CentER

Discussion Paper

No. 2010–08

ART AND MONEY

By William Goetzmann, Luc Renneboog, Christophe Spaenjers

January 2010

ISSN 0924-7815

TILBURG UNIVERSITY

Art and Money

William Goetzmann, Luc Renneboog, and Christophe Spaenjers*

This version: January 14, 2010

Abstract:

This paper investigates the impact of equity markets and top incomes on art prices. Using a newly constructed art market index, we demonstrate that equity market returns have had a significant impact on the price level in the art market over the last two centuries. We also find empirical evidence that an increase in income inequality may lead to higher prices for art, in line with the results of a numerical simulation analysis. Finally, the results of Johansen cointegration tests strongly suggest the existence of a long-run relation between top incomes and art prices.

JEL classification: D31, D44, G1, Z11.

Keywords: Art market; Equities; Income inequality; Cointegration; Comovement.

---

* William Goetzmann (william.goetzmann@yale.edu) is Edwin J. Beinecke Professor of Finance and Management, Yale School of Management, USA. Luc Renneboog (luc.renneboog@uvt.nl) is Professor of Corporate Finance, Tilburg University, the Netherlands. Christophe Spaenjers (c.spaenjers@uvt.nl) is a doctoral candidate in Finance, CentER Graduate School, Tilburg University, the Netherlands.

The authors would like to thank Tony Atkinson, Fabio Braggion, Elroy Dimson, Richard Grossman, Benjamin Mandel, Kim Oosterlinck, Emmanuel Saez, Darius Spieth, and John Turner for helpful comments and data. Spaenjers thanks the Netherlands Organisation for Scientific Research (NWO) for financial support. Part of this paper was written while Spaenjers was a Chazen Visiting Scholar at Columbia University, whose hospitality is gratefully acknowledged.

Art and Money

Abstract:

This paper investigates the impact of equity markets and top incomes on art prices. Using a newly constructed art market index, we demonstrate that equity market returns have had a significant impact on the price level in the art market over the last two centuries. We also find empirical evidence that an increase in income inequality may lead to higher prices for art, in line with the results of a numerical simulation analysis. Finally, the results of Johansen cointegration tests strongly suggest the existence of a long-run relation between top incomes and art prices.

JEL classification: D31, D44, G1, Z11.

Keywords: Art market; Equities; Income inequality; Cointegration; Comovement.

1. Introduction

Unless cast in platinum and covered with diamonds, as in the case of a 2007 Damien Hirst sculpture, a work of art has little intrinsic value. Nevertheless, works of art have from time to time fetched shockingly high prices, at least from the perspective of ordinary wage earners. The highest amounts have been paid for creations of deceased artists, but also living artists – Hirst being the exemplar – have commanded multi-million dollar or pound sums for their work. It is still largely a puzzle what determines these prices, and their pattern over time.

Mandel (2009) argues that "it is the dynamic demand for art that is the only meaningful driver of investment returns". He further points out that this demand may primarily be driven by a savings motive, as in his own theoretical framework, but also by changes in income. Indeed, at auctions, the price of an art object is only limited by how much collectors are willing and able to spend on it. When individuals' buying power rises, this can be expected to lead to higher art consumption, and thus to a higher price level in the art market. However, given the relatively fixed and limited supply of (high-quality) artworks, how wealthy the *wealthiest* are may matter more to the determination of art prices than total wealth. The Economist (2006) puts it as follows: "Trophy asset prices may be a function of the huge dispersion of incomes. What is the point of being rich if you cannot drink the finest wines while gazing at the world's most famous artworks on the walls of your penthouse flat?" This is especially relevant because many high net worth individuals seem to be attracted to art assets, and often consider investing a considerable part of their wealth in it (Cap Gemini, 2008).

One way to measure changes in wealthy individuals' buying power, is to look at stock market returns. Equities are typically held more widely among the most affluent. Without explicitly making this point, a number of studies (cf. Section 2) have indeed looked at the relation between stock market movements and art market trends. In this study, we extend this work over a much longer time frame, starting our study in the first half of the nineteenth century. By doing so, we may benefit from the fact that, at least in the earlier periods of our time frame, the art market was much less globalized, enabling us to calculate a less noisy measurement of the correlation between the equity market and the art market than has previously been possible.

Moreover, we dissect equity returns into capital growth and dividend yield in order to establish which type of equity returns has an effect on art prices.

A complementary approach to proxying for collectors' ability to purchase art consists of studying the evolution of top incomes over time, especially if the highest incomes also go to the wealthiest individuals. The simple simulation model in Section 3 of this paper, which builds on previous work by Goetzmann and Spiegel (1995), shows how changes in the total income in the economy, the income distribution, and the population of art collectors may impact on art prices. We also empirically investigate the links between total income and its distribution on the one hand and art prices on the other, relationships which have not been analyzed before.

We utilize a repeat sales methodology that incorporates a noise reduction technique to construct an annual art price index since 1765, based on art auction transaction data from a historical resource and an online sales database. Since the initial selection of artists conforms to British taste, and nearly all the art sales considered took place in London, we relate our GBP-denominated art price index to British equity market and income series. Our results show that, over the period 1830-2007, there is a strong positive relation between equity market and art market movements. Lagged equity capital changes show significantly positive correlation with changes in art prices. The effect is robust to several alternative specifications. Next, we also find evidence of a relation between income inequality and art prices over the period 1908-2005, the time frame for which the income inequality data are available. The significance of this result is largely driven by the large variation in the British income distribution during the first half of the twentieth century. Finally, we demonstrate the existence of a robust cointegrating relationship between top incomes and art prices.

This paper contributes to the literature in a number of respects. First, it constructs a novel annual long-run art price index, which is used to estimate the relationship between art and the stock market. The results clarify previous ambiguous evidence on the impact of equity markets on art prices, measured over shorter time windows. Second, this paper sheds light on the fundamentals of art prices; more specifically, this is the first study to investigate the interaction between income, inequality, and art prices. Third, it adds additional evidence to the growing literature on wealth effects and luxury consumption.

The remainder of this paper is structured as follows. Section 2 outlines the relevant literature on art prices, stock market wealth effects, and the market fundamentals of real assets. Section 3 outlines a simple model that relates total income and income inequality to art prices, and shows simulation results. Section 4 presents the data for our empirical part, while Section 5 gives an overview of our results. Section 6 includes a number of robustness checks. The final section concludes.

2. Related literature

Since the first studies by Anderson (1974) and Stein (1977), an expanding literature has investigated the returns to art investments. For example, using different estimation techniques and ever-larger auction sales datasets, Baumol (1986), Pesando (1993), Buelens and Ginsburgh (1993), Goetzmann (1993), Mei and Moses (2002), Campbell (2008), Pesando and Shum (2008), and Renneboog and Spaenjers (2009a) have studied the price appreciation of art over time, and compared art returns to those on financial assets. In addition, researchers have focused on a number of art market 'anomalies'.[1] We refer to Ashenfelter and Graddy (2003) and Ginsburgh et al. (2006) for more complete reviews of the literature on art auctions, prices, and price indices. In a recent contribution to the field, Mandel (2009) demonstrates how a utility dividend derived from conspicuous art consumption may affect art returns in a consumption-based asset pricing model.

There is relatively little work on the link between the art market and the broader economy, despite the anecdotal evidence that highlights the importance of the relationship. Goetzmann (1993) shows that art has a positive beta with respect to the stock market over the very long term. In contrast, however, Mei and Moses (2002) report a correlation coefficient of merely 0.04 between the S&P 500 and their art index (annual real returns, 1950-1999). Pesando

[1] Anomalies that have been identified in the art market include biases in presale estimates (Mei and Moses, 2005), violations of the law of one price (Pesando, 1993), lower returns for items that have been bought in (Beggs and Graddy, 2008), and anchoring effects (Beggs and Graddy, 2009). Many authors have also investigated whether there is a "masterpiece effect", in the sense that better art makes a better investment, as first put forward by Pesando (1993), but the evidence is conflicting.

and Shum (2008) find a correlation of 0.21 between the same stock index and their index for modern prints (semi-annual real returns, 1977-2004). Some of these differences may be due to the use of different intervals of observation and estimation, or to drawbacks of the repeat-sales regression, the method commonly used to build art indices. The low correlations may also be caused by a focus on U.S. stocks, while the art market has become a global trading place over the last few decades. Indeed, Renneboog and Spaenjers (2009a), using a hedonic pricing approach, report a much higher positive correlation (0.38) between a global art price index and the returns on a global stock index (annual real returns, 1951-2007), than between the same art index and the S&P 500 (0.19).

Correlations may not completely capture financial market wealth effects, for different reasons. First, most art indices aggregate pricing information over a calendar year while the financial returns are normally year-to-year changes in daily (or continuously) updated indices. This leads to non-synchroneity in the measured returns. Second, it may take some time before the wealth created in financial markets finds its way to art markets. Therefore, different authors have looked at the lagged relation between investor wealth and art prices. Goetzmann (1993) finds that, at least between 1900 and 1986, art prices follow stock market trends. Also Chanel (1995) and Worthington and Higgs (2003) present evidence that stocks markets Granger-cause art prices. However, Worthington and Higgs (2004) point out that the "exact strength and persistence" of this relationship remain unclear. Moreover, the interaction between wealth and art prices over the longer run is still unclear. For example, Ginsburgh and Jeanfils (1995) find no long-term impact of stock markets on art markets. Similarly, Worthington and Higgs (2003) and Chanel (1995) conclude that it is hard to make long-run forecasts of art prices. It is important to note that, up until now, the art markets literature has typically not considered proxies for changes in investors' wealth other than financial market movements.

