# Art as an investment: short and long-term comovements in major painting markets

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**Abstract.** This paper examines the short and long-term price linkages among major art and equity markets over the period 1976-2001. The art markets examined are Contemporary Masters, French Impressionists, Modern European, 19th Century European, Old Masters, Surrealists, 20th Century English and Modern US paintings. A global equity index (with dividends and capitalisation changes) is also included. Multivariate cointegration procedures, Granger non-causality tests, level VAR and generalised variance decomposition analyses based on error-correction and vector autoregressive models are conducted to analyse short and long-run relationships among these markets. The results indicate that there is a stationary long-run relationship and significant short and long run causal linkages between the various painting markets and between the equity market and painting markets. However, in terms of the percentage of variance explained most painting markets are relatively isolated, and other painting markets are generally more important than the equity market in explaining the variance that is not caused by innovations in the market itself. This suggests that opportunities for portfolio diversification in art works alone and in conjunction with equity markets exist, though in common with the literature in this area the study finds that the returns on paintings are much lower and the risks much higher than in conventional financial markets.

**Key words:** Art and collectibles, portfolio diversification, market efficiency, risk and return. **JEL :** C32, D12, G11

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## 1. Introduction

In March 1987 Vincent Van Gogh's *Sunflowers* sold at auction for $39.9 million (all dollar figures in USD), followed in November by the sale of *Irises* for $53.9 million. Other record-breaking sales in art markets closely followed. In May 1989, Pablo Picasso's *Yo Picasso* sold for $47.8 million, far exceeding the $5.8 million that it last commanded in May 1981: his *Noces de Pierette* later sold for $60.0 million. In May 1990, Van Gogh's *Portrait of Docteur Gachet* sold for $82.5 million and Pierre-Auguste Renoir's *At the Moulin de la Galette* for $78.1 million, becoming the two most expensive pictures ever sold at auction (Pesando and Shum, 1999). Indeed, even demand for Modern and contemporary paintings in the 1980s was

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so strong that works by (often still-living) artists such as Roy Lichtenstein, Jackson Pollock, Jasper Johns, Robert Rauschenberg, Willem de Kooning and Andy Warhol were frequently attracting prices in excess of $10 million (Anonymous, 2000).

In response to the commonly held belief that the art market yields huge profits in comparison to other more prosaic investment markets, a small but growing literature has examined the financial characteristics of the market in paintings, and art markets in general (paintings, sculpture, ceramics and prints, along with collectibles such as coins, stamps, antiques and furniture). This invariably accompanies a revival of interest in art investment by the business world [see, for example, Oleck and Dunkin (1999) and Peers and Jeffrey (1999)] Starting with the seminal work of Baumol (1986) much of this has been concerned with measuring the rate of return of paintings, however in recent years there has been an emerging emphasis on other analytical dimensions of art investment (Felton, 1998). In particular, the growing evidence of return predictability and cointegration in equity and bond markets has focused attention on the ability of auction series to provide meaningful forecasts of prices in art markets. This is especially important if the prices of art works can be taken as synthesising the effects of the artist, specificities of different media, reactions of art galleries, critics, museum directors, collectors and investors, etc.

Similarly, there is the suggestion that the returns on works of individual artists and schools may owe much to their interrelationships with other artists within their school and indeed other schools via a certain degree of substitutability. For example, for much of the last thirty years Impressionist, Modern and contemporary paintings have dominated international art markets. However, current trends indicate that Old Masters and Modern pictures are now returning to a longer-term equilibrium (Anonymous, 2000). This highlights additional prospects for price forecasting in these markets. Finally, if art is to be regarded as a valid (albeit imperfect) addition to traditional investments in stocks, bonds and real estate amongst others, there is the added requirement of examining the prospects for diversification in such portfolios (Flores et al., 1998). It is also desirous to examine the prospects for diversification in portfolios composed primarily of art held by investors, collectors, dealers and museums, amongst others. If low correlations of returns exist between both individual artists and schools of art, diversifying across various categories of art and artists may allow investors to reduce portfolio risk while holding expected return constant.

Unfortunately, little empirical evidence exists concerning short and long-term price linkages among differing art and financial markets and the concomitant prospects for portfolio diversification. The evidence that does exist is generally mixed. Ginsburgh and Jeanfils

(1995) used vector autoregressive models to examine the pricing relationships between three schools of painters [Impressionist, Modern and Contemporary European Masters, Minor European Painters and Contemporary US Painters] in three different auction markets [New York, London and Paris/Versailles]. They found that while the various art markets move together, and in the short-run financial markets do influence the price of collectibles; there was no long-run relationship between these markets. Chanel (1995) used similar techniques and a sample of eighty-two well-known artists to establish the relationships between art markets and equity markets in New York, London, Paris and Tokyo. Chanel (1995) concluded that financial markets influence the art market, though with a lag of about one year. Czujack et al. (1996) also employed cointegration techniques, though with the prints of five individual artists and a global print index. The purpose of the present paper is to add evidence to this nascent debate on comovements among art markets and between art and financial markets.

The remainder of the paper is organised as follows. Section 2 briefly surveys the literature concerning art as an investment. Section 3 explains the data and empirical methodology employed. The results are dealt with in Section 4. The paper ends with some brief concluding remarks.

## 2. Art as an investment

It goes without saying that art markets differ substantially from financial markets. Art works are not very liquid assets, almost never divisible, transaction costs are high, and there are lengthy delays between the decision to sell and actual sale. Investing in art typically requires substantial knowledge of art and the art world, and a large amount of capital to acquire the work of well-known artists. The market is also highly segmented and dominated by a few large auction houses, and risk is pervasive, deriving from both the physical risks of fire and theft and the possibility of reattribution to a different artist. And while auction prices represent, in part, a consensus opinion on the value of art works, values in turn are determined by a complex and subjective set of beliefs based on past, present and future prices, individual tastes and changing fashion.

In sharp contrast, most financial assets are almost always liquid, readily diversifiable and can be selected on the basis of a relatively small set of objective criteria. Such markets are characterised by a large number of buyers and sellers, transaction costs are low, and trades in perfectly or near identical assets are repeated millions of times daily in hundreds of competing markets and exchanges. Nevertheless, art has been traded on organised markets for some time, with the organisation of the global art market much the same as it was in the 17th Century, and the place attributed to an artist by aesthetic judgement depends more or less upon the prices set in these markets (Gérard-Varet, 1995). While this implies that at least some tools of orthodox financial analysis can, and frequently have, been applied to art markets, there is also the necessity to clearly identify the distinguishing characteristics of these markets so that their findings can be examined in an appropriate context. Likewise, there is also the general critique by Felton (1998: 286) and others, that many papers concerned with economics of the arts "demonstrate meticulous care with large and fragile data sets".

One major distinguishing feature of art markets is that the art objects themselves are created by individuals, and are for the most part produced as differentiated objects. Accordingly, and in principle, there is only one unique piece of original work: an extreme case of a heterogeneous commodity. However, heterogeneity does not mean singularity (Gerad-Varet, 1995). Some substitutability remains among the work of a single artist, or among the works of artists categorised within the same school. Nonetheless, as the creative outpouring of a single artist, or group of artists, their aggregate supply is nonaugmentable, comprised as it is of the works of deceased artists or outmoded or outdated schools.

These particular characteristics manifest themselves most abundantly in the risks associated with art investment. Attribution remains a perennial challenge, as does the problem with fakes and forgeries. Unfortunately, though the technical means of detecting fakes and forgeries has improved in recent years, transactions involving these works remain in the auction samples most often used to calculate the risk and return of art investment. Moreover, in addition to these financial risks arising from price uncertainty, there are purely material risks associated with the unique physical nature of art works. Paintings may be destroyed by fire, damaged during war, or stolen. Of course, while many material risks can be insured against, insurance costs as a percentage of appraised value are relatively high (up to one percent per annum), and for the most part unknown.

