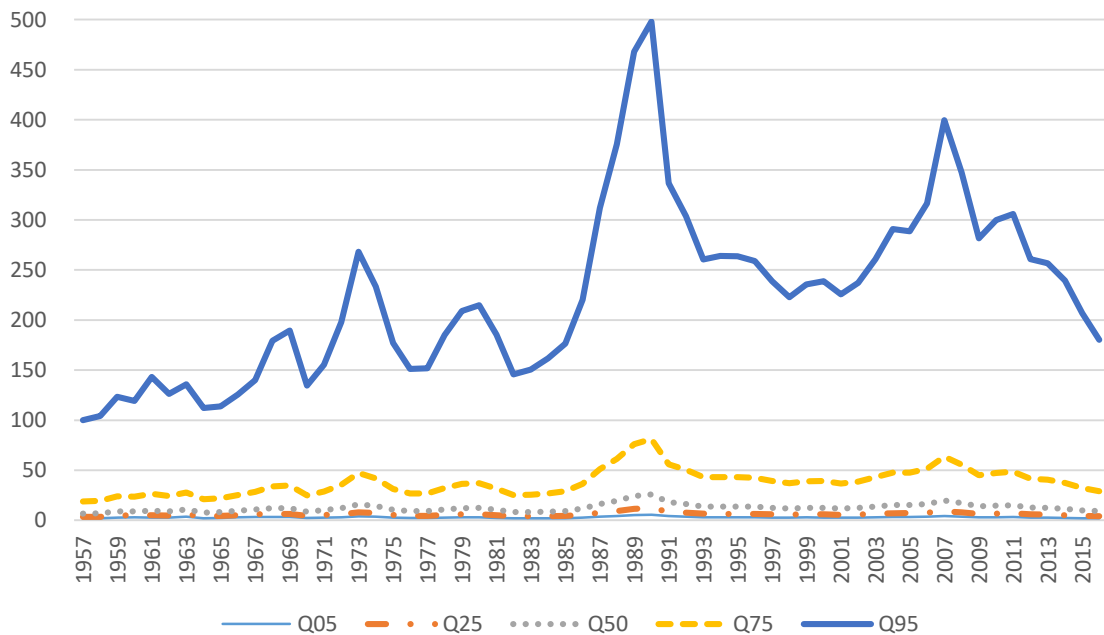


Figure 3 – Price Indices of by Medium (Price Levels)

This figure presents the baseline hedonic art price indices of oil and acrylic paintings, watercolours and gouaches, and drawings based on the model presented in Equation (1). The oil and acrylic painting index value in 1957 is set at 100; the initial index values of watercolour and drawing indices are normalised based on the 5-year average price from 1957 to 1961 relative to oil painting's index. The price trend figure of which the initial index values are set at 100 in 1957 for all groups is presented in Online Appendix Figure OA.3.

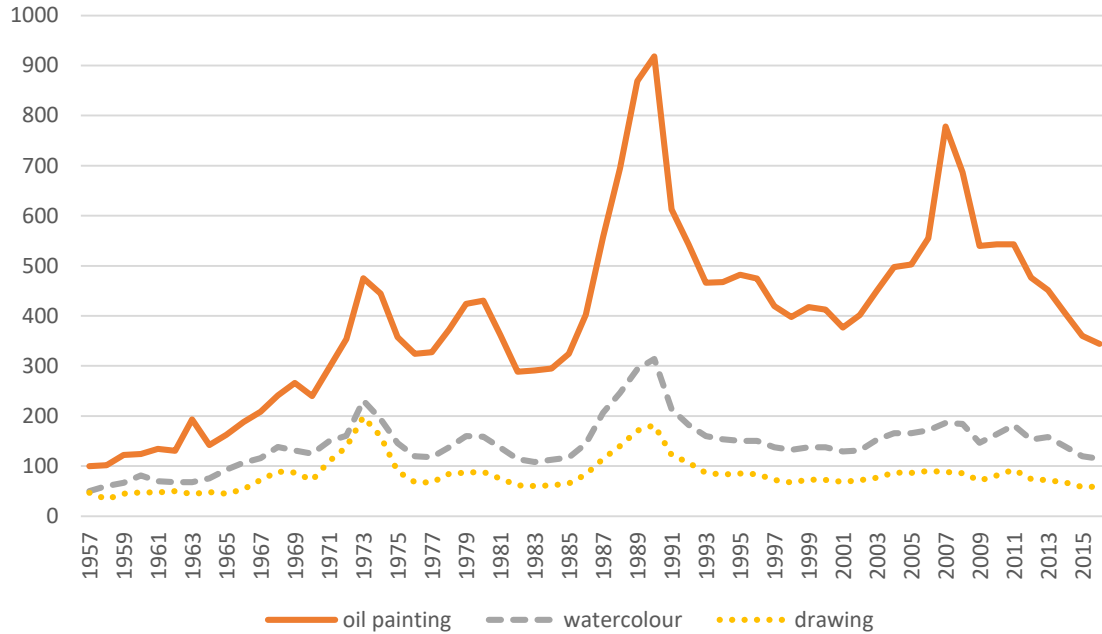


Figure 4 – Price Indices of Art Movements Since 1957 (Price Levels)

This figure presents the art price indices of movements since 1957. We classify art movements into five groups: (1) *Medieval and Renaissance, Baroque, and Rococo*; (2) *Neoclassicism, Romanticism, and Realism*; (3) *Impressionism and Symbolism*; (4) *Fauvism and Expressionism, Cubism, Futurism, and Constructivism, Dada and Surrealism*; and (5) *Abstract Expressionism, Pop Art, Minimalism and Contemporary*. The initial index value of the *Medieval and Renaissance, Baroque, and Rococo* group is set at 100 in 1957, and the initial index values of other art movement groups are normalised by the average price of the period from 1957 to 1961 relative to the *Medieval and Renaissance, Baroque, and Rococo* group. The price trend figure of which the initial index values are set at 100 in 1957 for all groups is presented in Online Appendix Figure OA.4.

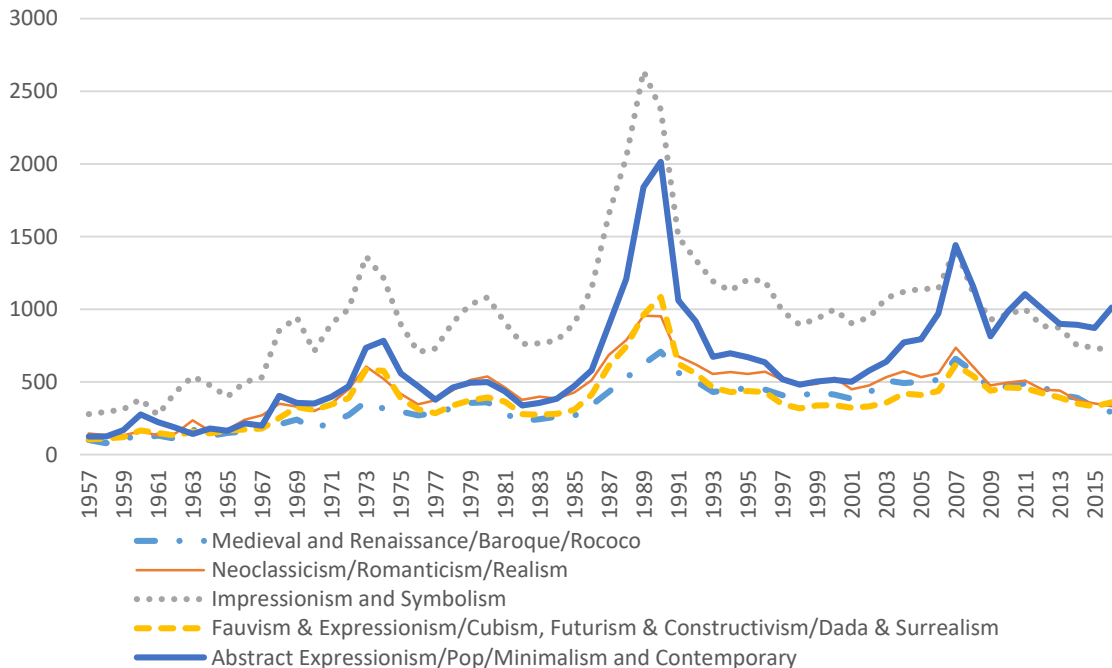


Figure 5 – Price Indices of Auction Markets Since 1970 (Price Levels)

This figure presents the art price indices of auction markets including UK, US, and continental Europe since 1970. The initial index value for UK sales is set at 100 in 1970 and the initial index values for US and Europe sales are normalised by the average prices from 1970 to 1974 relative to those of the UK. The figure in which the initial index values are set at 100 in 1970 is presented in Online Appendix Figure OA.5.

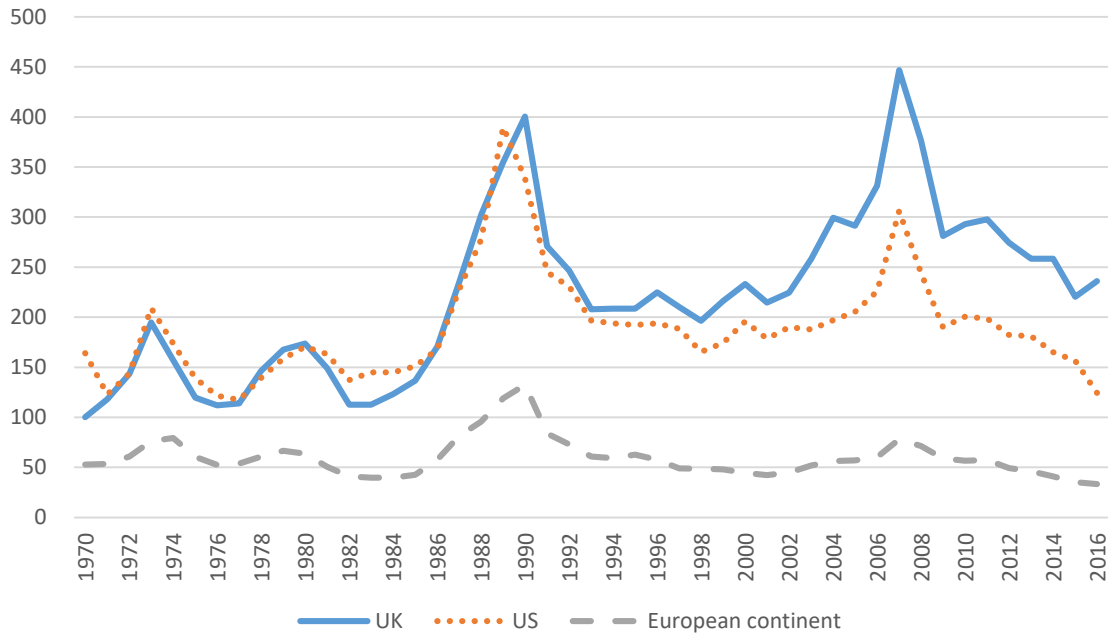


Figure 6 – Price Indices of Auction Houses Since 1970 (Price Trends)

This figure presents the art price indices of auction houses since 1970, including (1) Sotheby's and Christie's (S&C); (2) Bonhams and Phillips (B&P); and (3) important European auction houses (Important European AH); (4) important American auction houses (Important American AH); and (5) Other small worldwide auction houses (Other Small AH). The initial index values are set at 100 in 1970. The figure in which the initial index value for S&C is set at 100 in 1970 and the initial index values for other auction houses are normalised by the average prices from 1970 to 1974 relative to that of S&C is presented in Online Appendix Figure OA.6.

