Asset Pricing Theory and the Valuation of Canadian Paintings
Author(s): Douglas J. Hodgson and Keith P. Vorkink
Source: *The Canadian Journal of Economics / Revue canadienne d'Economique*, Vol. 37, No. 3 (Aug., 2004), pp. 629-655
Published by: Wiley on behalf of the Canadian Economics Association
Stable URL: http://www.jstor.org/stable/3696009
Accessed: 26/02/2014 07:13

Asset pricing theory and the valuation of Canadian paintings

Douglas J. Hodgson *Département des sciences économiques, Université du Québec à Montréal*
Keith P. Vorkink *Marriott School of Management, Brigham Young University*

Abstract. The valuation of Canadian paintings is analysed empirically. Using a sample of auction prices for major Canadian painters for the period 1968–2001, we run hedonic regressions to analyse the influence of various factors, including painter identity, on auction prices, as well as to construct a market price index. This index is used in a second-stage analysis in which we analyse the properties of Canadian art viewed as an investment asset. We apply standard asset pricing theory, as incorporated in the capital asset pricing model (CAPM), to the analysis of price movements in the market for Canadian paintings.

Théorie du prix des actifs et évaluation de peintures canadiennes. Les auteurs font une étude empirique de l'évaluation de peintures canadiennes. A partir d'un échantillon de prix d'encan pour la période 1968–2001, ils estiment une régression hédonique qui leur permet d'analyser l'effet sur le prix de quelques variables comme l'identité du peintre, et de construire un indice de prix dans le temps. Cet indice est utilisé pour étudier les rendements sur les peintures considérées comme des investissements. On utilise le modèle d'évaluation des actifs financiers (MÉDAF) pour analyser ces mouvements de prix.

1. Introduction

It is not unusual to find the mass news media reporting the latest blockbuster sale of a high-priced painting, a frequent occurrence, for example, during the

For their comments, we thank Georges Dionne, Pascal St-Amour, anonymous referees, and seminar participants at Toronto, Rice, Rochester, Journées du CIRPÉE (Montreal 2002), the 2003 CEA and SCSE Meetings, the 2003 European Workshop on Applied Cultural Economics, and the Montreal Econometrics Workshop. Financial support from the Montreal Institute of Mathematical Finance and the Social Sciences and the Humanities Research Council of Canada is also acknowledged. Email: hodgson.douglas-james@uqam.ca

Canadian Journal of Economics / Revue canadienne d'Economique, Vol. 37, No. 3
August / août 2004. Printed in Canada / Imprimé au Canada

0008-4085 / 04 / 629–655 / © Canadian Economics Association

art market boom of the late 1980s. There is a general interest in the value of art works, which can even lead to political controversy, as happened in 1990 when a work by Barnett Newman was purchased by the National Gallery of Canada. One argument made by those in favour of the acquisition was that the painting could be thought of as an investment – it was an asset being added to the capital stock of the nation, the monetary value of which had the potential for substantial future appreciation.

Although the price of any painting incorporates a portion that can be thought of as being paid in exchange for immediate consumption by the purchaser, it cannot be ignored that paintings are durable, capable of surviving in close to their original condition for centuries, and that therefore some portion of the price can be thought of as representing the discounted present value of the sums that may be paid by potential future owners in exchange for the consumption they may obtain from the painting. Two elements of uncertainty thus enter into consideration for the potential buyer of a painting: uncertainty over the future evolution of one's own taste and uncertainty over the future evolution of tastes of society in general. This dependence of the price of a painting on the expected present value of a future consumption stream of uncertain monetary value is analogous to that of a stock on the expected present value of a sequence of uncertain future dividend payments.

The latter consideration suggests the analysis of art prices within the context of asset pricing theory. The valuation of art works is an area that has received considerable attention from economists (see the books of Reitlinger 1961 and Grampp 1989), with the investment properties of paintings being a particular focus of academic investigation (see, for example, Stein 1977; Baumol 1986; Goetzmann 1993; Pesando 1993). The existing literature is focused on a few questions regarding the statistical properties of time series of art returns, in particular the first two moments of the return distribution. A time series index of prices and returns, for a given category of art work, is generally estimated from individual sale data at auctions using either the 'repeat-sale regression' or the 'hedonic regression' method, described in more detail in section 2. The sample average returns and return variances are compared with those of financial assets such as bonds and stocks. Covariances with the stock market and the associated market betas are also often computed.[1] Results in the literature vary, depending on the time period and the 'portfolio' of paintings under consideration, with some studies finding the return on art to be low on average relative to stocks and bonds and some finding it to be high. One feature of art returns that does seem to be robust is that they are at least as variable as stocks or bonds, so that art tends to be a risky investment. The

1 The 'beta' of a financial asset is the ratio between the covariance of the asset's return with that of a general market portfolio and the market variance. Beta represents the degree of non-diversifiable risk incurred in the holding of the asset and is, according to the capital asset pricing model (CAPM), the sole factor that should influence the equilibrium price of an asset.

correlations of art portfolios with the stock market tend to be positive, but are often close to zero. A non-positive correlation would suggest that art, despite its high variance, can serve a useful function in a diversified portfolio as an element that counters, or is at least neutral to, general market risk.

Most of the existing literature on art as an investment is concerned with European and American paintings. In the present paper, we conduct an empirical analysis of the valuation of Canadian paintings. We consider the behaviour of prices of oil and acrylic paintings, over the period 1968–2001, for a portfolio of major Canadian painters. We begin by estimating a price index and a return series using hedonic methods, reported in section 2. The results of our hedonic regression allow us to gauge the influence on auction prices of a number of separate factors, including the identity of the artist, the auction house, the size of the painting, and the medium and support. We depart from the literature in estimating the hedonic regression using the semi-parametric efficient adaptive estimator of Bickel (1982), motivated by the high leptokurtosis present in our auction price data and by our sample size of nearly 13,000 sales. The resulting estimates of returns are more precise than would be obtained using ordinary least squares, an important consideration because these *estimated* returns are treated as being *observed* returns when we proceed to the analysis of the investment properties of paintings. The results of the latter analysis are presented in section 3. We compare the investment properties of Canadian art with those of Canadian government bonds and stocks. We estimate the capital asset pricing model (CAPM) and also apply the conditional CAPM of Bollerslev, Engle, and Wooldridge (1988), in which conditional covariances and conditional betas are permitted to vary over time.

