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Art Return Rates from Old Master Paintings to Contemporary Art

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Abstract

We study return rates on art investment using a complete dataset on repeated sales for Old Master Paintings, Modern art and Contemporary art auctioned worldwide at Christie's and Sotheby's from 2000 to 2018. We show that return rates do not depend systematically on past prices or the place of sale, but we emphasize substantial differences in returns across sectors. We also control for changes in transaction costs (buyers' premiums and artists' resale rights), characteristics of the sale (evening sales, price guarantees and past bought-ins) and news on the lots (changed attributions, public exhibitions or death of the author) that appear reflected in art returns. We confirm the absence of masterpiece effects in American, Chinese and Ethnic art. Finally, using historical data on prices during Renaissance, Baroque and Neoclassical periods, we find evidence that price changes are independent from initial prices also in the long run.

Keywords: Art market, Mei-Moses index, Masterpiece effect, Contemporary art

JEL Classification: C23, Z11

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1 Introduction

Understanding what determines art prices and their changes is challenging for the very reason that each art object is unique. The economic perspective has made some progress by interpreting paintings, or other durable artistic goods, as particular assets that provide an aesthetic dividend and an appreciation which should be consistent with alternative forms of financial investment (Baumol, 1986; Mandel, 2009). However, empirical investigations of art returns over multiple centuries have provided puzzling results. According to Baumol (1986) art prices fluctuate aimlessly without being anchored to any fundamentals. The classic study by Mei and Moses (2002) and subsequent ones have found positive returns consistent with art investment as a tool of financial diversification, but also inconsistent with basic principles of market efficiency: returns tend to be systematically lower for artworks of higher value, generating the so-called negative "masterpiece effect", and different depending on the place of sale, in contradiction with implications of the law of one price (see also the surveys by Ashenfelter and Graddy, 2003, 2006).

In an efficient art market, price changes should reflect new information that is publically available, and should not depend systematically on the value of works (for instance, in the absence of risk differentials one cannot expect different returns from purchasing a \$1 million painting rather than ten paintings of \$100,000) or the place of trade, otherwise arbitrage opportunities could be exploited. Instead, news on the fundamental value of the artworks should affect their prices and therefore their ex post returns. To verify these hypothesis we investigate the determinants of art returns in the first two decades of this century for different art sectors,[1] including "Old Master Paintings", "Impressionism and Modern art" and "Contemporart art" as well as emerging ones such as "American art", "Chinese art" and "Ethnic art", and we also consider a long run perspective on art price changes in the last five centuries for the major old master painters.

Our main investigation is based on a unique dataset that contains the complete set of repeated sales for old master paintings, modern and contemporary art taking place in auctions at Sotheby's and Christie's in New York, London, Paris, Amsterdam, Milan and China between 2000 and 2018. This contributes to limit the survivorship bias of datasets based on the reconstruction of transactions of selected works over centuries as those of Baumol (1986) and Mei and Moses (2002), which tend to over-represent successful old master paintings, whose transactions have been repeatedly recorded over time, and to under-represent initially cheap

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[1]In this work we define art sectors on the basis of the auction departments of Sotheby's and Christie's.

artworks, whose appreciation went unrecorded. It also avoids biases of other datasets due to the identification of repeated sales by matching works with the same characteristics.[2] Finally, it allows us to jointly control for a variety of determinants of art returns and understand their impact on art prices. This provides new perspectives on the organization of the art market and the behavior of investors in this market.

Since 2000, we find that the average annual return of art investment has been around 4% per year in nominal terms. In each separate sector there is no evidence of masterpiece effects and we do not find significant differentials between return rates in different auction houses or places of sale, which is consistent with the efficiency hypothesis. Nevertheless, we find substantial differences in returns across art sectors, with contemporary art realizing higher returns than modern art and old master paintings realizing lower returns, part of which could be due to differences in aesthetic dividends for the investors, underlying risk of sales in the sector, and transaction costs. We then verify to what extent art returns reflect news emerging between purchase and sale, including changes in transaction costs (that are important due to the large increase in commissions over the last years),[3] news on risky characteristics of the sale (such as whether this has been moved to an evening sale, whether the lot has been subject to a new price guarantee or whether there was a failure to sell it in an auction between purchase and sale), and new information on the value of the artwork, for instance a new attribution for old master paintings, a public exhibition for modern artworks and the death of the author for contemporary art. Some of these factors have been considered alone (for instance, see Beggs and Graddy, 1997, 2008, 2009; Graddy *et al.*, 2014; Banternghansa and Graddy, 2011; Graddy and Hamilton, 2017; Ekelund *et al.*, 2000, 2017; Pownall *et al.*, 2019; Pénasse *et al.*, 2020; Ursprung and Zigova, 2020, , and others), but a joint analysis contributes to avoid the possibility of spurious relations. Changes in transaction costs and new information on the value of artworks emerge as crucial determinants of art returns, and allow us to present an adjusted art price index which is corrected for these effects. We cannot reject the absence of masterpiece effects and the validity of the law of one price also conditional on these controls,[4] but large

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[2]Most of the available datasets can only identify multiple sales by matching works with the same author, title, medium and size, but this procedure cannot separate transactions of different artworks with the same characteristics, cannot include repeated sales of works whose attribution has changed, and can also ignore unrecorded transactions between sales. While the bias could be limited for some purposes, we can avoid all these problems because our dataset identifies when the initial buyer is also the subsequent seller of the same artwork.

[3]Our control refers to the commissions on buyers. Information on commissions on sellers, which are typically lower or null, is not publicly available.

[4]Notice that we are not denying the possibility of inefficiencies in local art markets or profitable opportunities for players with market power in the primary market or trading in minor auction houses. In other words, efficiency in the strong form of Fama does not hold, but arbitrage opportunities are limited in the international auction market for major secondary sales.

differential returns across sectors remain. In particular the return on contemporary art is even higher compared to the return on modern and ancient art.

We submit our hypotheses to additional tests on different investments across space and over time. Other geographical regions or different artistic traditions experienced a flourishing trade in the last decades, as in case of American, Chinese and Ethnic art. We consider these sectors briefly and separately due to the limitation of the datasets, but also in this case we confirm the absence of masterpiece effects and, at least in part, of location effects. However, relevant exceptions derive mainly from Chinese art, whose booming trade may not be fully integrated in the international art market. Explaining large differential returns across art sectors remains a puzzle for future research.

We finally return to the long run analysis in the style of Baumol (1986) and Mei and Moses (2002) in a different perspective. Using art historical data from Renaissance, Baroque and Neoclassical periods we identify artists for whom we can match historical prices and contemporary prices, and we test whether price changes have been independent from the initial prices, a long run implication of the lack of masterpiece effects. The data derive from the primary market of Renaissance Italy (Etro, 2018), from inventories and auctions in the markets of the 1600s in Italy and Amsterdam (see Montias, 2002) and from auctions in Paris and London between 1700s and early 1800s (from the Getty Research Institute; see Etro and Stepanova, 2015, 2017). We focus on the highest prices per painter between the historical records and the highest prices per painter between the contemporary sales. For all periods and schools we cannot reject the independence of price changes from the initial price levels. While this evidence should be evaluated *cum grano salis*, it is consistent with the idea that art prices are effectively anchored to fundamentals reflecting a distribution of preferences of the art collectors, and price changes are independent from the initial prices and appear to be driven by aggregate fluctuations of art returns with large variations across sectors.[5]

The rest of the work is organized as follows. Section 2 reviews the literature on art returns. Section 3 describes the main dataset. Section 4 analyzes the empirical results. Section 5 analyzes other art sectors. Section 6 looks at the long run perspective. Section 7 concludes.

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[5]Notice that this independence of price changes from price levels reproduces a Gibrat's law of proportionate effect (Gibrat, 1931), which is consistent with a lognormal distribution of art prices.

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2   Review of the literature

The first major work on art return rates by Reitlinger (1961) has documented prices in the U.K. for famous painters in the period 1760-1960. Subsequent econometric investigations have adopted either the hedonic approach[6] controlling for different characteristics of the paintings, or the repeated sales approach (introduced by Bailey *et al.*, 1963) focused on multiple sales of the same paintings. The latter is appropriate when the control for the characteristics of each artwork is crucial but the quantifiable evidence is incomplete. The systematic investigation of art returns from repeated auction sales was started by Baumol (1986), who used the Reitlenger dataset to show that real annual return rates were normally distributed around an average of 0.6% for 640 multiple sales (selected with a distance of at least twenty years) and to argue that art prices are not anchored to any equilibrium level but float aimlessly. Goetzmann (1993) has extended the Reitlinger dataset with two additional decades of auction sales reaching an estimate for the real return rate of 2% over 3,329 multiple sales between 1716 and 1986, and with much higher return rates for the most recent periods, which is not surprising given the booming prices of paintings traded in the 1980s.

The fundamental work of Mei and Moses (2002) has analyzed auction prices mainly in New York for old masters and modern painters, reconstructing prices over a century of past transactions when possible, for a total of 4,896 multiple sales (with average holding periods of 28 years) from 1875 to 2000. Adopting the procedure of Case and Shiller (1987), the authors have proposed what is now known as the *Mei-Moses® Art Index*, estimating real return rates of 4.9% since 1875 and 8.9% since 1950, with a low correlation with returns of other assets: this has suggested that art investment appears to have a performance comparable to stocks, at least in the most recent periods, representing a good tool of portfolio diversification.

Studies on return rates based on repeated sales *ex post* reconstructed over centuries are often problematic (see Goetzmann, 1993; Ashenfelter and Graddy, 2003). It is well understood that datasets based on sales over multiple centuries suffer from a relevant survivorship bias, since more successful artworks are more likely to reach certain markets (such as London or New York in the XX century) and are more likely to have been sold repeatedly over long periods in recorded transactions without going out of fashion. This has two crucial implications. First, datasets based on sales reconstructed over long periods tend to overestimate the performance of investment in old master paintings and possibly modern art and cannot fully account for

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[6]The most comprehensive study of art returns based on the hedonic approach is probably the one by Renneboog and Spaenjers (2013). It finds a return rate of 4% on investment in paintings from all schools during the period 1951-2007.

the role of contemporary art. Second, artworks that are initially cheap and then become more expensive tend to be underrepresented (since records for the initial transactions are more likely to be lost), and this sample selection creates a bias in favor of return rates that are inversely related to initial prices: the negative masterpiece effect found by Mei and Moses (2002) and the subsequent literature could be the consequence of this.[7]

More recent datasets extract repeated sales directly from contemporary auctions. However, most of them, including recent important work by Renneboog and Spaenjers (2013) and Korteweg et al. (2015),[8] are based on the identification of repeated sales by matching works with the same author, title, medium and size. Such a procedure leads one to ignore artworks whose attribution has changed (which is typical of old master paintings and heavily affects their returns), to mix transactions of different artworks with the same characteristics (which is typical of modern art, often replicating works with the same title and size), and to neglect unrecorded transactions of the same artwork between two recorded sales (which is typical of contemporary art, but not only). This can create different forms of selection bias in a sample of repeated sales (with an impact on returns and holding periods).

We avoid these sources of survivorship and selection bias by using data from all the auctions taking place at Sotheby's and Christie's over the last two decades and by identifying all the repeated sales in this period thanks to precise information on when the initial buyer of a given work was also the subsequent seller of the same work. Most of the estimates of the determinants of return rates and tests of the law of one price on repeated sale regressions do not control in an exhaustive way for the new information emerging between purchase and resale that affect returns, and ignore the impact of changes in buyer's premia and artists' resale rights. These news are important because they should be reflected in prices and returns. Some of these factors have been considered separately, but not jointly, and not in the analysis of the law of one price, as we will do here. Moreover, we will deal separately with old master paintings, modern art and contemporary art, and confirm our results also on other art sectors as well as in the long run (using art historical price records).[9]

A few works have analyzed distinct factors that can predict (or at least correlate with) art returns. Mei and Moses (2002) have emphasized the existence of unexploited opportunities of

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[7]Many of the best artworks have been sold to museums during the XX century without ever returning to the market, which can create a further sample bias. This is less of a concern for the most recent decades.

[8]It is important to remark that these two works are mainly focused on different issues (that are not affected by possible false matches) in computing art returns, namely hedonic regressions for Renneboog and Spaenjers (2013) and endogenous decisions to sell for Korteweg et al. (2015).

