

Prices and Returns on Paintings: An Exercise on How to Price the Priceless

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Abstract

Art is priceless, but paintings, and other objects, have been sold on markets since the time of the Roman Empire. In this paper, we describe a method for constructing a price index for paintings and compare this index to the indices of various financial markets. In particular, we discuss whether the price of art is related to financial markets, whether the art market is weakly efficient, and whether it is more or less risky than financial markets.

Key words: Economics of the art market, price index, financial markets

1. Introduction

Art is priceless, but paintings, sculpture, and other art objects have been sold on markets since the time of the Roman empire, as has been proved by the ships, loaded with Greek sculpture, discovered over the years close to the Italian coast.

During the seventeenth century in the Low Countries, trade in art was regulated by artists' guilds, and paintings were sold mainly through art dealers (see Montias [1992]), though around that time, auctioneers started to emerge.¹ Sotheby's was founded in 1744, and its rival auction house Christie's in 1762; both were located in London. In Paris, Drouot began in 1854.

The organization of the art market as we know it today is roughly the same as it was during the seventeenth century. In particular, the history of paintings used as collateral for loans is a long one. There is evidence that by the end of the eighteenth century, works of art were widely regarded as a store of value, and markets were very active, especially in England. In 1761, a reader of the *St James Chronicle* complains, "It is a well known melancholy truth that the tribe of auctioneers, connoisseurs, picture dealers have monopolized the trade of pictures, and made it a matter of ridicule to purchase any modern production or encourage an English artist. By this craft the leaders of taste of these kingdoms acquire

fortunes and credit, whilst many of our painters are absolutely starving” (Buck and Dodd [1991, page 57]). Between 1800 and 1805, 25,000 paintings were the objects of transactions in London.

All this is not so different from what happened during the years 1987 to 1989, when prices of paintings were booming, before losing some 50 percent between 1990 and 1992. The headlines of many newspapers were devoted to the art market, from the optimistic “it went crazy, it stays crazy” in 1989 (*Time* [November 27, 1989]), to the pessimistic “debt, death and divorce, the three D’s at the auction business say keep the art market going on” in 1992 (*New York Times* [May 1, 1992]).

But to start with, why buy art? Not for financial reasons, according to Baumol. Indeed, Professor Baumol [1986] from Princeton University notes that art markets are unlikely to “possess anything like long-run equilibrium prices, let alone . . . reliable forces that drive market prices towards them.” He concludes that, as in the case of financial markets, prices movements are unpredictable and that it is impossible to “select with any degree of reliability the combination of purchase dates and art works that will produce a rate of return exceeding the opportunity cost of their investment.” To support this proposition, Baumol computes the annual increases in value (corrected for inflation) of 650 paintings sold at least twice over the period 1650 to 1960 (provided that more than twenty years separate a sale from a resale, to avoid taking into account speculative sales).² Data were extracted from the well-known compilation by Reitlinger [1961, 1971], who collected some 6,000 prices of paintings sold at auctions (mainly in London at Sotheby’s and Christie’s) over that period. Baumol finds that the distribution of returns is normally distributed, with an average of 0.55 percent per year, which is much lower than the 2 percent return a risk-averse investor could have obtained from bonds over the same period. Baumol attributes the difference of 1.5 percent to the utility derived from aesthetic pleasure.³

This is in sharp contrast with what happened on the art market at the end of the 1980s. Van Gogh’s *Irises* was sold for \$53.9 million in 1987, giving to its former owner a real return of some 12.5 percent per year, between 1948 and 1987. It later became obvious that the auction was manipulated,⁴ but Picasso’s *Noces de Piretette* (\$71 million in 1988) or Van Gogh’s *Docteur Gachet* (\$75 million in 1990) did probably produce similar returns.

The fact that in the very long run (Baumol’s 300 years) rates of return are low does not preclude shorter time intervals during which returns are much higher or specific painters or schools that do much better than average. This was pointed out by Buelens and Ginsburgh [1993], who consider the same data set as Baumol⁵ but subdivide the 300 years into five subperiods and consider broad schools (English painters and Others, which includes Italian, Dutch, and Impressionist artists). Their results are reproduced in Table 1, where rates of return for each school appear in the first line, while the number of resales is given between brackets under each rate of return.

The table points out that rates vary greatly by subperiods and school; the lowest rates were earned by English painters (which are probably overrepresented in the

Table 1. Returns per period and schools (all resales).