2. The hedonic regression

In this section, we compute a time series representing general movements in the market for Canadian art. Such an index is not readily available, but must be inferred from the individual sales of paintings that occur over time. Each painting is, to a certain extent, a unique object, and therefore the price at which it sells cannot be taken as a general indicator of the level of the market. The price will also be affected by factors such as the identity of the artist, the size, medium, and support of the painting, the location of the sale (the auction house, or city, for example), the condition and quality of the work itself, and a host of idiosyncratic factors.

The various approaches that have been taken to address this problem can be placed into two general classes, the 'repeat-sale regression' method and the use of hedonic regression. The former approach, used, for example, by Baumol (1986), Goetzmann (1993), Pesando (1993) and Pesando and Shum (1999), is based on a comparison of the prices at which an identical art work was sold in different time periods in order to compute a rate of return for the given art work and time interval; it then effectively averages over all art works for which such repeat-sales occurred to obtain an average rate of return in each time period. The application of the method to obtain a price index for paintings has obvious data problems – the identification of repeat sales of the same painting may be difficult to make based on published sale data, and the number of such repeat sales may be too small to construct an accurate price index. These problems are significantly mitigated in the work of Pesando (1993) and Pesando and Shum (1999), who analyse the valuation of prints, for which multiple impressions of the same image can effectively be considered as identical objects.

Hedonic regressions have been estimated in many previous studies, a few recent examples being Chanel, Gérad-Varet, and Ginsburgh (1996), Czujack (1997), and Locatelli-Biey and Zanola (2002). The essential approach is to gather data on a number of art sales through time (auction sales, for example), and to then regress the price of each work (or its logarithm) on other available characteristics of the work, such as the artist, the size, the medium, the auction house, the time period, and so forth. Many of the regressors, such as those associated with the time period, will take the form of a set of dummy variables. The estimated time period dummy parameters can be thought of as representing an index of variation of the price of an 'average' painting, within the class under consideration, after controlling for the art-work-specific variables represented by the other included variables. In our study, this would be the average price of a painting by a 'major' Canadian painter, as defined below. Such an index would be a relatively accurate reflection of the return to be earned by a collector holding a large, well-diversified collection of works by several painters. It would, of course, provide a less accurate reflection of the price variation of a single painting, or of the works of a single painter, or even of a specific school of painters, such as, for example, the Automatistes or the Group of Seven. An analysis of returns at such disaggregated levels would be desirable and is under consideration for future research, but data availability makes the analysis of returns at these levels problematic. For more discussion of the use of hedonic methods in the estimation of art prices, see Chanel, Gérad-Varet, and Ginsburgh (1996).

It should also be emphasized that the hedonic regression estimates a reduced-form model of price determination at auctions, with no attempt to disentangle supply and demand influences. We are not aware of existing efforts to separately model supply and demand functions in art auctions, but it seems to be a very difficult, if not impossible, task. This is principally because the sellers and buyers in this market are very similar – being a secondary market, both sides of the market consist of collectors. Indeed, the same individuals may be both buyers and sellers (of different works) at the same auction. What work has been done on supply and demand in art markets tends to focus on primary markets, where currently active artists market their new works through galleries (see, for example, Caves 2000).

2.1. Data

Records of sales of Canadian paintings at auction from 1968 to 2001 were collected by the authors from Campbell (1973–75, 1980), Sotheby's (1975, 1980), and Westbridge (1981–2002). Sales are recorded in these publications for an enormous number of artists, including quite minor ones. We chose to restrict our analysis to artists considered to have made contributions of some lasting importance to the development of Canadian art, so that we can claim to have assembled a sample of paintings by 'major' artists that should be expected to have solid long-term investment value. Our criterion for an artist to be 'important' is that his or her work be mentioned in Reid's (1973) survey of the history of Canadian painting. In addition to being a principal reference on Canadian painting, Reid (1973), having been published near the beginning of our sample period, provides us with a list of painters who had achieved some degree of renown, and presumably of investment value, by this time. This emphasis on 'blue-chip' artists is not unusual in the literature. As our focus is on art as an investment, we would like to consider paintings the current price of which can largely be considered as representing investment, as opposed to consumption, value. For relatively unknown artists or young contemporary artists, whose paintings are generally low priced, the investment motivation will generally be much less important than the consumption motivation for purchasers. As noted by Grampp (1989), the vast majority of paintings sold in the art market eventually become valueless.

We consider only oil and acrylic paintings – the vast majority of our observations are for oils. The number of painters listed in Reid (1973) and for whom we have at least one recorded sale of an oil or acrylic painting is 152, and the total number of sales in our data set is 12,821. We have included only sales for which the auction house's attribution is confident, so that paintings listed as being 'school of' or 'in the manner of,' say, Cornelius Krieghoff are excluded. For each painting, we recorded, in addition to the identity of the artist, the height and width in centimetres, the medium and support, the auction house, and the half-year of the sale. Since most auctions occur in fairly concentrated time periods (autumn auctions are mostly in October and November, and spring auctions in April and May), we have followed the standard practice in the literature on art pricing by using a semi-annual time index.

Throughout the empirical study, we use hammer prices as recorded in the publications listed above. No effort has been made to adjust or correct our numbers to account for costs such as auctioneers' commissions, taxes, insurance premia, maintenance and restoration costs, and so on. All these factors act to reduce the monetary returns of owning paintings below the levels recorded here. Factors acting to augment the monetary returns to art owners, such as reproduction fees and exhibition lending fees, are also omitted.