[9]The historical analysis relates to an emerging literature on the evolution of art markets and creativity (see Galenson, 2006; Graddy, 2013; Etro and Stepanova, 2018; Borowiecki and Greenwald, 2018; Borowiecki and Gross, 2020).

arbitrage across different auction houses: this confirms violations of the law of one price found also by Ashenfelter (1989), Pesando (1993) and Pesando and Shum (2008) in related auction markets (see Ashenfelter and Graddy, 2003, 2006, for surveys).[10] They have also tested for the masterpiece effect, according to which more expensive artworks would feature higher returns: contrary to this hypothesis, which is popular between art dealers, Mei and Moses (2002) have found that masterpieces tend to substantially underperform relative to other works, confirming findings on prints Pesando (1993) and contemporary art (Ashenfelter and Graddy, 2003, 2006). Such a negative masterpiece effect on repeated sales over more than a century, which appears unrelated to risk differentials, provides the undesirable implication that the price of masterpieces should gradually converge toward an average price, which appears counterfactual.[11]

Other works have analyzed the impact on prices and returns of some particular news. For instance, the same artwork sold at more exclusive evening sales or earlier between the lots on sale tends to have a higher return (Beggs and Graddy, 1997), artworks that went unsold in earlier auctions are burnt and tend to exhibit lower returns later on (Beggs and Graddy, 2008; Ekelund et al., 2017) and artworks that have a price guarantee may obtain higher (though riskier) returns (Graddy and Hamilton, 2017). We will jointly verify these predictions in our environment and test additional ones. For old masters' paintings, an upgrade from an uncertain attribution to the authorship of a master (due to the discovery of a signature or a critical revision) is going to increase returns: while the nature of the attribution is often exploited in hedonic models (for instance by Renneboog and Spaenjers, 2013), we are not aware of the use of upgraded attributions of the same painting in repeated sales regressions. For modern paintings, a new public exhibition increases the prestige of the work and the return at the time of sale (as found in hedonic models by Hellmanzik (2016) and emphasized by Fraiberger et al., 2018). For contemporary art, the death of the artist should generate a price increase due to the (negative) impact on the expected supply of the deceased author, and this should increase the effective return - see Ekelund et al. (2000), and more recently Coate and Fry (2012), Pénasse et al. (2020) and Ursprung and Zigova (2020). The impact of these and other news may be related (for instance, a painting with an upgraded attribution may be moved to an evening auction in a different location and one with a downgraded attribution may lose a price guarantee and go

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[10]Notice that deviations from the law of one price in the primary market would be consistent with natural forms of price dispersion on search goods, though according to Velthuis (2013) price dispersion is rare in the primary markets of New York and Amsterdam (where prices are set by few dealers for each artist, are fixed by size and hardly decreasing). Our focus is not on the primary market but on the international secondary market.

[11]The same negative masterpiece affect is replicated in the data by Renneboog and Spaenjers (2013, p.48), though these authors present also separate evidence (supported also by Korteweg et al., 2015) of a positive masterpiece effect when they focus on top price brackets in quantile regressions. As noticed by Galenson (2002, 2006) and these authors, the price level may not be sufficient to define masterpieces.

unsold): for this reason a joint econometric analysis is important to verify the determinants of art returns and test our efficiency hypotheses.

3 Data on old master paintings, modern art and contemporary art

We have built our dataset by web scraping catalogues of auctions accessible online by the two leading auction houses, Christie's and Sotheby's, in New York, London, Paris, Amsterdam, Milan and emerging centers in China (Hong Kong and Shanghai) in the first two decades of this century.[12] This period follows the decade of the 1990s in which the two auction houses had been engaged in illegal agreements to fix fees on sellers and precedes the pandemic crisis of 2020. It includes an initial decade of booming prices especially for contemporary art and, after the Great Recession, a period of either declining or moderately increasing prices depending on the sector. The average holding period between purchase and resale is 7.9 years for old master paintings, 7.1 years for modern art and 6.4 for contemporary art.

Overall, we collected data from 570 auctions of "Old Masters Paintings", 386 auctions of "Impressionists and Modern Art" and 656 auctions on "Post-War and Contemporary Art", for more than 220 thousand sales. Through detailed information on the provenance of the artworks we could identify precisely each repeated sale taking place in auctions by Sotheby's and Christie's between 2000 and 2018 worldwide, excluding false matches of different artworks with similar characteristics and unrecorded intermediate transactions.[13]

3.1 Data description

The dataset consists of 5,268 repeated sales, divided in 1,013 by old masters, 1,675 by modern artists and 2,580 by contemporary artists. The three joint datasets cover art investment in the main historical fields of Western art. Old master paintings cover most of the established European masters up to the mid 1800s, though many works are only attributed to a master, to a workshop, to followers of a master or just to a generic school. Modern artworks are

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[12]The dataset was updated in March 2019. Notice that auctions of old master paintings were recently discontinued in Amsterdam and Milan, and we omitted auctions of old master paintings from Christie's in Rome. We have not considered online auctions that were introduced in the last years for objects of lower value. We should also add that our dataset does not include separate auctions dedicated to the sale of important collections, which contain various artworks, some of which may have been resold at auction in this period.

[13]Of course, this dataset (as all datasets on repeated sales) excludes sales by art galleries, but one should keep in mind that a large majority of auction trade in artworks with international demand has been intermediated by Sotheby's and Christie's. Moreover, the sample is likely to exclude works purchased by museums (which are rarely deaccessioned).

mostly oil paintings, but include also drawings, watercolors, sculptures and more, and are distributed across more than two hundred artists.[14] Contemporary art refers to more than five hundred artists, and includes both paintings and sculptures; in spite of their recent emergence and unusual format, also street art and installations are represented by artists in the dataset, providing a rather comprehensive sample of the international contemporary art.[15]

Listed prices include the buyers' premium. We have computed the latter through publicly available data on the transaction cost schemes at Christie's and Sotheby's (see for instance Horowitz, 2014) and auction houses' websites. Through this, we have derived the hammer prices, which are our unit of analysis, in line with most of the previous literature. For the regression analysis we have converted all prices, commissions and estimates in US dollars of 2018 as the base year. For this reason, our empirical analysis should be interpreted in terms of real returns for American investors or at least in terms of US dollars.

We use information on the buyers' premium at purchase, in percentage of the hammer price, and on the change in the same percentage premium at the time of sale. A constant level of the commission rate should not affect the return rate (since what matters for prices is the total willingness to pay of the buyers), but its change between purchase and resale should have a large impact on the return, and in the last two decades buyers' premia have been increasing substantially (while sellers' premia are typically much lower or null, as well as unknown to the public). For instance, in 2000 Sotheby's fixed its commission rate at 20% on the first $15,000, 15% up to $100,000 and 10% thereafter, in 2005 introduced a 20% rate up to $200,000 with 12% above, in 2008 had a 25% rate on the first $50,000, 20% up to $1,000,000 and 12% thereafter, and new cut-offs were introduced in 2013 for prices in pounds and euros. The schemes of Christie's kept changing in similar ways, but differences in commissions by the two auction houses have been often existing in some price range. At the end of our timeframe Sotheby's applied a commission of 25% below $300,000 (or 200,000 pounds in London, or 180,000 euros in the Euroarea), 20% up to $4 millions (or 3 million pounds, or 2 million euros) and 12.9% thereafter (with exceptions for Amsterdam). Christie's had the same rates with dollar cut-offs set respectively at $300,000 and $3 millions (and different ones for pounds and euros). The

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[14]Top prices in the dataset refer to *Nu couché (sur le côté gauche)* by Modigliani sold for $ 157 million in 2018, a *Suprematist Composition* by Malevich sold for $ 85 million in 2018, *Femme assise, robe blue* by Picasso ($ 40 million in 2017) and *Vue de l'asile et de la Chapelle de Saint-Remy by Van Gogh* by Van Gogh ($ 35 million in 2018).

[15]Top prices within our repeated sales are achieved by Bacon, with a *Portrait of George Dyer Talking* and *Three Studies for a Portrait of John Edwards* sold in 2014 respectively for 42 million pounds and 80 million dollars, and three American artists, namely de Kooning with $ 66 million for an *Untitled XXV*, Basquiat with $ 57 million for an untitled work (both sold in 2016), and Warhol with $ 37 million for a *Double Elvis [Ferus Type]* (sold in 2018).

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overall pattern speaks of highly similar commission rates between Sotheby's and Christie's with increasing levels and regressivity during the last two decades.[16]

We also know when the sale was subject to the artist resale right, which was initially introduced in France (as *Droit de Suite*) and then extended to the European Union, and implies a small additional commission on the hammer price to be paid to the living author or the heirs (see Banternghansa and Graddy, 2011). While the impact of this burden is debated (Ginsburgh, 2011), it represents an additional transaction cost whose introduction or change can affect negatively art returns. We know whether the sale was an evening sale or not and whether there was a price guarantee on the lot: since we are interested in the impact of news on returns, we control for changes to or from evening sales and for the introduction or elimination of price guarantees between purchase and sale. For old masters, we have identified each change in attribution between sales as a new attribution, and we have identified paintings with attribution upgraded from a generic school to a precise attribution, and from an uncertain one to a sure authorship, as well as paintings with the opposite destiny (notice that attribution is rarely a relevant issue for ordinary modern and contemporary art): such changes happen for more than 12% of the observations, so they are quite relevant. For modern art we have identified artworks which were displayed in a public exhibition between sales (while this is too rare for old master paintings and too heterogeneous in terms of the type of exhibition for contemporary art). Finally, we have built dummies for paintings by contemporary artists who were already dead at the time of purchase, who were still alive at the time of resale, who died just one or two years before the resale (the group for which we expect the strongest death effect) and who died more than two years before the sale.

A preliminary look at the annual nominal return rates (for artworks of unchanged attribution) shows an average return of 4% over all three sectors, but this hides wide differences between sectors. Contemporary art features the highest return, 6%, but also the highest volatility, with a standard deviation of 18%, followed by modern art, with a return of 4% and a standard deviation of 14%, and by old master paintings, with a return of -1% and a standard deviation of 16%. These returns are broadly in line with findings by Renneboog and Spaenjers (2013) based on hedonic regressions, but lower than those found by Goetzmann (1993) and Mei and Moses (2002) on samples that reconstruct multiple sales back in time. Differences in returns between sectors may be due to differences in risk and aesthetic dividend. For instance, an average investor in old master paintings may obtain a higher aesthetic dividend from owning art (rather

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[16]We cannot control for differences in taxation on buyers because these depend both on the country of sale and the country of the buyer, whose identity is unknown, as well as on other factors.

than a standard asset) compared to the aesthetic dividend obtained by the average investor in contemporary art:[17] if this is the case, contemporary art commands a higher average return to attract investment. Also observable differences in risk may play a role, since contemporary art is riskier than old master paintings and modern art, but provides higher returns on average.[18] Of course, transaction costs, risk differentials or other factors that can be controlled for (in the empirical analysis) may contribute to explain the different performance across sectors.

Table A1 reports average prices and real returns for selected groups of artists for each sector. The most spectacular returns on art investment for old masters are typically related to paintings whose attribution has been upgraded to a sure authorship.[19] However, high returns are not confined to rare rediscovered paintings: the same authorship of a *Madonna* by Sassoferrato was associated with a purchase for $39,000 in 2003 and a resale for $346,000 in 2016, a drawing by Peter Paul Rubens on *Scipio Africanus welcomed outside the gates of Rome* purchased in 2008 for 250 thousands pounds was resold in 2017 above one and a half million dollars, while a still life by Jan Davids. de Heem purchased in 2005 at 132,000 euros was resold four years later at 337 thousand pounds. For modern art, some of the top return rates in our dataset, have been associated with Alberto Giacometti (with a bronze purchased at about two hundred thousand pounds in 2002 and resold for $1.8 million in 2016), Fernand Leger, Jacques Lipchitz, Édouard Manet, Paul Signac, and Pablo Picasso with multiple works (as a *Femme assise* purchased for about 444 thousand dollars in 2004 and resold for $2.8 million in 2018). For contemporary art, the best performance in our dataset is for two works by Peter Doig (*Swamped* and *The Architect's Home in the Ravine*, both purchased in 2002 just above £300,000 and resold respectively for $26 million and $20 million in 2015), followed by two works by Jean-Michel Basquiat (*Furious Man* and *PRE-AGRAV*).[20]

We report descriptive statistics on prices and returns in Table 1. The average old master painting is cheaper than the average modern or contemporary artwork. The average real return

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[17]Recently, neuroscience has studied different reactions to contemporary art, which is mostly abstract, and traditional art, which is mostly figurative, founding a possible basis for differences in aesthetic dividends (Kandel, 2016). Behavioral economics has instead argued for anchoring of art prices to past prices (Beggs and Graddy, 2009; Graddy *et al.*, 2014) and this bias may work differently across art sectors, for instance limiting price changes of old master paintings more than price changes of contemporary art.

[18]Considering reattributed old master paintings, which includes rare disasters and positive "black swans", increases the average return on old masters at similar levels as modern art.

[19]For instance, a *Horse with a rider* was sold in 2015 at Christie's in Amsterdam for $14,000 as a work by a follower of Van Dyck, but after further art historical studies (and the removal of overpainting) that have identified Rubens as its author, it was resold at an evening sale of Sotheby's in New York for $5.1 million in 2017. This is the only outlier omitted from the empirical analysis.