Similarly, substantial costs arise over time with maintenance and the restoration of art works, and these are seldom recognised in return calculations. It is also difficult to take into account the taxes due when transacting and holding an art object, though it is widely accepted that in many countries investment in art is a means of escaping or lowering the tax burden (Frey and Eichenberger, 1995a; 1995b). Regardless, a voluminous literature has arisen on calculating the returns on art investment. Starting with Baumol (1986), these include studies by Frey and Pommerehne (1989), Goetzmann (1993), Chanel et al. (1994), Candela and

Scorcu (1997) and Pesando and Shum (1999). And for the most part "his [Baumol's] results are here to stay: the (financial) rate of return on paintings is lower than for investment in financial assets (given higher risks in the former market) because paintings also yield a psychic return from owning and viewing the paintings" (Frey and Eichenberger, 1995b: 529).

Perhaps the main distinguishing feature between art markets and pure financial markets is that the expected return from art investment consists not only of price rises but also the aforementioned psychic return of art works: through their aesthetic qualities, possibly through their social characteristics, and in the case of pieces acquired by museums for their cultural significance, even public-good attributes. And almost without exception, most studies of art investment have been unable to quantify these psychic returns associated with art as a consumption good and add them to the understated financial returns from art as an investment good. Recognising art as a consumption good goes far in explaining the segmentation that characterises most art markets, and in part accounts for the presence of behavioural anomalies less well-known in modern financial markets.

For instance, market segmentation, and the concomitant propensity for anomalies, is likely to occur among art investors. Many private collectors are not profit orientated and are particularly prone to the anomalies that arise from 'endowment effects' (an art object is evaluated higher than one not owned), 'opportunity cost effects' (many collectors isolate themselves from considering the returns of alternative uses of funds) and a 'sunk cost effect' (past efforts to build a particular genre or school of art are important) (Frey and Eichenberger, 1995a; 1995b). Private collectors may also be subject to a 'bequest effect' whereby art objects given to their beneficiaries carry a psychic return over and above their notional value. Similarly, Felton (1998: 286) observes that the analysis of auction data is "…complicated by the fact that both professional and amateur bidders, who may have different risk aversions, [are] involved in the bidding [and] the amount of risk aversion seem[s] to depend on the unit sold and the existence of a penalty, not on the attribute of the subject". These conditions are rarely found in modern financial markets.

At the least, it could be expected that corporate collectors undertake their investments concerned largely with financial returns. Rarely, however, is the means of collection open to more than a small number of personalities within a firm and even then is primarily used for consumption purposes. Lastly, public museums are important buyers of art. Once art works are acquired it is rare for these organisations to either be willing or able to dispose of works in the market, nor to change the speciality of their collection. Many specific art works are also obtained with hypothecated grants from governments or fundraising activities and these cannot usually be used for other purposes. For these reasons it is argued that sellers to museums enjoy systematically higher rates of return. Frey and Eichenberger (1995a: 215) suggest *inter alia* that museums are also likely to be active in particular genres of art that do not attract individual or corporate collectors.

Frey and Eichenberger (1995a; 1995b) also used this evidence to argue that the behavioural characteristics of art market participants vary dramatically between 'pure speculators', whose activity in art investment markets in largely associated with changes in financial risk, and 'pure collectors' who are more attune to the psychic returns of art and less-sensitive to notions of financial risk. In the extreme, the more 'pure collectors' there are in a market, the lower is the financial return in equilibrium; the major part of investment return is made up of psychic benefits. An emerging literature has examined these efficiency aspects of art markets, including studies by Coffman (1991), Louargand and McDaniel (1991), Pesando (1993) and Goetzmann (1993).

At first impression, art markets would appear to have little in common with pure financial markets. Most art markets would appear to be characterised by product heterogeneity illiquidity, market segmentation, information asymmetries, behavioural abnormalities, and almost monopolistic price setting. And there is no doubting the fact that a substantial component of the return from art investment is derived not from financial returns rather its intrinsic aesthetic qualities. However, in recent years it has been widely accepted that most art markets have moved closer to the ideals set by financial markets. Turnover, for example, has increased dramatically among auction houses and the larger proportion of transactions are pursued in these as against traditional dealers. Information on alternative art investments is now more accessible through the attention of the media, and the publishing and dissemination of catalogues and price index series has increased the amount of information available to both buyers and sellers. Likewise, art markets are increasingly globalised and the widening of the asset pool to include collectibles, furniture, jewellery and wine, amongst others, has seen substantially greater participation in most art markets.

## 3. Empirical methodology

The data employed in the study is composed of indices for eight major categories of paintings and one equity market index. All art index data is obtained from UK-based Art Market Research (AMR) and encompasses the period January 1976 to February 2001. AMR art indexes are used widely by a variety of leading institutions concerned with price movements in the arts, including Christie's, Sotheby's, the British Inland Revenue Service and the New York Federal Reserve, along with the *Financial Times*, *Wall Street Journal*, *The Economist*, *Business Week*, *The Art Newspaper* and *Handelsblatt* (AMR, 2002) All monthly index data is specified in US dollars. Selected descriptive statistics of the annualised returns for these eight art indexes and the equity index are presented in Table 1.

<TABLE 1 HERE>

The eight major art indexes are specified as follows: (i) Contemporary Masters (CM), covering 5,106 sales of current masters including Basquiat, Clemente and Polke; (ii) 20th Century English (TE) encompassing 10,603 sales by artists such as Dawson, Flint, Moore and Munnings; (iii) 19th Century European (NE) with 50,510 sales by artists including Maris, Troyon, Constable and Corot; (iv) French Impressionist (FI) with sales of 6,242 works by painters including Degas, Monet and Renoir; (v) Modern European (ME) with 17,538 sales by artists like Bonnard, Picasso and Utrillo; (vi) Modern US Paintings (US) with 10,607 sales of works by painters such as Kooning, Rivers and Warhol; (vii) Old Masters (OM) with 6,412 sales by artists including Gainsborough, Reynolds and Storck; and (viii) Surrealists (SR) with 10,395 sales by artists including Dali, Magritte and Picabia. The indexes selected are consistent with studies in the area of art investment returns and risk and represent some of the most closely followed painting sub-sectors. The global equity index (EI) used in the study is the Morgan Stanley Capital International (MSCI) World Equity Index (including dividend reinvestment and capitalisation changes). This index is calculated using a sample of 1600 companies listed on stock exchanges in the 22 developed markets that make up the MSCI National Indices (excluding Luxembourg).

In common with most work in this area, the figures in Table 1 show that the mean annual returns on the various painting markets are lower than those obtained in global equity markets, irrespective of risk. Over the period 1976 to 2001 annual returns on the global equity market (EI) averaged 5.18 percent, while the largest art returns were 4.21 percent for Contemporary Masters (CM), 3.70 percent for French Impressionists (FI) and 3.32 percent for Modern US (US) paintings. And contrary to theoretical expectations, the risk (as measured by standard deviation) is much higher for art than equity markets. For example, the standard deviation of annual returns for the global equity index was only 5.84 percent, while the least risky art market (19th Century European) had a standard deviation of 7.14 percent and the most risky (French Impressionists) a standard deviation of 13.66 percent.

These suggestions are further reinforced by the coefficients of variation (standard deviation divided by mean return) in Table 1. The global equity market has the lowest coefficient of variation of 1.13. Among the art markets themselves, three sub-groups are noticeable. Markets with a relatively high coefficient of variation (more risk per unit of return) include Modern European (ME) and the Surrealists (SR). French Impressionists (FI) and Modern US (US) have coefficients of variation of 3.68 and 3.84 respectively. Art markets with low coefficients of variation include Contemporary Masters (CM), 19th Century European (NE), Old Masters (OM) and 20th Century English (TE). The coefficients of variation for this last group of art markets range between 2.49 and 2.99. Some indication of the popularly acclaimed appeal of art markets as an investment vehicle can be gained from the maximum returns in Table 1 with annual returns ranging as high as 34.20 percent (French Impressionists) as compared to a maximum global equity return over the period of 15.48 percent.