2.2. Econometric model

Our auction data are used to estimate a hedonic regression with time-period dummy variables, the associated parameter estimates being used to construct semi-annual and annual price indices. The econometric model is written:

$$p_i = \sum_{t=1}^{T} \gamma_t z_{it} + \sum_{j=1}^{J} \alpha_j w_{ij} + u_i,\ i = 1, \ldots, n, \tag{1}$$

where p_i is the logarithm of the price of sale i, the number of sales is $n = 12{,}821$, z_{it} is the value of a period-t dummy variable, equal to 1 if painting i was sold in period t and zero otherwise, with the number of time periods T being 66 when the data are grouped semi-annually and 33 when they are grouped annually. All auctions held during the months from January to June of a given year are considered to belong to the first half of the year, with the year's remaining auctions belonging to its second half. The semi-annual dummies thus run from 1968:2 to 2001:1. Owing to the low incidence of auctions during the summer months, we will consider an auction year in the same way as one would consider a school year or a hockey season, so that, for the purposes of forming an annual price series, the auction year is considered to run from July 1 of a given calendar year to June 30 of the following one. We thus have 33 annual dummies, starting with the 1968–69 auction year, followed by 1969–70 and concluding with 2000–2001. Our estimates of the vector of associated parameters $\{\gamma_t\}_{t=1}^{T}$ will form our price indices, to be used in the asset pricing analysis of the following section.

The regressors $\{w_{ij}\}$ in (1) represent the other characteristics of painting i. These include 151 dummy variables for the painting's artist, 19 medium/support dummies, and 35 auction house dummies (in all three cases, one dummy was omitted to avoid collinearity with the time period dummies; hence, 151 painter dummies corresponds to a set of 152 painters). Three additional variables reflecting a painting's dimensions – height, width, and surface area – were included. Equation (1) can be written more concisely as

$$p_i = x_i'\beta + u_i,\ i = 1, \ldots, n, \tag{2}$$

where $x_i' = (z_{i1}, \ldots, z_{iT}, w_{i1}, \ldots, w_{iJ})$ and $\beta = (\gamma_1, \ldots, \gamma_T, \alpha_1, \ldots, \alpha_J)'$. Note that we have $J = 208$ and $T = 66$ or $T = 33$ for semi-annual and annual dummies, respectively, giving us a dimension K for the parameter vector β of 274 or 241.

A note should be added on the interpretation of the dummy parameters. If we knew the time period dummies $\{\gamma_t\}_{t=1}^{T}$, we could compute the rate of return between, say, periods t and $t+1$ as follows:

$$r_{t+1} = \exp(\gamma_{t+1} - \gamma_t) - 1.$$

We can proceed similarly for the characteristic-related dummies. We will see below that the dummy for A.Y. Jackson was omitted from the regression (1), in other words it was arbitrarily set equal to zero. The dummy parameters α_j for each of the remaining painters can then be seen as reflecting their market values vis-à-vis Jackson. The percentage difference between the value of a work by painter j and a Jackson, controlling for all the other factors in our analysis, will be

$$\exp(\alpha_j) - 1.$$

The regression (1) and (2) can be, and usually is, estimated by ordinary least squares (OLS). Under the standard assumptions, OLS will be consistent and asymptotically normal and will be asymptotically efficient if the disturbances $\{u_i\}$ are normally distributed. An application of the Jarque-Bera (1980) normality test to our OLS residuals yielded an enormous statistic of 10,537 (the test has a chi-squared null distribution with two degrees of freedom), with an associated χ^2 (1) kurtosis statistic of 10,033. Hence, there is reason to suppose that a substantial efficiency loss is borne when the model is estimated by OLS, relative to maximum likelihood or to a robust estimator such as least absolute deviations. For our purposes, efficiency is a major concern. This is because our estimates of the time period dummies $\{\gamma_t\}_{t=1}^{T}$ and, more specifically, of the associated returns $\{r_t\}_{t=2}^{T}$, will be treated in our analysis of the following section as being observed series of prices and returns. Thus, these parameters should be estimated as precisely as possible. To this end, we estimate (2) adaptively, according to the procedure of Bickel (1982), designed to deliver asymptotically efficient estimates when the distribution function of the disturbances $\{u_i\}$ is unknown, and described in more detail in appendix A.

2.3. *Results*

The results of our estimation of the hedonic regression (1)–(2) are discussed here and reported in tables 1–3 and in appendix B.

2.3.1. Time series price index and estimated returns

In tables 1 and 2 are reported the semi-annual and annual dummy estimates, respectively. For each time period, we have provided the number of observations, with the estimated dummy parameter and its standard error, the estimated rate of return with standard error, and the real rate of return.[2] The returns are plotted in figures 1 and 2. Striking is the high volatility of the market, particularly prior to 1988, a phenomenon present in both data periodicities. Perhaps not merely coincidentally, the reduction in return volatility apparent in the late 1980s corresponds with a general increase in the number of observations. The latter is to an extent due to problems of data availability, particularly in the very early years of the period, but it probably also represents a general thickening and maturation of the Canadian art market in these years. The higher estimated volatility prior to 1988 may be partially due to imprecise

2 Computed using the CPI deflator, obtained from Bloomberg.

TABLE 1
Time period dummies and estimated returns (semi-annual)