[20]Other top returns are for works by Richter (*Gudrun*), Fontana (*Spatial concept, the end of God*), Castellani (*White surface*), Piene (an untitled work sold for 11,000 euros in 2003 and 360,000 euros in 2015, right after the death of the author) and Nara.

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rate for all the sectors is 2%, but again the differences are substantial across sectors: contemporary art has an average return of 4% in real terms against 2% for modern art and a negative return of -3% for old master paintings in real terms.

Table 1: Descriptive statistics

	Old Masters	Modern Art	Contemporary Art
Average hammer price at purchase (in USD 2018)	222,928 (677,335)	853,197 (2,803,094)	611,895 (1,854,780)
Average increase in buyers' premium (in % of hammer price)	4.0 (2.8)	3.7 (3.2)	2.6 (3.2)
Average increase in Artists' resale right (in % of hammer price)		0.40 (1.01)	0.17 (1.03)
Average annualized real return			
Overall	-0.033 (0.16)	0.018 (0.137)	0.035 (0.179)
Day → Evening	-0.013 (0.076)	0.046 (0.118)	0.110 (0.151)
Evening → Day	-0.059 (0.065)	-0.009 (0.087)	0.015 (0.142)
Previously not guaranteed item gets guarantee	0.029 (0.096)	0.026 (0.12)	0.113 (0.157)
Previously guaranteed item loses guarantee	-0.05 (0.075)	0.006 (0.079)	0.028 (0.173)
Previously Failed to sell	-0.093 (0.119)	-0.059 (0.084)	-0.096 (0.166)
Christie's → Christie's	-0.023 (0.233)	0.019 (0.153)	0.043 (0.177)
Sotheby's → Christie's	-0.031 (0.147)	0.012 (0.159)	0.033 (0.176)
Christie's → Sotheby's	-0.038 (0.102)	0.026 (0.116)	0.038 (0.173)
Sotheby's → Sotheby's	-0.03 (0.112)	0.008 (0.118)	0.024 (0.188)
NY → NY	-0.038 (0.089)	0.022 (0.134)	0.034 (0.172)
London → London	-0.034 (0.228)	0.003 (0.109)	0.013 (0.166)
NY → London	-0.022 (0.099)	0.034 (0.147)	0.072 (0.197)
London → NY	-0.051 (0.108)	-0.001 (0.106)	0.037 (0.206)
Paris → NY	-0.039 (0.144)	0.073 (0.198)	0.047 (0.157)
NY → Paris	-0.039 (0.06)	0.033 (0.143)	0.079 (0.199)
Paris → Paris	-0.119 (0.006)	0.017 (0.084)	0.003 (0.135)
Paris → London	-0.044 (0.065)	0.054 (0.291)	0.059 (0.177)
London → Paris	-0.019 (0.098)	0.000 (0.100)	-0.009 (0.157)

Note: Standard deviation in parenthesis

3.2   Empirical strategy

The repeated sales approach estimates a continuously compounded return r_{it} on artwork i in period t decomposed as $r_{it} = r_t + e_{it}$, where r_t is the average return in t and e_{it} is an error term, assumed uncorrelated over time. Given information on purchase price $P_{i,t}$ at time t and resale price $P_{i,t+h}$ after h periods, the logged relative price can be expressed as:

$$r_i = ln\left(\frac{P_{i,t+h}}{P_{i,t}}\right) = \sum_{s=t+1}^{s+h} r_s + \sum_{s=t+1}^{s+h} e_{is} \tag{1}$$

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This kind of equation has been estimated by Mei and Moses (2002) and the subsequent literature adopting the three-stage least-square (3SLS) procedure of Case and Shiller (1987) and Goetzmann (1993), which provides price indexes and return rates corrected for heteroskedasticity when the variance of the error term is not constant and changes with the holding period. We will replicate this estimate in our dataset. To test for our efficiency hypothesis we then augment (1) as follows:

$$r_i = \sum_{s=t+1}^{s+h} r_s + \alpha_0 ln P_{i,t} + \boldsymbol{\alpha} \boldsymbol{L_i} + \sum_{s=t+1}^{s+h} e_{is} \tag{2}$$

where α_0 is a coefficient on the initial log price and $\boldsymbol{\alpha}$ is a vector of coefficients for a set of dummies $\boldsymbol{L_i}$ concerning combinations of auction houses and locations where the paintings were purchased and resold. The absence of any masterpiece effect and the law of one price require all the coefficients α_j to be zero.

Between purchase and sale there are news and changed conditions that can affect prices and can be incorporated in the returns, possibly affecting our efficiency tests. Therefore, we simply augment (2) with a number of sale-specific controls as in:

$$r_i = \sum_{s=t+1}^{s+h} r_s + \alpha_0 ln P_{i,t} + \boldsymbol{\alpha} \boldsymbol{L_i} + \boldsymbol{\beta} \boldsymbol{X_i} + \sum_{s=t+1}^{s+h} e_{is} \tag{3}$$

where $\boldsymbol{\beta}$ are coefficients for changed conditions $\boldsymbol{X_i}$ between purchase and sale for a given artwork i.[21] This allows us to verify whether art returns incorporate new information that is publicly available and further investigate the determinants of art returns and the hypothesis of conditional efficiency. It also allows us to build a corrected price index which eliminates price variations due to changes in transaction costs and news on the artworks.

4   Empirical results

In Fig. 1 we show the nominal repeated sales price index for the three sectors, estimating (1) without any controls, as in the standard analysis of Mei and Moses (2002). In line with what we mentioned above about return rates, this emphasizes wide differences between sectors: while contemporary art experienced a rapid increase in prices until 2007 followed by a drastic decline

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[21]We found no influence of the size of paintings on return rates for old master paintings, which is consistent with the absence of arbitrage opportunities. It would be interesting to test the impact of other artists' characteristics on returns, such as the year when artworks were executed and the age of artist (emphasized by Galenson and Weinberg (2001), and Galenson (2002, 2006)), but our dataset does not provide sufficient information for this.

Figure 1: Nominal Price indexes for old master paintings, modern and contemporary art
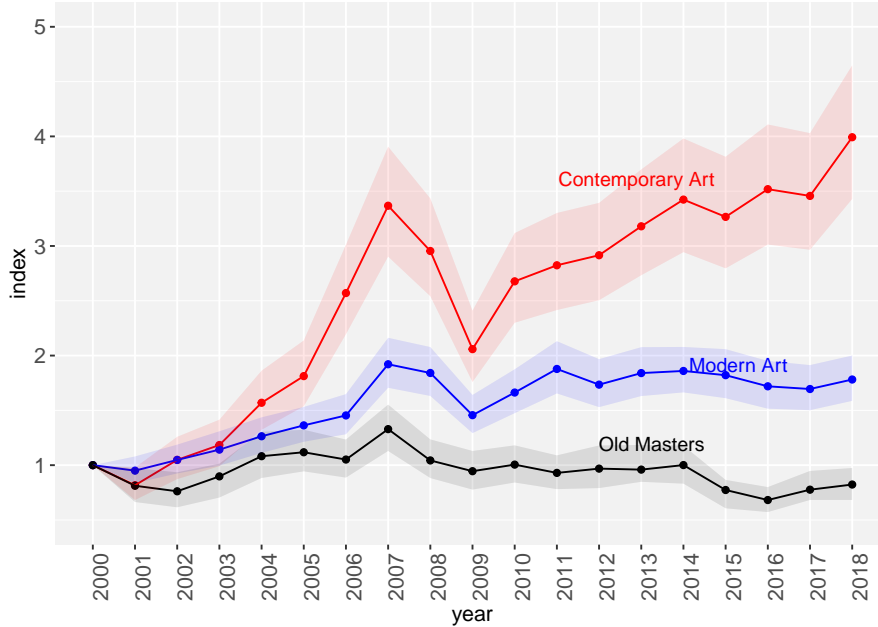
during the Great Recession, with a substantial recovery thereafter, modern art experienced a moderate initial increase in prices and stable valuations after the Great Recession, and old master paintings exhibited a minimal increase in the first decade of the century and a gradual decline in prices in the second one.[22] The initial pattern and the superior performance of contemporary art is consistent with findings by Renneboog and Spaenjers (2013) in hedonic regressions.

In Fig. 2 we display annualized return rates (hammer price on hammer price) in relation with the holding period for each repeated sale: the slope of the relation is not significantly different from zero, which suggests that there are no simple profitable opportunities from investment strategies that vary in terms of the holding period (but one should keep in mind for practical purposes that considering the fixed cost of the buyer's commission, the effective return from investing at art auctions would be increasing in the holding period).[23] This allows us to focus our empirical analysis of the determinants of art returns on the total returns.

We now move to the econometric analysis. We start in Table 2 by running regression (2) which controls for the initial price of the artworks and location dummies, as well as the year dummies.[24] In principle, we expect that, in the absence of risk differentials, investors could not

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[22]It is well known that a record sale of new works by Damien Hirst took place at Sotheby's on September 15, 2008, the same day in which Lehman Brothers went bankrupt. Things changed radically after that (see Horowitz, 2014).

[23]This is in contrast with findings by Lovo and Spaenjers (2018) who emphasize a negative correlation between residuals of a repeated sales regression and the holding period. The difference may be due to the fact that our sample covers a larger number of repeated sales. See also Penasse and Renneboog (2019) who show that the results change after accounting for transaction costs.

[24]Our main results are confirmed in simpler specifications accounting for changes in either location or auction

Table 2: Repeated sale regressions on old master paintings, impressionism & modern and post-war & contemporary art

						Dependent variable: Real total return					
						Old Masters		Modern Art		Contemporary Art	
$lnB_{i,t}$ Masterpiece effect						-0.007	(0.007)	0.001	(0.003)	-0.002	(0.003)
		Location at purchase $\rightarrow$ location at resale									
		(Transactions' volume in % for each of 3 art segments)									
Christie's	$\rightarrow$	**Christie's** benchmark	(28%,	34%,	28%)						
Sotheby's	$\rightarrow$	Christie's	(23%,	12%,	17%)	0.026	(0.062)	0.007	(0.037)	0.043	(0.047)
Christie's	$\rightarrow$	Sotheby's	(23%,	30%,	28%)	0.095	(0.058)	0.031	(0.029)	-0.041	(0.037)
Sotheby's	$\rightarrow$	Sotheby's	(26%,	24%,	27%)	0.004	(0.055)	0.021	(0.036)	0.029	(0.037)
NY	$\rightarrow$	**NY** benchmark	(20%,	33%,	36%)						
London	$\rightarrow$	London	(27%,	24%,	22%)	-0.056	(0.061)	-0.048	(0.037)	-0.084^{**}	(0.041)
NY	$\rightarrow$	London	(15%,	19%,	12%)	0.024	(0.074)	0.079^{**}	(0.038)	0.074	(0.050)
London	$\rightarrow$	NY	(13%,	13%,	13%)	0.046	(0.083)	-0.047	(0.035)	0.009	(0.045)
Paris	$\rightarrow$	NY	(3%,	3%,	1%)	-0.085	(0.133)	0.181^{***}	(0.060)	0.144	(0.166)
NY	$\rightarrow$	Paris	(1.6%,	2%,	1.3%)	-0.145	(0.180)	0.078	(0.134)	0.093	(0.111)
Paris	$\rightarrow$	London	(1.1%,	3%,	1.3%)	0.081	(0.157)	0.111	(0.087)	0.125	(0.114)
London	$\rightarrow$	Paris	(0.6%,	2%,	3%)	0.103	(0.372)	-0.075	(0.070)	-0.214^{**}	(0.080)
Paris	$\rightarrow$	Paris	(0.2%,	1%,	2.3%)	-0.287	(0.220)	0.161	(0.119)	0.002	(0.074)
Amsterdam	$\rightarrow$	Amsterdam	(4%,	,	0.3%)	0.033	(0.099)			0.070	(0.311)
Amsterdam	$\rightarrow$	London	(5%,	,	0.2%)	-0.061	(0.098)			0.002	(0.271)
London	$\rightarrow$	Amsterdam	(3%,	,	0.5%)	0.027	(0.109)			-0.209	(0.192)
Amsterdam	$\rightarrow$	NY	(2%,	,	0.2%)	-0.026	(0.128)			0.307^{***}	(0.086)
Milan	$\rightarrow$	London	(1.2%,	,	1.4%)	0.619^{***}	(0.180)			0.075	(0.103)
Milan	$\rightarrow$	Milan	(,	,	1.2%)					0.145^{**}	(0.071)
NY	$\rightarrow$	China	(,	,	0.7%)					0.563^{***}	(0.200)
London	$\rightarrow$	China	(,	,	0.6%)					-0.094	(0.273)
NY	$\rightarrow$	Amsterdam	(1.3%,	,	0.3%)	0.002	(0.165)			-0.544^{***}	(0.097)
London	$\rightarrow$	Milan	(0.2%,	,	0.5%)	0.407^{***}	(0.131)			0.208^{**}	(0.099)
Milan	$\rightarrow$	NY	(0.5%,	,	0.2%)	0.321	(0.282)			0.232	(0.299)
Milan	$\rightarrow$	Paris	(,	,	0.2%)					-0.120	(0.214)
Milan	$\rightarrow$	Amsterdam	(,	,	0.1%)					0.187	(0.689)
Paris	$\rightarrow$	Amsterdam	(0.3%,	,	0.1%)	0.007	(0.181)			-0.103	(0.128)
Paris	$\rightarrow$	China	(,	,	0.1%)					0.397^{**}	(0.160)
Year dummies						(YES)		(YES)		(YES)	
Observations						1,013		1,675		2,580	
R^2						0.24		0.16		0.21	

Note: *p<0.1; **p<0.05; ***p<0.01. (Artist) clustered standard errors in parenthesis.