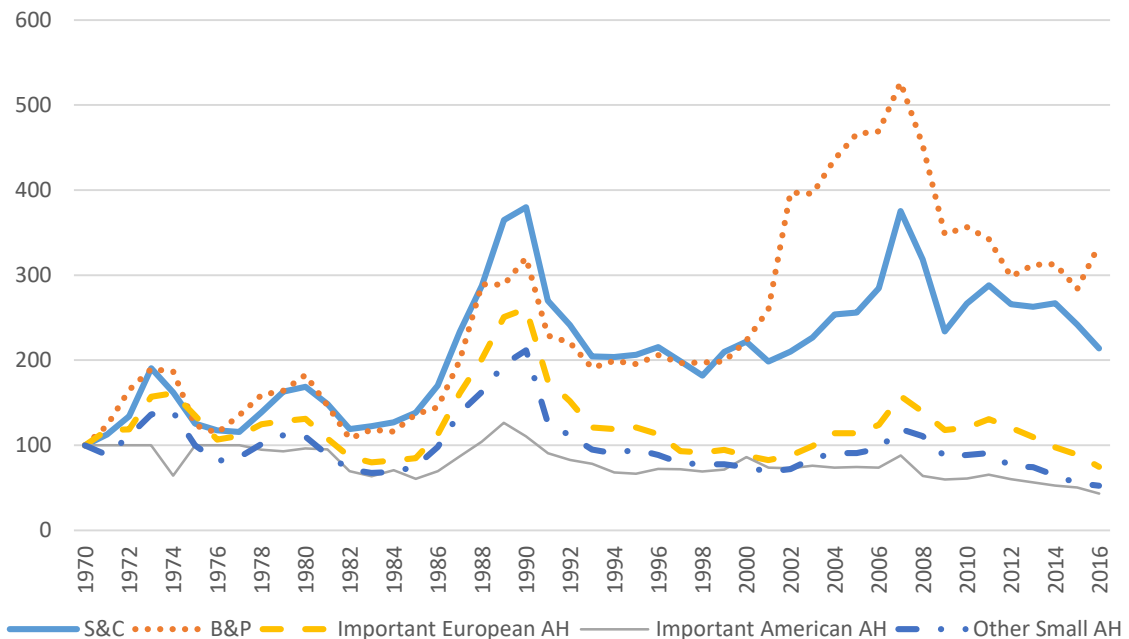


Figure 7 – Price Indices of Artist Nationalities (Price Levels)

This figure presents the art price indices of British, American, French, Italian, Dutch, and Belgian artists since 1957. The initial index value for British artists is set at 100 in 1957 and the initial index values are normalised by the average prices from 1957 to 1961 relative to British artists. The figure in which the initial index values are set at 100 in 1957 for all groups is presented in Online Appendix Figure OA.7.

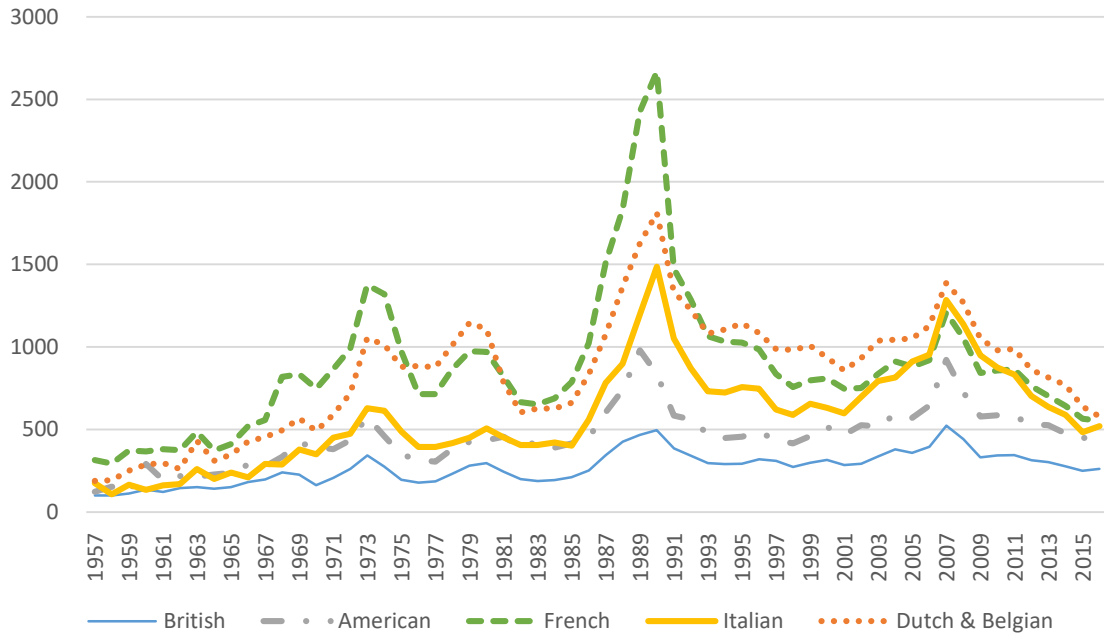


Figure 8a – Price Indices of Local and International Markets since 1957 (Price Trends)

This figure presents the art price indices of local and international markets since 1957. A local market comprises the sales of work of an artist whose nationality coincides with the country of the sale. The initial index values are set at 100 in 1957. The figure in which the initial index value for local markets is set at 100 in 1957 and the initial index value for international markets is normalised by the average price from 1957 to 1961 relative to local markets' is presented in Online Appendix Figure OA.8a.

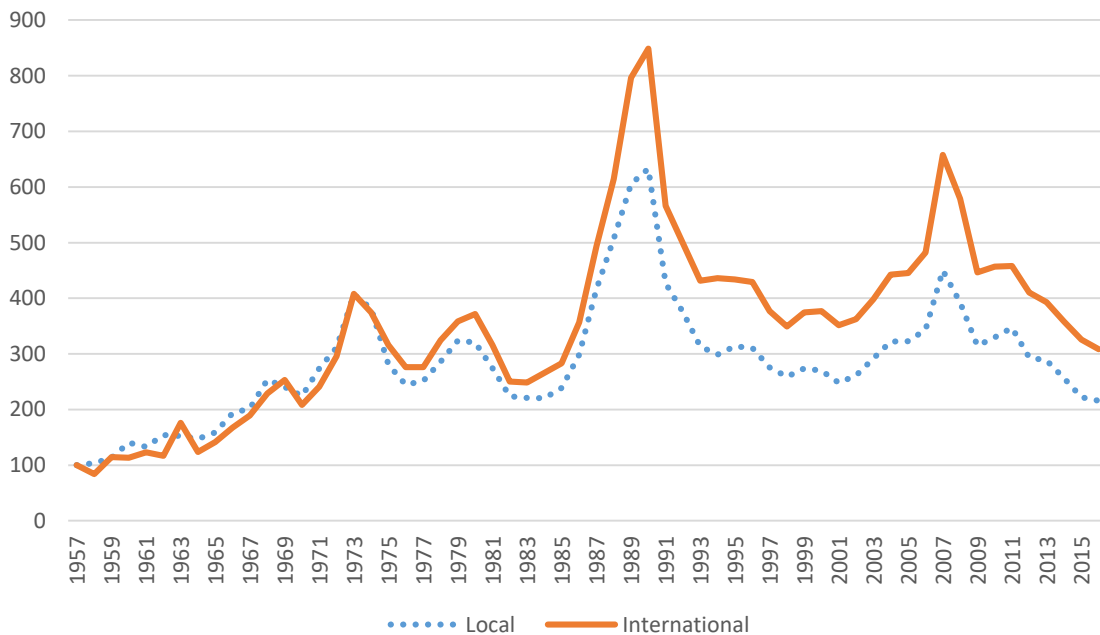


Figure 8b – Price Indices of Local and International Markets since 1970 (Price Trends)
(Excluding British and American Artists)

This figure presents the art price indices of local and international markets. A local market comprises the sales of work of an artist whose nationality coincides with the country of the sale (excluding British and American artists). The initial index values are set at 100 in 1970. The figure in which the initial index value for local markets is set at 100 in 1970 and the initial index value for international markets is normalised by the average price from 1970 to 1974 relative to local markets' is presented in Online Appendix Figure OA.8b.

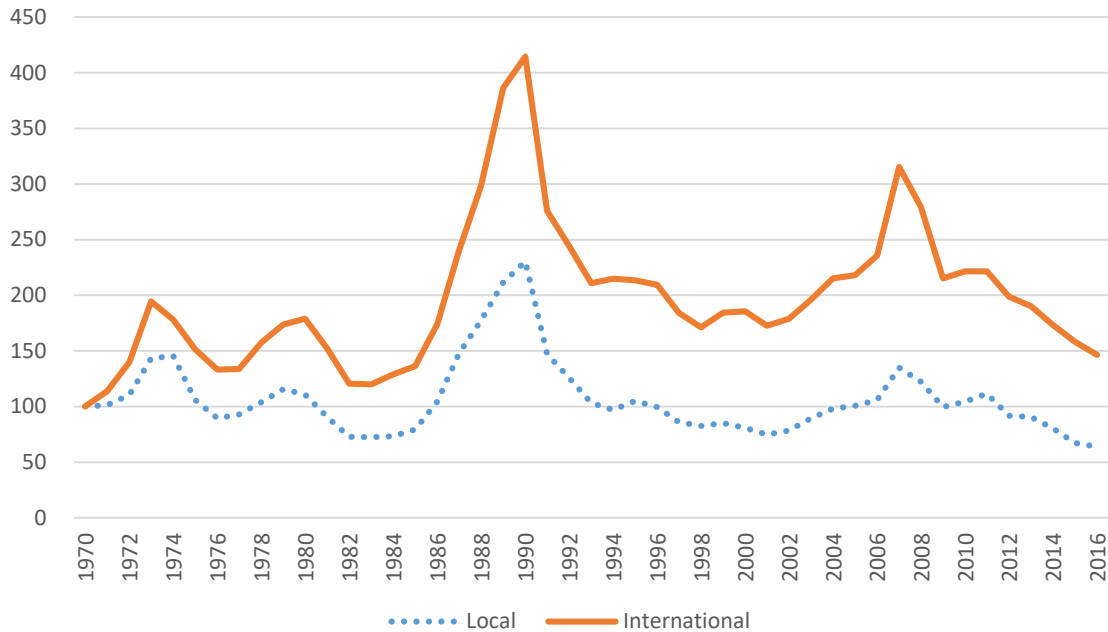


Figure 8c – Price Indices of Local and International Markets since 1970 (Price Trends)
(Sotheby's & Christie's London and New York branches = International)

This figure presents the art price indices of local and international markets since 1970. The observations are defined as International when the observations were sold at Sotheby's London, Sotheby's New York, Christie's London, or Christie's New York; the observations are defined as Local otherwise. The initial index values are set at 100 in 1970. The figure in which the initial index value for local markets is set at 100 in 1970 and the initial index value for international markets is normalised by the average price from 1970 to 1974 relative to that of local markets is presented in Online Appendix Figure OA.8c.