Time period	Number Of Obs.	Log-price dummy	Std error	Estimated nominal return (%)	Std error	Estimated real return (%)
68:2	39	7.21	.092			
69:1	61	7.57	.075	43.19	15.97	40.12
69:2	57	7.81	.077	27.78	12.76	26.08
70:1	130	7.29	.055	−40.38	5.15	−41.64
70:2	68	7.22	.071	−7.47	7.52	−7.47
71:1	168	7.28	.054	6.46	8.55	3.98
71:2	120	7.44	.061	17.59	7.63	15.17
72:1	170	7.48	.053	4.37	6.80	2.80
72:2	155	7.45	.056	−2.90	5.85	−6.39
73:1	134	7.63	.058	19.08	7.61	14.59
73:2	132	7.63	.057	−0.10	6.65	−4.76
74:1	145	7.89	.055	30.21	8.52	23.70
74:2	132	7.95	.057	5.65	6.94	0.18
75:1	58	7.99	.076	4.44	9.07	−0.13
75:2	47	7.96	.084	−2.91	10.36	−7.58
76:1	138	7.80	.057	−14.89	7.97	−17.96
76:2	92	8.09	.065	34.29	9.89	31.59
77:1	114	8.03	.059	−6.10	7.18	−11.10
77:2	91	8.17	.064	15.21	8.80	10.94
78:1	137	8.24	.055	7.24	7.88	2.44
78:2	126	8.45	.056	22.37	8.21	18.93
79:1	120	8.61	.057	18.35	8.20	13.02
79:2	123	8.68	.057	7.31	7.52	3.10
80:1	131	9.04	.055	42.71	9.75	37.26
80:2	195	9.04	.048	−0.10	6.12	−5.46
81:1	225	9.23	.046	20.50	6.39	13.41
81:2	205	9.09	.048	−12.52	4.61	−17.28
82:1	189	8.74	.049	−29.47	3.87	−35.80
82:2	116	8.46	.058	−24.49	4.85	−27.24
83:1	124	8.45	.057	−1.15	6.95	−3.82
83:2	121	8.67	.057	24.26	8.62	22.39
84:1	115	8.53	.058	−13.06	6.13	−15.32
84:2	131	8.66	.055	14.22	7.91	12.83
85:1	208	8.74	.047	8.08	6.54	5.48
85:2	223	8.83	.046	9.31	5.73	7.58
86:1	252	8.71	.044	−11.31	4.42	−13.28
86:2	342	9.08	.042	46.29	6.63	44.10
87:1	337	8.95	.041	−13.12	3.64	−15.63
87:2	303	9.17	.043	24.48	5.34	22.88
88:1	420	9.22	.041	5.99	4.48	3.69
88:2	336	9.28	.041	6.15	4.36	4.49
89:1	356	9.26	.041	−2.40	4.03	−6.00
89:2	324	9.31	.042	5.15	4.42	3.58
90:1	325	9.24	.042	−6.51	4.00	−9.27
90:2	294	9.16	.043	−8.14	4.02	−10.29
91:1	187	9.04	.049	−10.62	4.60	−14.62
91:2	220	9.03	.047	−1.35	5.40	−1.15
92:1	218	8.99	.048	−3.71	5.17	−5.03
92:2	218	9.07	.047	8.65	5.80	7.85
93:1	179	8.94	.050	−12.35	4.82	−13.14

(Continued)

Table 1 *Concluded*

Time period	Number Of Obs.	Log-price dummy	Std error	Estimated nominal return (%)	Std error	Estimated real return (%)
93:2	177	8.95	.050	0.14	5.77	−0.74
94:1	183	9.20	.050	28.97	7.39	29.85
94:2	229	9.10	.046	−9.26	4.91	−10.35
95:1	235	8.91	.046	−17.36	4.17	−19.02
95:2	217	8.99	.048	7.92	5.59	7.83
96:1	233	8.96	.047	−3.07	4.98	−4.41
96:2	236	9.01	.046	5.09	5.34	4.24
97:1	221	9.05	.047	4.59	5.37	3.74
97:2	275	9.10	.044	4.94	5.23	5.03
98:1	254	9.06	.045	−3.95	4.58	−5.06
98:2	335	9.08	.042	2.15	4.68	2.24
99:1	225	9.07	.047	−1.26	4.67	−2.92
99:2	278	9.19	.045	13.03	5.51	12.13
00:1	251	9.27	.046	8.10	5.11	6.13
00:2	298	9.33	.043	6.65	4.97	6.24
01:1	322	9.27	.043	−6.16	4.11	−7.17

estimates resulting from sparser data – the estimation error is clearly higher in this period – but cannot be entirely, or even predominantly, ascribed to this cause. Rather, we would contend that the thinness and immaturity of the market, coupled with an atmosphere of general macroeconomic instability in Canada during these years, would provide more likely explanations. Deeper investigation of this issue is warranted. We can also see that grouping the data annually leads to substantial reductions in standard errors. Similarly, the standard errors reported here for the adaptive estimator are generally about 30% below the OLS standard errors (not reported), suggesting that our precision gains in using the adaptive estimator are not negligible.

Looking at the annual returns, we can see that the market value grew very rapidly during the 1970s, with an average annual return between 1971 and 1981 of over 21% in nominal terms and 13% in real terms. A deep dip in the early 1980s can probably be ascribed to the general recession of this period, but the market gradually recovered during the remainder of the decade, with a moderate dip in the early 1990s, probably also due to the macroeconomic slowdown of these years. The market was generally stable during the 1990s.

2.3.2. Painters

The 152 painters included in the study are identified in appendix B, with information on the number of works sold for each painter and the estimated regression dummy parameter and standard error. As mentioned above, one dummy variable, that representing A.Y. Jackson, was omitted to prevent collinearity with the time period dummies. Thus, each painter's dummy estimate can be interpreted as representing his/her market value vis-à-vis that of Jackson. In table 3, we provide results on the 'Top 25' Canadian painters, that

TABLE 2
Time period dummies and estimated returns (annual)

Time period	Number Of Obs.	Log-price dummy	Std error	Estimated nominal return (%)	Std error	Estimated real return (%)
68–69	100	7.43	.062			
69–70	187	7.47	.048	3.65	7.06	0.67
70–71	236	7.27	.047	−17.68	4.57	−20.16
71–72	290	7.48	.046	22.65	5.91	18.62
72–73	289	7.55	.047	7.14	4.88	−1.00
73–74	277	7.78	.046	26.16	5.85	14.69
74–75	190	7.97	.049	20.97	6.33	10.68
75–76	185	7.85	.051	−11.09	5.06	−18.97
76–77	206	8.07	.049	24.02	6.92	16.18
77–78	228	8.22	.047	16.82	6.20	7.54
78–79	246	8.53	.045	35.92	6.95	26.97
79–80	254	8.87	.044	40.44	6.93	30.55
80–81	420	9.14	.039	31.18	5.72	18.35
81–82	394	8.93	.040	−18.97	3.14	−30.34
82–83	240	8.46	.045	−37.59	2.82	−43.08
83–84	236	8.61	.046	15.67	5.82	11.48
84–85	339	8.71	.041	11.61	5.19	7.58
85–86	475	8.77	.038	5.84	4.16	2.10
86–87	679	9.02	.036	24.43	4.23	23.67
87–88	723	9.21	.036	20.30	3.63	16.37
88–89	692	9.28	.036	7.54	3.21	2.22
89–90	649	9.28	.036	0.43	3.02	−3.94
90–91	481	9.12	.038	−14.79	2.82	−21.02
91–92	438	9.02	.040	−9.68	3.43	−10.79
92–93	397	9.02	.040	0.13	3.86	−1.47
93–94	360	9.08	.041	5.92	4.25	5.92
94–95	464	9.02	.039	−6.22	3.64	−8.98
95–96	450	8.98	.040	−3.44	3.60	−4.88
96–97	457	9.04	.039	5.83	3.93	4.13
97–98	529	9.09	.038	5.18	3.72	4.16
98–99	560	9.08	.038	−0.34	3.35	−1.19
99–00	530	9.24	.039	16.64	3.91	13.75
00–01	620	9.31	.037	7.28	3.50	5.84