	1700–1961	1700–1869	1870–1913	1914–1949	1950–1961
All painters	0.65 (1,111)	1.86 (199)	3.57 (219)	–6.00 (79)	20.30 (7)
English painters	–0.26 (554)	4.15 (50)	3.19 (127)	–6.90 (51)	—
Non-English painters, including:	1.55 (557)	1.09 (149)	4.10 (92)	–4.36 (28)	20.30 (7)
Dutch painters	2.59 (149)	1.75 (48)	7.69 (19)	–1.06 (7)	32.68 (2)
Italian painters	1.57 (169)	1.37 (58)	0.94 (26)	–1.10 (2)	—
Impressionists and followers	4.06 (37)	—	11.90 (10)	–19.48 (5)	28.40 (1)

sample, since data concern mainly public auctions held in London) and the years 1914 to 1949. If one excludes this subperiod and English painters, the average rate of return is larger than 3 percent. This should not lead us to believe that there are opportunities to beat the market, since one does not know what to choose.

Table 1 also points to a difficulty in Baumol's approach (and, more generally, in all approaches that use only repeat sales): the number of resales used to compute rates of return may get very small. For example, the rate of 28.4 percent obtained for Impressionists between 1950 and 1960 is based on a single sale! There is therefore a need for other methods if one wants to obtain valid market information over shorter time periods or selected schools or painters.

One could thus think of devising methods that are similar to those used in constructing price indices for bonds or stocks, such as the New York Stock Exchange or the Dow-Jones indices. However, while bonds or stocks are homogeneous goods for which markets open (almost) every day, paintings are heterogeneous, and the transactions for which prices are known are unfrequent. Even if prices were known more frequently, it is difficult to draw inferences on returns from comparing a Velasquez sold in 1870 with a Willem de Kooninck sold in 1985.

2. Art indices for the art market

Paintings are heterogeneous goods, bought and owned for their characteristics (such goods are called "hedonic goods", Lancaster [1966]), rather than for the commodity itself, and measuring price changes must take this into account. Therefore, any statistical method devised to infer price trends must control for the varying nature of the characteristics of the goods sold. The technique used to account for price variations due to changing characteristics is known as hedonic regression; it was introduced by Court [1941], revived by Griliches [1971a, 1971b], and extensively used since for various markets, like cars and housing.

The technique results in estimating some relationship between the price of a commodity (say, a painting) at date t , and objective characteristics that describe the commodity, including some representation of time. The equation reads

$$p_{kt} = f(x_{1,kt}, x_{2,kt}, \dots, x_{m,kt}, t), \quad (1)$$

where p_{kt} is the price of painting k sold at time t , $x_{i,kt}$ (for $i = 1, 2, \dots, m$) are m characteristics describing the painting sold and t is time.

It is not too restrictive to consider that the relationship $f(\cdot)$ is given by a product of three terms: the first measures the idiosyncratic effect of the characteristics on the price, the second is a marketwide effect at date t , the third a random factor, including unobservable or unmeasurable effects of components related to the painting, to time, and to a mixture of both. By taking logarithms for prices, this leads to the following additive representation:

$$\ln p_{kt} = a(x_{1,kt}, \dots, x_{m,kt}) + b(t) + \varepsilon_{kt}, \quad (2)$$

where $a(\cdot)$ is some function (stable over time) of the idiosyncratic characteristics, $b(t)$ is a marketwide price effect, and ε_{kt} is an error term.

For simplicity and estimation purposes, we shall specialize (2) even further to

$$\ln p_{kt} = \sum_{i=1}^m \alpha_i x_{i,kt} + b(t) + \varepsilon_{kt} \quad (3)$$

where different specifications of $b(t)$ can be considered, for instance, a linear growth of (the log of) prices:

$$b(t) = \beta t, \quad (4)$$

or alternatively:

$$b(t) = \sum_{t=\tau_0}^{\tau_1} \beta_t \delta_t, \quad (5)$$

where t indicates the year and δ_t is a dummy variable that takes the value 1 for a sale that occurred in year t , and 0 otherwise, while τ_0 and τ_1 are the first and the last years of the sample for which observations are available. The sequence of β_t 's in (5) will lead to an annual index of (the log of) prices.