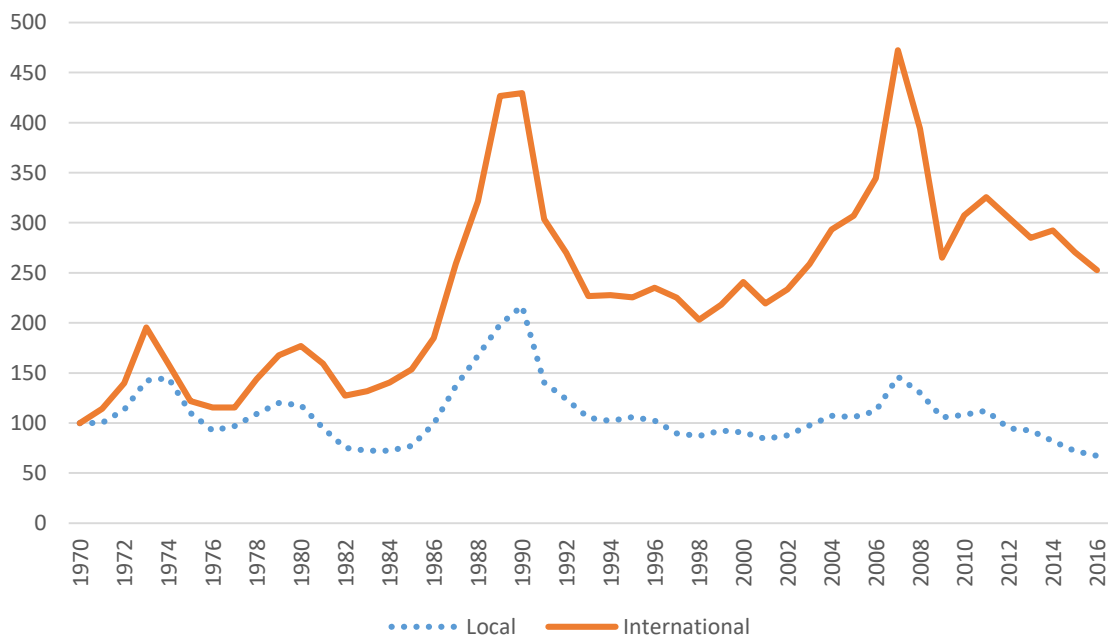


Figure 9a – Price Indices of Artist Career Cycle since 1957 (Price Trends)

This figure presents the art price indices of artist career cycle since 1957. The observations are classified into three subsamples by the relative age when the artist created the paintings whereby the following classification is based on terciles of the active artist’s life (since the age of 18 years): (1) Early, (2) Middle, and (3) Late. The initial index values are set at 100 in 1957.

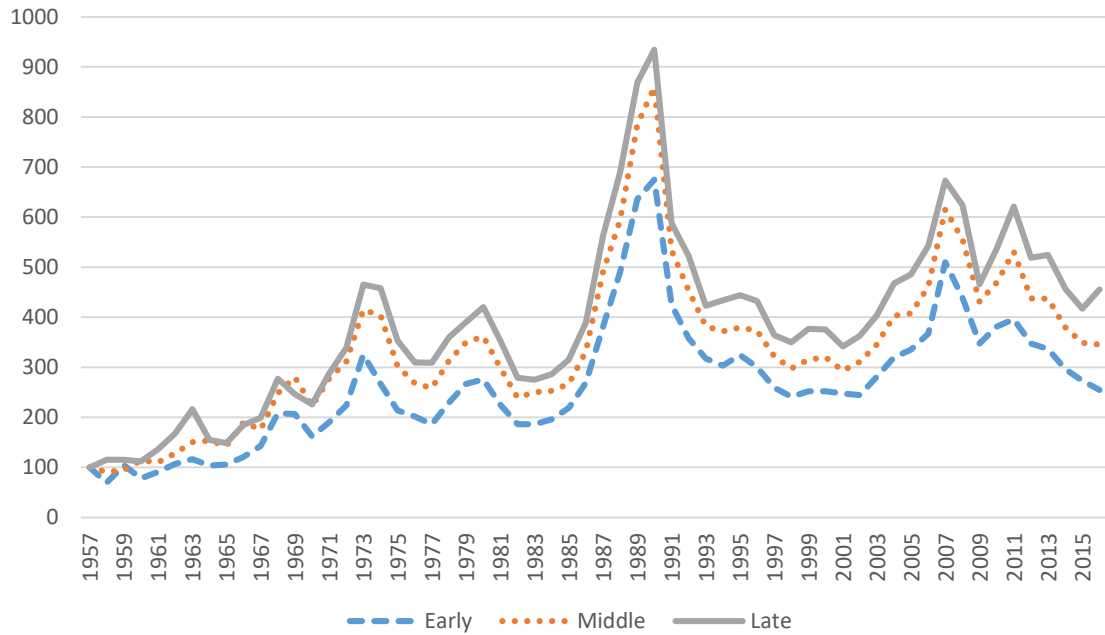
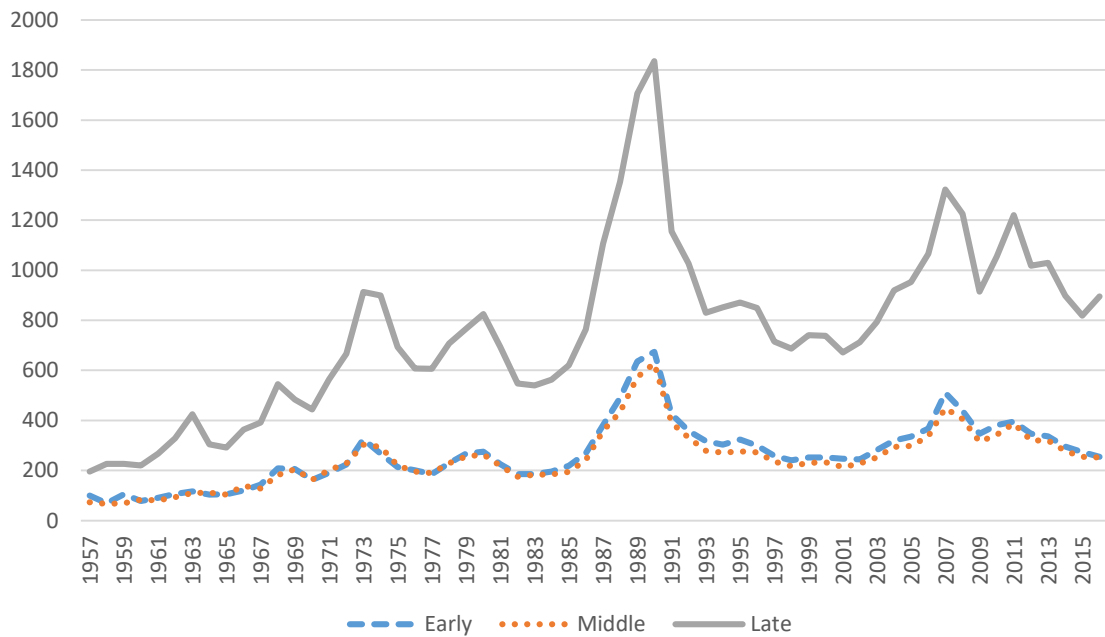


Figure 9b – Price Indices of Artist Career Cycle since 1957 (Price Levels)

This figure presents the art price indices of artist career cycle since 1957. The observations are classified into three subsamples by the relative age when the artist created the paintings whereby the following classification is based on terciles of the active artist’s life (since the age of 18 years): (1) Early, (2) Middle, and (3) Late. The initial index value for young-age group is set at 100 in 1957 and the initial index values for other age groups are normalised by the average price from 1957 to 1961 relative to that of the young age group.



Appendix

Appendix I – Variable Definitions

Variable	Definition
Ln(Price)	Ln(Price) is the natural logarithm of real hammer price (deflated in 2007 USD).
Deceased	Deceased is a dummy variable equal to one if the artist was deceased prior the sale of the auctioned lot.
Height	The height of a painting measured in centimetres.
Width	The width of a painting measured in centimetres.
Oil	Oil refers to the oil/acrylic painting category.
Watercolours	Watercolours and gouaches.
Drawing	Drawing refers to the drawing category.
Signed	Signed is a dummy variable that equals one if the artwork bears physically identifiable signature(s) in various forms: full names, monograms, initials, countersignatures, and stamps.
Dated	Dated is a dummy variable that equals one if the artwork bears physically identifiable date(s).
Inscribed	Inscribed is a dummy variable that equals one if the artwork bears physically identifiable inscription(s).
Attribution	Attribution variables (Attributed, Studio, Circle, School, After, Style) are dummy variables equal to one if the auctioned object had been recognised and disclosed by the auction house at the following levels: 1) attributed to the artist, 2) from the studio of the artist, 3) from the circle of the artist, 4) from the school of the artist, 5) after the artist, or 6) in the style or manner of the artist.
Pedigree	Pedigree is a dummy variable equal to one if there is textual information in the auction catalogue about the pedigree information (past ownership, previous sales information, etc.) of the auctioned lot.
Literature	Literature is a dummy variable equal to one if there is textual information in the auction catalogue about literature covering the auctioned lot.
Exhibition	Exhibited is a dummy variable equal one if there is textual information in the auction catalogue about the exhibition history of the auctioned lot.
Certification	Certification is a dummy variable equal to one if there is textual information in the auction catalogue about authentication either in the form of a physical certificate or oral confirmation.
Sotheby's London	Sotheby's London is a dummy variable that equals one if the sale takes place at Sotheby's London.
Sotheby's New York	Sotheby's New York is a dummy variable that equals one if the sale takes place at Sotheby's New York.
Sotheby's Other Branches	Sotheby's Other Branches is a dummy variable that equals one if the sale takes place at one of Sotheby's branches other than London and New York.
Christie's London	Christie's London is a dummy variable that equals one if the sale takes place at Christie's London.
Christie's New York	Christie's New York is a dummy variable that equals one if the sale takes place at Christie's New York.
Christie's Other Branches	Christie's Other Branches is a dummy variable that equals one if the sale takes place at one of Christie's branches other than London or New York.
Bonhams London	Bonhams London is a dummy variable that equals one if the sale takes place at Bonhams London.
Bonhams New York	Bonhams New York is a dummy variable that equals one if the sale takes place at Bonhams New York.
Bonhams Other Branches	Bonhams Other Branches is a dummy variable that equals one if the sale takes place at one of Bonhams branches other than London or New York.
Phillips London	Phillips London is a dummy variable that equals one if the sale takes place at Phillips London.
Phillips New York	Phillips New York is a dummy variable that equals one if the sale takes place at Phillips New York.
Important American AH	Important American AH is a dummy variable that equals one if the sale takes place at one of the following important American auction houses: Butterfields (until 2002), Swann Auction Galleries, Skinner, Doyle New York, Freeman's, and Leslie Hindman.