While the issue of art as a financial asset has long been of interest to scholars interested in the role of art in the economy, a broader economic issue is the relationship between consumption and the behavior of asset prices (Campbell, 1999). Standard pricing models typically assume the existence of a single "representative investor" – who consumes aggregate consumption – in the economy. However, motivated by the failure of the consumption CAPM to explain the relationship between aggregate consumption and equity prices, recent research has relaxed that assumption and taken into account the concentration of financial wealth in a small cohort of investors. Poterba (2000) argues that one would expect the strongest relationship between consumption and asset prices among the households that own the majority of all stocks. As a large share of the consumption of these households typically concerns luxury goods, this would imply a solid link between stock market wealth fluctuations and luxury spending. With respect to durable luxury goods in inelastic supply, such as art and wine, Poterba (2000) notes that the concentration of stock ownership and associated wealth gains in the 1990s led to an increased demand for such goods, which in turn resulted in "significant price appreciations". Empirically, Aït-Sahalia et al. (2003) find a strong correlation between stock market returns and luxury consumption, and show that this result goes far in explaining the equity premium puzzle. Likewise, Hiraki et al. (forthcoming) provide compelling evidence that such a "luxury consumption hypothesis" is valid in the art market. The authors use data on stock market returns, import/export flows, and art prices to show that positive wealth shocks to Japanese investors affected their art purchases in the 1980s, lifting the price level in the art market.

Another related literature is that on the fundamentals of real estate, one of the most important classes of real assets. The studies in this field have at times related house prices to per capita income, for example to investigate whether real estate can be considered overpriced (Case and Shiller, 2003). Recently, some authors have also acknowledged the importance of the distribution of income in determining price levels. For example, Nakajima (2005) shows that rising earnings inequality in the United States may have been an important factor in the rise of real estate prices in the second half of the twentieth century, through an increased demand for precautionary savings that made the housing asset more attractive than financial assets. More directly related to the effects we are interested in here, Gyourko et al. (2006) demonstrate that "the thickness and length of the right tail of the income distribution" can have an important effect on real estate prices. In places that are desirable, but where little new housing is constructed, high-income families will outbid lower-income families for scarce housing, effectively driving up prices. Prices will thus rise faster when the population or income inequality increases. The authors claim that "in this sense, living in a superstar city is like owning a scarce luxury good". In a similar spirit, Van Nieuwerburgh and Weill (forthcoming) show how the increase in house price dispersion in the United States over the last three decades can be explained by increases in the cross-sectional productivity dispersion (which directly translates into wage dispersion in their model). The simulation model in the next section makes clear how population growth, changes in total income, and shocks in income inequality may affect prices in the art market. In contrast to the situation in the real estate market, where there are important spatial differences in supply elasticity, the supply in the art market is almost completely fixed.

3. A model of income (inequality) and art returns

We develop a model of income and art prices (subsection 3.1), which is then used to simulate the effects of changes in the income distribution (subsection 3.2). Our model is based on Goetzmann and Spiegel (1995), who study private value returns in the art market. While a global risky asset portfolio is the primitive in the original model, we focus on personal income: we assume that an art collector buys art out of his income in each period, as he builds up his collection over time. Income is assumed to include both investment and employment income. In contrast to Goetzmann and Spiegel (1995) we allow for increases in the population of art collectors. In addition, in order to make our simulations exercise more realistic, we model the transactions in the art market as outcomes of second-price auctions.

3.1. The model

The private valuation V_{ijt} that a collector i has of artwork j in time t is defined as:

$$V_{ijt} \equiv \lambda_{ij} \gamma_{it} m_t \qquad (1),$$

where m_t is the total global income at time t, γ_{it} is the fraction of total income earned by investor i in time t, and λ_{ij} is the fraction of his income that i is willing to spend on object j. V_{ijt} reflects the maximum price collector i is willing to pay. The works are sold through an English ascending-bid auction: the collector with the highest valuation wins the auction, but the price paid is equal to the second-highest valuation. When we assume that there are N_t collectors in time t, the private valuation of object j of the winning bidder w is therefore equal to:

$$V^*_{jt} \equiv V_{wjt} = \lambda_{wj} \gamma_{wt} m_t = \max_i [V_{ijt}, i = 1,\ldots, N_t] \qquad (2).$$

However, the price P_{jt} paid for object j is equal to underbidder u's private valuation:

$$P_{jt} \equiv V_{ujt} = \lambda_{uj}\gamma_{ut}m_t = \max_i [V_{ijt}, i = 1,..., w-1, w+1,..., N_t] \qquad (3).$$

Assuming *u(b)* and *u(s)* represent the underbidders at the date of purchase, *b*, and the date of sale, *s*, the price appreciation of object *j* between purchase and sale can be expressed as follows:

$$\frac{P_{js}}{P_{jb}} = \frac{\lambda_{u(s)j}\gamma_{u(s)s}m_s}{\lambda_{u(b)j}\gamma_{u(b)b}m_b} \qquad (4).$$

Taking logs yields:

$$\ln\left(\frac{P_{js}}{P_{jb}}\right) = \ln\left(\frac{\lambda_{u(s)j}}{\lambda_{u(b)j}}\right) + \ln\left(\frac{\gamma_{u(s)s}}{\gamma_{u(b)b}}\right) + \ln\left(\frac{m_s}{m_b}\right) \qquad (5).$$

In each period, every painting comes on the market with a probability equal to *p*. All works are offered to the N_t art collectors at that point in time. The population of art buyers increases by a number *n* in each period. The growth rates in per capita income are random draws from a normal distribution with mean and standard deviation both equal to $\varphi > 0$. λ_{ij}, which reflects collector *i*'s personal taste of work *j* and does not vary over time, is drawn from a normal distribution with mean and standard deviation $\psi > 0$.[2] The variable is also censored at 0 and 1. We consider *Z* works of art.

We construct a repeat sales art price index from the simulated transactions in the model, via the following equation:

$$R = X\mu + \varepsilon \qquad (6),$$

where *R* is a vector of log returns, *X* is a matrix of dummy variables equal to 1 for all *t* for which $b < t \leq s$ for each observation (and zero otherwise), and μ is a vector of log geometric return estimates that can be used to construct the index. We use the exponents of μ to build our indices, in line with, for example, Ginsburgh et al. (2006).[3]

---

[2] It is clear from equation (1) that λ serves to break the otherwise perfect correlation between personal income and willingness-to-pay. Ceteris paribus, greater variation of λ (at least between zero and one) implies a relatively smaller role for income in our model, especially when the number of bidders is small. However, in our simulations, choosing a larger value for ψ yields qualitatively very similar results.

[3] In Section 4, we will correct our coefficients for the bias introduced by the concavity of the log. There is less need for such a correction in our simulations. In any case, it would not change our conclusions.

3.2. Simulations

We simulate an art market, and examine how the art price indices relate to the global changes in income. We first generate a series of average per capita income data over 20 periods, putting the first differences' mean and standard deviation (φ) equal to 0.05. We generate this time series of changes in income once and subsequently keep it fixed throughout our art market simulations. We assume that the personal taste variable λ_{ij} has a mean and a standard deviation (ψ) of 0.15. We put the number of artworks (Z) for which we follow prices, i.e. the supply side of the art market, equal to 50. We assume that every artwork is auctioned off in every period, thus $p = 1$, but the seller can simply buy the item back if he still has the highest valuation. In other words, we consider buy-ins as transactions at the second-highest valuation in the market. In the first period, the number of collectors (N_1) is equal to 20, and this number grows with n equal to 2 in each period. In each period, total income is equal to the average per capita income times the number of collectors. In the first scenario, each investor gets a share (γ_{it}) of total income that is drawn from a uniform distribution between zero and twice the average per capita income. This share stays fixed for each investor until $t = 10$. After the tenth period, there is a shock in the income distribution, leaving everyone with an equal income (i.e. the generated per capita income) from $t = 11$ until $t = 20$. Scenario 1 is thus that of a *decrease in income inequality*. In a second scenario, everyone starts with the average per capita income, but as from $t = 11$, the share of total income of each investor is again drawn from a uniform distribution. Scenario 2 is thus the opposite of scenario 1: *inequality increases*. Simulations for both scenarios are repeated 100 times, starting from the same randomly generated income time series. We also repeat the analysis with n, i.e. the increase in the population of art collectors per period, equal to 5 instead of 2, which indicates a more substantial growth of the market. The simulation results are shown in Figure 1.

[Insert Figure 1 about here]

Figure 1 shows the randomly generated per capita income index, which is equal over both scenarios (in Panels A and B) and all art market simulations. The same panels also include the average art price indices for the two values of n, the growth in the number of art collectors. All index values are put equal to 1 in the first period; the scale is logarithmic. Not surprisingly, we observe an almost perfect correlation between the art price indices and the per capita income index when there are no shocks to the income distribution. Since total income is equal to the linearly increasing number of collectors times the average income in every period, this also implies a very strong relation between art prices and total income. However, for the first ten periods, art prices are higher in the first scenario, where the total income is distributed unequally, than in the second scenario, while the opposite is true for the latter half of our time frame. We also see a clear drop in prices in Panel A after the introduction of identical incomes for everyone between $t = 10$ and $t = 11$, and a sharp rise in art prices in Panel B after the income distribution becomes more unequal. In short: income inequality induces higher art prices.

We also learn from Panels A and B that art index values are higher when the inflow of collectors into the market is larger, i.e. when n is higher. Panels C and D highlight one reason for this. For each of the first ten periods, these panels show the evolution of the average private valuation of the winning bidder as a fraction of total income (i.e. V^*/m, or $\lambda_w\gamma_w$), with the average relative valuation over all transactions in the first period normalized to 1. It is clear that we will see stronger increases in the winning bidders' relative valuations when more collectors are flowing into the art market, since this creates a larger chance that someone with a very high private valuation of an art object enters the market. We find weaker increases in art values over time when the income is distributed evenly (Panel D); in this case, since everyone has the same share of total income γ, the increase is solely driven by changes in the winning bidders' λ.

However, there is also another, less straightforward mechanism driving art price trends in our simulation, stemming from the second-price set-up. Panels E and F present the average proportion of the price paid to the valuation of the winning bidder (i.e. P/V^*). In Panel E, in the first period, the winning bidder has to pay on average less than 80% of his own private valuation to buy the work, but this percentage generally increases over time. Again, the increase is higher when more art buyers enter the auction market. Not surprisingly, this proportion is higher when incomes are identical for everyone (Panel F), but even then we see an increase over time.

Our model thus predicts that art prices will rise with (average and total) income and – when controlling for income – with income inequality. Cross-sectionally, we would also expect to see stronger price increases where the population of art collectors grows more strongly. In the next section, we will focus on the first two predictions. The third prediction falls beyond the empirical scope of this paper due to the fact that we limit ourselves to data from one country (with a rather stable growth in population).