Figure 2: Nominal annual return rates and holding period

Note: Blue line is linear regression fit with 95% confidence bands.

obtain higher returns by either increasing or reducing the monetary size of their investment. This contrasts with the common view among art dealers that investors should just buy the best (i.e. most expensive) artworks (per artist) they can afford. On the other side, a large part of the empirical evidence made available in earlier studies supports the opposite view, for which masterpieces command lower returns (Pesando, 1993; Mei and Moses, 2002; Ashenfelter and Graddy, 2003, 2006). Our results appear consistent with the efficiency hypothesis. We do not find any significant masterpiece effect for any of the three sectors (and we do not find relevant differences in variability of returns either). The coefficient for the logprice at purchase is negative for old masters, as in earlier investigations, but it is not statistically significant. The coefficients for modern and contemporary art art are neither economically nor statistically significant. Notice that, contrary to Mei and Moses (2002) we have not interacted the initial logprice with the holding period, therefore the magnitude of the coefficients would be even lower (and always statistically insignificant) if we had adopted their correction.[25]

The law of one price suggests that prices should not depend on the auction house or the location of sale, and therefore return rates should not depend on them either. Nevertheless, earlier works have often failed to support such an equalization of returns (see Pesando, 1993; Mei and Moses, 2002; Ashenfelter and Graddy, 2003, 2006). Our more recent and comprehensive dataset allows us to conclude that arbitrage opportunities have been largely eliminated. Table 2 reports for each combination of auction house and location at purchase and sale the percentage

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house (available from the authors).

[25]We have also explored the hypothesis that returns are not correlated with past returns on a sample of twice repeated sales and we could not reject the hypothesis. While in the short run price autocorrelation can arise in rational markets (due to variations in discount rates), it should not persist systematically over decades as in our underlying framework without attracting arbitrage.

of total observations for each sector. We do not find any significant differences in returns for artworks purchased either at Sotheby's or Christie's and sold in the same or a different auction house for each one of the three artistic sectors under consideration. Moreover, most of the coefficients on the different locations of purchase and resale are not significantly different compared to purchase and sale in New York. Most of the exceptions concern minor combinations (possibly affected by small sample bias)[26] and some of them will also vanish once we control for further determinants of art returns.

In Table 3 we report results from the full specification (3) controlling for news emerging between purchase and sale. We start by discussing the impact of the main control variables and then return to the test of the law of one price and the masterpiece effect. Changes in transaction costs have an important impact on returns. An increase in the buyer premium (as a percentage of the hammer price at purchase) is expected to reduce the hammer price at sale and therefore the return rate. If all what matters for bidders was the total paid price, we would expect that the additional commission would exactly crowd out the hammer price, but this ignores indirect effects on the demand side (and parallel changes on the supply side associated with unobservable changes in the seller' premium), which may generate a larger impact (see also Ekelund *et al.*, 2017). Indeed, we find a substantial negative impact between 10% and 15% of the total return as a consequence of a 1% increase in the commission rate. When the artwork is subject to new or increased artist resale rights, the return is reduced further, though the impact is small due to the limited size of these commissions (typically around 3% of the hammer price when in place).

The evidence shows that new information that solves uncertainty at the time of sale is incorporated in the return rates (though we cannot verify how quick is the price reaction). When the same artwork is moved from a day auction to a more selective evening auction, the auction house is signaling an upgrade in the valuation of the artwork by the experts of the auction house: in such a case we find that the total return increases, especially in case of old master paintings (by 38%) and less in case of modern art (by 17%), while a negative impact is associated with a move to a day auction, though this is significant only in case of modern and contemporary art (with a corresponding reduction of the return by 13% and 15%). In line with Graddy and Hamilton (2017) we do not find a clear impact on returns when artworks are insured by price guarantees of different types: probably, this kind of news could be interpreted in different ways in the market. Instead, an earlier failure to sell a painting represents bad

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[26]The sale of old master paintings in Italy is conditioned by a cultural heritage law which requires export license to leave the country.

news reflected in a reduced return in the future. In particular, we have identified 94 paintings with a sequence of sale, failure to sell and then sale, including 20 by old masters, 44 by modern painters and 30 by contemporary artists. The negative impact on the return is high, between 30% and 60% of the return rate, and significant in all cases (supporting the results of Beggs and Graddy, 2008). We also control for the number of times an artwork is resold in our timespan: this has no significant effects on old master paintings and modern art, but has a significant (and positive) impact in case of contemporary art (possibly due to more frequent sales for emerging artists).

In each sector there are particular forms of information that should be incorporated in the return rates once they become publicly available. For old master paintings, the impact of an upgrade from a school or an uncertain attribution to a certain authorship (due to new information by art experts) has a positive and large impact on returns that is not far, in absolute value, from the negative impact of a downgrade to an uncertain attribution or to a school, while a simple change of attribution has no significant impact on returns (since it is a mix of attributions to better and worse artists). For modern art, display in a public exhibition between purchase and resale adds to the perception of prestige of the artist and the artwork (see Fraiberger et al., 2018): indeed, we find that an exhibition exerts a positive and significant impact on prices, with an increase of the total return by 15%. For contemporary art, we checked for the existence of a death effect (due to the reduction in the expected supply of works by the artist). Compared to artists who did not die between purchase and sale, the return on artworks by artists who have died one or two years before the sale are 26% higher, with a smaller impact when the death occurred more than two years before the sale. Our sample includes 36 artists with works sold one or two years after their death, and their age at death ranges between 58 and 92 years. This offers an opportunity to interact the death dummy with the age at death and verify a significant quadratic relation with a peak for the magnitude of the death effect around 73 years old, in line with results by Ekelund et al. (2000), Ursprung and Wiermann (2011) and Pénasse et al. (2020) in hedonic models:[27] prices reflect a larger death effect when the news provide a larger revision of the expected supply of artworks by the author. Overall, art prices and return rates appear to reflect new public information in each one of the three sectors (though our data does not allow us to verify whether the price reaction is too slow or too low or inconsistent with risk and preferences).

Finally, we turn again our attention to whether return rates on art investment differ de-

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[27]See also Etro and Stepanova (2015) on a historical dataset and Pénasse et al. (2020) and Ursprung and Zigova (2020) for more sophisticated tests of the death effect. For theoretical examinations see Itaya and Ursprung (2016) and especially Pénasse et al. (2020).

Table 3: Repeated sale regressions on old master paintings, impressionism & modern and post-war & contemporary art

					Dependent variable: Real total return					
					Old Masters		Impressionism & Modern Art		Post-War & Contemporary Art	
$lnP_{i,t}$ Masterpiece effect					−0.005	(0.006)	0.002	(0.003)	−0.001	(0.004)
			Transaction costs							
$\Delta_{t,t+h}$ Buyers' premiums (in % of hammer price)					−0.132***	(0.014)	−0.101***	(0.009)	−0.143***	(0.039)
$\Delta_{t,t+h}$ Artist resale right (in % of hammer price)							−0.026**	(0.013)	−0.039**	(0.016)
			New information for bidders							
Day → Evening					0.383***	(0.070)	0.169**	(0.069)	0.326***	(0.053)
Evening → Day					−0.005	(0.113)	−0.127**	(0.055)	−0.147**	(0.060)
Previously not guaranteed item gets guarantee					0.054	(0.191)	0.037	(0.070)	0.165***	(0.046)
Previously guaranteed item loses guarantee					0.243	(0.131)	0.024	(0.047)	0.048	(0.049)
Previously Failed to sell					−0.301**	(0.123)	−0.379***	(0.072)	−0.568***	(0.147)
Downgraded to school					−0.774***	(0.234)				
Downgraded to uncertain attribution					−0.515***	(0.171)				
New attribution					0.058	(0.104)				
Upgraded from school					0.615***	(0.138)				
Upgraded to original					0.656***	(0.236)				
Exhibited on public							0.153***	(0.039)		
Died within 2 years before the resale									0.262***	(0.088)
Died more than 2 years before the resale									0.110	(0.092)
Location at purchase → location at resale										
(Transactions' volume in % for each of 3 art segments)										
Cristie's	→	**Christie's** benchmark	(28%,	34%, 28%)						
Sotheby's	→	Christie's	(23%,	12%, 17%)	0.011	(0.057)	−0.011	(0.033)	0.040	(0.039)
Christie's	→	Sotheby's	(23%,	30%, 28%)	0.080	(0.054)	0.043	(0.028)	−0.019	(0.031)
Sotheby's	→	Sotheby's	(26%,	24%, 27%)	0.007	(0.048)	0.033	(0.033)	0.054	(0.032)
NY	→	**NY** benchmark	(20%,	33%, 36%)						
London	→	London	(27%,	24%, 22%)	−0.079	(0.054)	−0.025	(0.033)	−0.058	(0.039)
NY	→	London	(15%,	19%, 12%)	0.044	(0.065)	0.050	(0.034)	0.017	(0.042)
London	→	NY	(13%,	13%, 13%)	0.031	(0.075)	−0.027	(0.037)	−0.012	(0.039)
Paris	→	NY	(3%,	3%, 1%)	−0.018	(0.120)	0.089	(0.068)	−0.015	(0.138)
NY	→	Paris	(1.6%,	2%, 1.3%)	−0.167	(0.174)	0.162	(0.140)	0.132	(0.120)
Paris	→	London	(1.1%,	3%, 1.3%)	0.048	(0.156)	0.006	(0.085)	0.115	(0.140)
London	→	Paris	(0.6%,	2%, 3%)	0.011	(0.324)	−0.075	(0.070)	−0.103	(0.094)
Paris	→	Paris	(0.2%,	1%, 2.3%)	−0.403	(0.233)	0.056	(0.087)	−0.090	(0.066)
Amsterdam	→	Amsterdam	(4%,	, 0.3%)	−0.051	(0.098)			0.030	(0.281)
Amsterdam	→	London	(5%,	, 0.2%)	−0.175*	(0.091)			−0.219	(0.261)
London	→	Amsterdam	(3%,	, 0.5%)	0.006	(0.098)			−0.055	(0.206)
Amsterdam	→	NY	(2%,	, 0.2%)	−0.118	(0.125)			0.137	(0.101)
Milan	→	London	(1.2%,	, 1.4%)	0.486***	(0.155)			−0.019	(0.099)
Milan	→	Milan	(,	, 1.2%)					0.154*	(0.079)
NY	→	China	(,	, 0.7%)					0.309*	(0.185)
London	→	China	(,	, 0.6%)					−0.164	(0.271)
NY	→	Amsterdam	(1.3%,	, 0.3%)	−0.030	(0.142)			−0.428**	(0.167)
London	→	Milan	(0.2%,	, 0.5%)	0.262***	(0.068)			0.429***	(0.105)
Milan	→	NY	(0.5%,	, 0.2%)	0.155	(0.205)			0.029	(0.347)
Milan	→	Paris	(,	, 0.2%)					−0.387	(0.254)
Milan	→	Amsterdam	(,	, 0.1%)					0.218	(0.704)
Paris	→	Amsterdam	(0.3%,	, 0.1%)	−0.034	(0.177)			−0.152	(0.188)
Paris	→	China	(,	, 0.1%)					0.248**	(0.112)
Year dummies					(YES)		(YES)		(YES)	
Number of previous appearances at auction since 2000					0.088	(0.099)	−0.028	(0.076)	0.161***	(0.042)
Observations					1,013		1,675		2,580	
R²					0.40		0.31		0.40	

Note: *p<0.1; **p<0.05; ***p<0.01. (Artist) clustered standard errors in parenthesis.

pending on price and location of sale to verify whether interactions with further determinants of price changes may have driven earlier results. As before, we do not find any significant master-piece effect for any of the three sectors, and we do not find any significant differences in returns for artworks purchased in either Sotheby's and Christie's and sold in the same or a different auction house for each one of the three artistic sectors under consideration. In conclusion, the mentioned implications of the efficiency hypothesis cannot be rejected in the main sectors of contemporary art auctions, which is in contrast with early findings of the literature. One would be tempted to conclude that only recently globalization has generated a fully integrated market (where auctions are broadcasted online and bidders can easily join online, via phone and via absentee bidding). In the following section we will present new evidence consistent with the same findings in other sectors.