Interpretation of this relationship depends crucially on the inclusion of the "correct" set of characteristics and the "correct" functional form. Conditional on that, the relationship can be used to disaggregate the price of a painting into two factors: the part that is attributable to the painting itself, given its characteristics, and the part attributable to time. The regression coefficient α_i can then be inter-

puted as the marginal effect of a change of characteristic i on the log of the price, since

$$\alpha_i = \partial \ln p_{kt} / \partial x_{i,kt}. \quad (6)$$

It is usual to refer to α_i as the “implicit price” of characteristic i . Equations (2) and (3) imply thus that the price of a painting k at time t does not have to be taken as such; it must be related to the implicit evaluation that the market provides for characteristics of the object itself. Note that in (2) and (3), we make the assumption that the implicit prices of characteristics remain constant over time; this is probably not the case in the very long run, since tastes change, and a characteristic that was desirable during the seventeenth century may not be found so in the late 1980s.⁶

The statistical results of the estimation of equations such as (3) can then be used to produce the function $b(t)$, which describes the way prices have adjusted over time. To see this in an intuitive way, observe that the estimation of equation (3) can be thought of as a three-step procedure:

1. One estimates the implicit prices α_i of the characteristics, obtaining some estimate $\hat{\alpha}_i$,
2. One subtracts from the price of a painting k sold in year t , the part of the price which is due to the characteristics of that painting, obtaining an estimated “characteristic-free” price z_{kt} :

$$z_{kt} = \ln p_{kt} - \sum_{i=1}^m \hat{\alpha}_i x_{i,kt}. \quad (7)$$

3. The within-year- t homogeneous z_{kt} 's are averaged, to obtain

$$\hat{\beta}_t = \frac{1}{n_t} \sum_j z_{jt}, \quad (8)$$

where the sum is taken over all paintings sold in year t (the number of which is n_t); $\hat{\beta}_t$ is then an estimate of the price of a standardized painting in year t , if the specification used for $b(t)$ is the one given in equation (5). This averaging procedure eliminates the randomness of the ε_{kt} terms, and $\hat{\beta}_t$ is a measure of a common trend of comparable, standardized paintings.

One can wonder whether one knows the relevant set of characteristics x_i , at least with reasonable certainty. If there is doubt, one can suggest that the characteristics of paintings be standardized with reference only to themselves and limit the analysis to paintings that have been sold more than once. This has the advantage of eliminating the idiosyncratic term $a(.)$ in equation (2) and is known as

repeat sales estimation, which also allows to construct price indices.⁷ The method used by Baumol, which was described earlier in this paper, is just a special case of this technique. We mentioned earlier that these techniques are valuable, as long as the number of repeat sales is large enough. They have been used by Anderson [1974], Frey and Pommerehne [1989], Goetzmann [1990b], and Stein [1977], among others. However, as is shown by Chanel, Gérard-Varet, and Ginsburgh [1992], using all paintings, even if the set of characteristics is not very rich, leads to results that are unbiased and more precise (smaller variance). The reason is that the number of observations is much larger, and one uses all the information, not only the one contained in resales.⁸

3. Prices and returns of paintings, 1957 to 1988

A database containing 24,000 observations was set up, containing all public sales⁹ since 1962 for some eighty well-known artists born after 1830 and who spent at least part of their life in France (see de la Barre, Docclo, and Ginsburgh [1993]). A subsample of thirty-two artists was selected; those thirty-two artists correspond to those who can be found in Reitlinger's selection.¹⁰ The two indices (eighty painters and thirty-two painters) are presented in Figure 1, which shows that the difference between the two indices is negligible, so that the thirty-two painters seem to be representative of the larger sample.

The reason for working with the thirty-two-artist index is to compare the more recent thirty years with what happened between 1850 and 1960. This is the topic of Table 2, which compares real (i.e., after inflation is removed) rates of return in different time periods. The low rate of 6.7 percent over the 1960 to 1988 period may seem surprising; it is due to the fact that between 1974 and 1975, prices for

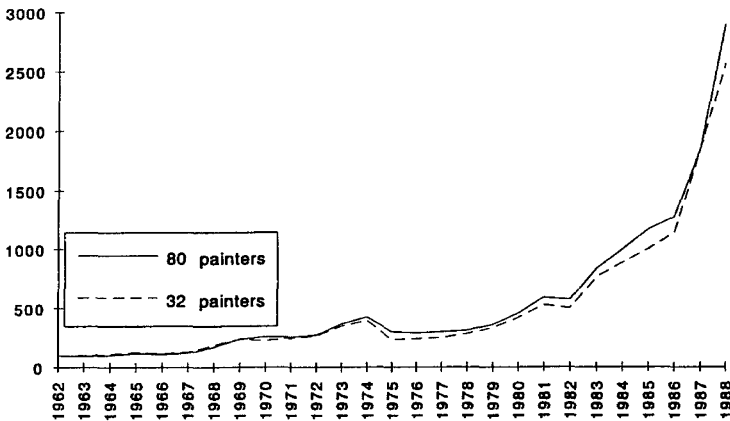


Figure 1. Price indices for eighty and thirty-two painters.