4. Data

In this section, we first construct a long-run art price index based on repeated sales information extracted from Reitlinger (1961) and the Art Sales Index (subsection 4.1). Since our art market index is mainly built on London sales, and is expressed in British pounds, we also collect equity market and income data for Great Britain (subsection 4.2). Insofar as it was mainly British individuals who bought the considered artists at British auctions over our time frame, this procedure seems justified.[4] Tests for stationarity, descriptive statistics, and correlations between our variables are discussed in subsection 4.3.

4.1. Art prices

We start by building a long-term art price index. To do so, we go back to the auction sales data collected by Gerard Reitlinger in his 1961 book 'The Economics of Taste', which was the first book in a series of three, and investigated the history of the British paintings and drawings market. The artists whose sales are listed in Reitlinger mostly conform to English standards of taste; Guerzoni (1995) reports that Reitlinger took into account sales of the "most important and prestigious collections". All transaction prices in Reitlinger (1961) are expressed in British pounds. Reitlinger's data have previously been used to calculate the returns on art by, amongst others, Anderson (1974), Baumol (1986), and Goetzmann (1993). In line with these studies, we identify all repeated sales within Reitlinger's book. (Reitlinger adds a short note, such as "see [year]" or "£[amount] in [year]", to many transactions, which makes it possible to correctly

[4] Of course, many of the great American collections of European art had already been formed by the late 19th and early 20th centuries, and the art market became more integrated over the course of the second half of the twentieth century. If anything, this will work against finding significant results when solely utilizing British data. In Section 6, we will also include American data in our analysis as a robustness check.

identify repeated sales.) This gives us a dataset of 1,096 sales pairs until 1961, excluding buy-ins. We then look up all 6,661 works listed in Reitlinger's book in the dataset constructed in Renneboog and Spaenjers (2009a), which contains more than one million transactions from the online database Art Sales Index [http://www.artinfo.com/artsalesindex] since the 1920s until 2007, and try to identify resales of those same works in Great Britain. We only classify a transaction as a resale when there is a unique match of a non-ambiguous title, which occurs in 253 cases.[5] In total we thus end up with a dataset containing 1,349 repeated sales. Since the data are very sparse for the first decades covered by Reitlinger, we delete the thirteen pairs for which the purchase occurred prior to 1765. This leaves us with 1,336 repeated sales.

There are some well-documented selection issues with the data. First, Reitlinger included a disproportionate high number of sales from Christie's London. However, if the sales at Christie's were representative for the higher end of the British market, this does not have to be a major problem. Second, Reitlinger also included relatively more artists that were famous in the beginning of the 1960s. The addition of transactions since the publication of the book, which affect the estimation of the whole index, should alleviate concerns about a potential upward bias. Third, in his critical review of the Reitlinger data series, Guerzoni (1995) shows that some transactions in between sales pairs seem to be missing. However, this is also the case in other repeated sales studies, and should not be expected to impact our index strongly. A more general concern is the survivorship bias in the art market. Simulating an art investment portfolio, without requiring resale, Goetzmann (1996) shows that survivorship issues can put a significant upward bias on estimated returns. However, insofar as this bias does not change significantly over time, this is not a major problem in the context of our research, since we are not focusing on the average long-term return, but on what determines the variation in art returns over time.

It is important to stress that, despite the caveats outlined in the previous paragraph, the Reitlinger data still constitute a unique overview of auction sales since the end of the eighteenth

[5] We classify a transaction in the Art Sales Index as a match to a sale in Reitlinger's list if we find strong evidence of the existence of only one work with the same title by the same artist. Also, we exclude objects with attribution classifications and with very general titles (or titles that point to a much-used subject of the artist), and objects that went to museums according to Reitlinger. Additionally, for the last ten years of our time frame, we can consult the provenance of the work in the online catalogue description on http://www.invaluable.com and delete a limited number of observations, for which the ownership history contradicted the original classification from our dataset.

century. Also, the art price index is a means to an end here. Our use of the Reitlinger data and the repeat-sales methodology is a function of our intention to examine very long-term trends in income and asset market behavior. For shorter time frames, return series can be estimated more precisely, for example via a hedonic approach that uses characteristics data not available in Reitlinger (1961).

To get an estimate of the index μ over T periods based on N repeated sales observations, we follow the Bayes formulation of a repeat sales regression, which imposes some additional restrictions on the estimation, outlined in Goetzmann (1992, 1993):

$$\hat{\mu} = \left[\left(X'\Omega^{-1} X \right) + \kappa \left(I - \frac{1}{T} J \right) \right]^{-1} X'\Omega^{-1} R \qquad (7),$$

where X again is a N x T matrix of dummy variables indicating the holding period for each object, the weights in Ω are the times between sales, and R is the N-dimensional vector of logged returns. Additionally, J is a matrix of ones, and κ is a constant that divides the variance of the residual error by the variance of the index:

$$\kappa = \frac{\sigma^2}{\sigma_\mu^2} \qquad (8).$$

We approximate κ by first running a simple GLS repeat sales regression on our data, which provides us with estimates of σ and σ_μ. The Bayes formulation avoids spurious negative autocorrelation in the estimated return series, and leads to a much more accurate estimator when the number of observations is relatively small (Goetzmann, 1992).

A good approximation of the annual arithmetic returns is then given by $\exp(\hat{\mu}_t + \hat{\sigma}_t^2 / 2)$ where the cross-sectional variance of the return can be estimated in the second stage of the Case-Shiller repeat-sales regression under the assumption that it is constant over time (Goetzmann, 1992). This specification corrects for a downward bias of the arithmetic mean that is due to the log transformation of the art prices. The return estimates can then be used to build a price index over the period of interest.

We perform the analysis outlined in the previous paragraph using our dataset of repeated sales. All prices were deflated using the U.K. RPI (Officer, 2009b) before the log transformation. (We start from real prices because the Bayes repeated sales estimator assumes that the returns conform to a prior distribution, which is more realistic in the context of real returns.) The resulting art price index, in real British pounds, is shown in Figure 2.

[Insert Figure 2 about here]

A visual inspection of the figure suggests a relationship between the real economy and art prices. For example, we see significant price drops during World War I, over the Great Depression in the 1930s, and after the oil crisis in 1973. There is no such an effect over the Second World War, when the price level was already the lowest of the whole twentieth century. Consistent with previous studies that have investigated the late twentieth century art market, we find strong price appreciations throughout the 1960s, during the art market boom at the end of the 1980s (until 1990), and in the 2000s (until 2007). In the nineteenth century, we observe strong price rises in the decades leading up to the so-called "Long Depression" that started around 1873. We will henceforward refer to the natural log of our art price index as *Art*. Our analysis will focus on the period after 1830, the first year for which all the necessary economic data are available.

4.2. Equity and income data

We build a history of British stock price returns, based on the following sources: Acheson et al. (2009) for the period 1830-1870, Grossman (2002) for the period 1870-1900, and Dimson, Marsh, and Staunton (2002, 2009) for the years thereafter. We create yearly indices covering total return, capital appreciation, and dividend yield, transformed into real terms by deflating using the U.K. RPI (Officer, 2009b). We call the natural log series *Equities*, *Equities (capital)*, and *Equities (dividends)*.

A recent literature has investigated the evolution of top incomes over the course of the twentieth century. Piketty and Saez (2006) document that the general pattern is one of a decline of top income in the inter-war period (mainly due to a decline of top capital income), and a sudden rise in top income in the Anglo-Saxon countries since the 1970s (mainly caused by a rise of top wages, i.e. executive compensation, in those countries). We use data from Atkinson and Piketty (2010) – who themselves rely on income tax data – to build a consistent series of the share of total income received by the top 0.1% of all income earners in the U.K. for the period 1908-2005.[6] This series will be referred to as *Inequality*. We refer to Atkinson (2007) for more details on data sources and methodology. However, it is important to note that the data exclude most capital gains and losses, and certain remunerations in kind. Part of the investment income will thus be captured by the equity capital appreciation variable presented before.

Atkinson (2007) observes that the time trends in the distribution of income among the employed and the distribution of personal wealth among individuals are similar. This is important in our context for two related reasons. First, it suggests that we are measuring the share of income earned by the wealthy. Second, it indicates that, by measuring (changes in) inequality in the income distribution, we also proxy for (changes in) inequality in the distribution of wealth.

We also use the data on the total personal income from Atkinson and Piketty (2010) for the years 1908-2005. The natural log of the deflated series is called *Income*. We calculate a similar series *Top income* that measures the log amount earned by the top 0.1% in every year. Yearly data on an alternative measure of total income, namely real GDP, come from Officer (2009a). The data are available from 1830 to 2007, and the logged series is labeled as *GDP*. Due to relatively stable population growth, the variation in changes in total income over time is mainly driven by fluctuations in average income, just like in our simulation model.

4.3. Tests for stationarity, descriptive statistics, and correlations

As is well known, relating non-stationary series to each other would lead to spurious results. Therefore, we first want to determine whether our series are stationary or not. Table 1 shows the results of our Dickey-Fuller tests, which test for the existence of a unit root in time series. Next to the test statistics for the standard Dickey-Fuller test, we also report the results for an

[6] Data on the top 0.1% income share are missing for a limited number of years. For the period 1908-1912, we estimate the share of the top 0.1% based on the coefficients of a linear regression model without intercept that relates the top 0.1% share to the top 0.05% and top 0.01% shares. The model was estimated based on the period 1913-1922. We estimate a similar model relating the top 0.1% share to the top 1% and top 0.5% shares using data from the periods 1982-1986 and 1993-1997 to get estimates of the top 0.01% for the 1987-1992 time frame. For the years 1961 and 1980 we linearly interpolated the income share based on the shares in the surrounding years.

augmented version with one lagged difference, which accounts for potential higher-order autocorrelation. In each case, the null hypothesis is that of a unit root, or non-stationarity.

[Insert Table 1 about here]

The results in Table 1 show that we cannot reject the null hypothesis for all our original time series, implying that we cannot exclude non-stationarity. However, when considering the first differences in our time series, which measure the rate of change or indeed the return, we are able to reject non-stationarity at very high significance levels. This indicates that our series are integrated of order one; henceforward, we will thus mainly work with the first differences of the variables of interest.