Important European AH	Important European AH is a dummy variable that equals one if the sale takes place at one of the following important European auction houses: 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).
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Appendix II – Real Art Returns by Subsample in Bubble and Bust Periods

This table presents annualised real art returns calculated by means of hedonic indices, for various subsamples in Bubble (1985–1990; 2003–2007) and Bust (1991–1995; 2008–2010) periods. The subsamples are split by price level (as to enable quantile regressions); by art medium; by art movement; by auction market location; by auction houses type; by artist nationalities; by market segment (local vs. international market); and by artist career cycle. Regarding the holding period returns, the starting year commences on 1 January and the end year ends on 31 December.

	Arithmetic Mean Real Returns				Geometric Mean Real Returns			
	Bubble Periods		Bust Periods		Bubble Periods		Bust Periods	
	1985–1990	2003–2007	1991–1995	2008–2010	1985–1990	2003–2007	1991–1995	2008–2010
Panel A: Price Levels (Quantile regressions)								
Price Quantile 5% (cheapest)	14.05%	3.83%	-5.72%	-4.24%	11.89%	3.40%	-5.96%	-4.87%
Price Quantile 25%	14.10%	4.56%	-5.52%	-4.05%	11.75%	4.06%	-5.74%	-4.68%
Price Quantile 50%	14.14%	5.21%	-5.34%	-3.88%	11.64%	4.61%	-5.55%	-4.52%
Price Quantile 75%	14.18%	5.89%	-5.15%	-3.70%	11.52%	5.20%	-5.36%	-4.35%
Price Quantile 95% (most expensive)	14.25%	6.72%	-4.91%	-3.50%	11.37%	5.91%	-5.10%	-4.18%
Panel B: Mediums (Hedonic Pricing)								
Oil painting	14.12%	10.05%	-4.74%	-6.93%	11.18%	8.78%	-4.99%	-7.53%
Watercolour	13.30%	3.86%	-6.59%	0.76%	10.54%	3.78%	-6.78%	-0.46%
Drawing	13.84%	2.31%	-6.89%	3.93%	11.03%	2.14%	-7.22%	2.84%
Panel C: Art Movements (Hedonic Pricing)								
Medieval & Renaissance	17.21%	3.95%	-4.28%	-0.85%	14.43%	2.53%	-4.50%	-1.49%
Baroque	14.53%	2.28%	-3.68%	-4.69%	13.28%	1.55%	-4.02%	-5.38%
Rococo	12.84%	5.36%	-5.09%	-3.34%	11.74%	4.48%	-5.43%	-5.19%
Neoclassicism	12.68%	1.89%	-1.95%	-3.46%	10.28%	0.24%	-2.49%	-3.89%
Romanticism	8.74%	5.91%	-3.29%	-6.39%	7.11%	4.27%	-3.40%	-7.35%
Realism	10.92%	3.52%	-3.72%	-4.66%	8.11%	2.45%	-3.92%	-5.89%
Impressionism & Symbolism	12.87%	1.70%	-4.16%	-2.94%	8.82%	0.60%	-4.38%	-3.44%
Fauvism & Expressionism	15.33%	8.50%	-4.45%	-7.26%	10.79%	7.77%	-4.88%	-7.84%
Cubism, Futurism, & Constructivism	19.54%	11.49%	-7.87%	-5.02%	13.75%	9.50%	-8.00%	-5.73%
Dada & Surrealism	17.66%	9.25%	-8.89%	-0.51%	13.22%	7.38%	-9.34%	-0.80%
Abstract Expressionism	20.02%	12.77%	-9.66%	1.32%	13.33%	10.78%	-10.17%	-0.20%
Pop Art	25.98%	15.33%	-8.43%	5.43%	17.16%	10.89%	-9.32%	1.95%
Minimalism & Contemporary	20.99%	18.06%	-9.02%	-1.99%	15.41%	16.44%	-10.02%	-6.11%

	Arithmetic Mean Real Returns				Geometric Mean Real Returns			
	Bubble Periods		Bust Periods		Bubble Periods		Bust Periods	
	1985–1990	2003–2007	1991–1995	2008–2010	1985–1990	2003–2007	1991–1995	2008–2010
Panel D: Auction Market Location (Hedonic Pricing)								
UK	14.84%	9.23%	-3.32%	-6.53%	12.08%	7.85%	-3.67%	-7.56%
US	11.39%	6.91%	-4.41%	-5.90%	8.39%	5.42%	-4.58%	-6.69%
Continental Europe	15.53%	7.28%	-6.88%	-6.72%	11.97%	6.58%	-7.20%	-7.07%
France	17.71%	5.65%	-8.76%	-6.89%	12.00%	4.98%	-9.14%	-7.45%
Germany	13.03%	6.12%	-6.82%	-3.01%	11.97%	5.64%	-7.19%	-3.20%
Panel E: Auction House (Hedonic Pricing)								
Sotheby's & Christie's	14.28%	8.15%	-4.12%	-1.51%	11.83%	7.04%	-4.42%	-3.30%
Bonhams & Phillips	11.88%	3.20%	-1.85%	-8.23%	9.03%	2.74%	-2.09%	-8.90%
Important American Auction House	8.41%	-2.19%	-4.16%	0.87%	6.96%	-3.41%	-4.44%	0.72%
Important European Auction House	16.12%	7.90%	-8.09%	-1.55%	12.91%	7.09%	-8.45%	-2.10%
Other Small Worldwide Auction House	12.93%	6.09%	-6.63%	-5.73%	9.09%	5.59%	-6.86%	-6.42%
Panel F: Artist Nationalities (Hedonic Pricing)								
American	8.81%	9.08%	-3.43%	-6.70%	5.90%	6.97%	-3.71%	-7.23%
Belgian	14.39%	4.26%	-4.22%	-7.17%	12.34%	3.61%	-4.45%	-7.48%
British	12.31%	6.85%	-3.38%	-6.87%	10.64%	5.57%	-3.73%	-7.82%
Dutch	14.68%	4.64%	-3.87%	-8.21%	12.83%	4.13%	-4.05%	-8.53%
Dutch & Belgian	14.37%	4.60%	-3.87%	-7.75%	12.41%	4.10%	-4.05%	-8.05%
French	16.05%	5.77%	-7.52%	-5.87%	11.00%	4.78%	-7.74%	-6.45%
German	14.84%	7.37%	-5.49%	-3.46%	12.85%	6.51%	-5.75%	-3.79%
Italian	20.29%	8.51%	-6.20%	-9.73%	17.35%	7.50%	-6.62%	-9.87%
Russian	19.84%	19.58%	-5.42%	-7.28%	12.59%	17.77%	-5.73%	-9.53%
Spanish	27.48%	10.62%	-9.58%	-6.71%	21.00%	8.22%	-10.22%	-7.18%

Online Appendix

Table OA.1– Art Indices and Real Returns

This table presents the art price indices and real returns for the baseline hedonic regression model (Table 2). For each year, we report the estimated time dummy coefficient, the baseline hedonic price index and real return (Π and r), and the adjusted price index and real return, corrected for changes in price dispersion over time (Π^* and r^* , see Subsection 2.1.1, Equations (4) and (5)). This table also includes the repeat sale index and real arithmetic and geometric returns over the period 1957 to 2016.

Year	Coefficient	Baseline Hedonic Index	Baseline Return	Adjusted Index	Adjusted Return	Repeat Sales Index	Repeat Sales Return
1957		100.00		100.00		100.00	
1958	-0.1410	86.85	-13.15%	81.28	-18.72%	58.09	-41.91%
1959	0.1221	112.99	30.10%	108.19	33.11%	94.67	62.97%
1960	0.1788	119.58	5.83%	112.87	4.32%	82.07	-13.31%
1961	0.2217	124.82	4.38%	120.33	6.62%	153.49	87.02%
1962	0.2519	128.65	3.07%	123.00	2.21%	127.58	-16.88%
1963	0.5213	168.42	30.92%	155.04	26.05%	166.54	30.54%
1964	0.2730	131.39	-21.99%	123.69	-20.22%	119.73	-28.11%
1965	0.3932	148.17	12.77%	136.65	10.47%	148.66	24.16%
1966	0.5554	174.26	17.61%	148.41	8.61%	163.31	9.86%
1967	0.6695	195.33	12.09%	166.41	12.13%	164.19	0.54%
1968	0.8747	239.82	22.78%	222.15	33.50%	208.67	27.09%
1969	0.9323	254.03	5.93%	226.29	1.87%	228.08	9.30%
1970	0.8084	224.43	-11.65%	193.06	-14.69%	174.94	-23.30%
1971	1.0066	273.63	21.92%	230.33	19.30%	192.19	9.86%
1972	1.1665	321.07	17.34%	276.89	20.22%	233.24	21.36%
1973	1.4589	430.12	33.96%	366.65	32.42%	306.32	31.34%
1974	1.3880	400.68	-6.84%	337.62	-7.92%	281.77	-8.02%
1975	1.1501	315.85	-21.17%	262.10	-22.37%	219.13	-22.23%
1976	1.0139	275.63	-12.73%	226.82	-13.46%	193.27	-11.80%
1977	1.0217	277.79	0.78%	227.15	0.15%	190.79	-1.28%
1978	1.1758	324.07	16.66%	267.17	17.61%	217.72	14.12%
1979	1.2869	362.15	11.75%	293.97	10.03%	245.43	12.72%
1980	1.3010	367.30	1.42%	296.00	0.69%	264.33	7.70%
1981	1.1377	311.96	-15.07%	254.28	-14.09%	241.15	-8.77%
1982	0.9202	250.98	-19.55%	202.66	-20.30%	206.51	-14.36%
1983	0.9141	249.45	-0.61%	201.79	-0.43%	199.14	-3.57%
1984	0.9382	255.54	2.44%	212.32	5.22%	208.91	4.91%
1985	1.0164	276.32	8.13%	228.90	7.81%	242.21	15.94%
1986	1.2368	344.46	24.66%	285.13	24.56%	285.40	17.83%
1987	1.5707	481.00	39.64%	405.57	42.24%	407.39	42.75%
1988	1.7767	591.03	22.88%	493.82	21.76%	492.64	20.93%
1989	1.9904	731.85	23.83%	633.13	28.21%	638.76	29.66%
1990	2.0470	774.46	5.82%	662.17	4.59%	671.04	5.05%
1991	1.6449	518.05	-33.11%	410.82	-37.96%	413.37	-38.40%
1992	1.5219	458.09	-11.57%	361.37	-12.04%	337.73	-18.30%
1993	1.3547	387.56	-15.40%	309.40	-14.38%	294.63	-12.76%
1994	1.3338	379.54	-2.07%	308.57	-0.27%	295.40	0.26%
1995	1.3607	389.89	2.73%	315.80	2.34%	301.73	2.14%
1996	1.3520	386.51	-0.87%	312.06	-1.18%	312.53	3.58%
1997	1.2187	338.28	-12.48%	276.48	-11.40%	304.78	-2.48%
1998	1.1514	316.26	-6.51%	254.44	-7.97%	308.11	1.09%
1999	1.2141	336.73	6.47%	270.29	6.23%	336.91	9.35%
2000	1.2060	334.01	-0.81%	271.62	0.49%	338.43	0.45%
2001	1.1275	308.79	-7.55%	253.55	-6.65%	322.80	-4.62%
2002	1.1691	321.91	4.25%	264.61	4.36%	329.52	2.08%
2003	1.2761	358.26	11.29%	291.12	10.02%	383.91	16.50%
2004	1.3783	396.82	10.76%	323.25	11.04%	420.12	9.43%
2005	1.3831	398.72	0.48%	327.87	1.43%	428.81	2.07%
2006	1.4521	427.21	7.14%	362.87	10.68%	522.49	21.85%