Table 2. Real returns for the thirty-two painter sample

Time period	Growth rate
1855–1914	6.2
1915–1949	–2.0
1950–1960	22.6
1960–1988	6.6
1976–1988	13.3
1960–1988	6.7

Table 3. Price indices for painters and inflation

Year	80 painters (nominal)	32 painters (nominal)	32 painters (real)	Inflation OECD
1962	100	100	100	100
1963	94	101	98	103
1964	101	111	105	108
1965	119	126	115	110
1966	111	116	102	114
1967	121	130	111	117
1968	171	187	153	122
1969	238	238	186	128
1970	231	228	168	136
1971	258	247	172	144
1972	275	266	174	153
1973	370	352	215	164
1974	428	398	217	183
1975	300	233	115	202
1976	291	242	111	218
1977	300	251	107	235
1978	312	284	112	253
1979	361	335	122	274
1980	455	418	139	301
1981	592	530	162	327
1982	576	502	143	351
1983	839	766	208	368
1984	999	889	231	385
1985	1,172	1,001	250	400
1986	1,273	1,137	275	414
1987	1,852	1,852	434	427
1988	2,904	2,574	582	442

some pieces dropped 50 percent. The details can be found in Table 3, where we reproduce the various price indices used in our computations.

The price index is constructed along the lines of equation (3). The list of characteristics contains: (1) the dimensions of the paintings (height, width, and surface), (2) the saleroom, (3) the name of the artist, and (4) variables that capture

the time trend. This is not a very rich description of a painting, though it turns out to explain 74 percent of the variance of prices of some 12,000 paintings sold over more than thirty years.

Beside the price index itself, such an equation also permits to price the thirty-two artists; these prices are obtained from the α_i coefficients corresponding to the names of the artists. They are given in Table 4 and are compared with the 1855 to 1969 prices, obtained in the same way.¹¹ All prices are relative to Renoir, whose price is normalized to 100 in both periods. As can be seen, there are many relative price changes, but only very few are drastic: Derain lost 50 percent, while Chagall, Kandinski, Modigliani, and Seurat tripled, relatively to Renoir. Interestingly enough, even during the first period, Cézanne and Van Gogh were already more expensive than Renoir. This remained so during the last thirty years, but many other painters were added to this group: Gauguin, Manet, Matisse, Modigliani,

Table 4. Relative ranking of the thirty-two painters (Renoir = 100)

Painter	1860-1969	1962-1988
Bonnard	55	66
Braque	64	76
Cézanne	164	184
Chagall	34	93
Degas	94	90
Derain	26	14
De Stael	22	30
Dufy	25	30
Ernst	14	31
Gauguin	72	125
Gris	37	88
Kandinsky	24	80
Klee	31	75
Lautrec	65	72
Léger	21	45
Manet	83	132
Matisse	70	114
Miro	20	43
Modigliani	59	150
Monet	78	133
Picasso	67	90
Redon	24	46
Renoir	100	100
Rouault	38	49
Rousseau	29	66
Seurat	93	388
Soutine	34	47
Utrillo	29	38
Van Dongen	18	30
Van Gogh	117	213
Vlaminck	25	31
Vuillard	35	32

Monet, and Seurat. It is difficult to say whether this is due to a change of tastes or to a shift in relative scarcities of available paintings.