The paper investigates the comovements among art and equity markets as follows. To start with, since the variance of a nonstationary series is not constant over time, conventional asymptotic theory cannot be applied for those series. Unit root tests of the null hypothesis of nonstationarity are conducted in the form of an Augmented Dickey-Fuller (ADF) regression equation. Following Engle and Granger (1987) suppose we have a set of $m$ indices $y_t = [Y_{1t,} Y_{2t}, \cdots, Y_{mt}]'$ such that all are I(1) and $\beta' y_t = u_t$ is I(0), then $\beta$ is said to be a cointegrated vector and $\beta' y_t = u_t$ is called the cointegrating regression. The components of $y_t$ are said to be cointegrated of order ($d$, $b$) and is denoted by $y_t \sim$ CI($d$, $b$) where $d > b > 0$, if (i) each component of $y_t$ is integrated of order ($d$, $b$) and (ii) there exists at least one vector $\beta = (\beta_1, \beta_2, \ldots, \beta_m)$, such that the linear combination is integrated of order ($d$ - $b$). By Granger's theorem, if the indices are cointegrated, they can be expressed in an Error Correction Model (ECM) encompassing the notion of a long-run equilibrium relationship and the introduction of past disequilibrium as explanatory variables in the dynamic behaviour of current variables. This model thus allows a test for both short-term and long-term relationships between the indices. The ECM is specified as follows:

$$\Delta y_t = a_0 + \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta y_{t-i} + \varepsilon_t \tag{1}$$

where , $\Pi = \alpha\beta'$, $\alpha$ and $\beta$ are $m \times r$ matrices, $r$ is the cointegrating rank, $\Gamma_i$ is the matrix of coefficients of the lagged difference terms, and all other variables are as previously defined.

In (1) the long-run relationship is captured by $\beta' y_t$, and the differenced terms and the terms that are adjusted by the long-run relationship (the summation term on the right-hand side) capture the short-run relationship.

In order to implement the ECM, the order of cointegration must be known. A useful statistical test for determining the cointegrating rank *r* is proposed by Johansen (1991) and Johansen and Juselius (1990). The test is based on the MLE and the rank of $\Pi$ (denoted by *r*) is tested based on its eigenvalues. The trace test is proposed. The trace statistic tests the null hypothesis of the number of distinct cointegrating vectors as $r = 0$ versus $r > 0$, $r \leq 1$ versus $r > 1$, and so on. For example, to test for no cointegrating relationship, *r* is set to zero and the null hypothesis is $H_0 : r = 0$ and the alternative is $H_1 : r > 0$.

One potential problem is that the Johansen (1991) test can be affected by the lag order in (1). The lag order is determined by using the likelihood ratio test. The likelihood ratio (LR) test statistic is assumed to be asymptotically distributed $\chi^2$ with degrees of freedom equal to the number of restrictions. The test statistic is used to test the null hypothesis of the number of lags being equal to $k - 1$ against the alternative hypotheses that $k = 2, 3, \ldots$ and so on. The test procedure continues until the null hypothesis fails to be rejected, thereby indicating the optimal lag corresponds to the lag of the null hypothesis.

These cointegration tests examine long-term causality among the eight art markets and the global equity market. In order to examine the short-run relationships, Granger (1969) non-causality tests are specified. Essentially tests of the prediction ability of time series models, an index causes another index in the Granger sense if past values of the first index explain the second, but past values of the second index do not explain the first. If the indices in question are cointegrated, Granger non-causality is tested using the ECM:

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{r} \psi_i \Theta_{t-1} + \sum_{i=1}^{m} \gamma_i \Delta y_{t-i} + \varepsilon_t \tag{2}$$

where $\Theta$ contains *r* individual error-correction terms, *r* is the number of long-term cointegrating vectors via the Johansen procedure, $\psi$ and $\gamma$ are parameters to be estimated, and all other variables are as previously defined. If there is no cointegrated relationship, the causality tests are conducted using the following VAR model:

$$\Delta y_t = \gamma_0 + \sum_{i=1}^{m} \gamma_i \Delta y_{t-i} + \varepsilon_t \; . \tag{3}$$

In both cases, the causality test is based on an $F$-statistic that is calculated using the constrained and unconstrained form of each equation. If the hypothesis $\gamma_{ijl} = 0 \, (i = 1,2,\cdots,m)$ fails to be rejected the $j$-th index does not Granger cause the $l$-th index, and current changes in $l$-th index cannot be explained by changes in the $j$-th index. If the hypothesis is rejected, the $j$-th index Granger-causes the $l$-th index and current changes in the $l$-th index can be explained by past changes in the $j$-th index, thereby indicating a causal relationship.

One problem with a Granger non-causality test based on (2) is that it is affected by the specification of the model. ECM is estimated under the assumption of a certain number of lags and cointegrating equations, which means that the actual specification thereby depends on the pre-test unit root (ADF) and cointegration (Johansen) tests. To avoid possible pre-test bias, Toda and Yamamoto (1995) propose the level VAR procedure. Essentially, the level VAR procedure is based on VAR for the level of variables with the lag order $p$ in the VAR equations given by $p=k+d_{max}$, where $k$ is the true lag length and $d_{max}$ is the possible maximum integration order of variables. Therefore, the estimated VAR is expressed as:

$$y_t = \hat{\gamma}_0 + \hat{\gamma}_1 t + \cdots + \hat{\gamma}_q t^q + \hat{J}_1 y_{t-1} + \cdots + \hat{J}_k y_{t-k} + \cdots + \hat{J}_p y_{t-p} + \hat{\varepsilon}_t, \tag{4}$$

where $t = 1, \ldots, T$ is the trend term and $\hat{\gamma}_i, \hat{J}_j$ are parameters estimated by OLS. Note that $d_{max}$ does not exceed the true lag length $k$. Equation (4) can be written as:

$$Y' = \hat{\Gamma}\Lambda + \hat{\Phi}X + \hat{\Psi}Z' + \hat{\mathrm{E}}' \tag{5}$$

where $\hat{\Gamma} = (\hat{\gamma}_0, \ldots, \hat{\gamma}_q)$, $\Lambda = (\tau_1, \ldots, \tau_q)$ with $\tau_t = (1, t, \ldots, t^q)'$, $\hat{\Phi} = (\hat{J}_1, \ldots, \hat{J}_k)$, $\hat{\Psi} = (\hat{J}_{k+1}, \ldots, \hat{J}_p)$, $X = (x_1, \cdots, x_T)$ with $x_t = (y'_{t-1}, \ldots, y'_{t-k})'$, $Z = (z_1, \cdots, z_T)$ with $z_t = (y'_{t-k-1}, \ldots, y'_{t-p})'$ and $\hat{\mathrm{E}}' = (\hat{\varepsilon}_1, \ldots, \hat{\varepsilon}_T)$. As restrictions in parameters, the null hypothesis $H_0 : f(\phi) = 0$ where $\phi = vec(\Phi)$ is a parameter vector and may be tested by a Wald statistic defined as:

$$W = f(\hat{\phi})' \left[ F(\hat{\phi}) \left\{ \hat{\Sigma}_\varepsilon \otimes (X'QX)^{-1} \right\} F(\hat{\phi})' \right]^{-1} f(\hat{\phi}) \tag{6}$$

where $F(\phi) = \partial f(\phi) / \partial \phi', \hat{\Sigma}_\varepsilon = T^{-1} \hat{\mathrm{E}}' \hat{\mathrm{E}}$, $Q = \hat{Q}_\tau - \hat{Q}_\tau Z (Z' \hat{Q}_\tau Z)^{-1} Z' \hat{Q}_\tau$ and $\hat{Q}_\tau = I_T - \hat{\Lambda}(\hat{\Lambda}'\hat{\Lambda})^{-1} \hat{\Lambda}'$ where $I_T$ is a $T \times T$ identity matrix. Under the null hypothesis, the Wald statistic (6) has an asymptotic chi-square distribution with $m$ degrees of freedom that corresponds to the number of restrictions. Although Toda and Yamamoto (1995) present this method principally for the purpose of Granger non-causality testing, tests based on level VAR equations can also be used to examine long-run relationships. Test results based on the ECM can then be regarded as an indicator of short-run causality, while the causality tests by the level VAR can complement the result of the cointegration tests in terms of long-run information.