Table 2 gives the descriptive statistics for these first differences. For art, we see an average annual log return of 3.20% over the period 1830-2007, with a standard deviation of almost 11%; for equities the mean is 6.51%, with a standard deviation of more than 15%. As can be expected, we find much lower volatility in the series measuring the changes in GDP and total income. The average first difference in *Inequality* is small (-0.06%), but the standard error is 0.32%, indicating some variation in this variable. We also include the regression results of an autoregressive model with two lags in Table 2, to measure autocorrelation in the first differences. One can see that several of our first-differenced variables have highly significant first-order autocorrelation in returns. We will have to take this into account in our empirical analysis.

[Insert Table 2 about here]

Table 3 gives an overview of the pairwise correlations between the different variables. The returns on art have a significantly positive correlation with the total equity returns and capital growth in equities, and with changes in GDP. We also witness a strong positive correlation between art returns and changes in income inequality, and a weaker positive correlation between the first differences in art prices and those in top income. Note that there is also a highly significant positive correlation between *Δ Equities* (and both of its components) and *Δ Inequality*, even though the latter measure does not include capital gains. This may be due to business cycle effects, for example.

[Insert Table 3 about here]

5. Empirical results

The results of our comovement analysis are outlined in subsection 5.1. First, we look at the relation between the equity market and the art market. Second, we consider the correlation between changes in income inequality and art returns. Third, we combine equity returns and changes at the top of the income distribution into a single analysis. Thereafter, we undertake a cointegration analysis in subsection 5.2, to investigate whether we can identify a long-run driver of art prices.

5.1. Comovement

The data series constructed in Section 4 enable a long-term view on the relationship between art prices and equity markets. Panel A of Table 4 outlines the baseline OLS regression results. Model (1) relates our art market returns to yearly changes in our measure of income for which we have information since 1830, namely *GDP*. We thereafter include equity market returns in our analysis. However, since the price of an equity is a 'stock' variable measured at year-ends (and thus not a 'flow' variable like GDP or dividends), we also include the lagged first differences for both *Equities* and *Equities (capital)*. Models (2) and (3) look at overall equity returns, while models (4) and (5) differentiate between capital growth and dividend yield. We present Newey-West standard errors that account for heteroskedasticity and first-order autocorrelation in the error terms (which is signaled by (non-reported) Durbin-Watson test statistics). We also show the number of observations and F-value for each regression.

[Insert Table 4 about here]

The results for the estimation of model (1) in Panel A indicate that overall income does not explain art price changes at a meaningful statistical significance level. The coefficient on *Δ GDP* is positive, but has a p-value of slightly more than 0.10. It is possible that the low variation in GDP changes makes it hard to identify the effect of changes in total income. Models (2) and (3) in Panel A of Table 4 show positive coefficients on both same-year and lagged equity market returns that are statistically significant. The results of model (4) and (5) show that it is mainly lagged capital gains / losses that drive art returns.

Up to now, we have found strong evidence that capital appreciation and depreciation drive art prices, but only very weak evidence that a proxy for overall income is helpful in explaining art price trends. However, delving deeper into the relation between income inequality and art prices, we report in panel B of Table 4 the results of additional regression models linking art returns to alternative proxies for both total income and its distribution. We limit our analysis to the period since 1908, the first year for which data on the income distribution are available.

As before, models (1) and (2) indicate that changes in overall income variables (such as GDP or total personal income) are not statistically significantly related to art returns. Models (3) and (4) add the first differences in *Inequality* to the regression specification, and in both cases we find positive and highly significant coefficients, indicating that art prices rise when income inequality goes up, in line with our simulation model.[7] The inequality coefficient in model (4) suggests that a one percentage point increase in the share of total income earned by the top 0.1% triggers an increase in art prices of about 14 percent. Model (5) relates art price changes to the changes in *Top income*, the variable that combines information on personal income and income inequality. We observe a positive relation, but the coefficient is not significantly different from zero (t-statistic of 1.58). Also here this may be due to the relatively low year-to-year variation. A cointegration analysis below sheds more light on the long-run relationship between top income and art prices.

In models (1) and (2) of Panel C of Table 4, we check whether our inequality measure retains its explanatory power when controlling for same-year and lagged equity capital growth variables. We exclude the dividend variable, because dividends are very sticky, and already captured by the personal income inequality variable. We still control for total income employing the different proxies presented above. Model (3) revisits the changes in top incomes.

[7] We also re-estimated our models in Panels B and C adding the squares of *Δ Inequality*, to allow for the possibility of higher-order effects. This may be relevant since our inequality measures measure the curvature of the income distribution. However, in all cases the coefficients on *Δ Inequality* were still significantly positive and in the same order of magnitude as those reported in Table 4. In contrast, the coefficients on the quadratic terms were never statistically significant from zero at the 5% level.

The results from the three models in Panel C confirm our previous findings, in that equity markets strongly affect art prices. However, although the coefficient is somewhat smaller, our income inequality measure is still a highly significant determinant of the art price level. We find less support for the hypothesis that art returns can readily be associated with short-term changes in top incomes.

We illustrate the trends in total personal income, the share held by the top 0.1%, and art prices since 1908 in Figure 3. This figure shows that art prices were lingering below the pre-World War I level until the very end of the 1960s. If we only consider total income measures, this is quite surprising. Indeed, total personal income had by then increased almost fourfold – would one not expect rises in income to lead to an upward art price trend? The results presented here suggest that the changes in the income distribution may have played an important role: the share of total income earned by the top 0.1% decreased enormously in the first half of the twentieth century, potentially eroding the buying power of the wealthiest.

[Insert Figure 3 about here]

5.2. Cointegration

Our previous observations provide evidence of comovement between equity markets and income inequality on the one hand and art markets on the other. However, this analysis has been concentrated on relatively short-term effects. The long-term nature of our data series and the fact that the series are integrated of order one call for further exploration of the factors that drive art prices over the long run. If it is really the wealthy or high-income individuals that determine the price level in the art market, then one would expect *Top income* (but not necessarily *GDP* or *Income*) to be cointegrated with art prices.

Panel A of Table 5 shows the results of Johansen's cointegration tests applied to our time series over the period since 1908. We report the results of the trace and maximum eigenvalue tests assuming no trend in the cointegrating equation. We include one lagged first difference in our test, which seems reasonable given that we are working with yearly data. Also, lag selection criteria, like the Akaike Information Criterion or the Schwarz Bayesian Criterion (not reported), suggest the inclusion of just one lag in most cases. Table 5 presents both the results with and without lagged equity capital growth as an exogenous variable. We find that the null hypothesis of no cointegration cannot be consistently rejected, except in the case of *Top income*. This is in line with the intuition behind our simulation model. Over the long run, the income of the wealthy seems the key factor in the price formation in the art market.

[Insert Table 5 about here]

Panel B of Table 5 shows the resulting cointegrating equations, in which the coefficients are normalized, which is a standard procedure that allows better insight in the interaction between the variables. Setting the coefficient on *Art* equal to one, we find significantly negative coefficients on *Top income*, in line with expectations. However, note that the absolute values of these coefficients are also significantly smaller than one, implying that there is no one-to-one relationship between our proxy for top incomes and art prices.

6. Robustness checks

This section includes a number of robustness checks. First, we add lagged art returns to our comovement models (subsection 6.1). Second, to test the robustness of our cointegration results, we repeat the analysis, but now adding a linear trend to the cointegrating equation (subsection 6.2). Third, we do a comovement analysis by subperiod, before and after the end of the Second World War (subsection 6.3). Fourth, and last, we check whether our baseline results still hold after adding information on the American income distribution to our analysis (subsection 6.4).

6.1. Adding lagged art returns to comovement models

We previously reported strong autocorrelation in our returns on art. There are several possible reasons for this. First, the repeat-sales regression is known to induce serial dependency, and the shrinkage estimator used to construct the index may also have this effect (Goetzmann, 1992). Second, autocorrelation may be explained by speculative dynamics also relevant in other asset markets (Cutler et al., 1991). Third, it may also partially be attributable to a 'Working effect' (Working, 1960; Schwert, 1990): our index is smoothed and will have autocorrelated returns by construction due to the implicit averaging of art prices per period. Therefore, as a first robustness check, we add the lagged art market return to some crucial comovement regressions from the previous section. The results are shown in Panel A of Table 6. Models (1), (2), and (3) repeat key regressions from Panels A, B, and C of Table 4, respectively. Durbin-Watson test statistics (not reported) indicate that the error terms no longer show significant autocorrelation, and therefore we report traditional robust (instead of Newey-West) standard errors.

[Insert Table 6 about here]

Even though the lagged art returns are highly significant in all specifications of Table 6, the coefficients of the equity related variables and their significance are largely similar to those in Table 4. Also the coefficient on *Δ Inequality* in model (2) of Table 6 is still very strongly significant. In model (3) the coefficient on the income inequality variable is positive and more than a standard deviation above zero, albeit not statistically significant (p-value of 0.14). We conclude from this analysis that including lagged art market returns somewhat weakens our results, but does not lead to different conclusions.

6.2. Adding a linear trend to cointegrating equations

In Section 5, we reported the results of a cointegration analysis that assumed no trend in the cointegrating equation. We now repeat this analysis adding such a linear trend. The results can be found in Panel B of Table 6. As before, we find statistically significant evidence of a cointegrating relationship between top incomes and art prices. The cointegrating equations (not reported) show highly significant coefficients on *Top income* of about -0.50, while the coefficients on the time trend are not statistically significant.

6.3. Analysis per subperiod

Profound changes have taken place in the art market since the middle of the previous century. Without doubt, the art market has become more globalized. One may thus expect the relation between our art price index on the one hand and the British equity market and income distribution on the other to be weaker after the Second World War. Therefore, Panel C of Table 6 repeats the same comovement analyses as before, but now differentiates between the period prior to 1945 and the post-war period.