4. Art and financial assets

Let us turn now to the question of paintings as investment and to the art market as a financial institution. Whether the art market, which is international, behaves like a financial market is a matter of empirical observation. Figure 2 compares the price index of the art market with indices of five stock exchanges: the Standard and Poors index for New York, the Nikkei for Japan, the INSEE index of industrial stocks for Paris, the Federal Statistical Institute for Frankfurt, and the F.T. Actuaries for London. All these indices are computed on a four-month basis

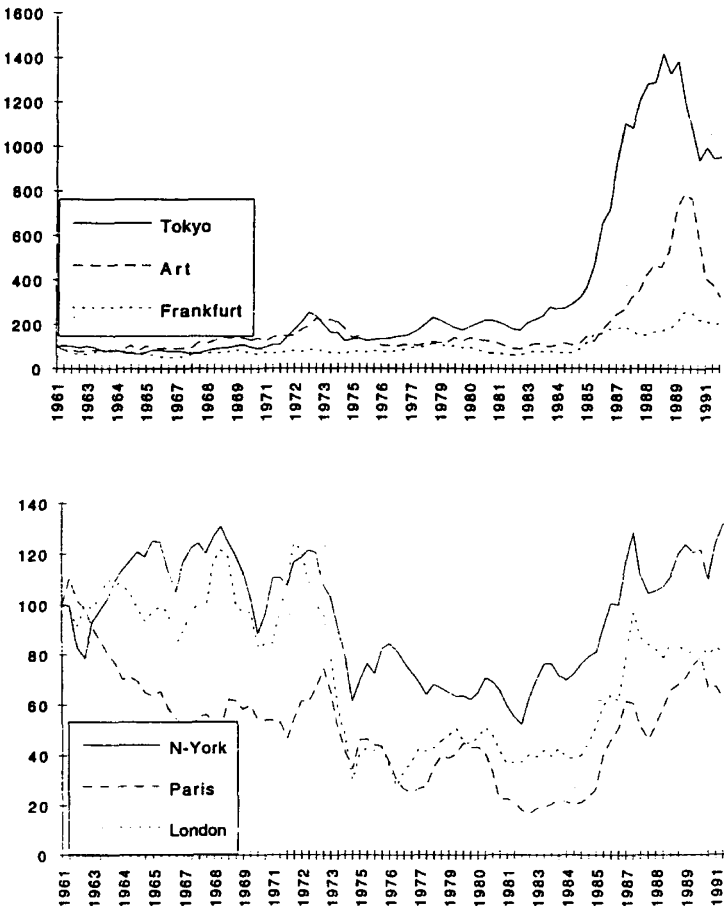


Figure 2. The art market, and stock markets in Japan, Germany, France, Great Britain, and the United States.

b(three periods of four months per year),¹² starting with the last four months of 1961 and ending in 1991; they are all measured in U.S. dollars and deflated by the OECD consumption price index.

From Figure 2, it is apparent that the art market behaves in a way that bears some resemblance to the German and the Japanese stock markets but seems to have little relation to the three other stock markets. Observing common trends among markets does not mean that one explains the others: it may well be a spurious relationship, with all markets reacting to common events. Chanel [1993] was however able to show that, with the exception of the London F.T. index, the other four stock exchanges seem to cause (in the econometric sense) the art market index, while the art market has, as expected, no influence on the stock markets.

A second interesting question is whether art markets are efficient. It is often argued that they are not, and there are indeed many reasons for this. Informational asymmetries between sellers and buyers are essential features of the art market, and dealers or market makers can be thought of making high profits since they have information about the willingness to pay of collectors interested by a specific painting.¹³ Another possible explanation is based on the valuation mechanism itself: the value of art is primarily driven by changing tastes, and some of these changes are shocks resulting in swings in relative prices. Dealers may then be seen as aesthetic risk arbitragists.

These phenomena are often taken as signs of the informational inefficiencies of the art market. Actually, market efficiency—the notion that prices provide all relevant information about the quality and availability of the assets traded—is not a testable concept except under some specific assumptions about the underlying equilibrium model. To check for weak efficiency (does the price in period t reflect all the past information?), we perform a random walk test by running a regression of the form

$$p_t = \alpha + \gamma p_{t-1} + \varepsilon_t, \quad (9)$$

where p_t is (the logarithm of) the price index in t , α and γ are parameters to be estimated, and ε_t is a random error. The hypothesis we want to test is $H_0: [\alpha, \gamma] = [0, 1]$; if H_0 is accepted, (9) is a random walk, and the market is said to be weakly efficient (Shiller [1990]).¹⁴ The resulting regression is

$$p_t = 0.113 + 0.980p_{t-1} \quad R^2 = 0.944 \\ (0.127) \quad (0.025)$$

The likelihood ratio test is computed as (see Dickey and Fuller [1981])