One final limitation of these tests is that while they indicate which markets Granger-cause another, they do not indicate whether yet other markets can influence a given market through other equations in the system. Likewise, Granger causality does not provide an indication of the dynamic properties of the system, nor does it allow the relative strength of the Granger-causal chain to be evaluated. However, decomposition of the variance of forecast errors of a given market allows the relative importance of other markets in causing fluctuations in that market to be ascertained. One likely problem is that the decomposition of variances is sensitive to the assumed origin of the shock. That is, the results of the variance decomposition depend on the ordering of variables. One approach to this problem is to randomly order the variables a number of times and compare the results. Unfortunately, random ordering of nine indexes is neither practical nor sufficient to clearly highlight any disparities. The most realistic ordering criterion under these circumstances is to order markets by their effect to other markets: that is, in descending order of the number of causes in the causality tests.

## 4. Empirical results

Table 2 presents the ADF unit root tests for the eight painting indices and the global equity index in price level and price-differenced forms. In all instances, the null hypothesis of nonstationarity is tested. Analysis of the price levels series indicates non-stationarity for all painting and equity markets. However, all of the ADF test statistics are significant in first differenced form at the .10 level, indicating stationarity and the suggestion that each index series is integrated of order 1 or I(1). The finding of non-stationarity in levels and stationarity in first differences provides comparable art market evidence to Chanel (1995), Ginsburgh and Jeanfils (1995) and Taylor (1995). However, it should be noted that all three of these studies used quarterly rather than monthly data.

<TABLE 2 HERE>

As discussed, Johansen cointegration trace tests are used to obtain the cointegrating rank. The likelihood ratio trace test statistics are detailed in Table 3. As multivariate cointegration tests, the results cover all the included markets simultaneously rather than simple bivariate combinations. They therefore consider the wide range of portfolio diversification options available to investors, as well as the scope of market interrelationships that may not be reflected in pairwise combinations. Also included in Table 3 are critical values at the .10 and .05 level. For the period in question, the trace test statistics are greater than the critical values at the .05 level for the null hypotheses of r = 0 to r ≤ 6 thereby rejecting the null hypothesis. However, the null hypothesis of r ≤ 7 fails to be rejected in favour of r > 7 thereby indicating a cointegrating rank of 7. The primary finding obtained from the Johansen cointegration tests is that a stationary long-run relationship exists between all the art and equity markets. That is, all nine series are cointegrated. Finding such cointegration among art markets and between art markets and the equity market is a nontrivial fact because it implies that, in the long run, the prices for various markets do not diverge and also that their short-run variations are influenced by this long-run equilibrium. Nevertheless, while the cointegrating relationship found is over the entire sample period, there may well have been sub-periods when the various series did diverge.

<TABLE 3 HERE>

Since cointegration exists between the art and equity indices, Granger non-causality tests are performed on the basis of the ECM in (2). *F*-statistics are calculated to test the null hypothesis that the first index series does not Granger-cause the second, against the alternative hypothesis that the first index Granger-causes the second. Calculated statistics and *p*-values for the various markets are detailed in Table 4. Among the nine markets, twenty-eight significant causal links are found (at the 5 percent level or lower). For example, column 3 shows that the 19$^{th}$ Century European (NE), Old Masters (OM) and Modern US (US) painting markets and the equity market affect the Modern European (ME) painting market. Further insights are gained by examining the rows in Table 4 indicating the effects of a particular market on all markets. The Modern European (ME) market, for example, influences four art markets: Contemporary Masters (CM), French Impressionists (FI), 20$^{th}$ Century English (TE) and Modern US (US) painting markets. The fact that the Modern US (US) painting market is influenced by, and in turn influences, the market for Modern European (ME) paintings suggests that there is 'feedback' in these two art markets. There is also an indication that there is feedback at play in several other pairwise combinations: for example, the Old Masters (OM) market Granger-causes Contemporary Masters (CM) and Contemporary Masters (CM) Granger-causes the Old Masters (OM).

<TABLE 4 HERE>

It is evident that the equity market is the most influential market in terms of Granger-causation in the short-run. Five markets are influenced by the global equity market; namely, Modern European (ME), 19th Century European (NE), Old Masters (OM), 20th Century English (TE) and Modern US (US) paintings. However, Contemporary Masters (CM), French Impressionists (FI) and the Surrealists (SR) are unaffected by the global equity market in the short run, at least at the .05 level. Among the art markets the most significant (in terms of the number of significant causes) is the 19th Century European (NE) and Old Masters (OM) paintings. Both of these art markets significantly influence five other markets. Another relatively influential market is Modern European (ME) painting that Granger-causes four markets. The least influential art markets in terms of Granger-causality include Contemporary Masters (CM) and 20th Century English (TE) paintings.

It can be difficult to apply a particular economic interpretation to the interrelationships that have been found between the various painting markets. On one level the various painting sub-sectors are comparable to industry sub-sectors within an equity market. In that case, relationships exist between industries because of underlying economic fundamentals or market effects to which they are exposed in common. This could be also expected to hold for the painting sub-sectors where many market fundamentals [including the wealth effects between financial markets and investment in art and collectables] are common to the various schools and genres of paintings. And as with equity market industries at least some painting sub-sectors will respond earlier and more significantly to changes in particular variables and therefore may be used, amongst other things, for forecasting purposes.

On another level, the relationships between the various painting sub-sectors may also owe much to variables that have not been specified in the analysis. For example, the causal linkages that exist among the painting markets may not entirely be due to the markets themselves, rather with overriding influences that have not been included in the analysis. For example, the overall demand for investment in art and collectibles is one such overriding factor and would be associated with myriad differences in tastes and fashions, income and wealth effects, taxation and the rate of bequests to museums, the degree of substitution between schools and genres, etc., all of which could be expected to vary across painting sub-sectors and throughout time. Unfortunately, the present analysis is unable (nor intended) to provide theoretical guidance on why such relationships exist, only that they do exist empirically.

One plausible implication of the results in Table 4 is that there may be no gains from pairwise portfolio diversification between those markets where a significant causal relationship exists. Also, since we have a finding of causality these markets must be seen as violating weak-form efficiency since one of the markets can help forecast the other. In all other cases, the absence of Granger causality implies that there are sufficient short-run differences between the markets for investors to gain by portfolio diversification. However, these results should consider that Granger causality only indicates the most significant direct causal relationship. For example, it may be that markets such as Contemporary Masters (CM), which has only one significant causal link with 20th Century English (TE), may influence non-Granger caused markets indirectly through other markets. Likewise, some of the short-run interrelationships shown are likely to arise not from direct relationships between art markets and art and equity markets, rather through the influence of markets that have not been included in the analysis. For example, an equity index has been used in this study as a financial market relevant to investment in art markets. It may well be that the global property or bond markets, amongst others, are far more important in this respect, and in turn influence both art markets and the equity market. Equally likely are the various leading indicators of economic activity.