Models (1) and (4) in Panel C show that (lagged) British equity capital growth has a statistically significant impact on our art price index for both subperiods. This is reassuring: at least for our analysis of the impact of equity markets, our results are not driven by one particular era. The other models, however, suggest that our findings on the role of income inequality in the determination of art prices are caused by trends in the first decades of the twentieth century. Indeed, the coefficient on *Δ Inequality* is significantly positive and economically large in model (2), which considers the period up to 1945, but close to zero in model (5). Models (3) and (6) combine the information on income and equities. Although for the first subperiod we do not find any statistical significance, all coefficients have the expected sign and order of magnitude. The low power probably originates from the limited number of yearly observations. The results for the second subperiod, since World War II, confirm the points made earlier in this paragraph: equity markets have a clear impact, while we do not find evidence of a role for changes in the income distribution in setting art prices.

As discussed earlier, comovement analyses investigate short-term effects. The much lower variation in changes in income inequality since 1945 may make it harder to identify those effects. It may still be the case that personal income and its distribution over the population are driving art prices over the longer term. Therefore, we also repeat the cointegration analysis for the post-war period. The results are reported in Panel D of Table 6.

Panel D shows that equities and GDP cannot be identified as long-term determinants of art prices, in line with our previous findings. In contrast, we cannot reject the hypotheses that total personal income and top incomes (in three out of four cases) are cointegrated with art prices. That both of these income series seem relevant since the end of World War II should not be too surprising. It became clear from the simulation exercise that art prices can be expected to move in line with overall income as long as there are no strong shocks in income inequality. Over the course of the twentieth century, the strongest shifts in income distribution occurred in the first decades.

6.4. Role of U.S. income distribution

We perform a final robustness analysis incorporating data on income and income inequality in the United States. Americans have been one of the most important groups of art collectors in the global art market over the whole twentieth century. As before, the data come from Atkinson and Piketty (2010) and are available as of 1913. *Δ Income U.S.* and *Δ Inequality U.S.* refer to the newly introduced American data. In some specifications, we also control for GBP-denominated U.S. equity capital returns, using NYSE data from Goetzmann et al. (2001) for the pre-1925 period and from CRSP for the period after. The results are shown in Panel E of Table 6. Model (1) considers the comovement of art returns with U.S. income and income inequality. Model (2) and (3) add British income and equity variables. Model (4) combines U.S. income, inequality, and equity prices. Model (5) adds all British information.

We find that there is a significant correlation between American income inequality and art returns in model (1), but that the significance of the coefficient disappears once British data are added in models (2) and (3). Something similar happens in models (4) and (5): lagged American equity capital growth is a significant factor until British variables are added to the model. That the British income inequality and lagged equity capital appreciation variables are significant factors in the determination of British art prices in models (3) and (5) show that our results are robust, and hint at some country-specificity in the relationship between economic fundamentals and art prices, even in a globalized world.[8]

[8] Renneboog and Spaenjers (2009b) reach similar conclusions after studying the market for Russian art. For example, over the period 1997-2007, they find much higher correlations between the Russian stock market and prices for Russian art than between this Russian art index and other stock markets. Also, anecdotal evidence suggests the existence of a 'home bias' in the art market.

7. Conclusion

Motivated by a growing literature on stock market wealth effects and the effects of income dispersion on the prices of real assets, this article has investigated how investment and employment income – more generally, money – determines the price of art. On a theoretical level, our simulation exercise shows how art prices rise not only when average or total income (or the size of the population) goes up, but also when income inequality rises. The evolution of the highest incomes may thus be important in driving art market trends. Empirically, we are able to confirm and strengthen previous evidence that equity market movements affect art prices, using a newly constructed art price index. This result is robust to many different specifications and holds even when we split the overall 1830-2007 time frame in two subperiods. We find weaker evidence for the impact of income inequality. Although there is evidence that changes in income inequality had an important effect on British art prices in the first half of the twentieth century, and that this effect is significant for the overall time frame, we do not confirm the result for the post-war period. Arguably more important, however, is that we find cointegrating relationships between top incomes and art prices, both for the total 1908-2005 period and since 1945.

Taken together, these results demonstrate that it is indeed the wealth of the wealthy that drives art prices. This implies that we can expect art booms whenever income inequality rises quickly. This seems exactly what we witnessed during the last period of strong art price appreciation, 2002-2007. Indeed, in many countries with large numbers of art buyers, income inequality has risen significantly in those years, mainly due to strong increases in managerial compensation. Andy Warhol, for one, would probably have applauded this evolution: “I don’t think everybody should have money. It shouldn’t be for everybody – you wouldn’t know who was important” (Warhol, 1975).

References

Acheson, Graeme G., Charles R. Hickson, John D. Turner, and Qing Je. 2009. "Rule Britannia!: British stock market returns, 1825-1870." *Journal of Economic History*, 69 (4): 1106-1136.

Aït-Sahalia, Yacine, Jonathan A. Parker, and Motohiro Yogo. 2004. "Luxury goods and the equity premium." *Journal of Finance*, 59 (6): 2959-3004.

Anderson, Robert C. 1974. "Paintings as an investment." *Economic Inquiry*, 12 (1): 13-26.

Ashenfelter, Orley, and Kathryn Graddy. 2003. "Auctions and the price of art." *Journal of Economic Literature*, 41 (3): 763-786.

Atkinson, Anthony B. 2007. "The distribution of top incomes in the United Kingdom." In *Top Incomes over the Twentieth Century*, ed. Anthony B. Atkinson and Thomas Piketty. Oxford: Oxford University Press.

Atkinson, Anthony B., and Thomas Piketty, ed. 2010. *Top Incomes over the Twentieth Century. Volume 2*. Oxford: Oxford University Press.

Baumol, William J. 1986. "Unnatural value: Or art investment as floating crap game." *American Economic Review*, 76 (2): 10-14.

Beggs, Alan, and Kathryn Graddy. 2008. "Failure to meet the reserve price: The impact on returns to art." *Journal of Cultural Economics*, 32 (4): 301-320.

Beggs, Alan, and Kathryn Graddy. 2009. "Anchoring effects: Evidence from art auctions." *American Economic Review*, 99 (3): 1027-1039.

Buelens, Nathalie, and Victor Ginsburgh. 1993. "Revisiting Baumol's 'art as floating crap game'." *European Economic Review*, 39 (7): 1351-1371.

Campbell, John Y. 1999. "Asset prices, consumption, and the business cycle." In *Handbook of Macroeconomics*, ed. John B. Taylor and Michael Woodford. Amsterdam: Elsevier.

Campbell, Rachel. 2008. "Art as a financial investment." *Journal of Alternative Investments*, 10 (4): 64-81.

Cap Gemini. 2008. *World Wealth Report* [http://www.us.capgemini.com/worldwealthreport08].

Case, Karl E., and Robert J. Shiller. 2003. "Is there a bubble in the housing market?" *Brookings Paper on Economic Activity*, 2003 (2): 299-342.

Chanel, Olivier. 1995. "Is art market behaviour predictable?" *European Economic Review*, 39 (3/4): 519-527.

Cutler, David M., James M. Poterba, and Lawrence H. Summers. 1991. “Speculative dynamics.” *Review of Economic Studies*, 58 (3): 529-546.

Dimson, Elroy, Paul Marsh, and Mike Staunton. 2002. *Triumph of the Optimists*. Princeton: Princeton University Press.

Dimson, Elroy, Paul Marsh, and Mike Staunton. 2009. *Credit Suisse Global Investment Returns Yearbook*. Zurich: Credit Suisse.

Ginsburgh, Victor, and Philippe Jeanfils. 1995. “Long-term comovements in international markets for paintings.” *European Economic Review*, 39 (3/4): 538-548.

Ginsburgh, Victor, Jianping Mei, and Michael Moses. 2006. “On the computation of price indices.” In *Handbook of the Economics of Art and Culture*, ed. Victor A. Ginsburgh and David Throsby. Amsterdam: Elsevier

Goetzmann, William N. 1992. “The accuracy of real estate indices: Repeat sale estimators.” *Journal of Real Estate Finance and Economics*, 5 (1): 5-53.

Goetzmann, William N. 1993. “Accounting for taste: Art and financial markets over three centuries.” *American Economic Review*, 83 (5): 1370-1376.

Goetzmann, William N. 1996. “How costly is the fall from fashion? Survivorship bias in the painting market” In *Economics of the Arts – Selected Essays*, ed. Victor A. Ginsburgh and Pierre-Michel Menger. Amsterdam: Elsevier.

Goetzmann, William N., Roger G. Ibbotson, and Lian Peng. 2001. “A new historical database for the NYSE 1815 to 1925: Performance and predictability.” *Journal of Financial Markets*, 4 (1): 1-32.

Goetzmann, William N., and Matthew Spiegel. 1995. “Private value components, and the winner’s curse in an art index.” *European Economic Review*, 39 (3/4): 549-555.

Grossman, Richard S. 2002. “New indices of British equity prices.” *Journal of Economic History*, 62 (1): 121-146.

Guerzoni, Guido. 1995. “Reflections on historical series of art prices: Reitlinger’s data revisited.” *Journal of Cultural Economics*, 19 (3): 251-260.

Gyourko, Joseph, Christopher Mayer, and Todd Sinai. 2006. “Superstar cities”. NBER Working Paper 12355.

Hiraki, Takato, Akitoshi Ito, Darius A. Spieth, and Naoya Takezawa. Forthcoming. "How did Japanese investments influence international art prices?" *Journal of Financial and Quantitative Analysis*.

Mandel, Benjamin R. 2009. "Art as an investment and conspicuous consumption good." *American Economic Review,* 99 (4): 1653-1663.

Mei, Jianping, and Michael Moses. 2002. "Art as an investment and the underperformance of masterpieces." *American Economic Review*, 92 (5): 1656-1668.

Mei, Jianping, and Michael Moses. 2005. "Vested interest and biased price estimates." *Journal of Finance,* 60 (5): 2409-2435.

Nakajima, Makoto. 2005. "Rising earnings instability, portfolio choice, and housing prices." University of Illinois Working Paper.

Officer, Lawrence H. 2009a. *What was the UK GDP then?* [http://www.measuringworth.com].

Officer, Lawrence H. 2009b. *What were the UK earnings rate and retail price index then?* [http://www.measuringworth.com].

Pesando, James E. 1993. "Art as an investment: The market for modern prints." *American Economic Review*, 83 (5): 1075-1089.