is, those with the 25 highest dummy point estimates, ranked in descending order. For each of these painters, we compute the percentage difference between the value of one of his/her works and a work of Jackson, controlling for the other variables included in the regression. In the following discussion of these results and of the artists, we will often rely on information provided by Reid (1973), without specific citation in each case.

When analysing table 3, a few considerations should be borne in mind. First, the ranking is not necessarily statistically significant. The reported standard errors allow us to infer the significance of the parameter estimate relative to A.Y. Jackson, but not relative to any of the other artists on the list. Secondly, the precision of these estimates varies widely by artist, depending on the number of observations available, the latter varying from a low of 1 for

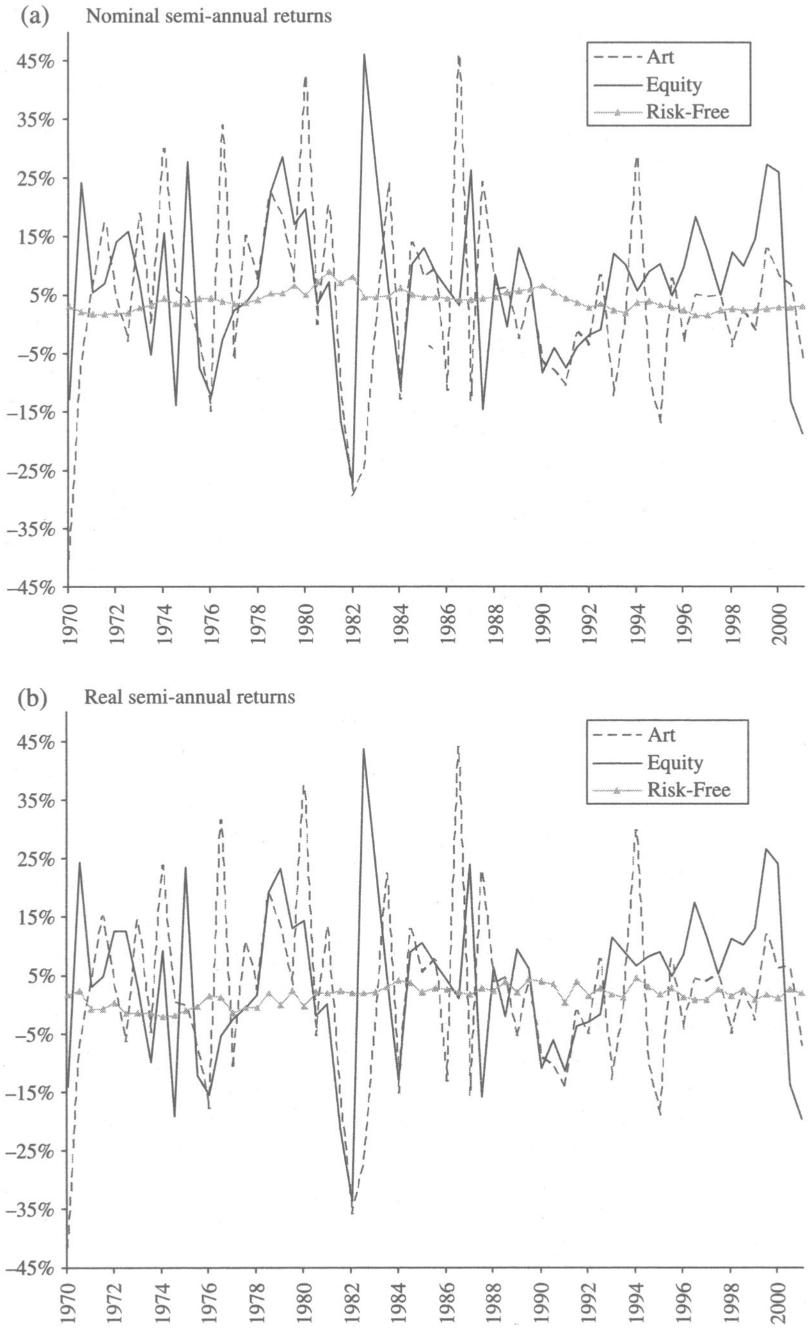

FIGURE 1 **A time series of semi-annual Canadian art price, equity, and risk-free returns from the period July 1970 through June 2001**

FIGURE 2 A time series of annual Canadian art price, equity, and risk-free returns from the period July 1970 through June 2001

TABLE 3
Dummy estimates for top 25 painters

Rank	Artist	No. obs.	Dummy estimate	Std Err.	% change rel. A.Y. Jackson	Std Err.
1	Tom Thomson	95	1.7381	.0578	468.68	32.90
2	William Berczy	2	1.2258	.3817	240.69	130.04
3	Frank Carmichael	68	1.1390	.0676	212.35	21.13
4	Cornelius Krieghoff	472	1.0400	.0311	182.92	8.81
5	James Duncan	2	0.9118	.3831	148.87	95.35
6	Lawren S. Harris	364	0.8866	.0329	142.68	7.99
7	J.W. Morrice	191	0.7704	.0427	116.07	9.23
8	David Milne	98	0.7502	.0579	111.74	12.26
9	Emily Carr	182	0.7177	.0489	104.98	10.01
10	Paul-Emile Borduas	56	0.6804	.0748	97.47	14.77
11	Christopher Pratt	3	0.5187	.3120	67.99	52.42
12	J.-B. Roy-Audy	1	0.3384	.5398	40.26	75.71
13	J.-P. Riopelle	150	0.3102	.0485	36.37	6.62
14	Fred Varley	121	0.2981	.0519	34.74	7.00
15	Paul Kane	7	0.1248	.2053	13.29	23.26
16	J.-P. Lemieux	142	0.1061	.0491	11.19	5.46
17	W.G.R. Hind	2	0.0984	.3827	10.34	42.22
18	A.J. Casson	579	0.0700	.0290	7.25	3.11
19	J.E.H. Macdonald	406	0.0672	.0326	6.95	3.49
20	Clarence Gagnon	234	0.0592	.0389	6.10	4.13
21	A.Y. Jackson	1246	–	–	0	0
22	Alex Colville	5	−0.0304	.2436	−2.99	23.63
23	Paul Peel	78	−0.1055	.0645	−10.01	5.80
24	Maurice Cullen	204	−0.1570	.0414	−14.53	3.54
25	Edwin Holgate	104	−0.2250	.0552	−20.15	4.41