Year	Coefficient	Baseline Hedonic Index	Baseline Return	Adjusted Index	Adjusted Return	Repeat Sales Index	Repeat Sales Return
2007	1.7381	568.65	33.11%	428.75	18.15%	571.35	9.35%
2008	1.6068	498.68	-12.30%	383.66	-10.52%	475.47	-16.78%
2009	1.3720	394.32	-20.93%	296.42	-22.74%	413.39	-13.06%
2010	1.4110	410.01	3.98%	309.76	4.50%	407.90	-1.33%
2011	1.4518	427.08	4.16%	330.87	6.82%	441.00	8.11%
2012	1.2931	364.41	-14.67%	280.05	-15.36%	374.87	-14.99%
2013	1.2624	353.39	-3.02%	272.41	-2.73%	364.50	-2.77%
2014	1.1504	315.95	-10.60%	247.34	-9.20%	341.38	-6.34%
2015	1.0260	278.99	-11.70%	217.34	-12.13%	313.75	-8.09%
2016	0.9905	269.26	-3.49%	204.30	-6.00%	300.44	-4.24%
Arithmetic Mean Real Return:			2.90%			2.49%	3.97%
Geometric Mean Real Return:			1.69%			1.22%	1.88%
Volatility:			15.91%			16.21%	21.67%

Table OA.2 – Adjacent-period Art Index and Real Returns

This table presents the art price indices and real arithmetic and geometric returns for the adjacent-period hedonic regressions. We run regressions for every 2 consecutive years and then chain-link the coefficients on time dummies for the full sample over the sample period 1957–2016 (Baseline column). We apply quantile regression for every 2-year periods for the 5th, 25th, 50th, 75th, and 95th percentiles (columns Q5, Q25, Q50, Q75, and Q95, respectively). We apply the adjacent-period method to ensure that the quantile regression coefficients pick up variation in the valuation of hedonic attributes across price levels and then link the coefficients on the time dummies for each quantile. We report the price index and real return (for the method, see Subsection 2.1.1).

Year	Baseline	Q5	Q25	Q50	Q75	Q95
1957	100.00	100.00	100.00	100.00	100.00	100.00
1958	102.42	100.88	101.58	102.33	103.29	104.22
1959	130.79	138.71	134.66	130.90	127.01	123.45
1960	134.04	151.06	142.26	134.22	126.28	119.18
1961	141.50	140.85	140.85	141.45	142.01	143.16
1962	130.90	135.81	133.12	131.14	128.54	126.28
1963	161.88	191.92	176.09	162.50	148.68	135.73
1964	111.82	111.23	111.26	112.16	112.41	112.14
1965	121.02	127.60	124.09	121.64	118.08	113.81
1966	140.05	154.03	146.73	140.95	133.70	125.73
1967	159.94	179.80	169.47	161.09	150.95	140.12
1968	181.63	183.90	182.32	182.14	181.00	179.28
1969	181.38	174.49	177.38	181.43	185.60	189.63
1970	129.98	126.36	127.76	130.03	132.31	134.42
1971	151.48	148.39	149.47	151.56	153.63	155.39
1972	180.38	166.40	172.75	180.22	188.42	197.68
1973	238.24	214.38	225.44	237.93	251.86	268.10
1974	213.98	198.34	205.36	213.74	223.04	233.45
1975	158.47	143.62	150.46	158.26	166.96	176.95
1976	136.75	125.17	130.46	136.60	143.39	151.09
1977	136.79	124.66	130.23	136.64	143.73	151.86
1978	159.92	140.14	149.44	159.65	171.09	185.02
1979	181.76	160.18	170.28	181.45	193.94	209.05
1980	184.39	160.59	171.81	184.04	197.80	214.73
1981	156.10	133.58	144.25	155.75	168.79	185.24
1982	124.68	108.13	115.94	124.42	134.02	145.88
1983	124.53	104.69	114.15	124.20	135.76	150.65
1984	128.16	103.66	115.41	127.71	142.15	161.61
1985	140.02	113.36	126.14	139.53	155.22	176.37
1986	175.14	142.02	157.90	174.54	194.02	220.25
1987	243.51	193.98	217.80	242.64	271.91	311.96
1988	292.74	232.77	261.61	291.68	327.13	375.69
1989	362.55	286.74	323.23	361.25	406.13	467.91
1990	385.55	304.74	343.63	384.16	431.98	497.89
1991	270.99	222.42	245.64	270.15	298.59	336.46
1992	243.85	199.65	220.80	243.08	268.99	303.53
1993	206.43	166.85	185.82	205.73	229.03	260.44
1994	204.71	162.04	182.50	203.93	229.29	264.14
1995	205.05	162.91	183.11	204.30	229.31	263.58
1996	203.72	163.59	182.80	203.01	226.76	258.93
1997	187.78	150.65	168.42	187.12	209.09	238.91
1998	177.86	144.86	160.62	177.30	196.74	222.62
1999	187.63	152.44	169.27	187.05	207.80	235.49
2000	187.33	150.07	167.92	186.71	208.80	238.71
2001	174.30	137.59	155.19	173.69	195.52	225.58
2002	184.74	147.05	165.12	184.12	206.47	237.03
2003	206.97	167.60	186.41	206.31	229.56	260.83
2004	226.91	180.85	202.91	226.12	253.45	290.75
2005	227.44	182.98	204.21	226.66	253.00	288.61
2006	243.63	191.61	216.58	242.73	273.71	316.58
2007	295.71	223.74	258.05	294.53	338.41	399.52

Year	Baseline	Q5	Q25	Q50	Q75	Q95
2008	259.50	198.14	227.41	258.47	295.74	347.50
2009	209.95	160.10	183.88	209.11	239.41	281.48
2010	218.80	163.15	189.61	217.91	252.14	299.91
2011	225.89	170.59	196.93	224.97	258.78	305.75
2012	193.07	146.16	168.51	192.28	220.94	260.70
2013	187.84	140.61	163.08	187.09	216.08	256.51
2014	169.94	123.16	145.38	169.28	198.40	239.50
2015	148.87	109.48	128.22	148.28	172.62	206.82
2016	136.78	106.15	120.99	136.22	154.43	180.16
Arithmetic Return:	1.72%	1.46%	1.58%	1.72%	1.92%	2.23%
Geometric Return:	0.53%	0.10%	0.32%	0.53%	0.74%	1.00%
Volatility:	15.52%	16.54%	15.89%	15.52%	15.48%	15.93%

Table OA.3 – Hedonic Regressions by Art Movements: Artist Nationalities

This table presents the hedonic regression results of movements including artist nationality variables. Equation (1) is estimated using OLS. The dependent variable is the natural log of deflated hammer price. This table includes the artist nationality variables (British; Dutch and Belgian; French; German; Italian; Spanish; Russian; and American) and exclude the artist control variables. We run regressions on 13 subsamples of movements: (1) *Medieval and Renaissance*; (2) *Baroque*; (3) *Rococo*; (4) *Neoclassicism*; (5) *Romanticism*; (6) *Realism*; (7) *Impressionism and Symbolism*; (8) *Fauvism and Expressionism*; (9) *Cubism, Futurism, and Constructivism*; (10) *Dada and Surrealism*; (11) *Abstract Expressionism*; (12) *Pop Art*; (13) *Minimalism and Contemporary*. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. Standard errors are clustered at auction branch level and reported in parentheses.

Panel A: Movements (1)–(7)

Dept. Var.: Ln(Price)	(1) Medieval & Renaissance	(2) Baroque	(3) Rococo	(4) Neoclassicism	(5) Romanticism	(6) Realism	(7) Impressionism & Symbolism
British	0.210 (0.297)	-0.256*** (0.020)	-0.058* (0.034)	-0.225*** (0.039)	-0.101*** (0.021)	-0.746*** (0.020)	-0.833*** (0.021)
Dutch & Belgian	-0.008 (0.038)	0.312*** (0.016)	-0.491*** (0.045)	-0.545*** (0.057)	0.173*** (0.024)	-0.650*** (0.022)	-0.150*** (0.017)
French	0.171*** (0.054)	0.268*** (0.017)	0.416*** (0.029)	0.347*** (0.029)	0.265*** (0.018)	0.355*** (0.016)	0.278*** (0.012)
German	0.137*** (0.047)	-0.181*** (0.019)	-0.173*** (0.041)	-0.014 (0.037)	0.056** (0.023)	0.322*** (0.017)	-0.021 (0.022)
Italian	-0.159*** (0.037)	0.195*** (0.016)	0.596*** (0.030)	0.402*** (0.035)	0.068 (0.049)	0.068*** (0.024)	-0.108*** (0.034)
Spanish	0.064 (0.067)	0.325*** (0.025)	1.189*** (0.094)	-0.022 (0.135)	0.668*** (0.083)	0.618*** (0.042)	0.313*** (0.039)
Russian		0.390 (0.444)	0.970* (0.555)	0.612*** (0.199)	0.954*** (0.041)	-0.147*** (0.043)	-0.579*** (0.027)
American			-0.693*** (0.236)	-0.055 (0.053)	0.060*** (0.021)	-0.295*** (0.016)	-0.515*** (0.017)
Artist F.E.	No	No	No	No	No	No	No
Other Artist Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Artwork Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Provenance Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Transaction Characteristics	Yes	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs.	35,103	141,204	34,575	15,165	50,434	73,762	117,077
Adj. R-squared	0.433	0.445	0.461	0.451	0.409	0.472	0.501