The long-run causality Wald test statistics and *p*-values based on Toda and Yamamoto's (1995) level VAR procedure are presented in Table 5. The model is estimated for the levels, such that a significant Wald test statistic indicates a long-term relationship. This serves to supplement the findings obtained from the Granger causality (short run) results in Table 4. Among the nine markets, forty-five significant causal links are found (at the 5 percent level or lower). This suggests immediately that there are many more significant causal links among art markets and between art and equity markets in the long run than in the short run. For example, column 5 shows that the Contemporary Masters (CM), Modern European (ME), 19th Century European (NE), Surrealists (SR) painting markets and the global equity market affect the Old Masters (OM) market. This contrasts to the short run where the Surrealists (SR) market was not influential, though the 20th European (TE) painting market was. The rows in Table 5 indicate the effects of a particular market on all markets. It is evident that the 19th Century European (NE) market is again one of the most influential markets among the art markets, influencing all art markets except 20th Century English (TE). However, the Contemporary Masters (CM) painting market, which was one of the least influential markets in the short run, causes just as many art markets as the 19th Century European (NE) market. The least influential market in the long run is French Impressionist (FI) paintings. Once again, the global equity market is highly influential, causing seven art markets with the exception of the French Impressionists (FI). The finding of significant short and long run relations between equity and art markets contrasts strongly with the results of Ginsburgh and Jeanfils (1995). In that study, it was found that though financial markets did influence art markets in the short run, "…there is no long relation between these two assets" (Ginsburgh and Jeanfils, 1995: 538).

<TABLE 5 HERE>

Table 6 presents the decomposition of the forecast error variance for 1-month, 3-month, 6-month and 12-month ahead horizons for the equity markets and the art markets. An average forecast error variance across these horizons is also included in Table 6 for each market (AVG), while the final column in Table 6 (OTH) sums the percentage of forecast error variance of each market explained by all other art markets other then the market itself. The final row in Table 6 (ALL) averages the percentage of forecast variance for each market across itself and all other markets in all forecast time periods. Each row in Table 6 indicates the percentage of forecast error variance explained by the column heading for the market indicated in the first column. For example, at the 1-month horizon, the variance in the 19$^{th}$ Century European (NE) market is completely explained by its own innovations (100.00), whereas in the remaining markets some percentage of variance is explained by innovations in other markets. For example, in the Contemporary Masters (CM) market 85.43 percent of variance is explained by its own innovation, while in the 20$^{th}$ Century English (TE) painting market 88.47 percent is explained by variations in itself. At the 1-month horizon, other painting markets explain 12.18 percent of variance in the Contemporary Masters (CM) market, 39.50 for French Impressionists (FI), 3.87 for Modern European (ME), 0.03 for Old Masters (OM), 8.23 for the Surrealists (SR), 9.01 for 20$^{th}$ Century English (TE), and 9.37 for Modern US (US) paintings. These would indicate that the 19$^{th}$ Century European (NE) painting market is the least influenced by innovation in other painting markets in the 1-month forecast period, while the French Impressionist (FI) market is the most sensitive.

<TABLE 6 HERE>

Nonetheless, all the painting markets included in the analysis are relatively isolated from each other at the 1-month horizon period. This is consistent with the extreme lack of liquidity and the slow diffusion of information in art markets. However, within a 3-month forecast horizon period most of the variance that will ever be explained in any painting market, whether through its own innovations or though other painting market innovations, has occurred. This suggests that there are lags in the transmission of information among art markets, though they are certainly less than what could normally be expected. Once again, the most influential painting market is 19th Century European (NE) paintings with some 15.44 percent of forecast error variance across all markets and forecast horizons. The next most influential painting markets in terms of forecast error variance are Old Masters (OM) (13.04%) and Modern European (ME) (12.52%). The least influential markets are composed of Contemporary Masters (CM) (8.81%) and French Impressionists (FI) (6.95%).

Just as the painting markets are relatively isolated from each other, they are also relatively isolated from the equity market. For example, at the 1-month horizon period no forecast error variance in the 19th Century European (NE) and Old Masters (OM) painting markets and just 2.51 percent in the 20th Century English (TE) painting market, are explained by innovations in the equity markets. Though this steadily increases as the forecast error horizon is extended, even at the end of one year the percentage accounted for in these three markets by the equity market is just 6.98, 8.00 and 10.31 percent respectively. On average, and across time horizons, the market that has the most forecast error variance explained by the equity market is the 20th Century English (TE) painting market with 6.62 percent, while the least forecast error variance is explained in the Modern US (US) painting market.

## 5. Concluding remarks

This paper investigates long-term and short-term relationships among eight major painting markets and the global equity market during the period 1976 to 2001. Multivariate cointegrating techniques are used to establish relationships among these markets; Granger non-causality tests within an error-correcting model (ECM) are used to measure causal relationships in the short-term, while Wald test statistics in a level VAR approach are used to measure long-run causality. The results indicate, as expected, that the art markets are highly integrated and that there are a large number of significant causal linkages in both the short and long run among art markets and between the equity market and art markets.

The findings obtained in this paper have obvious implications, amongst other things, for the purported benefits of portfolio diversification among the several alternative painting markets. In effect, the strong short-term and long-term causal linkages among the markets would indicate that the expected returns from such a strategy may not be as great as expected.

However, the results also suggest that opportunities for diversification may still exist. This is further reinforced by a decomposition of variance analysis that indicates that a distinguishing characteristic of most art markets is the extremely low level of variance explained by other markets, including the equity market. Even in the least isolated art markets, other painting markets explain no more than thirty percent of the forecast error variance across all horizon periods.

The sole exception in this case is the market for French Impressionist paintings, which is the least endogenous market examined in this study. Interestingly, the most isolated painting market is that of Old Masters. With the former is most associated with the art bear market in the early 1990s and the later with a resurgence in the final years of the last century there is the suggestion that market segmentation has much to do with pricing behaviour in these markets. Unfortunately, it is not possible in this particular study to examine how these relationships have changed over time since no decomposition of the sample period is attempted.

In terms of the interrelationships between art and equity markets this study has quantified the significant short and long-run causal linkages that exist. However, the percentage of forecast error variance explained in art markets by the equity market is extremely low. Chanel (1995: 527) has used similar findings to conclude: “It would appear, then, that financial markets react quickly to economic shocks, and that the profits generated on these markets may be invested in art, so that stock exchanges may be considered as advanced indicators to predict what happens on the art market”. Nevertheless, and as concluded by Chanel (1995), art markets are subject to varying fashions, tastes and fads, and thus the endogeneity of these markets makes forecasting extremely difficult. Unfortunately, the present analysis is unable to comment particularly on the many economic, cultural and institutional factors associated with the interrelationships between these painting markets and this, of course, presents an avenue for future research.

## References

Anonymous (2000) New century, old masters. The Economist 356:84.

Art Market Research (2002) http://www.artmarketresearch.com/> Accessed April 2002.

Baumol WJ (1986) Unnatural value: or art investment as a floating crap game. American Economic Review 76: 10–14.

Candela G, Scorcu AE (1997) A price index for art market auctions. Journal of Cultural Economics 21:175–196.

Chanel O (1995) Is art market behaviour predictable? European Economic Review 39:519–527.

Chanel O, Gerard-Varet LA, Ginsburgh V (1994) Prices and returns on paintings: an exercise on how to price the priceless. Geneva Papers on Risk and Insurance Theory 19:7–21.

Coffman RB (1991) Art investment and asymmetrical information. Journal of Cultural Economics 15:83–94.