We conclude this section by presenting in Fig. 3 an adjusted price index which corrects price variations from changes in transaction costs, news and other controls on the basis of our last regression analysis. In principle, this shows the real return on investment in a representative artwork of each sector abstracting from changed conditions in the auction market concerning commission rates or other transaction costs (as if the artwork was privately traded) and changed conditions of the actual artwork whose impact could not be expected *ex ante*. Our corrected price index shows a better performance for investment in all sectors (compared to the baseline Mei-Moses index of Fig. 1). Most of the differential is due to changes in commission rates of the auction houses during the last two decades, both through the increase of the average commission rate (which, for instance, moved from 10% to 25% for most transactions), and through the increase of the average prices on which the same commissions are computed. The corrected price index suggests that Sotheby's and Christie's obtained a large portion of the capital gains in the art market of this period. Nevertheless the corrected return rates on art investment in this century appear to have been positive for all sectors, including old master paintings, and quite high for contemporary art, also in the period after the Great Recession. Once again, differential returns across sectors remain the main puzzle for the performance of art investments in the last two decades.

5   Price changes in American, Chinese and Ethnic art

In this Section we investigate other sectors that have recently attracted a lot of investment, namely American art, Chinese art and Ethnic art (a label under which auction houses trade works mainly from Africa, Oceania and Pre-Columbian America). We repeat the basic analysis

Figure 3: Corrected real price indexes for old master paintings, modern and contemporary art
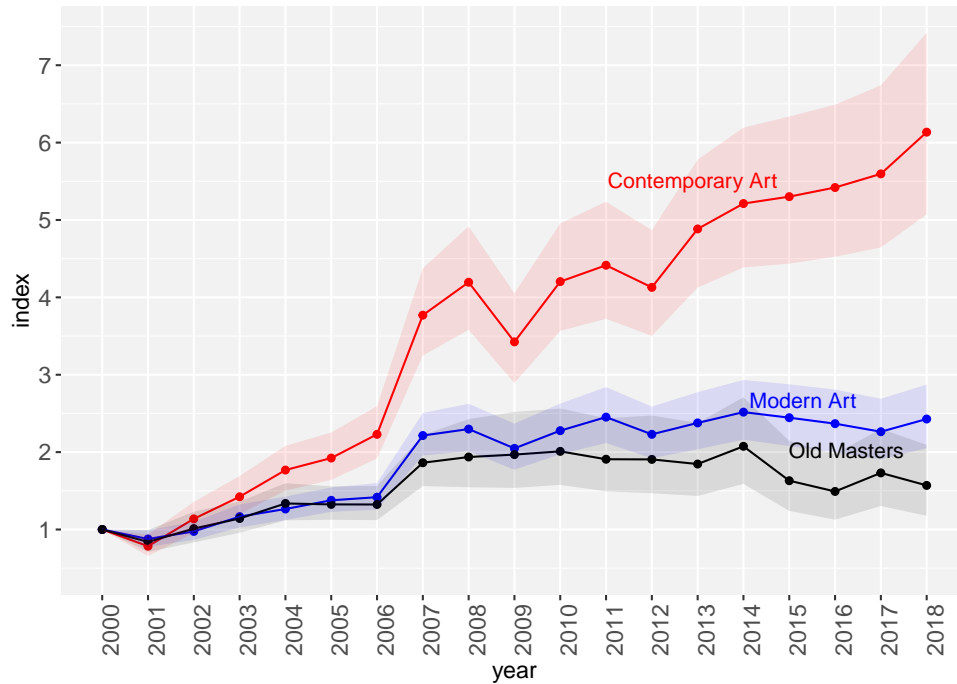
of the determinants of art returns for these sectors to verify whether the lack of masterpiece effects and location effects holds here as well.[28]

The sector of American art includes early American painters,[29] recognized masters of the 1800s such as Sargent and Whistler and modern artists of the early 1900s, but does not include abstract artists of the second half of the 1900s, whose works are traded in contemporary art auctions.[30] A comprehensive analysis of auctions on early American art can be found in Ekelund et al. (2017), whose empirical work is based on 105 observations of repeated sales between 1987 and 2011 (on 31 selected artists born before 1900), and emphasizes returns rate that are much lower than those for contemporary art and in particular contemporary American art. As shown in Table A2 where we report annual real return rates for selected artists and in Fig. 4, where we present the basic price index for American art, we can broadly confirm their result in our wider dataset of 359 pairs of repeated sales, with an average annual return close to zero in nominal terms, which is comparable to what we found for old master paintings.

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[28]The analysis is preliminary for location effects due to the smaller samples of repeated sales and to the more limited international trade for these sectors, since auctions for American art are mainly located in New York, auctions for Ethnic art in New York and Paris and auctions for Chinese paintings in New York, Hong Kong and Shanghai. Some minor sectors have been recently investigated, but without a focus on our efficiency hypothesis: see Kraeussl and Logher (2010) on Chinese art and Ekelund et al. (2017) on American art.

[29]For instance, they include Gilbert Stuart, the most successful portrait painter of the 1700s, John Trumbull, winner in 1817 of the first large commission in American art (four canvases for the rotunda of the Capitol building in Washington, paid 8,000 dollars each) and the landscape painters of the Hudson River School.

[30] The most expensive paintings in our dataset include works by George Bellows (*Evening swell*) and Georgia O'Keeffe (*Red hills with pedernal, white clouds*). We have found the best return rates for works such as a *Mountain landscape* by Albert Bierstadt, *Narcissa* by Hovsep Pushman and *The visit* by John Falter.

The most lively sector of art trade in the last two decades has been Chinese art (see Robertson, 2005). Investment in Chinese paintings has been booming, mainly in China, but we are not aware of empirical works on repeated sales in this sector. Traded artworks cover a wide period ranging from old masters of the Ming dynasty (as Shen Zhou, Tang Yin or Dong Qichang) to those of the early Qing dinasty associated with court painters of Beijing and academic painters (including Wang Hui and the Italian Jesuit painter Castiglione, who introduced European techniques in China) and academic painters of other provinces (as the Loudong and Nanjing masters, Anhui landscapists and Yangzhou flower painters).[31] It includes also traditional painters active in the early and mid 1900s, such as Zhang Daqian and Fu Baoshi, to mention some of the artists who have reached the top prices, while abstract art is confined to contemporary art auctions. Our sample includes 205 repeated sales, and it shows a rapid increase in evaluations over the most recent years, as emerging from Table A2 reporting real returns for selected artists and Fig. 4 reporting the price index.[32] Annual return rates have been quite high, around 17% in nominal terms, though our evidence is limited to a few years and reveals also a high volatility, resembling qualitatively the performance of contemporary art. This pattern is unique, also compared to closer artistic traditions, as those of Korea and Japan. Therefore, it is natural to conclude that the increasing prices of both old and contemporary Chinese art reflect the emerging role of China in the world economy and its increasing domestic demand for art as a luxury good (see Pownall *et al.*, 2019, for a dynamic perspective on the demand of art).

We finally provide the first exploration of returns on investment in Ethnic art with a sample of 264 repeated sales. Trade in this sector includes mostly masks, statues and other objects from Africa, South-East Asia and Oceania, as well as artworks from ancient Aztec, Maya, Inca and other pre-Columbian civilizations, ranging over many centuries. Most of the traded works are African masks and small statues (notably from Mali, Ivory Coast, Nigeria, the Congo basin and eastern Africa) often from recent periods.[33] As shown in Fig. 4, prices for this sector have been raising in the last years: the average annual return rate is around 3% in nominal terms.

Repeated sales regressions in these three sectors are shown in Table 4. The explanatory power of the regressions for American and Ethnic art is comparable to what found for the three benchmark sectors in Table 4 due to the limited number of controls, while it is larger

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[31]Many artists are known by name. Some of them were probably active in a lively primary market (mainly for hanging scrolls painted with ink and colours on silk or paper) that unfortunately has not left us much evidence (see Watson, 2007).

[32]We found the best returns for recent works as a *Banquet* by Huang Yongyu and *Bird and magnolia* by Yu Fei'an or classic ones as *Listening to the Running Streams* by Tang Yin.

[33]We found the best return rates for statues from Congo and Gabon, a Maori hand club from New Zealand, statues from Easter Islands, and an Inca poncho.

Figure 4: Nominal Price indexes for American, Chinese and Ethnic art
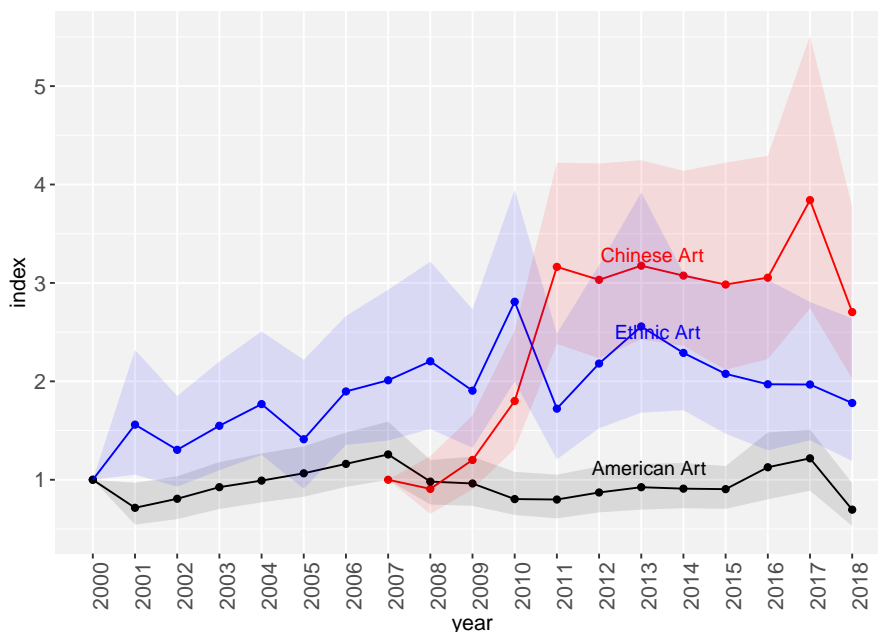
for Chinese art mainly because of the largely positive trend in prices captured by the year dummies. The most important result is that also here there is no evidence of masterpiece effects for any of the three sectors, which provides additional convincing evidence that the monetary size of art investment is unrelated to its return. Also most of the location dummies have coefficients insignificantly different from zero, but the limited sample size does not allow us to draw firm conclusions. We also tried to add few available controls in unreported regressions, which strengthened these results (confirming the role of transaction costs, and the fact that price guarantees, available only for American art, do not generate significant effects on returns), with remaining arbitrage opportunities only in Chinese art (probably due to the fact that this sector is still in a transition phase with rapidly increasing demand). In spite of differences in the institutional features of the six sectors considered until now, none of them presents any evidence of masterpiece effects. However, art returns vary a lot across sectors, suggesting differences in the nature of art investment by sector that deserve further investigations.

6   Price changes in the long run

Long run analysis of art price changes by Baumol (1986) and Mei and Moses (2002) have been based on repeated sales reconstructed over multiple centuries, going back to the 1700s in the former case and to the 1800s in the latter. As mentioned before, an intrinsic bias of this methodology of data collection is that it tends to select artworks that have been successful *ex post* but were already valuable *ex ante*, which may generate an artificial (negative) masterpiece

Table 4: Repeated sale regressions on American, Chinese and Ethnic art

					Dependent variable: Real total return		
					American Art	Ethnic Art	Chinese Art
$lnP_{i,t}$ Masterpiece effect					−0.007 (0.007)	−0.008 (0.012)	0.009 (0.013)
Location at purchase → location at resale							
(Transactions' volume in % for each of 3 art segments)							
Sotheby's	→	**Sotheby's** benchmark	(36%,	68%, 44%)			
Sotheby's	→	Christie's	(27 %,	18%, 7%)	0.037 (0.078)	−0.229* (0.128)	−0.335** (0.177)
Christie's	→	Sotheby's	(9 %,	11%, 9%)	−0.026 (0.087)	0.190 (0.150)	0.044 (0.169)
Christie's	→	Christie's	(28 %,	4%, 39%)	−0.109 (0.068)	−0.118 (0.249)	−0.064 (0.090)
NY	→	**NY** benchmark	(100%,	35%, 10%)			
NY	→	Paris	(,	27%,)		0.212* (0.121)	
Paris	→	NY	(,	10%,)		0.032 (0.155)	
Paris	→	Paris	(,	28%,)		0.125 (0.122)	
China	→	China	(,	, 79%)			0.144 (0.157)
NY	→	China	(,	, 2%)			0.422 (0.408)
China	→	NY	(,	, 8%)			−0.240 (0.188)
Year dummies					(YES)	(YES)	(YES)
Observations					359	264	205
R^2					0.28	0.18	0.66

Note: *p<0.1; **p<0.05; ***p<0.01. Standard errors in parenthesis. In the cases of American Art and Chinese Art, standard errors are (artist) clustered.

effect. We have avoided this potential survivorship bias by focusing on the complete set of repeated sales in Christie's and Sotheby's auctions of two decades. However, the long run perspective is important to verify whether the implications of art market efficiency are a recent phenomenon or there is some stable law of art price change. In this section we use data on art markets since Renaissance, Baroque and Neoclassical periods to take a new look at price changes over the long run.