Pesando, James E., and Pauline M. Shum. 2008. "The auction market for modern prints: Confirmations, contradictions, and new puzzles." *Economic Inquiry*, 46 (2): 149-159.

Piketty, Thomas, and Emmanuel Saez. 2006. "The evolution of top incomes: A historical and international perspective." *American Economic Review*, 96 (2): 200-205.

Poterba, James M. 2000. "Stock market wealth and consumption." *Journal of Economic Perspectives*, 14 (2): 99-118.

Reitlinger, Gerard. 1961. *The Economics of Taste (Volume 1): The Rise and Fall of Picture Prices 1760-1960*. London: Barrie and Rockliff.

Renneboog, Luc, and Christophe Spaenjers. 2009a. "Buying beauty: On prices and returns in the art market." Tilburg University Working Paper.

Renneboog, Luc, and Christophe Spaenjers. 2009b. "The iconic boom in modern Russian art." Tilburg University Working Paper.

Schwert, G. William. 1990. "Indexes of U.S. stock prices from 1802 to 1987." *Journal of Business*, 63 (3): 399-426.

Stein, John P. 1977. "The monetary appreciation of paintings." *Journal of Political Economy*, 85 (5): 1021-1036.

The Economist. 2006. "The rich are different." November 16.

Van Nieuwerburgh, Stijn, and Pierre-Olivier Weill. Forthcoming. "Why has house price dispersion gone up?: *Review of Economic Studies*.

Warhol, Andy. 1975. *The Philosophy of Andy Warhol (From A to B and Back Again)*. Orlando: Harcourt Books.

Working, Holbrook. 1960. "Note on the correlation of first differences of averages in a random chain." *Econometrica*, 28 (4): 916-918.

Worthington, Andrew C., and Helen Higgs. 2003. "Art as an investment: Short- and long-term comovements in major painting markets." *Empirical Economics*, 28 (4): 649-668.

Worthington, Andrew C., and Helen Higgs. 2004. "Art as an investment: Risk, return and portfolio diversification in major painting markets." *Accounting & Finance*, 44 (2): 257-271.

Table 1: Tests for stationarity

	Period	Original series		First differences			
		DF	ADF(1)	DF		ADF(1)	
Art	1830-2007	-1.062	-1.742	-8.642	***	-7.575	***
Equities	1830-2007	-2.568	-2.727	-13.065	***	-10.030	***
Equities (capital)	1830-2007	-2.556	-2.716	-13.090	***	-10.052	***
Equities (dividends)	1830-2007	-0.173	-0.906	-6.642	***	-6.634	***
GDP	1830-2007	-1.148	-2.059	-9.294	***	-8.264	***
Income	1908-2005	-1.460	-1.557	-4.830	***	-3.982	***
Inequality	1908-2005	-1.913	-2.573	-6.089	***	-5.607	***
Top income	1908-2005	0.362	-0.141	-5.328	***	-4.063	***

Notes. This table presents the Dickey-Fuller test statistics of the original series and their first differences. *Art* is a newly constructed annual art price index based on repeated sales data from Reitlinger (1961) and the Art Sales Index. *Equities* is an index capturing total returns on British equities, based on Acheson et al. (2009), Grossman (2002), and Dimson, Marsh and Staunton (2002, 2009). *Equities (capital)* and *Equities (dividends)* cover capital appreciation and dividend yield on British equities, based on the same sources. *GDP* data come from Officer (2009a). *Income* is equal to total personal income in the U.K. *Inequality* is the share of total income earned by the top 0.1% income earners in the U.K. *Top income* is the amount of income earned by the top 0.1% income earners. Data on income and income inequality come from Atkinson and Piketty (2010). The price and income series are deflated using inflation data from Officer (2009b) and log transformed. More information on the data can be found in Section 4. In each case, we show the results of a standard Dickey-Fuller (DF) test and of an augmented Dickey-Fuller (ADF) test including one lag. For all original series, we compare with the critical values with trend. We do not assume trends for the first differences. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 2: Descriptive statistics

	Period	Mean	S.D.	Min	Max	L1		L2
Δ Art	1830-2007	0.0320	0.1077	-0.3520	0.3248	0.4197	***	-0.0515
						0.1023		0.0903
Δ Equities	1830-2007	0.0651	0.1563	-0.8189	0.6820	0.0125		-0.0838
						0.1685		0.1107
Δ Equities (capital)	1830-2007	0.0216	0.1579	-0.8948	0.6249	0.0106		-0.0851
						0.1679		0.1112
Δ Equities (dividends)	1830-2007	0.0211	0.0555	-0.1290	0.2745	0.6591	***	-0.1105
						0.1258		0.1127
Δ GDP	1830-2007	0.0196	0.0288	-0.1031	0.0947	0.3700	***	-0.0935
						0.1227		0.0864
Δ Income	1908-2005	0.0623	0.0581	-0.1415	0.2237	0.5655	***	0.0689
						0.1569		0.1299
Δ Inequality	1908-2005	-0.0006	0.0032	-0.0121	0.0099	0.2461		-0.1708
						0.1557		0.1845
Δ Top income	1908-2005	0.0547	0.0846	-0.1353	0.3451	0.4645	***	0.1081
						0.0888		0.1096

Notes. This table presents the descriptive statistics (mean, standard deviation (S.D.), minimum, and maximum) of the first differences of our variables. The variables are defined below Table 1. L1 and L2 show the coefficients and robust standard errors of an AR(2) model that relates the first differences to the lagged first differences. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 3: Correlation matrix

	Δ Art	Δ Eq.	Δ Eq. (cap.)	Δ Eq. (div.)	Δ GDP	Δ Inc.	Δ Ineq.	Δ Top
Δ Art	1.0000							
Δ Equities	0.1763 **	1.0000						
Δ Equities (cap.)	0.1849 **	0.9980 ***	1.0000					
Δ Equities (div.)	0.0988	0.4352 ***	0.4333 ***	1.0000				
Δ GDP	0.1670 **	0.1032	0.1136	-0.0457	1.0000			
Δ Income	-0.0157	-0.1859 *	-0.1943 *	-0.8164 ***	0.1466	1.0000		
Δ Inequality	0.3438 ***	0.3239 ***	0.3305 ***	0.3389 ***	0.1325	-0.2271 **	1.0000	
Δ Top income	0.1721 *	0.0421	0.0396	-0.3850 ***	0.1655	0.5698 ***	0.5588 ***	1.0000

Notes. This table presents the pairwise correlations for the first differences of our variables. The variables are defined below Table 1. All correlations except those involving the first differences in *Income*, *Inequality*, and *Top income* (1908-2005) are calculated over the time frame 1830-2007. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 4: Comovement analysis

Panel A: Art and equity markets (since 1830)

	(1)		(2)		(3)		(4)		(5)	
	Δ Art		**Δ Art**		**Δ Art**		**Δ Art**		**Δ Art**	
Δ GDP	0.6258				0.2929				0.2774	
	0.3853				0.3970				0.3917	
Δ Equities			0.1189	*	0.1133	*				
			0.0641		0.0634					
Δ(-1) Equities			0.2113	***	0.1976	***				
			0.0517		0.0550					
Δ Equities (capital)							0.1252	*	0.1163	
							0.0732		0.0725	
Δ(-1) Equities (capital)							0.2114	***	0.1978	***
							0.0537		0.0574	
Δ Equities (dividends)							-0.0092		0.0116	
							0.2080		0.2052	
Number of obs.	177		176		176		176		176	
F-value	2.64		9.09	***	6.12	***	6.88	***	5.31	***

Panel B: Art and income (since 1908)

	(1)		(2)		(3)		(4)		(5)	
	Δ Art		**Δ Art**		**Δ Art**		**Δ Art**		**Δ Art**	
Δ GDP	0.8027				0.6322					
	0.5199				0.4602					
Δ Income			-0.0344				0.1438			
			0.2849				0.2592			
Δ Inequality					12.9007	***	14.3493	***		
					3.3648		4.1834			
Δ Top income									0.2587	
									0.1635	
Number of obs.	99		97		97		97		97	
F-value	2.38		0.01		8.38	***	7.60	***	2.50	

Panel C: Art, income, and equity markets (since 1908)

	(1)		(2)		(3)	
	Δ Art		**Δ Art**		**Δ Art**	
Δ GDP	0.3598					
	0.5036					
Δ Income			0.1998			
			0.2580			
Δ Inequality	8.7570	**	9.5855	**		
	3.8380		4.1283			
Δ Top income					0.1626	
					0.1565	
Δ Equities (capital)	0.0950		0.1086		0.1458	*
	0.0738		0.0701		0.0743	
Δ(-1) Equities (capital)	0.1927	***	0.2070	***	0.2265	***
	0.0620		0.0631		0.0574	
Number of obs.	96		96		96	
F-value	6.90	***	8.16	***	5.90	***

Notes. This table shows the results of comovement regressions. The returns on art are regressed on a constant and a changing set of independent variables, listed in the first column. The variables are defined below Table 1. All models are estimated using ordinary least squares. Below each coefficient is the Newey-West standard error, taking into account first-order autocorrelation in the error structure. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 5: Testing for cointegrating relationships

Panel A: Johansen's cointegration tests (since 1908)

Exogenous variable	None				Δ(-1) Equities (cap.)			
	Trace		Max. Eigenval.		Trace		Max. Eigenval.	
Equities	5.6742		5.6616					
Equities (capital)	8.2766		8.2750					
GDP	7.2942		7.2465		7.4525		7.4044	
Income	10.1755		9.5352		8.0594		7.5196	
Top income	20.2675	***	17.8214	**	20.1233	***	18.5579	***

Notes. This panel shows the results of Johansen's cointegration tests. The variables are defined below Table 1. In each case, the null hypothesis is that of no cointegrating relation. No trend is assumed in the cointegrating equation. The test statistics of both the trace and the maximum eigenvalue tests are reported. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel B: Cointegrating equations

Exogenous variable	None		Δ(-1) Equities (cap.)	
	Normalized coeff.		Normalized coeff.	
Art	1.0000		1.0000	
Top income	-0.4059	***	-0.4045	***
	0.0664		0.0653	