Jean-Baptiste Roy-Audy to a maximum of 1246 for A.Y. Jackson. Thirdly, the hedonic regression estimates a reduced-form model in which no attempt is made to distinguish between supply and demand influences on price.

The painter by far the most highly valued in the Canadian art market is Tom Thomson (1877–1917). This is not surprising, since Thomson is considered by many to be Canada's greatest painter. He is credited as being the first painter to develop a characteristic national style, which responds in an intuitive manner to the country's rugged landscape. His work provided the impetus for the development of the Group of Seven, whose members included Frank Carmichael, Lawren S. Harris, Fred Varley, A.J. Casson, J.E.H. MacDonald, A.Y. Jackson, and Edwin Holgate.

Among the painters on our list for whom very few observations are available, many were early pioneers of Canadian art. In this category fall William Berczy (1744–1813), James Duncan (1806–81), Jean–Baptiste Roy-Audy (1778–c.1848), Paul Kane (1810–71), and W.G.R. Hind (1833–89). Aside from their inherent quality, these painters' works are valued for their historical interest and their scarcity, the latter factor highlighting the importance of distinguishing between supply and demand influences on the art market.

Most of the painters on our list are associated with one or another of the two major Canadian urban centres during the period when most of the artists considered here were active, viz., Montreal and Toronto. Thomson and the Group of Seven were mostly based in Toronto, and the lion's share of their paintings depict the rural wilderness of the province of Ontario. The regional aspect is worth stressing for a couple of reasons. First, Canada is large and sparsely populated, with regional identifications tending to be strong. Second, the existence of a dominant region such as Ontario can have an important impact, from a purely economic standpoint, on the style and content that is valued in the art market as a whole. In this context, it is worth citing the work of Valsan (2002), whose comparison of the markets for Canadian and American paintings finds a relation of the latter to the former analogous to the relation of Ontario to the rest of Canada noted here.

Nevertheless, a number of painters associated with the province of Quebec find their way onto our list. Aside from the aforementioned Duncan, one can cite the Group of Seven painters Jackson and Holgate, as well as Cornelius Krieghoff, James Wilson Morrice, Maurice Cullen, and the francophones Paul-Emile Borduas, Jean-Paul Riopelle, Jean-Paul Lemieux, and Clarence Gagnon. Setting aside the early figure of Roy-Audy, the most highly valued francophone artists are Borduas (1905–60) and Riopelle (1923–2002). This is not surprising, since these two represent the pillars of the fecund abstract and surrealist school that emerged in Montreal in the late 1940s and 1950s. What may initially seem surprising is the placement of Borduas ahead of Riopelle. After all, Riopelle is the most internationally well known Canadian painter, and the only one mentioned in Arnason's (1986) comprehensive survey of the history of modern art.

One can nevertheless posit several hypotheses to explain Borduas's higher market valuation. First, from the standpoint of Canadian art history, he is arguably of greater importance than Riopelle. Secondly, from a supply-side standpoint, his lifespan was over two decades shorter than that of Riopelle, and his paintings are therefore presumably harder to come by, a hypothesis consistent with the fact that, in our sample, there were three times as many Riopelles as Borduases sold at auction. There is a third potential explanation, perhaps more compelling than the first two. It derives from the structure and functioning of the post-war market for avante-garde art, as analysed and interpreted by Galenson (2000). In a study of American modern artists, Galenson (2000) finds that the function relating the auction value of an artist's work with the artist's age at the time of the execution of the work has a shape that depends heavily on whether the artist was born before or after 1920, that is, on whether or not the artist's professional career commenced before or after the mid-1940s. For artists born after 1920, the function is tilted more significantly in favour of paintings executed early in the artist's career. Galenson (2000) interprets this finding as reflecting changes that occurred in the American art world in the post-war era, with an emphasis among critics and collectors on craftsmanship gradually being replaced by one on formal innovation.

Galenson's (2000) conclusions are relevant to us because a comparison of the careers of Borduas (born in 1905) and Riopelle (born in 1923) conforms in large measure with his analysis. Borduas received a classical training and worked for many years as an assistant of the 'Old Master' Ozias Leduc. He was well into his thirties before turning to a modern idiom in painting, but once doing so, he continued to produce important, original, high-quality work until the very end of his life. Riopelle, on the other hand, came of age in the post-war avant-garde climate of abstract formal innovation, and his best-known works by a large margin are his abstract-expressionist canvases of the late 1940s and 1950s. The critical reputation of the works produced during the remaining four decades of his life is much lower than his early work. We therefore hypothesize that the overall lower market value of Riopelle's work relative to that of Borduas is due to a declining age profile in the former, with many low-priced late works more than compensating for the presence of some high-priced early works. A more complete and formal analysis of this hypothesis is left for future work.

2.3.3. Other factors

We do not report the parameter estimates for the remaining hedonic variables,[3] but briefly remark on some of the results. We found that medium and support can significantly affect price, with a large premium for oil on canvas. The identity of the auction house also has a large effect. In both cases, these variables are proxies for quality. Oils on canvas tend to be more finished and carefully worked than, for example, oils on board or panel, which are often quick preparatory sketches and are discounted relative to canvas by 30% and 25%, respectively. As for auction houses, certain ones are known to deal in works of relatively high quality, such as Sotheby's, which holds two auctions each year, whereas Empire (discounted by 26% relative to Sotheby's), for example, holds monthly auctions at each of its three locations and is presumably less discriminating in what it chooses to sell.