We identify painters for whom we can match records of prices in different historical periods and in contemporary auctions.[34] We focus on the highest price per painter between the historical records and the highest price per painter between contemporary sales (rather than average prices that may be affected by selection bias).

We identify painters for whom we can match records of prices in different historical periods and in contemporary auctions.[35] To limit the survivorship bias and expand the number of

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[34]Contemporary prices used in this analysis are from all transactions (not just repeated sales) taking place at Sotheby's or Christie's from 2000 to 2018 worldwide. We have more than 80 thousand observations for old master paintings traded in this period. Notice that the *Salvator Mundi* by Leonardo da Vinci was exceptionally auctioned in a contemporary art sale in 2017. It was sold for $450 million (including the buyer's premium), the record price for an artwork, and indeed for an handmade object.

[35]Contemporary prices used in this analysis are from all transactions (not just repeated sales) taking place at Sotheby's or Christie's in 2000-2018 worldwide. We have more than 80 thousand observations for old master

observations, we focus on the highest price per painter between the historical records and the highest price per painter between contemporary sales. Each historical price for artist k is expressed in terms of the historical currency in a base year t, say $P_{k,t}$. Likewise, each contemporary price for the same artist is expressed in dollars of a base year T, say $P_{k,T}$. The base years are fixed at the beginning of the historical period and in 2018 for the contemporary prices. Given an exchange rate $E_{t,T}$, one could express the price change of artist k as $ln\left(\frac{E_{t,T} \cdot P_{k,T}}{P_{k,t}}\right)$, and test whether price changes are correlated with initial prices. For our purposes, it is easier to run a regression on the prices of painters as $ln\left(P_{k,T}\right) = \delta + \phi ln\left(P_{k,t}\right) + \varepsilon_k$, where δ is a constant capturing the cumulative return on art and absorbing the exchange rate between historical and contemporary currencies, ϕ represents the elasticity of prices today with respect to historical prices and ε_k is an error term for the painter. Alternatively, defining $r_{k,T} = ln\left(\frac{P_{k,T}}{P_{k,t}}\right)$ as the long run rate of change of art price for artist k, we obtain:

$$r_k = \delta + \left(\phi - 1\right) ln P_{k,t} + \varepsilon_k \tag{4}$$

We test the hypothesis $\phi \approx 1$, which implies that historical prices predict contemporary prices, or alternatively $\phi - 1 \approx 0$, which implies that art price changes in the long run do not depend on the initial prices and therefore there are no persistent masterpiece effects.

There are many reasons why our hypothesis may not hold in our experiment. The historical price records are (to say the least) incomplete and only for a limited subset of painters we can match past and current prices, though gaps refer to both high quality and low quality painters. The preferences of the collectors may have changed over centuries, rediscovering certain authors and de-emphasizing others, with an impact on the distribution of aesthetic dividends of art and therefore on the distribution of prices, though there is some evidence of persistence in the preferences of art collectors (see Graddy, 2013) and there is no reason to suspect that preferences change with a systematic increase in value of initially underestimated artists and a systematic decrease in value of initially overestimated artists. Last, but not least, art markets may have not been as efficient as today in the past and in different geographical areas, and deviations from general rules of price change may have not been corrected over time (though a long run perspective should only amplify the opportunities to exploit mispricing). All of this is enough to seriously doubt that the lack of masterpiece effect should hold over centuries, but evidence that $\phi \approx 1$ would provide further support in a long run perspective. We

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paintings traded in this period. We notice that the *Salvator Mundi* by Leonardo da Vinci was exceptionally sold in an auction of contemporary art in 2017. It was sold for \$450 million (including the buyer's premium), the record price for an artwork, and indeed for an handmade object.

will test for this hypothesis on five different historical periods for which we have collected prices from art historical sources. The results are displayed in Fig. 5 (reporting regressions coefficients and R^2): the positive linear relation between past and current prices emerges clearly, and the unitary slope is also a fair approximation in most cases, though in all cases the slope is less than unitary.

In the case of Renaissance, we collected prices of primary sales (commissioned by private patrons, churches or public buildings) between 1285 and 1550 all over Italy. More than three hundred price records are all converted into *gold florins* and are available for all the most famous Renaissance masters of Florence, Venice, Rome, Milan, Neaples, Mantua and other minor artistic centers of Italy, as well as for some minor painters. One of us has presented the original dataset elsewhere (Etro, 2018), arguing that this primary art market was already quite competitive, with price differentials reflecting quality differentials as perceived at the time and independent from the regional destinations of the commissions. The number of artists for whom we could match historical and contemporary records is limited to 51 artists, and the data show that price changes are quite variable across painters, which should not be surprising since primary prices reflect evaluations that can be widely revised over more than five centuries. Nevertheless the correlation between Renaissance and contemporary prices is positive and the estimated coefficient $\phi = 0.73$ is not far from unity. Moreover, the unitary slope remains in the 95% confidence interval, though the power of the test is admittedly low. Similar results hold for the subsequent Baroque period in Italy, whose primary market has been analyzed in Etro *et al.* (2015) with particular reference to Baroque Rome, providing further evidence of competitive forces, as those allocating painters between artistic genres (portraits, still lifes, landscapes, genre and historical paintings) to the point of equalizing the marginal profitability of each genre. Here we have analyzed data on the secondary market (from the Getty Research Institute), namely evaluations of paintings from 157 inventories of private collections, mainly from Rome, Tuscany, Mantua as well as other Italian towns between 1598 and 1718. Prices are expressed in Roman *silver scudi* adjusted for the cost of living. The inventories include about three thousand paintings by most artists of the Baroque period active in Italy, and also by older masters whose works had been inherited or purchased by the same collectors. The number of artists with evaluations recorded in these inventories and traded in contemporary auctions almost doubles compared to the earlier period, with 91 artists matched. The data confirm the linear relation with a coefficient increased to $\phi = 0.84$ We cannot reject the hypothesis of independence of art price changes from the initial price levels.

For Dutch and Flemish artists we have more than ten thousand prices of paintings from

inventories and auctions recorded in Amsterdam between 1600 and 1700. They have been initially collected and presented by Montias (2002), who has documented that art production by Dutch and Flemish artists was quite prolific in this period and art trade was extremely competitive (see also De Marchi, 1995). In Etro and Stepanova (2016) we have supported this claim with econometric evidence that the same entry of artists in the market was highly sensitive to profitability, and anecdotal evidence that competition generated cost saving innovations that reduced prices in the second part of the century. The Dutch market of the golden age provides the richest historical dataset in our possession for our purposes, with 129 painters for which we have prices from historical inventories and from our contemporary dataset (historical prices are expressed in Dutch *guilders* of 1600). Celebrated masters such as Rembrandt and Rubens lead the ranking in both periods, and the overall relation is quite precise, with a coefficient $\phi = 0.83$ which is close to unity. If we directly run the regression (4), we obtain:

$$r_k = 9.435^{***} - 0.162 ln\left(P_{k1600}\right) \qquad \text{N.obs.} 129, R^2 = 0.012$$
$$\quad (0.576) \qquad (0.133)$$

confirming that we cannot reject that price changes are independent from initial prices. This resonates well with art historical evidence on a broad persistence of taste for Dutch and Flemish painters in the last three centuries by Carpreau (2017), which is however based on the evolution of median auction prices author by author.

Similar results emerge between the second half of the 1700s and the first half of the 1800s in the secondary market of France and England (original data from the Getty Research Institute). This period starts with the Rococo period, includes all the Neoclassical period, and concludes with Romanticism. Etro and Stepanova (2015) have analyzed prices in *livres* from more than a thousand auctions and ninety thousand sales taking place between 1745 and 1820 in Paris, when this was becoming the main art center of the world: these data provide evidence of price adjustments reflecting new information on artworks, as the earliest available evidence of positive price jumps at the death of the authors. To focus on prices by artists active in the domestic market, here we restrict the sample to French artists, and for 79 of them we can match modern price records. This dataset provides a very precisely estimated coefficient of $\phi = 0.87$, which is again close to unitary. Finally, we consider the auction market in London between 1780 and 1840, using price data in *pounds* for over 200,000 sales. In Etro and Stepanova (2017) we have argued that this secondary market (where Christie's and Sotheby's were already active) represented an important opportunity of portfolio diversification for British investors (see also

De Silva *et al.*, 2020, on this market). Again we focus on local artists for a period that is known as the golden age of British art, and we obtain 73 matches with contemporary price data. The usual regression provides a coefficient of $\phi = 0.8$, and also in this case a unitary slope remains in the 95% confidence interval. Considering the long period under consideration, we can conclude that there is no evidence of relevant price convergence in the art market for old master paintings.[36]

Overall, the investigations of this and earlier sections suggest that art prices have been anchored to persistent differentials between artists, with changes over time that are driven by return rates depending on aggregate factors and without systematic differences for artworks of different value. Moreover, the independence of price changes from price levels has implications for the same distribution of art prices, since it reproduces a form of the Gibrat's law of proportionate effect (Gibrat, 1931), which perpetuates a lognormal distribution of art prices over time. This is consistent with empirical investigations on art pricing in different historical periods.[37]

Note to Figure 5: Y-axis is centered logarithm of maximal USD price in contemporary auctions. X-axis is centered logarithm of maximal historical price. The datasets and the consumer price inflation used are described and analyzed further in Etro (2018) and Etro and Stepanova (2015, 2016, 2017, 2019).

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[36]We also experimented quantile regressions without finding systematic changes in the coefficients across samples in spite of limited number of observations.

[37]It is also well known that frictions in the data generating process or differences in growth rates of average prices per artists can deliver power laws in the tail of related distributions: this is what we found for the distribution of artistic talent (proxied by the average real price per artists with multiple observations) over different artistic periods (Etro and Stepanova, 2018).

Figure 5: Price correlations over centuries

(a) Renaissance (1285-1550)

slope 0.73 (0.14), R^2 34%, corr 58%, obs. 51
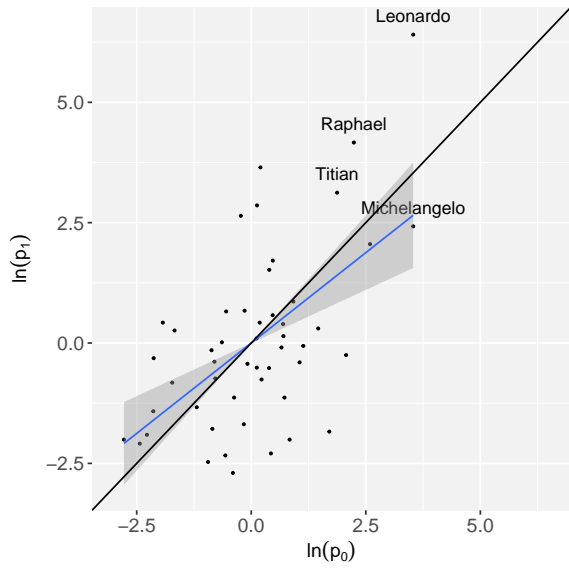
(b) Italian Baroque Art (1598-1718)

slope 0.84 (0.10), R^2 41%, corr 65%, obs. 91
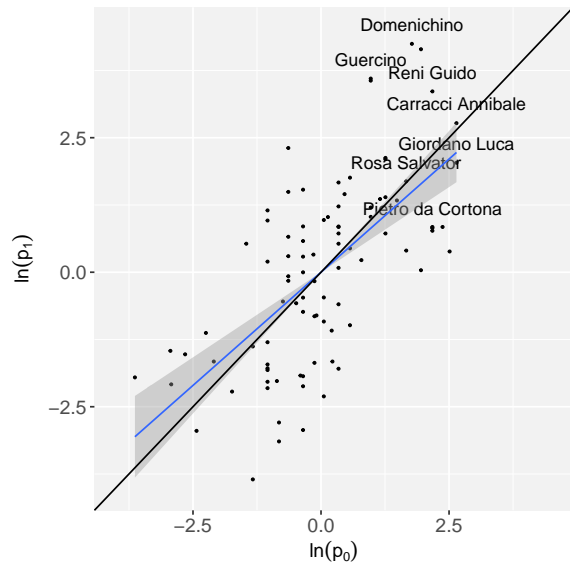
(c) Dutch & Flemish Golden Age (1597-1600)