Notes. This panel shows the normalized coefficients in the cointegrating relationship between art and top income. The variables are defined below Table 1. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 6: Robustness checks

Panel A: Comovement analysis including lagged art returns

	(1)		(2)		(3)	
	1830-2007		1908-2005		1908-2005	
	Δ Art		**Δ Art**		**Δ Art**	
Δ GDP	0.0692					
	0.3486					
Δ Income			0.0183		0.0895	
			0.2300		0.2369	
Δ Inequality			9.6221	**	5.7150	
			3.9087		3.8736	
Δ Equities (capital)	0.1135	**			0.1147	**
	0.0542				0.0554	
Δ(-1) Equities (capital)	0.1649	***			0.1734	***
	0.0493				0.0596	
Δ Equities (div.)	-0.0109					
	0.1612					
Δ(-1) Art	0.3438	***	0.3562	***	0.3164	**
	0.0810		0.1102		0.1073	
Number of obs.	176		96		96	
R2	0.2459		0.2347		0.3206	

Notes. This table shows the results of comovement regressions. The returns on art are regressed on a constant and a changing set of independent variables, listed in the first column. The variables are defined below Table 1. All models are estimated using ordinary least squares. Below each coefficient is the robust standard error. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel B: Cointegration analysis including trend in cointegrating equation

Exogenous variable	**None**				**Δ(-1) Equities (cap.)**			
	Trace		Max. Eigenval.		Trace		Max. Eigenval.	
Equities	15.8616		10.5152					
Equities (capital)	16.1153		11.1468					
GDP	18.4915		11.2468		17.5318		10.7848	
Income	23.2010		17.2622	*	21.4551		16.0473	
Top income	25.6605	*	18.6019	*	26.1225	**	19.8579	**

Notes. This panel shows the results of Johansen's cointegration tests. The variables are defined below Table 1. In each case, the null hypothesis is that of no cointegrating relation. A linear trend is assumed in the cointegrating equation. The test statistics of both the trace and the maximum eigenvalue tests are reported. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 6: Robustness checks (cont.)

Panel C: Comovement analysis by subperiod (before and after 1945)

	(1)		(2)		(3)		(4)		(5)		(6)	
	1830-1945		1908-1945		1908-1945		1945-2007		1945-2005		1945-2005	
	Δ Art		**Δ Art**		**Δ Art**		**Δ Art**		**Δ Art**		**Δ Art**	
Δ GDP	0.0329						0.7858					
	0.4417						1.0055					
Δ Income			0.3419		0.2478				-0.0436		0.1043	
			0.5735		0.5479				0.3772		0.3025	
Δ Inequality			21.0694	**	10.1098				1.8530		-1.5564	
			9.2915		11.5472				4.4696		5.2515	
Δ Equities (capital)	0.2870	***			0.3019		0.0266				0.0479	
	0.1378				0.2027		0.0568				0.0534	
Δ(-1) Equities (capital)	0.2078	**			0.2264		0.1513	**			0.1919	***
	0.1066				0.1524		0.0600				0.0647	
Δ Equities (div.)	-0.0866						0.0852					
	0.2695						0.4675					
Number of obs.	114		37		36		61		60		59	
F-value	3.22	**	7.37	***	5.63	***	3.51	**	0.09		2.85	**

Notes. This table shows the results of comovement regressions for two different subperiods (until 1945 and since 1945). The returns on art are regressed on a constant and a changing set of independent variables, listed in the first column. The variables are defined below Table 1. All models are estimated using ordinary least squares. Below each coefficient is the Newey-West standard error, taking into account first-order autocorrelation in the error structure. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Panel D: Cointegration analysis on post-war data

Exogenous variable	**None**				**Δ(-1) Equities (cap.)**			
	Trace		Max. Eigenval.		Trace		Max. Eigenval.	
Equities	3.8718		3.8180					
Equities (capital)	4.8334		4.4677					
GDP	7.4998		7.4664		7.2402		7.1566	
Income	16.1455	**	15.8426	**	14.7599	*	14.4027	**
Top income	12.8065		12.7460	*	14.0398	*	14.0333	*

Notes. This panel shows the results of Johansen's cointegration tests. The variables are defined below Table 1. In each case, the null hypothesis is that of no cointegrating relation. No linear trend is assumed in the cointegrating equation. The test statistics of both the trace and the maximum eigenvalue tests are reported. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Table 6: Robustness checks (cont.)

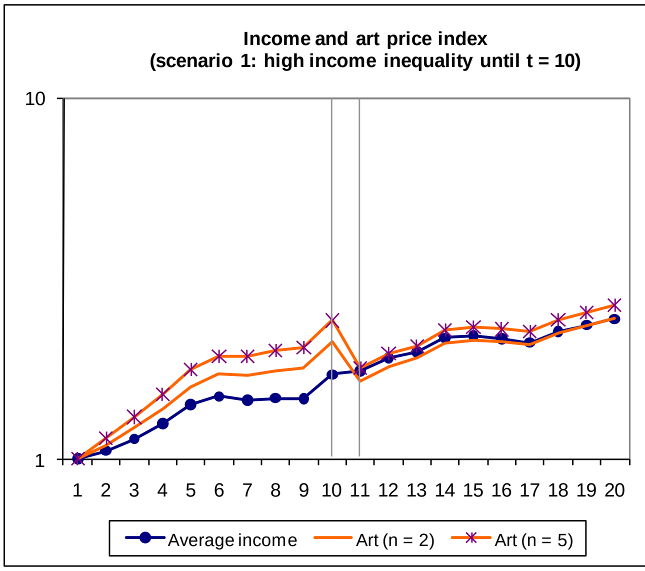
Panel E: Comovement analysis including U.S. data

	(1)		(2)		(3)		(4)		(5)	
	1913-2007		1913-2005		1913-2005		1913-2007		1913-2005	
	Δ Art		**Δ Art**		**Δ Art**		**Δ Art**		**Δ Art**	
Δ Income U.S.	0.1764		0.1456		-0.0064		0.0049		0.0073	
	0.2001		0.1981		0.1598		0.1720		0.1580	
Δ Inequality U.S.	5.1387	*	0.8583		0.9534		2.3071		0.8736	
	2.7483		2.8745		2.5514		2.9839		2.6057	
Δ Equities (capital) U.S.							0.0825		-0.0519	
							0.0725		0.1044	
Δ(-1) Equities (capital) U.S.							0.1636	**	0.0375	
							0.0765		0.0944	
Δ Income			0.1575		0.1919				0.1828	
			0.2629		0.2750				0.3016	
Δ Inequality			13.2699	***	7.7677	*			8.3915	*
			4.2293		4.3895				4.3597	
Δ Equities (capital)					0.1137				0.1395	
					0.0716				0.0865	
Δ(-1) Equities (capital)					0.2146	***			0.1956	**
					0.0593				0.0790	
Number of obs.	94		92		91		93		91	
F-value	2.21		3.74	***	5.42	***	1.98		4.11	***

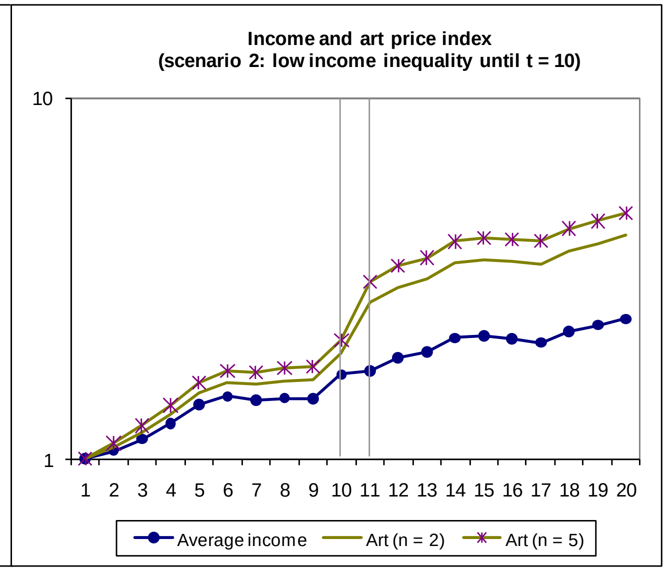
Notes. This table shows the results of comovement regressions. The returns on art are regressed on a constant and a changing set of independent variables, listed in the first column. The U.S. income and inequality data come from Atkinson and Piketty (2010); the U.S. equity data stem from Goetzmann et al. (2001) and CRSP. The other variables are defined below Table 1. All models are estimated using ordinary least squares. Below each coefficient is the Newey-West standard error, taking into account first-order autocorrelation in the error structure. ***, **, and * indicate significance at the 1%, 5%, and 10% level, respectively.