Panel B: Movements (8)–(13)

	(8)	(9)	(10)	(11)	(12)	(13)
Dept. Var.: Ln(Price)	Fauvism & Expressionism	Cubism, Futurism, & Constructivism	Dada & Surrealism	Abstract Expressionism	Pop	Minimalism & Contemporary
British	-0.772*** (0.041)	0.398*** (0.038)	-0.106*** (0.026)	-0.849 (0.000)	-0.257*** (0.044)	-0.329*** (0.029)
Dutch & Belgian	-0.209*** (0.020)	0.019 (0.045)	0.765*** (0.025)	0.148 (0.000)	-0.579** (0.291)	-0.394*** (0.073)
French	-0.234*** (0.014)	0.389*** (0.015)	0.269*** (0.014)	0.103 (0.000)	0.732*** (0.038)	0.004 (0.045)
German	0.343*** (0.014)	0.860*** (0.029)	0.443*** (0.018)	0.070 (0.000)	0.616*** (0.036)	-0.317*** (0.024)
Italian	0.220*** (0.024)	0.503*** (0.020)	1.061*** (0.027)	0.759 (0.000)	0.103*** (0.035)	-0.364*** (0.026)
Spanish	0.487*** (0.141)	2.055*** (0.022)	1.416*** (0.016)	0.439 (0.000)		
Russian	0.738*** (0.023)	0.339*** (0.016)	-0.332*** (0.019)	-1.102 (0.000)		-0.155 (0.116)
American	-0.542*** (0.017)	-0.363*** (0.028)	-0.279*** (0.020)	-0.173 (0.000)	0.629*** (0.034)	-0.213*** (0.023)
Artist F.E.	No	No	No	No	No	No
Other Artist Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Artwork Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Provenance Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
Transaction Characteristics	Yes	Yes	Yes	Yes	Yes	Yes
# of Obs.	90,839	62,254	63,156	49,651	27,106	31,023
Adj. R-squared	0.538	0.574	0.596	0.537	0.592	0.548

Table OA.4 – Pairwise Correlation of Art and Financial Assets in Sub-Periods

This table presents the pairwise correlation coefficients for art, other alternative investments and financial assets in 1958–1986 (Panel A) and 1987–2016 (Panel B). Stamp returns (1958–2008) are from Dimson and Spaenjers (2011); red Bordeaux wine returns (1958–2012) are from Dimson et al. (2015); classic car returns (1999–2016) are from Laurs and Renneboog (2019); sculpture returns (1986–2013) are from Vosilov (2015); white diamond returns (2000–2012) are from Renneboog and Spaenjers (2012) and Renneboog (2013); and violin returns (1981–2009) are from Graddy and Margolis (2011). Real returns of the S&P 500, FTSE 100, Global Government Bond (using 10-year bonds from the countries of Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Italy, Japan, Netherlands, New Zealand, South Africa, Spain, Sweden, the UK, and the US, and are weighted by GDP), Dow Jones Corporate Bond, US AAA 10-year Corporate Bond, Goldman Sachs Commodity (a composite index of 24 commodity sector returns, representing an unleveraged, long-only investment in commodity futures that is broadly diversified across the spectrum of commodities), and LME Gold are calculated based on Global Financial Data. US housing real returns are from Shiller (2016). T-bill rates are downloaded from the Federal Reserve Bank of St. Louis and are a proxy for the risk-free rate. Numbers in bold refer to statistical significance at the 5% level.

Panel A: Pairwise Correlation of Art and Financial Assets (1958–1986; in Real Terms)

	Paintings	Stamps	Red Bordeaux Wines	S&P 500 Stock	Global Govt. Bond	Dow Jones Corp Bond	US AAA 10-Yr Corp. Bond	Commodity	Gold	US Housing	T-Bill
Paintings	1										
Stamps	-0.06	1									
Red Bordeaux Wines	-0.02	-0.06	1								
S&P 500 Stock	-0.13	-0.16	0.19	1							
Global Govt. Bond	-0.10	-0.36	0.05	0.36	1						
Dow Jones Corporate Bond	-0.20	-0.30	0.15	0.42	0.93	1					
US AAA 10-Yr Corporate Bond	-0.20	-0.39	0.17	0.39	0.94	0.97	1				
Goldman Sachs Commodity	0.55	0.03	0.13	-0.33	-0.24	-0.29	-0.33	1			
Gold	0.38	0.28	-0.18	-0.27	-0.21	-0.31	-0.34	0.70	1		
US Housing	0.15	0.22	0.25	0.11	0.37	0.25	0.26	-0.21	-0.01	1	
T-Bill	-0.08	-0.51	0.25	0.32	0.64	0.67	0.74	-0.38	-0.56	0.04	1

Panel B: Pairwise Correlation of Art and Financial Assets (1987–2016; in Real Terms)

	Paintings	Stamps	Red Bordeaux Wines	Cars	Sculptures	White Diamonds	Violins	S&P 500 Stock	FTSE 100 Stock	Global Govt. Bond	Dow Jones Corp Bond	US AAA 10-Yr Corp. Bond	Commodity	Gold	US Housing	T-Bill
Paintings	1															
Stamps	0.01	1														
Red Bordeaux Wines	0.01	-0.06	1													
Classic cars	0.19	0.21	0.09	1												
Sculptures	0.76	-0.17	0.24	0.17	1											
White Diamonds	0.70	-0.09	0.01	0.53	0.45	1										
Violins	-0.17	0.06	0.25	0.21	-0.05	-0.45	1									
S&P 500 Stock	-0.05	-0.49	0.10	-0.03	0.21	0.05	-0.15	1								
FTSE 100 Stock	-0.04	-0.43	0.22	-0.03	0.26	0.17	-0.13	0.87	1							
Global Govt. Bond	-0.04	-0.29	-0.13	-0.23	0.13	-0.23	0.05	0.30	0.14	1						
Dow Jones Corporate Bond	-0.26	-0.23	0.02	-0.52	-0.04	-0.85	0.23	0.31	0.24	0.71	1					
US AAA 10-Yr Corporate Bond	-0.08	0.12	-0.20	-0.22	-0.14	-0.13	0.04	-0.08	-0.12	0.48	0.67	1				
Goldman Sachs Commodity	0.39	-0.09	0.44	-0.02	0.40	0.04	0.01	0.08	0.27	0.01	-0.10	-0.43	1			
Gold	0.13	0.43	0.31	-0.23	0.22	0.35	0.13	-0.21	-0.03	0.23	0.07	0.01	0.42	1		
US Housing	0.09	-0.04	0.03	0.26	0.22	-0.15	-0.19	0.21	0.19	-0.08	-0.16	-0.16	0.10	-0.23	1	
T-Bill	0.12	-0.38	-0.10	-0.06	-0.01	0.12	-0.20	0.13	0.08	0.08	0.12	0.28	-0.28	-0.41	-0.06	1

Figure OA.1– Accounting for Changes in Taste: Adjacent-period Hedonic Price Index

This figure presents the baseline hedonic art price index since 1957 detailed in Online Appendix Table OA.1. The initial index value is set at 100 in 1957 (see Equation (2) in Subsection 2.1.1).

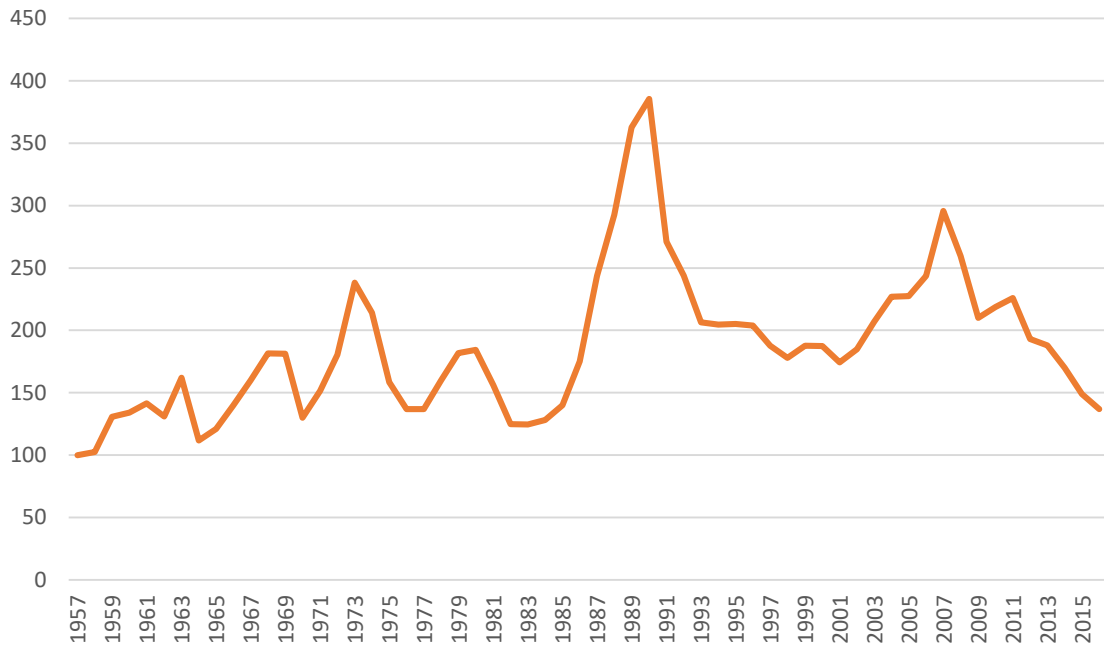


Figure OA.2 – Quantile Price Indices (Price Trends)

This figure presents the art price indices since 1957 that result from the quantile regressions for the percentiles 5th, 25th, 50th, 75th, and 95th (for details, see Online Appendix Table OA.2). The initial index values are set at 100 in 1957 for all groups. The figure in which the Q95 index value in 1957 is set at 100 and the initial index values of Q05, Q25, Q50, and Q75 indices are normalised based on the 5-year average percentiles from 1957 to 1961 relative to the Q95 index is presented in Figure 2.