slope 0.83 (0.13), R^2 24%, corr 49%, obs. 129
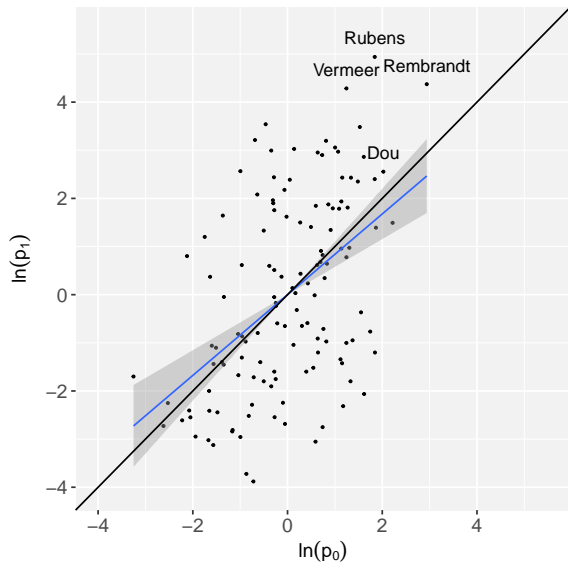
(d) French Art (1745-1820)

slope 0.87 (0.06), R^2 73%, corr 76%, obs. 93
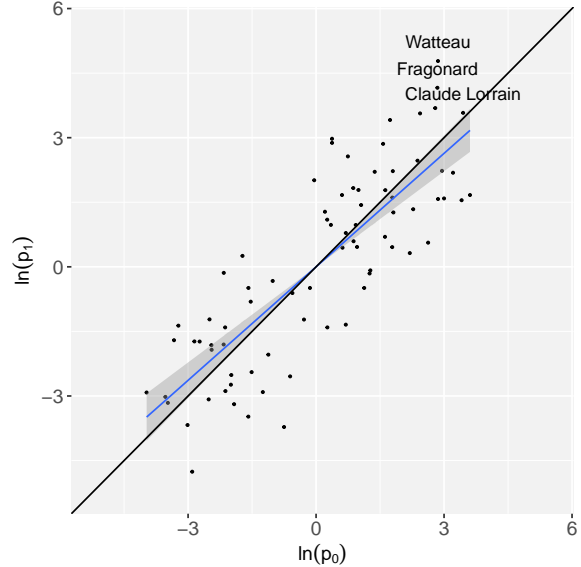
(e) British Golden Age (1780-1840)

slope 0.8 (0.11), R^2 41%, corr 64%, obs. 74
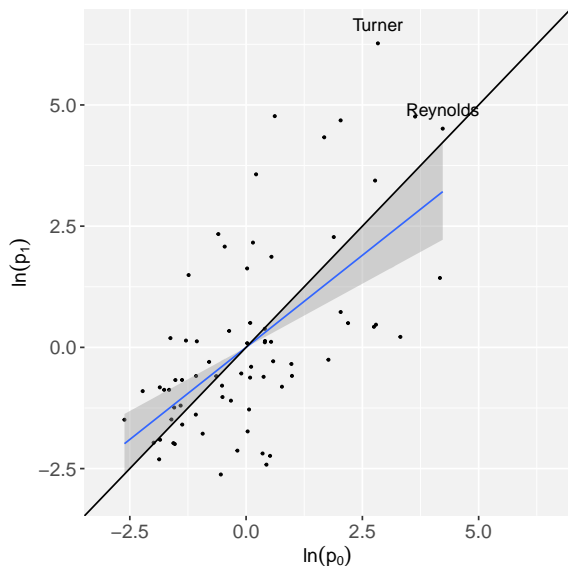
7   Conclusion

In this work we have investigated the sources of art price variation by examining art returns in the short run from recent art auctions of different sectors and art price changes in the long run. Consistently with basic economic principles, a variety of shocks to the fundamental value of artworks as perceived by collectors appear to affect art prices and therefore art returns, but we did not find evidence of significant masterpiece effects or location effects: art returns appear to be independent from the initial value of the artworks and they are equalized between auction houses and international locations, as one should expect in efficient market.

Our analysis has also shown that return rates differ widely across sectors. In the last two decades, the highest returns were derived from investments in Chinese art followed by Contemporary art, with intermediate performance for investments in Modern art and Ethnic art and lower returns for Old Master Paintings and old American Art. Differences in transactions costs, risk and aesthetic dividends can definitely account for some of these return differentials, but further investigations on their sources appear to be a promising avenue for future research.

While we believe that our dataset based on a complete set of repeated sales and our methodology extending the one of Mei and Moses (2002) with more control variables have been useful to shed new light on the determinants of art returns, more work is definitely needed. The analysis of a longer timespan would allow one to test our results in a more satisfactory way. Our datasets on emerging sectors are still limited and could be extended to many other sectors with lively international trade in art auctions. We also neglected minor auction houses for which data are increasingly available. Finally, our long run analysis could be explored further while new art historical datasets are made available.

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A Appendix I

Table A1: Artists' descriptive statistics

Old Masters Art

Artist	Repeated sales	Average price, in USD 2018		Average annualized real return	
Francois Boucher (1703 − 1770)	10	167,192	(225,836)	-0.1%	(6.6%)
Hubert Robert (1733 − 1808)	9	29,869	(27,642)	-1.5%	(8.5%)
Jan Josefsz. van Goyen (1596 − 1656)	9	123,098	(132,580)	-5.0%	(10.7%)
Sir Anthony van Dyck (1599 − 1641)	8	1,012,952	(1,370,967)	6.3%	(22.7%)
Adriaen van de Venne (1589 − 1662)	7	83,009	(95,307)	-7.9%	(13.9%)
Giovanni Battista Tiepolo (1696 − 1770)	6	558,519	(1,186,305)	-6.0%	(8.9%)
Abraham Bloemaert (1566 − 1651)	5	13,221	(8,773)	0.5%	(7.3%)
Esaias van de Velde (1587 − 1630)	5	18,235	(21,897)	-8.1%	(10.1%)
Giandomenico Tiepolo (1727 − 1804)	5	384,137	(829,844)	-0.5%	(2.8%)
Isaac van Ostade (1621 − 1649)	5	28,199	(25,918)	-1.1%	(13.2%)
Jacob van Hulsdonck (1582 − 1647)	5	454,180	(190,131)	-6.3%	(6.0%)
Joseph Mallord William Turner (1775 − 1851)	5	462,647	(538,017)	-3.9%	(15.1%)
Pieter Brueghel II (1564 − 1637)	5	3,645,381	(2,334,366)	-0.3%	(9.3%)
Adriaen Jansz. van Ostade (1610 − 1685)	4	171,358	(183,798)	-6.8%	(12.1%)
Antonio Joli (1700 − 1777)	4	195,524	(205,054)	2.1%	(11.6%)
Claude-Joseph Vernet (1714 − 1789)	4	219,352	(126,201)	-6.9%	(3.2%)
Francesco Guardi (1712 − 1793)	4	188,653	(125,254)	-5.2%	(5.2%)
Gaetano Gandolfi (1734 − 1802)	4	174,363	(200,650)	-6.8%	(2.9%)
Giovanni Francesco Barbieri, il Guercino (1591 − 1666)	4	60,076	(29,280)	-5.5%	(5.8%)
Jan Breughel II (1601 − 1678)	4	162,998	(166,196)	-2.4%	(4.4%)
Jean Auguste Dominique Ingres (1780 − 1867)	4	60,779	(74,152)	-6.3%	(15.6%)
Jean-Baptiste Greuze Tournus (1725 − 1805)	4	104,987	(95,940)	-9.1%	(15.0%)
John Constable (1776 − 1837)	4	120,406	(156,884)	-4.6%	(12.6%)
Nicolaes Maes (1634 − 1693)	4	43,577	(34,911)	-6.0%	(1.5%)
Peter Paul Rubens (1577 − 1640)	4	200,017	(121,566)	0.7%	(10.3%)
Sebastiaen Vrancx (1573 − 1647)	4	54,972	(10,994)	-7.9%	(5.0%)
Willem van Mieris (1662 − 1747)	4	101,713	(81,445)	-3.3%	(14.9%)
Alessandro Magnasco, Il Lissandrino (1667 − 1749)	3	74,950	(53,875)	-9.4%	(6.1%)
Bartolome Esteban Murillo (1618 − 1682)	3	1,353,563	(1,704,798)	-6.7%	(3.0%)
Biagio dalle Lame, called Biagio Pupini	3	83,279	(35,246)	-7.9%	(7.4%)
Frans Snyders (1579 − 1657)	3	159,318	(151,919)	-3.9%	(2.3%)
Giovanni Battista Salvi, il Sassoferrato (1609 − 1685)	3	107,857	(119,195)	11.5%	(5.4%)
Giovanni di Ser Giovanni Guidi (1406 − 1486)	3	126,071	(22,154)	-5.5%	(10.1%)
Govaert Flinck (1615 − 1660)	3	808,710	(1,350,242)	16.4%	(19.8%)
Guido Reni (1575 − 1642)	3	307,133	(202,823)	-0.5%	(6.2%)
Jan Davidsz. de Heem (1606 − 1684)	3	454,745	(304,935)	4.5%	(24.7%)
Jean-Antoine Watteau (1684 − 1721)	3	149,138	(189,471)	-1.9%	(4.0%)
Louis de Caullery (1555 − 1622)	4	25,877	(21,635)	6.9%	(27.0%)
Marco Ricci (1676 − 1730)	3	48,240	(1,206)	-5.5%	(4.2%)
Melchior d'Hondecoeter (1636 − 1695)	3	257,620	(140,155)	2.2%	(8.9%)
Joshua Reynolds (1723 − 1792)	3	53,808	(40,166)	-2.5%	(9.1%)
The Master of the Langmatt Foundation Views	3	38,044	(22,277)	17.1%	(31.2%)
Thomas Gainsborough (1727 − 1788)	3	77,740	(74,456)	-0.8%	(7.8%)
Ambrosius Bosschaert I (1573 − 1621)	2	1,106,699	(266,155)	-8.4%	(6.0%)
Bernardo Bellotto (1721 − 1780)	2	2,420,999	(1,621,804)	-1.7%	(5.2%)
Francisco Jose de Goya y Lucientes (1746 − 1828)	2	299,151	(232,177)	3.7%	(0.6%)
Jacopo da Ponte, called Bassano (1515 − 1592)	2	69,883	(20,045)	7.1%	(7.5%)
Joost Cornelisz. Droochsloot (1586 − 1666)	2	15,847	(1,955)	13.6%	(24.4%)
Lucas Cranach I (1472 − 1553)	2	1,312,770	(873,694)	5.1%	(2.3%)
Paolo Caliari, called Il Veronese (1528 − 1588)	2	32,970	(37,140)	4.5%	(4.9%)
Lavinia Fontana (1552 − 1614)	1	53,975		-1.5%	