Czujack C, Flores R, Ginsburgh V (1996) On long-run price comovements between paintings and prints. In: Ginsburgh VA, Menger PM (eds.) Economics of the arts: selected essays, Contributions to economic analysis, Vol. 237. Elsevier North-Holland, Amsterdam, pp. 85–112.
Engle RF, Granger CWJ (1987) Cointegration and error correction: representation, estimation and testing. Econometrica 55:251–276.
Felton MV (1998) Review of: economics of the arts: selected essays. Journal of Economic Literature 36:286–287.
Flores RG, Ginsburgh V, Jeanfils P (1998) Long and short term portfolio choices of paintings. Journal of Cultural Economics 23:193–201.
Frey BS, Eichenberger R (1995a) On the return of art investment return analyses. Journal of Cultural Economics 19:207–220.
Frey BS, Einchenberger R (1995b) On the rate of return in the art market: survey and evaluation. European Economic Review 39:528–537.
Frey BS, Pommerehne WW (1989) Art investment: an empirical inquiry. Southern Economic Journal 56:396–409.
Gerard-Varet LA (1995) On pricing the priceless: comments on the economics of the visual art market. European Economic Review 39:509–518.
Ginsburg V, Jeanfils P (1995) Long term comovements in international markets for paintings. European Economic Review 39:538–548.
Goetzmann WN (1993) Accounting for taste: art and the finance markets over three centuries. American Economic Review 83:1370–1376.
Granger CWJ (1969) Investigating causal relations by econometric models and cross-spectral methods. Econometrica 37:424–438.
Johansen S (1991) Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. Econometrica 59:1551–1580.
Johansen S, Juselius K (1990) Maximum likelihood estimation and inferences on cointegration – with applications to the demand for money. Oxford Bulletin of Economics and Statistics 52:169–210.
Louargand MA, McDaniel JR (1991) Price efficiency in the art auction market. Journal of Cultural Economics 15:53–65.
Oleck J, Dunkin A (1999) The art of collecting art. Business Week 3629:160
Peers A, Jeffrey NA (1999) Art and money. Wall Street Journal, Nov 12:10.
Pesando JE (1993) Arts as an investment: the market for modern prints. American Economic Review 83:1075–1089.
Pesando JE, Shum PM (1999) The returns to Picasso's prints and to traditional financial assets, 1977 to 1996. Journal of Cultural Economics 23:183–192.
Taylor MW (1995) The cointegration of auction price series. Managerial Finance 21:35–46.
Toda HY, Yamamoto T (1995) Statistical inference in vector autoregressions with possibly integrated processes. Journal of Econometrics 66:225–250.

**Table 1.** Selected descriptive statistics of annual art and global equity returns, 1976-2001

| | CM | FI | ME | NE | OM | SR | TE | US | EI |
|---|---|---|---|---|---|---|---|---|---|
| Mean | 4.2090 | 3.7045 | 2.1398 | 2.4645 | 2.8132 | 2.0307 | 2.5541 | 3.3180 | 5.1736 |
| Median | 3.9766 | 6.0617 | 2.7789 | 1.3484 | 3.1091 | 3.0168 | 3.2300 | 1.5463 | 6.6307 |
| Maximum | 29.7088 | 34.2042 | 21.6283 | 17.0330 | 18.2180 | 22.6799 | 13.4611 | 26.4745 | 15.4727 |
| Minimum | -15.2562 | -40.5108 | -23.7159 | -16.0957 | -8.1525 | -29.3774 | -12.1199 | -27.4104 | -7.8406 |
| Standard deviation | 10.5006 | 13.6610 | 11.2592 | 7.1423 | 7.5800 | 11.2977 | 7.6386 | 12.7691 | 5.8390 |
| Coefficient of variation | 2.4948 | 3.6876 | 5.2618 | 2.8981 | 2.6944 | 5.5636 | 2.9908 | 3.8485 | 1.1286 |
| Skewness | 0.4858 | -0.9286 | -0.4300 | -0.0624 | 0.3586 | -0.6922 | -0.2471 | -0.1118 | -0.4650 |
| Kurtosis | 3.4723 | 5.9786 | 2.5919 | 3.5388 | 1.9856 | 3.8568 | 2.0100 | 2.8911 | 2.7842 |
| Jarque-Bera | 1.2643 | 13.3475 | 0.9818 | 0.3313 | 1.6718 | 2.8718 | 1.3265 | 0.0670 | 0.9872 |
| JB *p*-value | 0.5314 | 0.0013 | 0.6121 | 0.8473 | 0.4335 | 0.2379 | 0.5152 | 0.9670 | 0.6104 |

*Notes:* CM – Contemporary Masters, FI – French Impressionists, ME – Modern European, NE – 19$^{th}$ Century European, OM – Old Masters, SR – Surrealists, TE – 20$^{th}$ Century English, US – Modern US Paintings, EI –Global Equity.

**Table 2.** Augmented Dickey-Fuller (ADF) unit root tests

| Market | Code | Level series | First differenced series |
|---|---|---|---|
| Contemporary Masters | CM | -2.5941 | -4.9155$^{***}$ |
| French Impressionists | FI | -2.5638 | -4.8539$^{***}$ |
| Modern European | ME | -2.1271 | -4.2649$^{***}$ |
| 19$^{th}$ Century European | NE | -1.9306 | -4.1228$^{***}$ |
| Old Masters | OM | -1.7545 | -5.5394$^{***}$ |
| Surrealists | SR | -2.7438 | -3.8669$^{***}$ |
| 20$^{th}$ Century English | TE | -1.7606 | -4.9656$^{***}$ |
| Modern US Paintings | US | -2.3868 | -4.5105$^{***}$ |
| Global Equity | EI | -1.9452 | -2.8332$^{*}$ |
| 1% critical value | | -3.9930 | -3.4546 |
| 5% critical value | | -3.4266 | -2.8716 |
| 10% critical value | | -3.1363 | -2.5721 |

*Notes:* Hypotheses $H_0$: unit root, $H_1$: no unit root (stationary). The lag orders in the ADF equations are determined by the significance of the coefficient for the lagged terms. Intercepts and trends are included in the levels series, intercepts only in the first-differenced series. Asterisks denote significance at: $^{***}$ – .01 level and $^{*}$ – .10 level.

**Table 3.** Cointegration tests and eigenvalues

| $H_0$ | $H_1$ | Eigenvalue | Likelihood ratio | 5 percent critical value | 10 percent critical value |
|---|---|---|---|---|---|
| $r = 0$ | $r > 0$ | 0.3152 | 354.2646 | 192.8900 | 204.9500 |
| $r \leq 1$ | $r > 1$ | 0.1711 | 241.0357 | 156.0000 | 168.3600 |
| $r \leq 2$ | $r > 2$ | 0.1654 | 184.9150 | 124.2400 | 133.5700 |
| $r \leq 3$ | $r > 3$ | 0.1292 | 130.8410 | 94.1500 | 103.1800 |
| $r \leq 4$ | $r > 4$ | 0.0975 | 89.4914 | 68.5200 | 76.0700 |
| $r \leq 5$ | $r > 5$ | 0.0798 | 58.8222 | 47.2100 | 54.4600 |
| $r \leq 6$ | $r > 6$ | 0.0749 | 33.9596 | 29.6800 | 35.6500 |
| $r \leq 7$ | $r > 7$ | 0.0233 | 10.6752 | 15.4100 | 20.0400 |
| $r \leq 8$ | $r = 9$ | 0.0120 | 3.6154 | 3.7600 | 6.6500 |
| Accepted | | | 7 | | |

*Notes:* The optimal lag order of each VAR model was selected using likelihood ratio (LR) tests for the significance of the coefficient for maximum lags and Schwarz's Bayesian Information Criterion (BIC). In each cointegrating equation, the intercept (no trend) is included.