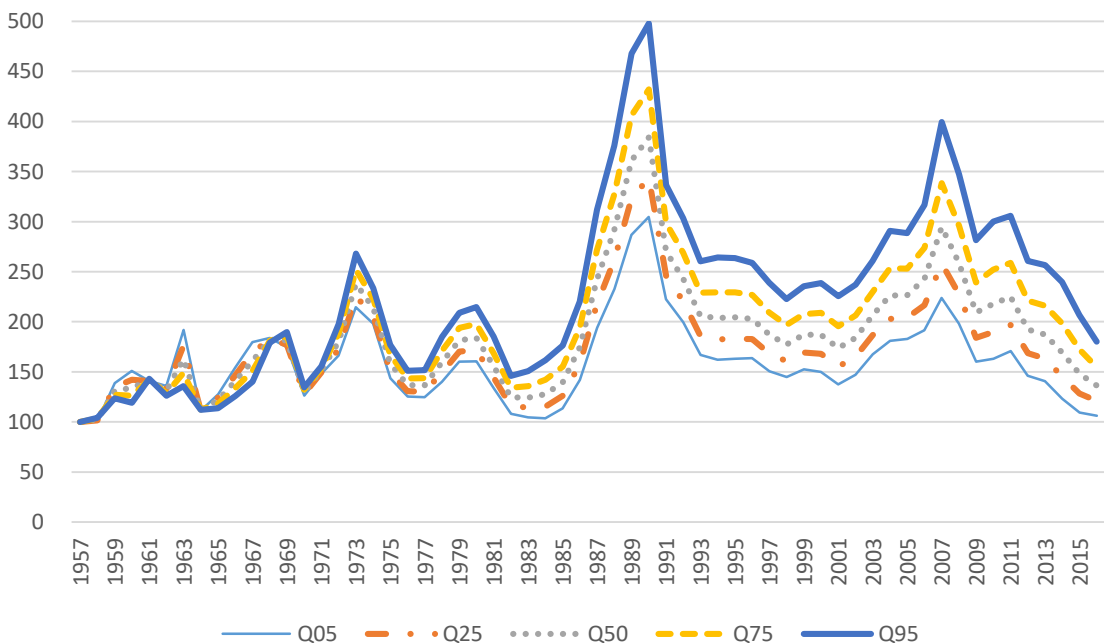


Figure OA.3 – Price Indices by Medium since 1957 (Price Trends)

This figure presents the art price indices of oil and acrylic paintings, watercolours and gouaches, and drawings based on the model presented in Equation (1). The initial index values are set at 100 in 1957 for each medium. The case in which the oil and acrylic painting index value in 1957 is set at 100 and the initial index values of the watercolour and gouaches and of the drawing indices are normalised based on the 5-year average price from 1957 to 1961 relative to the oil and acrylic painting's index is presented in Figure 3.

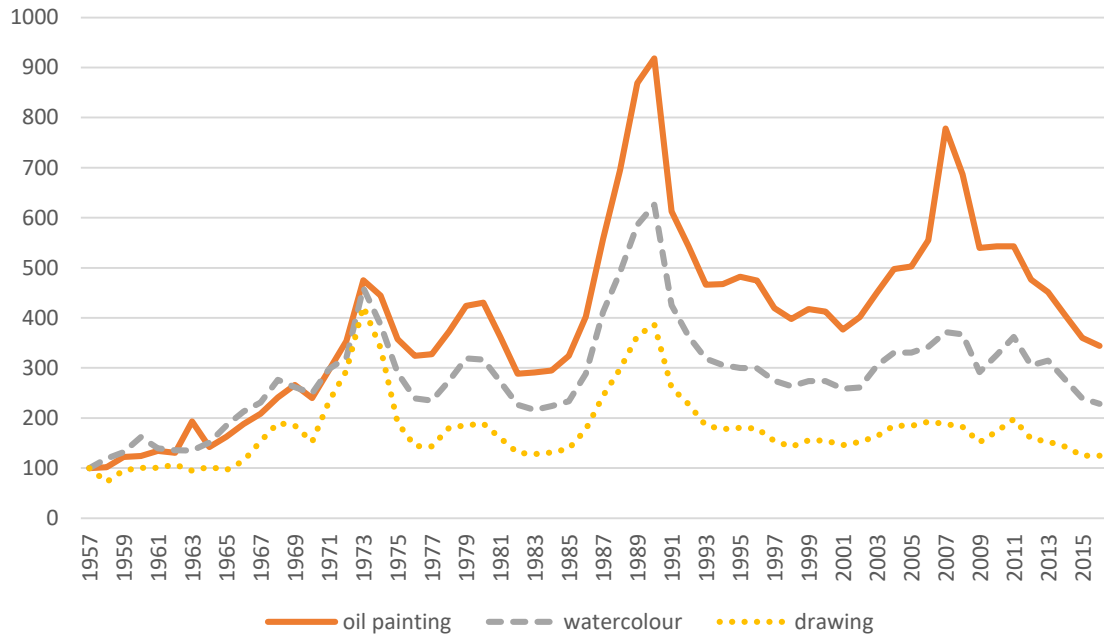


Figure OA.4 – Price Indices of Art Movements Since 1957 (Price Trends)

This figure presents the art price indices of clusters of art movements since 1957. We classify artists into five clusters: (1) *Medieval and Renaissance, Baroque, Rococo*; (2) *Neoclassicism, Romanticism, Realism*; (3) *Impressionism and Symbolism*; (4) *Fauvism and Expressionism, Cubism, Futurism, and Constructivism, Dada and Surrealism*; (5) *Abstract Expressionism, Pop Art, Minimalism and Contemporary*. The initial values of all indices are set at 100 in 1957. The case in which the initial index value of *Medieval and Renaissance, Baroque, and Rococo* group is set at 100 in 1957 and the initial index values of other art movement groups are normalised by the average price of the period from 1957 to 1961 relative to those of the *Medieval and Renaissance, Baroque, and Rococo* group is presented in Figure 4.

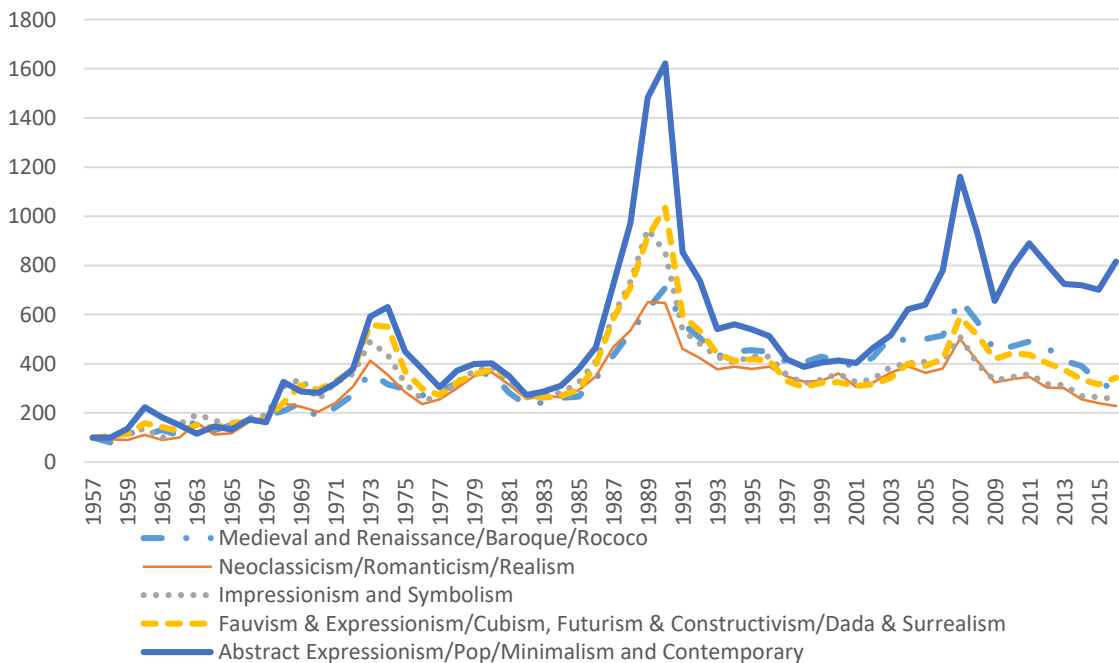


Figure OA.5 – Price Indices of Auction Markets Since 1970 (Price Trends)

This figure presents the art price indices of the auction markets of the UK, US, and continental Europe since 1970. The initial index values are set at 100 in 1970. The case in which the initial index value for UK sales is set at 100 in 1970 and the initial index values for US and Europe sales are normalised by the average prices from 1970 to 1974 relative to those of the UK is presented in Figure 5.

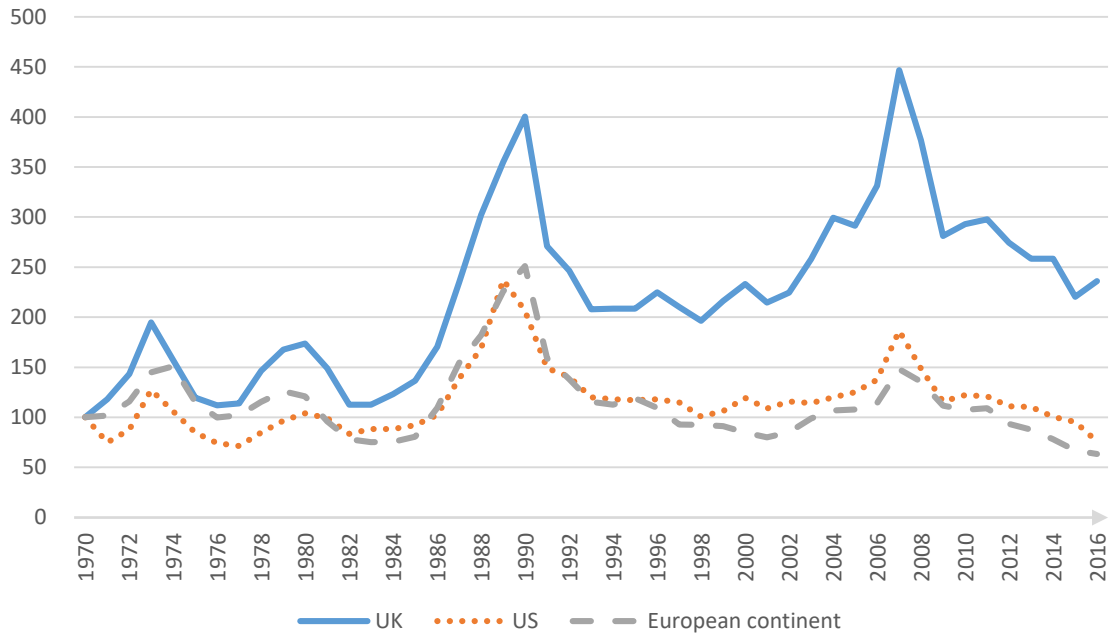


Figure OA.6 – Price Indices of Auction Houses Since 1970 (Price Levels)

This figure presents the art price indices of auction houses including (1) Sotheby's and Christie's (S&C); (2) Bonhams and Phillips (B&P); (3) important European auction houses (Important European AH); (4) important American auction houses (Important American AH); and (5) other small worldwide auction houses (Other Small AH) since 1970. The initial index value for S&C is set at 100 in 1970 and the initial index values for other auction houses are normalised by the average prices from 1970 to 1974 relative to S&C's. The case in which the initial index values are set at 100 in 1970 is presented in Figure 6.