Note: Standard deviation in parenthesis

Impressionism and Modern Art

Artist	Repeated sales	Average price, in USD 2018		Average annualized real return	
Pablo Picasso (1881 − 1973)	115	1,496,946	(3,405,535)	2.9%	(9.5%)
Pierre-Auguste Renoir (1841 − 1919)	57	380,607	(481,765)	0.1%	(11.7%)
Marc Chagall (1887 − 1985)	54	587,628	(808,957)	4.3%	(9.9%)
Raoul Dufy (1877 − 1953)	52	130,890	(148,160)	-1.0%	(7.5%)
Camille Pissarro (1830 − 1903)	43	955,465	(1,434,894)	0.1%	(5.5%)
Auguste Rodin (1840 − 1917)	40	277,385	(488,119)	9.7%	(35.4%)
Henri Matisse (1869 − 1954)	38	1,698,092	(2,334,424)	0.4%	(7.2%)
Maurice de Vlaminck (1876 − 1958)	35	73,759	(76,310)	-1.7%	(7.8%)
Alfred Sisley (1839 − 1899)	33	783,679	(777,526)	0.2%	(8.3%)
Bernard Buffet (1928 − 1999)	30	54,721	(31,040)	5.3%	(10.0%)
Kees van Dongen (1877 − 1968)	29	564,086	(718,578)	0.5%	(11.1%)
Edgar Degas (1834 − 1917)	28	458,165	(701,578)	-0.5%	(10.8%)
Fernand Leger (1881 − 1955)	27	541,022	(650,284)	4.0%	(16.4%)
Maurice Utrillo (1883 − 1955)	27	146,638	(108,883)	-5.9%	(8.0%)
Joan Miro (1893 − 1983)	26	876,836	(2,012,698)	0.6%	(7.6%)
Pierre Bonnard (1867 − 1947)	26	374,927	(318,659)	0.5%	(11.2%)
Salvador Dali (1904 − 1989)	25	357,013	(855,463)	3.7%	(10.2%)
Claude Monet (1840 − 1926)	25	3,305,150	(4,433,264)	5.9%	(5.6%)
Jean Dufy (1888 − 1964)	24	28,238	(17,826)	3.1%	(8.1%)
Gustave Loiseau (1865 − 1935)	23	52,179	(30,591)	8.4%	(39.5%)
Louis Valtat (1869 − 1952)	23	45,077	(32,066)	3.3%	(14.7%)
Edouard Vuillard (1868 − 1940)	23	176,663	(152,207)	-0.7%	(11.1%)
Eugene Boudin (1824 − 1898)	22	139,167	(172,841)	-2.0%	(6.7%)
Francis Picabia (1839 − 1953)	22	192,148	(364,129)	6.4%	(26.6%)
Henri Jean Guillaume Martin (1860 − 1943)	21	182,209	(179,157)	0.2%	(11.0%)
Henri le Sidaner (1862 − 1939)	19	88,804	(81,341)	3.6%	(6.6%)
Moise Kisling (1891 − 1953)	19	52,731	(43,184)	1.0%	(6.3%)
Paul Signac (1863 − 1935)	19	697,850	(1,385,360)	6.4%	(10.0%)
Marie Laurencin (1883 − 1956)	18	47,260	(26,970)	-2.9%	(11.0%)
Aristide Maillol (1861 − 1944)	17	389,610	(509,367)	-4.2%	(10.3%)
Maximilien Luce (1858 − 1941)	17	127,955	(233,060)	6.0%	(15.0%)
Chaim Soutine (1893 − 1943)	17	764,740	(1,284,577)	10.6%	(17.2%)
Albert Marquet (1875 − 1947)	16	74,551	(96,565)	1.1%	(9.9%)
Henri Lebasque (1865 − 1937)	16	150,625	(149,656)	0.9%	(11.2%)
Wassily Kandinsky (1866 − 1944)	16	1,419,639	(2,948,127)	-1.1%	(23.2%)
Auguste Herbin (1882 − 1960)	15	73,371	(92,606)	7.9%	(8.2%)
Henry Moore (1898 − 1986)	15	371,232	(1,022,678)	1.1%	(7.1%)
Paul Cezanne (1839 − 1906)	15	1,804,566	(4,145,619)	2.4%	(5.7%)
Georges Braque (1882 − 1963)	14	170,098	(162,751)	2.7%	(11.2%)
Andre Lhote (1885 − 1962)	14	51,958	(41,813)	-3.8%	(15.2%)
Theo van Rysselberghe (1862 − 1926)	14	498,743	(800,595)	-0.4%	(12.0%)
Paul Gauguin (1848 − 1903)	13	1,285,161	(1,691,116)	1.9%	(4.3%)
Vincent van Gogh (1853 − 1890)	13	2,852,885	(3,596,873)	4.1%	(9.9%)
Rene Magritte (1898 − 1967)	11	617,849	(649,474)	5.1%	(7.2%)
Alberto Giacometti (1901 − 1966)	10	2,088,675	(2,042,051)	-1.6%	(9.5%)
Tamara de Lempicka (1898 − 1980)	8	365,552	(769,080)	-4.3%	(12.0%)
Giorgio de Chirico (1888 − 1978)	7	194,578	(272,899)	5.8%	(14.5%)
Amedeo Modigliani (1884 − 1920)	5	7,283,974	(8,532,029)	1.8%	(9.1%)
Eva Gonzales (1849 − 1883)	4	303,306	(209,035)	2.2%	(6.8%)
Berthe Morisot (1841 − 1895)	3	141,313	(63,753)	3.0%	(11.7%)

Note:	Standard deviation in parenthesis

Post-war & Contemporary Art

Artist	Repeated sales	Average price, in USD 2018		Average annualized real return	
Andy Warhol (1928 − 1987)	145	1,316,494	(3,193,292)	5.2%	(14.6%)
Jean-Michel Basquiat (1960 − 1988)	69	1,195,893	(1,952,927)	9.7%	(21.9%)
Alexander Calder (1898 − 1976)	65	403,667	(544,647)	7.5%	(9.7%)
Damien Hirst (1965 −)	63	311,778	(376,735)	-2.7%	(14.7%)
Sam Francis (1923 − 1994)	56	196,240	(451,821)	3.9%	(10.8%)
Gerhard Richter (1932 −)	56	1,264,070	(1,886,053)	10.2%	(14.2%)
Jean Dubuffet (1901 − 1985)	48	386,054	(682,598)	3.9%	(9.6%)
Lucio Fontana (1899 − 1968)	39	449,430	(461,918)	6.8%	(11.6%)
Yves Klein (1928 − 1962)	35	1,221,799	(1,640,074)	9.7%	(12.8%)
Tom Wesselmann (1931 −)	33	409,919	(674,584)	2.5%	(16.4%)
Willem de Kooning (1904 − 1997)	32	1,881,878	(3,816,115)	7.0%	(26.1%)
Peter Doig (1959 −)	31	1,922,930	(3,356,779)	14.3%	(18.8%)
Richard Prince (1949 −)	30	511,184	(781,127)	2.5%	(10.9%)
Keith Haring (1958 − 1990)	28	211,475	(313,192)	11.5%	(12.9%)
George Condo (1957 −)	24	68,588	(101,788)	11.7%	(16.9%)
Kusama Yayoi (1929 −)	23	87,804	(103,136)	24.5%	(13.7%)
Alighiero Boetti (1940 − 1994)	22	107,297	(169,587)	8.2%	(10.8%)
Yoshitomo Nara (1959 −)	22	147,815	(239,989)	16.5%	(17.2%)
Cy Twombly (1928 −)	21	1,225,068	(2,531,039)	7.8%	(11.0%)
Josef Albers (1888 − 1976)	20	272,979	(214,169)	4.2%	(13.3%)
Frank Stella (1936 −)	20	657,781	(636,366)	12.8%	(17.0%)
Victor Vasarely (1906 − 1997)	19	65,516	(53,111)	5.7%	(21.2%)
Joan Mitchell (1925 − 1992)	19	1,011,316	(1,177,098)	11.2%	(14.5%)
Ed Ruscha (1937 −)	18	330,675	(511,358)	6.9%	(11.0%)
Takashi Murakami (1962 −)	18	164,155	(172,265)	10.7%	(29.4%)
Anselm Kiefer (1945 −)	18	409,687	(613,650)	0.5%	(8.2%)
Karel Appel (1921 −)	17	81,481	(88,740)	-0.6%	(8.7%)
Roy Lichtenstein (1923 − 1997)	17	1,487,471	(1,787,378)	-1.8%	(11.0%)
Robert Rauschenberg (1925 −)	17	336,759	(463,663)	2.1%	(11.5%)
Robert Motherwell (1915 − 1991)	17	336,689	(583,595)	2.8%	(10.7%)
Arman (1928 −)	16	43,761	(25,927)	-9.3%	(14.0%)
Cindy Sherman (1954 −)	16	70,771	(48,031)	8.7%	(12.3%)
Jean-Paul Riopelle (1923 − 2002)	16	239,741	(286,546)	2.5%	(12.4%)
Andreas Gursky (1955 −)	15	140,448	(121,838)	-2.9%	(11.3%)
Anish Kapoor (1954 −)	15	526,380	(381,545)	-2.1%	(14.2%)
Banksy (1975 −)	15	104,042	(73,336)	7.4%	(14.8%)
Jeff Koons (1955 −)	15	1,448,421	(2,788,299)	5.2%	(19.4%)
Francis Bacon (1909 − 1992)	12	2,385,964	(1,844,582)	20.2%	(34.1%)
Dan Flavin (1933 − 1996)	10	160,538	(108,718)	1.1%	(6.7%)
Maurizio Cattelan (1960 −)	9	191,240	(315,223)	4.9%	(17.5%)
Chris Ofili (1968 −)	7	40,069	(27,162)	-3.9%	(7.9%)
Piero Manzoni (1933 − 1963)	7	548,834	(788,937)	11.5%	(14.5%)
Arshile Gorky (1904 − 1948)	7	1,460,785	(1,391,726)	-2.2%	(10.0%)
Mark Rothko (1903 − 1970)	5	1,206,228	(704,480)	7.6%	(3.5%)
Jasper Johns (1930 −)	5	2,074,882	(1,967,644)	4.8%	(4.7%)
Julian Schnabel (1951 −)	5	137,180	(141,030)	-4.6%	(1.3%)
Alberto Burri (1915 − 1995)	4	1,001,495	(1,195,367)	8.6%	(7.0%)
Jackson Pollock (1912 − 1956)	4	1,207,125	(2,099,526)	11.8%	(17.3%)
Barnett Newman (1905 − 1970)	3	2,651,283	(953,851)	-6.5%	(11.5%)
Kara Walker (1969 −)	2	189,982	(77,603)	3.6%	(3.3%)

Note: Standard deviation in parenthesis

Table A2: Artists' descriptive statistics

American Art

Artist	Repeated sales	Average price, in USD 2018		Average annualized real return	
Childe Hassam (1859 − 1935)	16	466,343	(672,440)	-6.1%	(11.7%)
Milton Avery (1885 − 1965)	10	141,452	(125,968)	-7.2%	(8.6%)
Grandma Moses (1860 − 1961)	8	62,862	(22,764)	-1.2%	(11.5%)
Guy Carleton Wiggins (1883 − 1962)	8	52,599	(32,195)	-2.5%	(4.2%)
Albert Bierstadt (1830 − 1902)	7	123,617	(243,714)	0.6%	(16.1%)
John George Brown (1831 − 1913)	7	36,217	(20,404)	-1.5%	(7.7%)
Norman Rockwell (1894 − 1978)	7	112,622	(214,753)	3.1%	(4.7%)
Marsden Hartley (1877 − 1943)	6	607,790	(709,468)	-1.9%	(4.4%)
George Inness (1825 − 1894)	6	44,629	(30,001)	-4.1%	(3.9%)
Frederic Remington (1861 − 1909)	5	98,733	(89,818)	0.5%	(4.4%)
Jasper Francis Cropsey (1823 − 1900)	5	38,527	(36,135)	-5.0%	(5.2%)
George Wesley Bellows (1882 − 1925)	5	523,363	(926,266)	0.3%	(5.4%)
Georgia O'Keeffe (1887 − 1986)	5	932,184	(808,438)	3.2%	(4.8%)
Andrew Wyeth (1917 − 2009)	4	111,621	(71,211)	1.8%	(3.6%)
John Marin (1870 − 1953)	4	76,004	(45,029)	-3.9%	(5.7%)
Thomas Moran (1837 − 1926)	4	71,265	(55,260)	-2.1%	(5.7%)
John Singer Sargent (1856 − 1925)	4	482,242	(715,838)	1.5%	(18.2%)

Chinese Art

Artist	Repeated sales	Average price, in USD 2018		Average annualized real return	
Zhang Daqian (1899 −1983)	16	158,224	(214,973)	24.8%	(24.4%)
Lin Fengmian (1900 − 1991)	13	76,284	(59,731)	13.6%	(21.2%)
Qi Baishi (1863 −1957)	10	120,579	(114,144)	17.2%	(16.8%)
Zhao Shao'ang (1905 −1998)	9	53,127	(52,580)	6.6%	(22.3%)
Huang Binhong (1864 −1955)	8	62,521	(52,743)	22.4%	(17.2%)
Cheng Shifa (1921 −2007)	6	43,543	(64,449)	29.2%	(15.6%)
Feng Zikai (1898 −1975)	6	21,540	(10,371)	9.0%	(19.6%)
Wu Guanzhong (1919 − 2010)	6	113,223	(153,453)	13.1%	(10.5%)
Pu Ru (1896 −1963)	5	24,017	(17,227)	-2.4%	(12.9%)
Xu Beihong (1895 −1953)	5	156,967	(80,639)	20.7%	(20.1%)
Zhu Qizhan (1892 −1996)	5	26,604	(26,018)	3.0%	(10.9%)
Wu Changshuo (1844 −1927)	5	29,714	(23,000)	15.5%	(10.1%)
Fu Baoshi (1904 −1965)	4	464,397	(540,081)	30.6%	(26.6%)
Li Keran (1907 −1989)	4	123,968	(101,693)	6.4%	(2.6%)
Bada Shanren (1626 −1705)	2	271,097	(334,242)	8.6%	(6.4%)
Wang Hui (1632 − 1717)	2	51,654	(60,949)	24.3%	(56.9%)
Wang Yuanqi (1642 − 1715)	2	19,769	(18,219)	11.7%	(18.5%)

Note: Standard deviation in parenthesis