Regarding size, we find that greater height can add somewhat to the value of a painting, whereas width and surface area have negligible marginal effects. This could be because landscapes, usually of horizontal format, are in great supply on the market, which may lead to a scarcity-driven premium on compositions of vertical format.

3. Asset pricing tests

We conduct tests of the returns to our art index in the framework of the capital asset pricing model (CAPM) of Sharpe (1964) and Lintner (1965). The following equation demonstrates the main result of the CAPM, stating that the

3 Available on request from the authors.

expectation of the return on asset i, denoted as $R_{i,t}$, in excess of the return on a risk-free security, $R_{f,t}$, is a linear function of the expected excess return on the market portfolio, $R_{m,t}$:

$$E_{t-1}[R_{i,t}] - R_{ft} = E_{t-1}[R_{m,t} - R_{f,t}]\beta_{i,t}, \tag{3}$$

where

$$\beta_{i,t} = \frac{\text{cov}_{t-1}(R_{m,t}, R_{i,t})}{\text{var}_{t-1}(R_{m,t})}$$

is the conditional 'beta' for asset i in period t, and the subscripts on expectations and covariances indicate conditional moments. Assuming that no dynamics exist in the conditional expectations, (3) reduces to the unconditional CAPM

$$E[R_{i,t}] - R_{f,t} = E[R_{m,t} - R_{f,t}]\beta_i. \tag{4}$$

There is an extensive empirical literature on the unconditional CAPM, most of which has tested how well this model can explain stock returns, with important early work by Black, Jensen, and Scholes (1972) and Fama and MacBeth (1973).[4] However, the CAPM has been used as a model to explain the returns on other assets. For example Bryan (1985) uses it to perform asset pricing tests of art, while Gyourko and Nelling (1996) use it to analyse the performance of real estate investment trusts (REIT). In a similar fashion to these and other studies, we use the following empirical version of the unconditional CAPM:

$$r_t = \alpha + \beta r_{M,t} + e_t, \tag{5}$$

where r_t is the excess return on the art index in period t (return on the art index minus the yield on a risk-free security), $r_{M,t}$ is the excess market return, e_t is a disturbance, and α and β are parameters. The CAPM suggests that β measures how much of the return to a particular asset (in our case art) is priced as systematic risk, or the portion of returns that are generated by the asset's correlation to that of the market. A simple t-test of the parameter will test if any portion of the asset's return is systematic, that is, if $\beta = 0$.

If there is some component of returns that is not due to market risk exposure as measured by β, but is persistent, it will appear in the intercept, α. If the CAPM is the true model describing returns, $\alpha = 0$, whereas a finding that $\alpha \neq 0$ would signal average returns that cannot be explained by market risk. A t-test of $\alpha = 0$ will test the CAPM's ability to explain the returns of a particular asset. One could also test for the significance of additional regressors in (5). For example, in analyses of stock returns, Banz (1981) includes market size and Fama and French (1992, 1993) consider a firm's book value to market value ratio as well as size.

4 See Campbell, Lo, and MacKinlay (1997) for a more comprehensive discussion of empirical tests of the CAPM.

Alternative to the unconditional model, if we believe the dynamics in the conditional moments play an important role then our estimation and testing should allow for these moments to move over time. To do so we redefine the $\mathbf{r}_t$ (now bolded) as a vector that includes the excess return on the art index as its first element and the market portfolio as its second. We also define the conditional covariance matrix of $\mathbf{r}_t$ to be $\mathbf{H}_t$. This reformulation leads to the following return model for a single asset's return

$$E_{t-1}[r_{i,t}] = \varphi \frac{H_{i2,t}}{H_{22,t}}, \tag{6}$$

where φ is E_{t-1} $[r_{m,t}]$ and $H_{i2,t}$ corresponds to the off diagonal element of $\mathbf{H}_t$, or the conditional covariance of $r_{i,t}$ with $r_{m,t}$ or the market return.

Empirically, (6) can be written in the following manner:

$$\mathbf{r}_t = \boldsymbol{\alpha} + \frac{\varphi}{H_{22,t}} \mathbf{H}_{i,t} + \mathbf{e}_t \tag{7}$$

where $\boldsymbol{\alpha} = [\alpha \,|\, 0]$, $\mathbf{H}_{i,t}$ is a 2×1 vector with the covariance between asset i in the first element and the market variance in the second, and $\mathbf{e}_t$ is a vector of residuals. In order to arrive at a completely specified econometric model we must specify the form of our conditional covariance matrix $\mathbf{H}_t$ and our disturbance process $\{\mathbf{e}_t\}$. Perhaps the most popular parametric model of conditional covariances are of the generalized autoregressive conditional heteroscedasticity (GARCH) family. Models of this type were developed by Engle (1982) and Bollerslev (1987) with a vast literature of models and empirical applications. GARCH models of volatility have been shown to parsimoniously capture time-varying second moments. Our model draws heavily on that of Baba, Engle, Kraft, and Kroner (BEKK).[5] Our general model of conditional volatility will be the following modified version of the BEKK model:

$$\mathbf{H}_t = \mathbf{C}^T\mathbf{C} + \mathbf{A}^T\mathbf{e}_{t-1}\mathbf{e}_{t-1}^T\mathbf{A}, \tag{8}$$

where $\mathbf{C}$ and $\mathbf{A}$ are defined as

$$\mathbf{C} = \begin{bmatrix} c_{11} & 0 \\ c_{21} & c_{22} \end{bmatrix}$$
$$\mathbf{A} = \begin{bmatrix} a_{11} & 0 \\ a_{21} & a_{22} \end{bmatrix}$$

Hence, conditional covariances will have an unconditional component as measured by $\mathbf{C}$, and the dynamic component will allow last period's return

5 Named after a working paper referenced by Engle and Kroner (1995).

shock, $\mathbf{e}_t$, to influence the conditional covariance as measured by $\mathbf{A}$. We call our version an ARCH model because we only allow last period's shock to influence covariance, while the more general GARCH models include an autoregressive term in the conditional covariances. Given our model defined above, our parameter vector to estimate will have eight elements: α, φ, c_{11}, c_{12}, c_{22}, a_{11}, a_{12}, and a_{22}. Last, we will assume the distribution of the conditional residuals to be multivariate normal for the purposes of estimation.