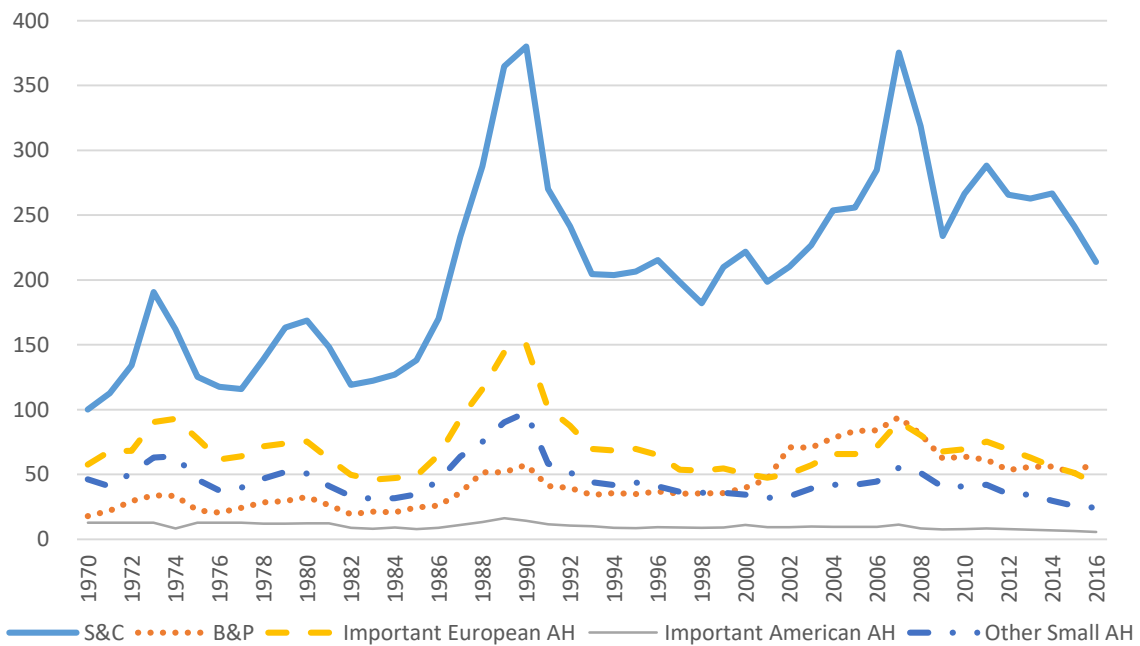


Figure OA.7 – Price Indices of Artist Nationalities (Price Trends)

This figure presents the art price indices of British, American, French, Italian, Dutch, and Belgian artists since 1957. The initial index values are set at 100 in 1957. The case in which the initial index value for British artists is set at 100 in 1957 and the initial index values are normalised by the average prices from 1957 to 1961 relative to British artists' is presented in Figure 7.

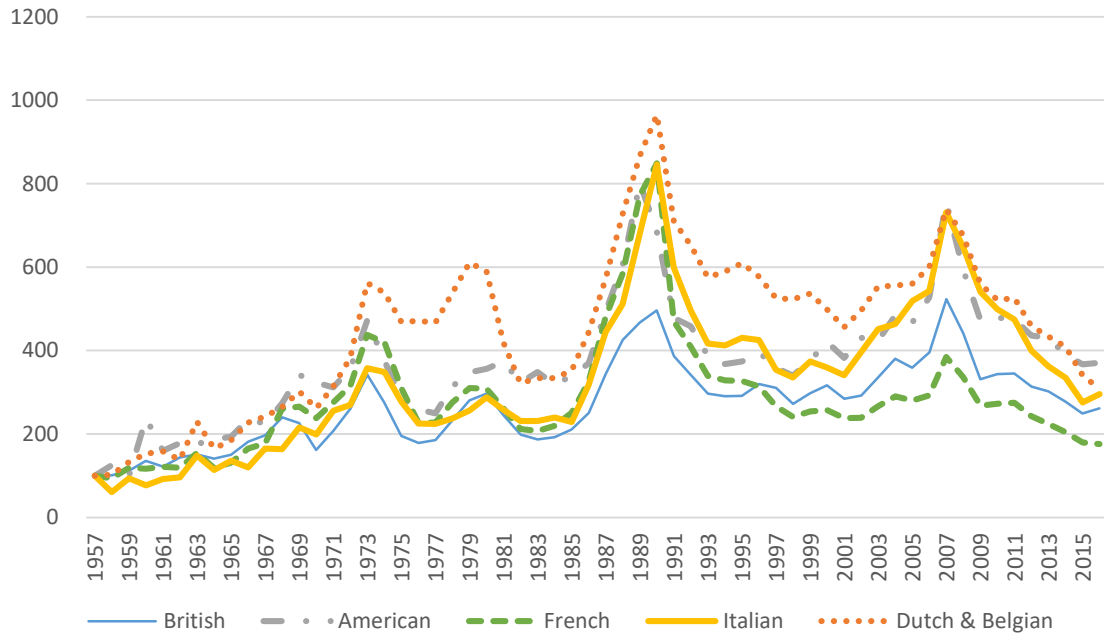


Figure OA.8a – Price Indices of Local and International Markets since 1957 (Price Levels)

This figure presents the art price indices of local and international markets since 1957. The observations are defined as local when the artist nationality is the same as the sale country. The observations are defined as international when the artist nationality is different from the sale country. The initial index value for local markets is set at 100 in 1957 and the initial index value for international markets is normalised by the average price from 1957 to 1961 relative to local markets. The case in which the initial index values are set at 100 in 1957 is presented in Figure 8a.

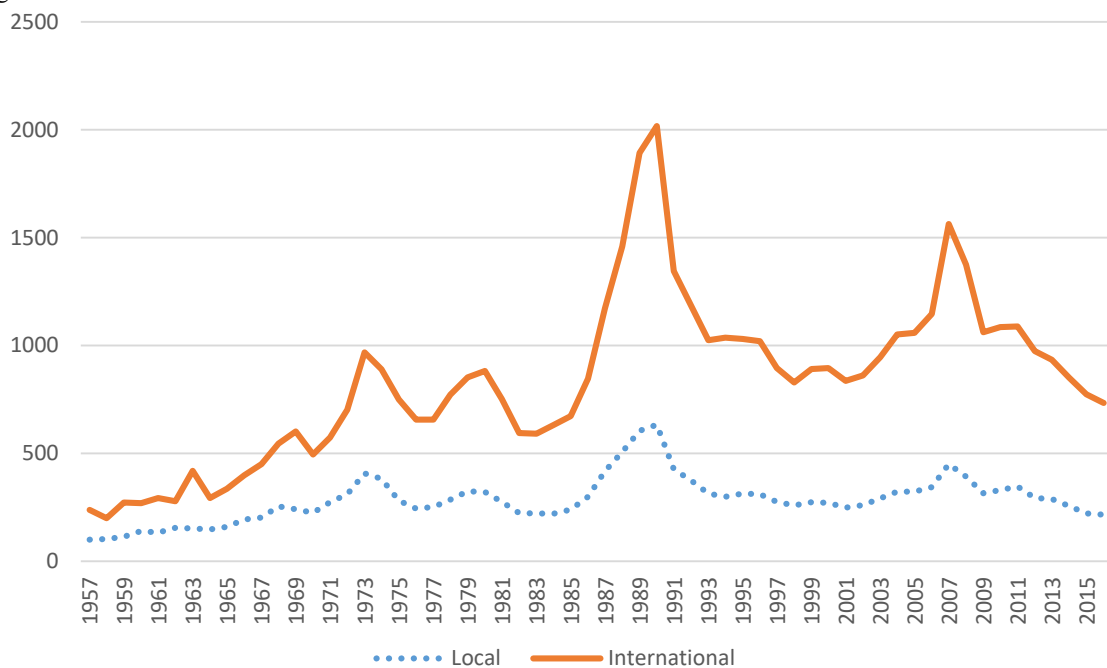


Figure OA.8b – Price Indices of Local and International Markets since 1970 (Price Levels)
(Excluding British and American Artists)

This figure presents the art price indices of local and international markets excluding British and American artists since 1970. The observations are defined as local when the artist nationality (excluding British and American artists) is the same as the sale country. The observations are defined as international when the artist nationality (excluding British and American artists) is different from the sale country. The initial index value for local markets is set at 100 in 1970 and the initial index value for international markets is normalised by the average price from 1970 to 1974 relative to those of local markets. The case in which the initial index values are set at 100 in 1957 is presented in Figure 8b.

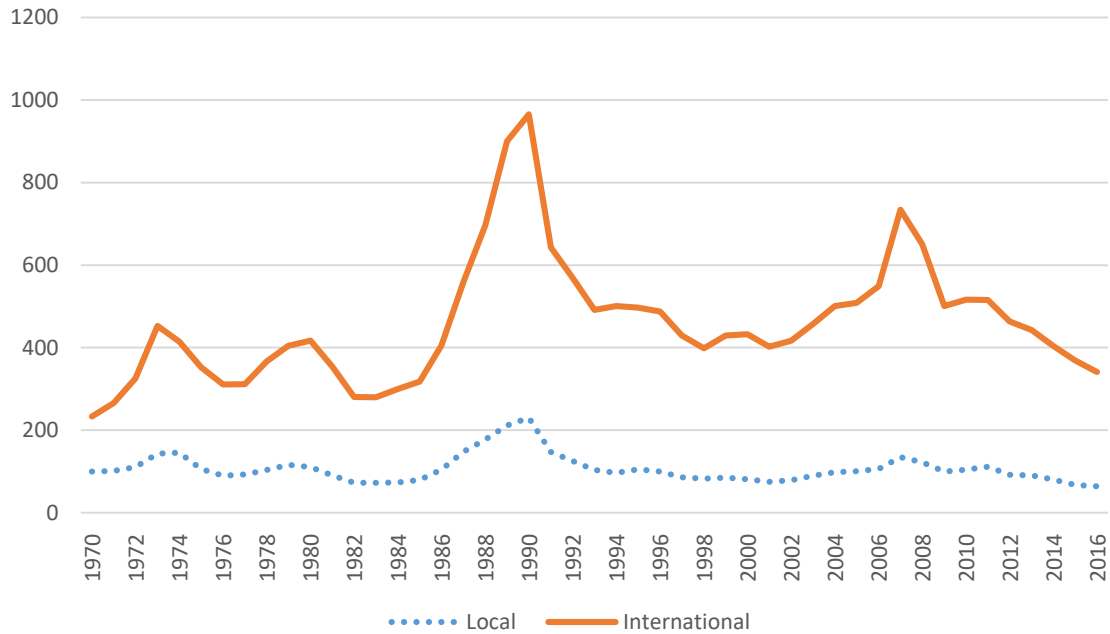


Figure OA.8c – Price Indices of Local and International Markets since 1970 (Price Levels)
(Sotheby’s & Christie’s London and New York branches = International)

This figure presents the art price indices of local and international markets since 1970. The observations are defined as international when the observations were sold at Sotheby’s London, Sotheby’s New York, Christie’s London or Christie’s New York and the observations are defined as local otherwise. The starting points of the indices are adjusted by the average price of the subsamples from 1970 to 1974. The case in which the initial index values are set at 100 in 1957 is presented in Figure 8c.