$$\phi = \frac{(RSSc - RSSnc)(T - 2)}{(2RSSnc)},$$

where RSS_c and RSS_{nc} are the residual sum of squares of the constrained (the model where one imposes $\alpha = 0$ and $\gamma = 1$) and the unconstrained model (in which α and γ are left free), respectively, and T is the number of observations (ninety in our case). If the calculated ϕ is smaller than the tabulated one, one accepts H_0 . Here, $\phi = 0.394$, while the tabulated ϕ is equal to 4.71 at the 5 percent probability level. Thus, the assumption that art prices behave like a random walk cannot be rejected. This is, however, not the last word on returns predictability for the art market. There are many open questions. Paintings are in competition with other assets (though, in many cases, they are also valued for themselves), and more work is needed (some of it is under way) to test for the semistrong efficiency hypothesis that agents are unable to use public information to hedge and make profits on the art market.

Our third point is concerned with risk considerations: is the systematic risk of the art market smaller or larger than that of financial assets? The traditional tool for measuring this systematic risk is the capital asset pricing model:

$$R_{jt} - R_{ft} = \alpha_j + \beta_j(R_{mt} - R_{ft}) + \varepsilon_{jt}. \quad (10)$$

In (10), R_{jt} , R_{mt} , and R_{ft} , respectively, represent the return of asset j , the market return and the return on the riskless asset at time t ; ε_{jt} is a random error, while α_j and β_j are coefficients to be estimated. The coefficient β_j can be interpreted as the systematic risk associated to asset j ; if $\beta_j > 1$ (resp. < 1), asset j is more (resp. less) risky than the market portfolio. In the traditional asset pricing model, $\alpha = 0$; when the asset is art, α can be interpreted as the nonfinancial return—here, the aesthetic return¹⁵—and may thus turn out to be different from zero.

In our case, R_{jt} is the return of art, R_{mt} is a specific stock market, and R_{ft} is represented by the rate of long-term U.S. government bonds. The results of our regressions are reproduced in Table 5 (see also Chanel [1993]). Though as is often the case, the adjustments are rather poor (see the values of the R^2), the results

Table 5. Results of the CAPM for art

	α	β	R^2
New York	0.0091 (0.0146)	0.2015 (0.1832)	0.0135
Tokyo	0.0014 (0.0013)	0.3689 (0.1604)	0.0569
Paris	0.0098 (0.1400)	0.1747 (0.1409)	0.0271
London	0.0122 (0.0149)	0.0288 (0.1309)	0.0005
Frankfurt	0.0111 (0.0139)	0.1647 (0.1646)	0.0211

Note: Standard deviations appear between parentheses under the coefficients.

show that, whatever the stock market considered, the risk on art (the β coefficient) is systematically and very significantly lower than 1, which implies that an art portfolio (made up of the thirty-two painters mentioned above) is much less risky than any portfolio of national stocks. The coefficient α , which measures the return from aesthetic pleasure, is positive in all cases, though not significantly different from zero. Note that with the exception of Japan, α is close to 1 percent in all cases.

5. Conclusions

In this paper, we have tried to give an overview of current research aiming at (1) constructing price indices and returns for the most active segment of the art market, paintings,¹⁶ and (2) trying to relate art markets to the financial markets with which they may compete, though the former are much smaller than the latter.

We suggest that returns can be computed using all sales and not resales only, as was done until now by most of those who have written on the economics of the art market. These are gross returns, which take into account neither transaction costs incurred at the moment of the sale¹⁷ nor insurance and other costs incurred to restore and preserve (insurance, storage, and so on) art works. These are indeed difficult to deal with, since the annual rate depends on how long the work is held by the same owner.

The returns we compute are, for the group of painters under consideration, of the same order of magnitude if not higher than those obtained by stocks; their risk seems to be lower, as shown by the β coefficients of the CAPM model; and they have, at least in the eye of those who collect paintings, an aesthetic return.

Much more work is needed to gain a deeper understanding of the art market. First, the artists on which our index is based may not represent the market for paintings as a whole: private transactions are ignored (because they cannot be observed), and the sample of painters is very specific and needs to be extended (see, however, de la Barre, Docclo, and Ginsburgh [1993]). Second, the links between financial markets and the art market should be analyzed in much more depth; in particular, we have some indications that the art market is "caused" by financial markets and that it may be possible to predict short run variations of art prices. According to Montias [1982] or Grampp [1989], art is a complementary good whose value is enhanced by the owner's other possessions. If the demand for the art of an agent depends on his wealth, one can expect aggregate demand to increase with aggregate wealth. Since the supply of paintings (especially for deceased artists) is (relatively) fixed, the price appreciation of paintings has to be explained by that of other risky assets such as stocks.