**Table 4.** Short-run causality tests by ECM for art and equity markets, 1976-2001

| | CM | FI | ME | NE | OM | SR | TE | US | EI | Causes |
|---|---|---|---|---|---|---|---|---|---|---|
| CM | — | 1.1231 | 1.7660 | 1.0768 | 2.3603 | 1.1844 | 2.0126 | 1.6960 | 1.4383 | 1 |
| | | (0.3486) | (0.1203) | (0.3737) | (0.0407) | (0.3172) | (0.0774) | (0.1360) | (0.2110) | |
| FI | 1.3291 | — | 0.5409 | 1.6871 | 1.0072 | 0.7218 | 1.1846 | 5.4898 | 3.8121 | 2 |
| | (0.2523) | | (0.7452) | (0.1382) | (0.4140) | (0.6076) | (0.3172) | (0.0001) | (0.0024) | |
| ME | 3.0808 | 4.2381 | — | 1.7566 | 2.4512 | 1.0725 | 2.2845 | 1.9958 | 1.2331 | 4 |
| | (0.0102) | (0.0010) | | (0.1223) | (0.0343) | (0.3761) | (0.0469) | (0.0798) | (0.2940) | |
| NE | 4.6156 | 8.4547 | 5.7950 | — | 1.3726 | 2.3122 | 1.7104 | 1.1250 | 2.3189 | 5 |
| | (0.0005) | 0.0000) | (0.0000) | | (0.2351) | (0.0445) | (0.1327) | (0.3475) | (0.0440) | |
| OM | 2.9187 | (0.7837 | 3.0013 | 3.2939 | — | 4.0715 | 0.6881 | 1.8513 | 2.2509 | 5 |
| | (0.0140) | 0.5623) | (0.0119) | (0.0067) | | (0.0014) | (0.6329) | (0.1035) | (0.0499) | |
| SR | 2.5632 | (0.4763 | 1.6197 | 1.2576 | 1.2920 | — | 0.5185 | 0.7343 | 6.6547 | 2 |
| | (0.0277) | 0.7938) | (0.1553) | (0.2829) | (0.2678) | | (0.7622) | (0.5984) | (0.0000) | |
| TE | 1.8181 | 1.8047 | 1.4202 | 2.1622 | 3.1239 | 2.0145 | — | 2.1148 | 0.3933 | 1 |
| | (0.1097) | (0.1124) | (0.2174) | (0.0588) | (0.0094) | (0.0771) | | (0.0642) | (0.8532) | |
| US | 0.6984 | 11.0730 | 5.4894 | 3.0378 | 0.9750 | 1.0625 | 0.7313 | — | 1.9902 | 3 |
| | (0.6251) | (0.0000) | (0.0001) | (0.0111) | (0.4336) | (0.3817) | (0.6006) | | (0.0806) | |
| EI | 1.5642 | 1.7918 | 2.4459 | 3.4854 | 3.1664 | 1.3132 | 2.5282 | 2.4693 | — | 5 |
| | (0.1707) | (0.1150) | (0.0346) | (0.0046) | (0.0086) | (0.2588) | (0.0296) | (0.0331) | | |
| Caused | 4 | 3 | 4 | 3 | 4 | 2 | 2 | 2 | 4 | 28 |

*Notes:* Granger causality tests are conducted by adjusting the long-term cointegrating relationship by the ECM. Figures in brackets are p-values. Tests indicate Granger causality by row to column and Granger caused by column to row. For example, Contemporary Masters (row) Granger-causes one art market (Old Masters) and is Granger-caused by four (Modern European, European Nineteenth Century, Old Masters and Surrealists) using a 5% critical value.

**Table 5.** Long-run causality tests by level-VAR for art and equity markets, 1976-2001

| | CM | FI | ME | NE | OM | SR | TE | US | EI | Causes |
|---|---|---|---|---|---|---|---|---|---|---|
| CM | — | 29.4186 | 46.7627 | 46.7779 | 58.6541 | 66.7693 | 9.3312 | 61.9109 | 23.7095 | 7 |
| | | (0.0034) | (0.0000) | (0.0000) | (0.0000) | (0.0000) | (0.6744) | (0.0000) | (0.0223) | |
| FI | 14.6739 | — | 20.8347 | 44.0360 | 20.9137 | 18.5037 | 12.2163 | 96.3209 | 20.7284 | 2 |
| | (0.2598) | | (0.0529) | (0.0000) | (0.0517) | (0.1012) | (0.4285) | (0.0000) | (0.0545) | |
| ME | 38.4130 | 43.6902 | — | 54.0052 | 34.3326 | 7.9780 | 14.7625 | 47.9736 | 13.3999 | 5 |
| | (0.0001) | (0.0000) | | (0.0000) | (0.0006) | (0.7869) | (0.2547) | (0.0000) | (0.3407) | |
| NE | 60.1726 | 55.3636 | 53.7748 | — | 32.6718 | 45.5748 | 20.6269 | 47.6644 | 32.8021 | 7 |
| | (0.0000) | (0.0000) | (0.0000) | | (0.0011) | (0.0000) | (0.0561) | (0.0000) | (0.0010) | |
| OM | 24.3637 | 14.9585 | 19.8596 | 36.3916 | — | 38.0209 | 5.9912 | 32.6648 | 16.6198 | 4 |
| | (0.0181) | (0.2437) | (0.0698) | (0.0003) | | (0.0002) | (0.9165) | (0.0011) | (0.1645) | |
| SR | 46.8706 | 17.4831 | 19.1867 | 20.9968 | 43.2282 | — | 16.5297 | 37.3573 | 35.8460 | 4 |
| | (0.0000) | (0.1323) | (0.0841) | (0.0504) | (0.0000) | | (0.1682) | (0.0002) | (0.0003) | |
| TE | 28.7351 | 17.4921 | 14.1261 | 37.1426 | 19.5714 | 16.3734 | — | 31.9333 | 27.5306 | 4 |
| | (0.0043) | (0.1320) | (0.2927) | (0.0002) | (0.0756) | (0.1747) | | (0.0014) | (0.0065) | |
| US | 22.5489 | 32.5945 | 31.3874 | 32.3687 | 15.3725 | 17.2368 | 22.5184 | — | 15.4039 | 5 |
| | (0.0318) | (0.0011) | (0.0017) | (0.0012) | (0.2217) | (0.1409) | (0.0321) | | (0.2201) | |
| EI | 26.3749 | 20.6504 | 25.8609 | 48.3209 | 37.2244 | 41.6945 | 22.1980 | 35.3859 | — | 7 |
| | (0.0095) | (0.0557) | (0.0112) | (0.0000) | (0.0002) | (0.0000) | (0.0354) | (0.0004) | | |
| Caused | 7 | 4 | 4 | 7 | 5 | 4 | 2 | 8 | 4 | 45 |

*Notes:* Unbracketed figures in table are Wald statistics for Granger non-causality tests. Figures in brackets are *p*-values. The level VARs are estimated with lag order of $p = k + d_{max}$; k is selected by the LR test in (5) and $d_{max}$ is set to one. Tests indicate Granger causality by row to column and Granger caused by column to row. For example Contemporary Masters (CM) Granger causes all art markets with the exception of 20$^{th}$ Century English (TE) and is Granger-caused by all art markets with the exception of French Impressionists (FI).