Figure 1: Simulation results

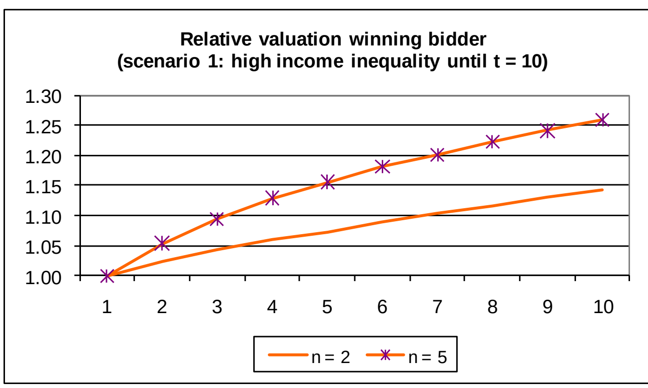
Panel A



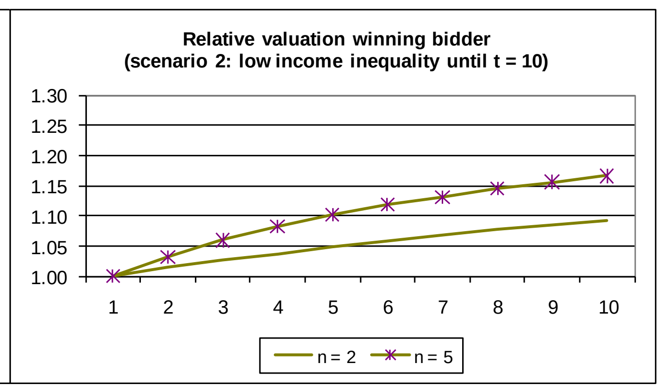
Panel B



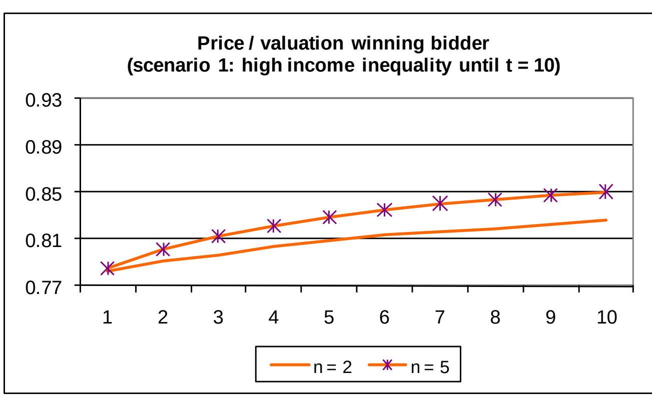
Panel C



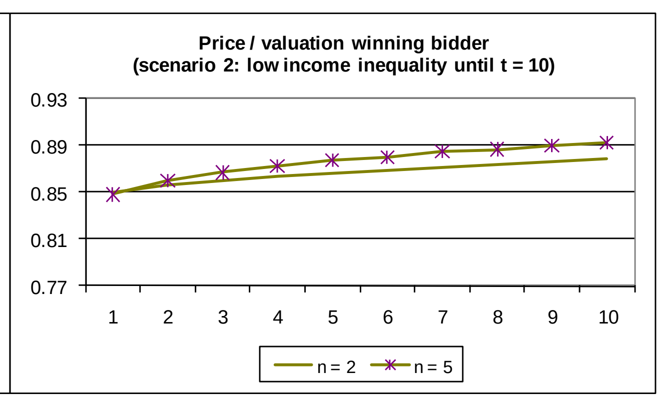
Panel D



Panel E

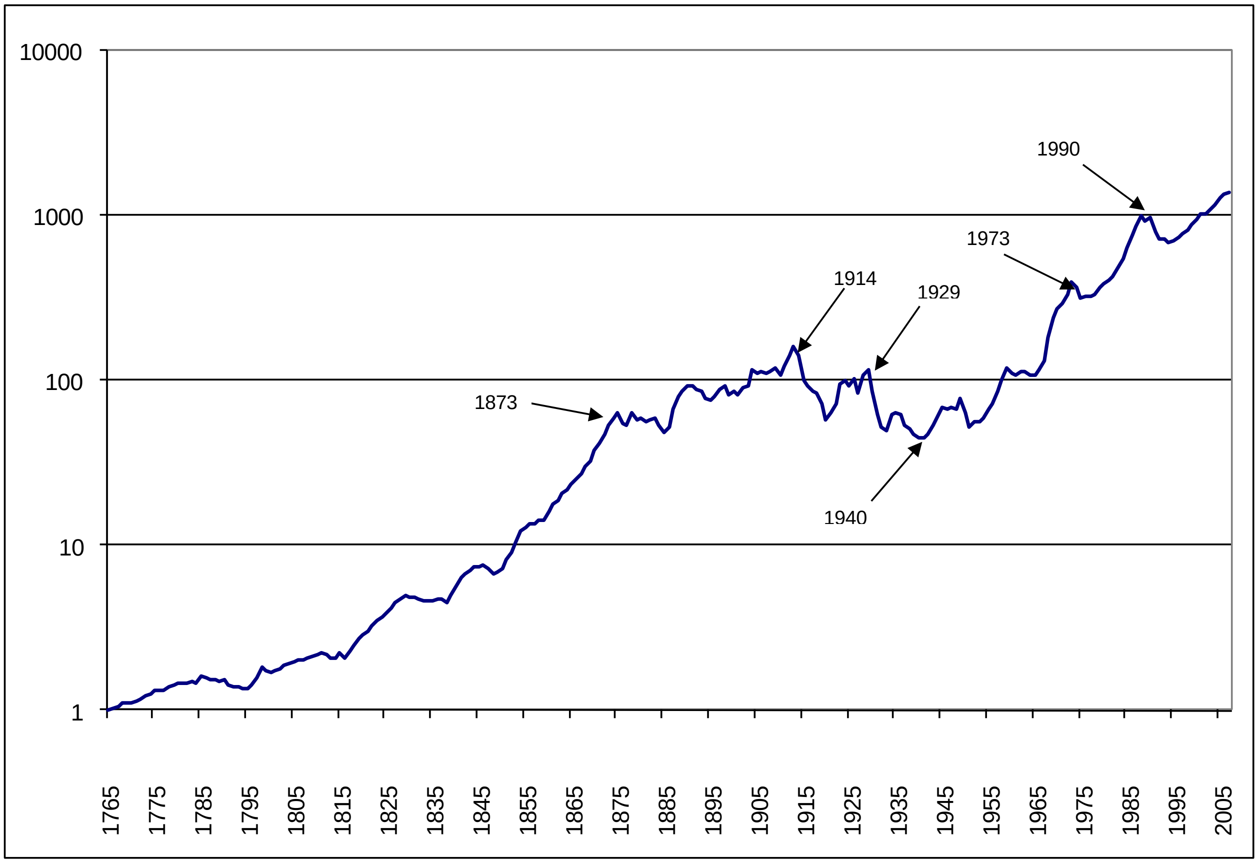


Panel F



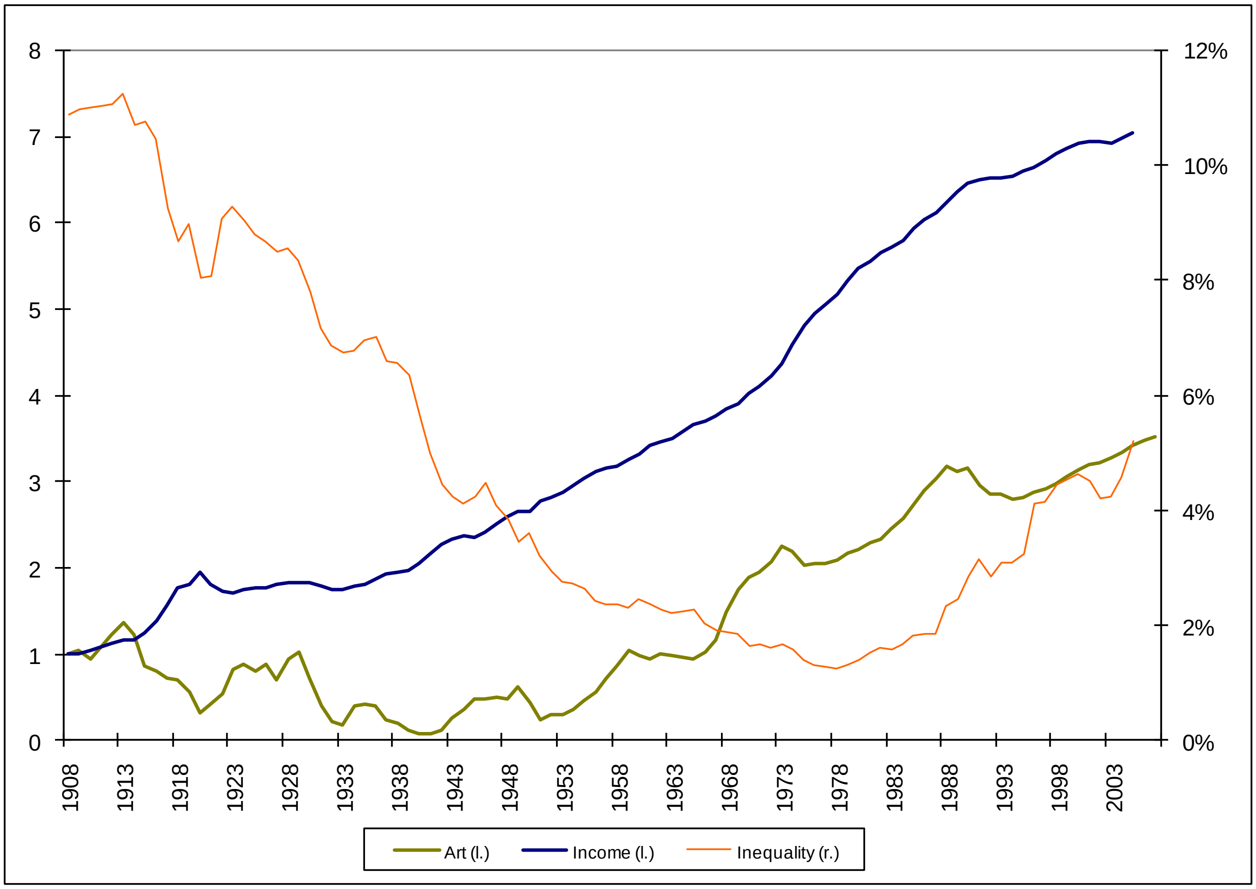
Notes. This figure shows the results of the simulation exercise outlined in Section 3. Scenario 1 (resp. 2) is that of decreasing (resp. increasing) inequality. Panels A and B show the per capita income index and the average art price indices (on a logarithmic scale). Panels C and D show the evolution of the average private valuation, relative to total income, of the winning bidder, with the value in the first period put equal to 1. Panels E and F show the evolution of the average ratio of the price to the winning bidder's private valuation.

Figure 2: Yearly art price index



Notes. This figure shows the constructed annual art price index in real GBP for the period 1765-2007, on a logarithmic scale. The index value in 1765 is put equal to 1. The transaction data come from Reitlinger (1961) and the Art Sales Index. The index is estimated using the Bayes repeated sales methodology outlined in subsection 4.1.

Figure 3: *Art, Income,* and *Inequality*



Notes. This figure shows the evolution of the time series *Art*, *Income*, and *Inequality* since 1908. The variables are defined below Table 1. The values of *Art* and *Income* in 1908 are put equal to 1; these series are plotted against the left-hand side axis. In each year, the value of *Inequality* is equal to the percentage share of the top 0.1% income earners in total income; this series is read against the right-hand side axis.