There is another possible explanation: common variation in expected returns result from irrational bubbles correlated across assets and (domestic and international) markets. In that case, one would have to make the following observa-

tion. Recent work on financial markets suggest that the predictability of returns of bonds and stocks represents a part of the variance of the returns that is increasing with the length of the horizon. Risks on stocks are about fundamentals, and the longer the horizon, the better the prediction. For the art market things go the other way round: in the case of paintings, uncertainty is concerned with the tastes of future generations. In the long run the art market is hardly predictable but may well be predictable in the short run.

Acknowledgment

Olivier Chanel and Victor Ginsburgh acknowledge financial support from project PAT n° 26 from the Belgian government.

Notes

1. The first known public auction of art was organized in Venice in 1506. See Pomian [1992, page 19].
2. As shown in Buelens and Ginsburgh [1993], the conclusion is unchanged if all resales are taken into consideration.
3. Note that this figure is consistent with the 1.6 percent estimated by Stein [1977].
4. The auction house had lent half of the \$53.9 million to the buyer, who was eventually not able to reimburse.
5. They discard data from before 1700, since there were very few resales, and take into account all resales, even if the painting was hold during less than twenty years. The average return they obtain (0.65 percent per year) is very close to the result obtained by Baumol (0.55 percent per year).
6. Note that, if the data set is sufficiently large, nothing prevents from estimating time-dependent implicit prices. Equation (3) would then be written $\ln p_{kt} = \sum_{i=1}^m \alpha_i(t)x_{i,kt} + b(t) + \gamma_{kt}$, where functional forms would have to be specified for the $\alpha_i(t)$'s. This is done in the study by Buelens and Ginsburgh [1993], who find large swings in prices for characteristics, which they interpret as changes in tastes. For example, during the eighteenth century, a painting by Rembrandt was cheaper than a "17th century landscape"; his works are six times more expensive than such paintings in the twentieth century. Such changes are of course much smaller for shorter time periods. See de la Barre, Docclo, and Ginsburgh [1993].
7. See, e.g., Goetzmann [1990a] or Shiller [1990] for the techniques and for references.
8. Note that moreover, using resales only may lead to a bias if resold paintings are different from those which are not resold.
9. At least those that are recorded by Mayer's, *Annuaire International des Ventes* (Paris and Zurich: Editions Mayer).
10. The thirty-two painters are Bonnard, Braque, Cézanne, Chagall, Degas, Derain, De Stael, Dufy, Ernst, Gauguin, Gris, Kandinski, Klee, Lautrec, Léger, Matisse, Miro, Manet, Modigliani, Monet, Picasso, Redon, Renoir, Rouault, Rousseau, Seurat, Soutine, Utrillo, Van Dongen, Van Gogh, Vlaminck, Vuillard.
11. For the 1855 to 1969 period, see Chanel, Gérard-Varet, and Ginsburgh [1992].
12. The reason for this unusual time periods is due to the fact that during the third quarter (July,

August, and September), there are almost no public art sales and that it makes little sense to compute quarterly indices for the art market. The three four-months period are thus January to April, May to August, and September to December.

13. This is due to the fact that, in contrast to stocks of some company, which are perfectly homogeneous, paintings by, say, Picasso are far from being so.
14. Before running this test, we have to make sure that there is no seasonal pattern present in the data, otherwise this pattern could be used to hedge. The absence of seasonality was tested by running a regression of the (log) of the prices on three (the three four-month periods) seasonal dummies η_t . The result is

$$p_t = \underset{(0.024)}{-0.022}\eta_{1t} + \underset{(0.024)}{0.027}\eta_{2t} + \underset{(0.024)}{0.034}\eta_{3t}.$$

The standard deviations that appear between brackets under each coefficient show that none of these is significantly different from zero at the 1 percent probability level. From this, we may conclude that prices do not vary in some systematic way over the year.

15. This can be shown more formally and is the topic of a forthcoming paper. Note that this coefficient need not (and in general will not) be constant.
16. The same approach has been applied to many other segments (coins, silver, Old Masters' drawings, violins, lithos, Japanese netsuke, antique books) with good results.
17. At least for sales at auctions on which all our work is based; these costs are much larger than those that concern financial transactions.

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