**Table 6.** Generalised variance decomposition for the painting and equity markets, 1976-2001

| MKT | PER | CM | FI | ME | NE | OM | SR | TE | US | EI | OTH |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CM | 1 | 85.4393 | 0.6254 | 1.5824 | 5.1951 | 0.0639 | 4.0762 | 0.0000 | 0.6395 | 2.3779 | 12.1827 |
| | 3 | 74.4839 | 0.4272 | 1.1268 | 12.3650 | 3.6831 | 2.7499 | 1.2882 | 1.7341 | 2.1412 | 23.3748 |
| | 6 | 63.5276 | 0.7304 | 1.8010 | 13.8983 | 10.5146 | 2.9714 | 1.5263 | 1.9532 | 3.0769 | 33.3954 |
| | 12 | 49.4975 | 2.8334 | 3.8752 | 19.8930 | 12.8114 | 2.6447 | 1.6836 | 3.5158 | 3.2452 | 47.2572 |
| | AVG | 68.2371 | 1.1541 | 2.0963 | 12.8380 | 6.7682 | 3.1106 | 1.1245 | 1.9607 | 2.7103 | 29.0525 |
| FI | 1 | 0.0000 | 60.4956 | 29.7923 | 7.2018 | 1.6258 | 0.0000 | 0.0000 | 0.4531 | 0.4313 | 39.5044 |
| | 3 | 0.0782 | 57.6493 | 21.6226 | 12.0686 | 1.1989 | 0.1548 | 0.7265 | 4.4070 | 2.0940 | 42.3507 |
| | 6 | 0.1596 | 45.0947 | 16.0130 | 19.6644 | 1.4301 | 0.2340 | 2.2124 | 13.0096 | 2.1820 | 54.9052 |
| | 12 | 0.8445 | 31.5792 | 10.4102 | 29.8261 | 6.2413 | 0.2458 | 1.9310 | 15.5601 | 3.3616 | 68.4207 |
| | AVG | 0.2706 | 48.7047 | 19.4595 | 17.1902 | 2.6241 | 0.1586 | 1.2175 | 8.3574 | 2.0172 | 51.2952 |
| ME | 1 | 0.0000 | 0.0000 | 96.0180 | 1.8310 | 2.0408 | 0.0000 | 0.0000 | 0.0000 | 0.1101 | 3.8718 |
| | 3 | 0.7494 | 0.3261 | 79.8583 | 8.4027 | 2.3226 | 0.0951 | 0.4110 | 5.3869 | 2.4477 | 17.6939 |
| | 6 | 0.9664 | 0.4250 | 70.4063 | 10.8735 | 5.3890 | 0.7957 | 0.7609 | 5.5884 | 4.7947 | 24.7989 |
| | 12 | 1.3624 | 2.8527 | 50.0013 | 22.0143 | 10.3680 | 1.1011 | 0.8250 | 6.3280 | 5.1471 | 44.8516 |
| | AVG | 0.7695 | 0.9009 | 74.0710 | 10.7804 | 5.0301 | 0.4980 | 0.4992 | 4.3258 | 3.1249 | 22.8040 |
| NE | 1 | 0.0000 | 0.0000 | 0.0000 | 100.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| | 3 | 0.6495 | 1.8253 | 1.5558 | 90.0740 | 0.7773 | 1.2037 | 0.0201 | 0.6596 | 3.2345 | 6.6914 |
| | 6 | 0.8992 | 1.4321 | 2.3795 | 75.7457 | 6.1583 | 1.2727 | 3.3092 | 4.0717 | 4.7313 | 19.5229 |
| | 12 | 1.8904 | 2.4388 | 1.7568 | 62.0904 | 12.0368 | 1.7279 | 4.0048 | 7.0683 | 6.9857 | 30.9238 |
| | AVG | 0.8598 | 1.4240 | 1.4230 | 81.9775 | 4.7431 | 1.0511 | 1.8335 | 2.9499 | 3.7379 | 14.2845 |
| OM | 1 | 0.0000 | 0.0000 | 0.0000 | 0.0359 | 99.9641 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0359 |
| | 3 | 0.4081 | 1.3153 | 2.0741 | 0.2305 | 91.5195 | 0.5777 | 3.3901 | 0.2305 | 0.2540 | 8.2264 |
| | 6 | 1.9675 | 2.1339 | 2.0101 | 0.6890 | 80.5745 | 1.5564 | 4.5109 | 0.9519 | 5.6057 | 13.8197 |
| | 12 | 2.8195 | 2.0449 | 2.1535 | 3.3567 | 70.9074 | 3.6585 | 5.5120 | 1.5393 | 8.0081 | 21.0845 |
| | AVG | 1.2988 | 1.3735 | 1.5594 | 1.0781 | 85.7414 | 1.4481 | 3.3532 | 0.6804 | 3.4670 | 10.7916 |
| SR | 1 | 0.0000 | 2.9680 | 3.9098 | 0.0022 | 0.5369 | 90.4765 | 0.0000 | 0.8184 | 1.2882 | 8.2353 |
| | 3 | 0.0326 | 3.1912 | 4.4370 | 2.6570 | 1.5530 | 82.7571 | 1.6909 | 1.8189 | 1.8621 | 15.3808 |
| | 6 | 0.1362 | 3.1877 | 6.0997 | 4.1026 | 5.1847 | 74.3641 | 2.1442 | 2.5341 | 2.2466 | 23.3893 |
| | 12 | 0.2430 | 2.8859 | 5.6235 | 12.3039 | 13.0664 | 54.6669 | 3.5307 | 2.3081 | 5.3719 | 39.9611 |
| | AVG | 0.1029 | 3.0582 | 5.0174 | 4.7664 | 5.0852 | 75.5662 | 1.8415 | 1.8699 | 2.6922 | 21.7416 |
| TE | 1 | 1.3843 | 0.0019 | 1.0636 | 5.5053 | 0.3488 | 0.2259 | 88.4671 | 0.4888 | 2.5141 | 9.0187 |
| | 3 | 2.5932 | 0.3128 | 1.8008 | 6.2269 | 0.5904 | 0.6394 | 82.5397 | 0.4580 | 4.8386 | 12.6216 |
| | 6 | 6.7733 | 1.0751 | 3.1851 | 5.8140 | 2.1141 | 0.8078 | 70.5911 | 0.8282 | 8.8111 | 20.5978 |
| | 12 | 8.3852 | 1.4675 | 4.9261 | 5.2599 | 4.5647 | 0.8459 | 63.4011 | 0.8308 | 10.3187 | 26.2801 |
| | AVG | 4.7840 | 0.7143 | 2.7439 | 5.7015 | 1.9045 | 0.6298 | 76.2498 | 0.6514 | 6.6206 | 17.1296 |
| US | 1 | 0.0000 | 0.0000 | 4.8261 | 1.0304 | 3.5126 | 0.0000 | 0.0000 | 90.6287 | 0.0023 | 9.3690 |
| | 3 | 0.3943 | 0.8551 | 3.4202 | 0.7738 | 2.5216 | 1.0082 | 0.8768 | 89.8206 | 0.3293 | 9.8501 |
| | 6 | 1.3418 | 4.5225 | 3.5232 | 3.7749 | 3.1547 | 0.9120 | 4.5077 | 76.7242 | 1.5389 | 21.7360 |
| | 12 | 5.6936 | 7.2777 | 3.8411 | 8.3928 | 3.6055 | 1.4638 | 5.0162 | 62.4239 | 2.2853 | 35.2908 |
| | AVG | 1.8574 | 3.1638 | 3.9026 | 3.4930 | 3.1986 | 0.8460 | 2.6002 | 79.8993 | 1.0389 | 19.0617 |
| EI | 1 | 0.0000 | 0.0000 | 0.0000 | 0.3109 | 0.3644 | 0.0000 | 0.0000 | 0.0000 | 99.3247 | 0.6753 |
| | 3 | 1.2856 | 0.6672 | 1.6137 | 0.3970 | 2.0325 | 7.9600 | 0.3604 | 0.7668 | 84.9168 | 15.0831 |
| | 6 | 1.6468 | 3.9128 | 3.8759 | 2.0357 | 3.2632 | 7.9338 | 0.7930 | 1.8749 | 74.6638 | 25.3361 |
| | 12 | 1.6343 | 3.9844 | 4.2678 | 2.0448 | 3.4742 | 7.9151 | 1.1251 | 2.0828 | 73.4713 | 26.5286 |
| | AVG | 1.1417 | 2.1411 | 2.4393 | 1.1971 | 2.2836 | 5.9522 | 0.5696 | 1.1811 | 83.0942 | 16.9058 |
| ALL | 1-12 | 8.8135 | 6.9594 | 12.5236 | 15.4469 | 13.0421 | 9.9178 | 9.9210 | 11.3196 | 12.0559 | 22.5629 |

*Notes:* The final column (OTH) is the percentage of forecast error variance of the market indicated in the first column (MKT) explained by all art markets except the market's own innovations; the periods (PER) in the second column are in months. The ordering for the variance decomposition is based on the number of 'causes' in Table 4, i.e. NE, OM, EI, ME, US, FI, SR, CM and TE. 'AVG' is the arithmetic mean of the 1-month, 3-month, 6-month and 12-month horizons. 'ALL' in the final row is the average forecast error variance explained by the market in the first row across all markets and forecast horizons.