3.1. Data and estimation

We make use of the art price index developed in the previous section to generate a series of art returns. We construct a series of 65 returns by calculating percent changes in the semi-annual (July–December and January–June) index data and a series of 32 returns using the annual (July–June) data.[6] To construct excess returns we subtract from our art returns the yield of a maturity-matched Canadian government bond, where yields are obtained from the Bank of Canada. For the semi-annual data, we use the yield on six-month to maturity bonds at months ending June and December. We use the yield on bonds with maturities ranging from one to three years for the annual data.[7]

Our measure of market returns is taken from Morgan Stanley Capital International's (MSCI) Canadian equity index. This is a broad-based Canadian equity index that includes capital gains as well as dividends on over 85% of the country's market capitalization. We construct returns to the market portfolio, $R_{m,t}$, as the percent change in this index from 1 July to 31 December and 1 January to 30 June for the semi-annual data and 1 July to 30 June for the annual data. We are only able to obtain data on the market index starting January 1969, so our semi-annual sample includes 63 observations and the annual sample includes 31 observations.

Summary statistics for the art index returns, risk-free rates, and market returns are found in table 4 and a plot of the semi-annual data is shown in figure 1. Table 4 and figure 2 report the results for the annual data. In table 4 we provide results for nominal returns in panel A and real returns (returns adjusted by percent change in the CPI index) in panel B. In general, our results are similar to those of earlier studies. For example, Mei and Moses (2002) find that during the last 50 years the annual return to art based on New York auctions was 8.2% with a standard deviation of 21%, while our studies find Canadian art returning 7.6% annually with a standard deviation of 17.3%. We find that Canadian market equity index returned 14.2% annually, with a

6 Preliminary fitting of an AR(1) model to the returns suggested little autocorrelation in the semi-annual series, with parameter estimate and standard error of −0.066 and 0.121, respectively. The AR parameter estimate in the annual series was greater, at 0.305, but was not significant, since the standard error was 0.179. The respective R^2 were 0.005 and 0.093.

7 These maturities are not identical to the art index return horizons but were the closest yields associated with maturities greater than or equal to one year.

TABLE 4
Summary Statistics

Panel A: Nominal returns

	Mean	Std Dev.	Min	Max	Correlations Art	Market	Risk-free
Semi-annual							
art index (R_t)	0.036	0.158	−0.404	0.463	1	0.20	−0.01
Market ($R_{M,t}$)	0.065	0.137	−0.273	0.462		1	−0.21
Risk-free ($R_{f,t}$)	0.040	0.016	0.016	0.089			1
Annual							
R_t	0.076	0.174	−0.376	0.404	1	0.03	0.13
$R_{M,t}$	0.142	0.245	−0.394	0.848		1	−0.16
$R_{f,t}$	0.082	0.032	0.033	0.170			1

Panel B: Real returns

	Mean	Std Dev	Min	Max	Correlations Art	Market	Risk-free
Semi-annual							
R_t	0.011	0.158	−0.416	0.441	1	0.21	−0.06
$R_{M,t}$	0.039	0.138	−0.336	0.434		1	−0.07
$R_{f,t}$	0.014	0.016	−0.020	0.046			1
Annual							
R_t	0.023	0.164	−0.431	0.306	1	0.02	−0.19
$R_{M,t}$	0.090	0.251	−0.507	0.793		1	0.02
$R_{f,t}$	0.030	0.029	−0.038	0.084			1

NOTES: This table provides summary statistics on art index returns, market returns, and risk-free rates for semi-annual and annual horizons over the period July 1970 through June 2001 measured in percentage points. Art index returns are constructed from the hedonic regressions. Market returns are the return of the value-weighted composite from the MSCI Canadian equity index including dividends. Risk-free rates are yield-to-maturities of bond with either six-month for panel A or one-year horizons for panel B, and are obtained from the Bank of Canada.

standard deviation of 24.5%. Our correlations show that, on both a semi-annual and an annual basis, art did provide diversification benefit to a portfolio of Canadian equities. This result is similar to that of Mei and Moses (2002) in the relationship between U.S. equities and art, but is in sharp contrast to Goetzmann's (1993) finding based on London art auctions and the London Stock Exchange index returns.

Results from estimating the CAPM on our two data sets are found in table 5.[8] For the unconditional CAPM, whose results are found in panel A, we find

8 We report our estimations of the CAPM using nominal returns. Estimations using real returns were similar to those reported and consequently were not reported.

TABLE 5
CAPM Estimations

Panel A: Unconditional CAPM

		α	β	R^2	J-B	GRS
Semi-annual	Est	−0.011	0.251	0.051	2.51	0.005
	SE	0.02	0.149		(0.28)	(0.94)
Annual	Est	−0.008	0.042	0.014	2.951	0.78
	SE	0.032	0.128		(0.22)	(0.38)

Panel B: Conditional CAPM

		a	ψ	c_1	c_2	c_3	a_1	a_2	a_3
Semi-Annual	Est	−0.003	0.029	0.150	0.025	0.137	−0.038	0.042	−0.010
	SE	0.019	0.018	0.013	0.018	0.012	0.048	0.055	0.053

NOTES: This table includes estimated coefficients (Est) and standard errors (SE) of coefficients from estimation of two different CAPMs using both semi-annual and annual Canadian art index returns. In panel A, an unconditional CAPM is estimated using the following model: $r_t = a + \beta r_{m,t} + u_t$, where r_t is the excess return on the art index and $r_{m,t}$ is the excess return on the MSCI Canadian equity index return. Standard errors in this panel are computed using Newey and West (1987) correction for the presence of heteroscedasticity and serial correlation. In this panel we also report the R^2, Jarque-Bera (J-B) normality test on the residual of the regression, and the Gibbons, Ross, and Shanken (1989) (GRS) market efficiency test statistic (p-value below in parenthesis). In panel B, we report the estimated coefficients and standard errors of the following conditional CAPM on the semi-annual data: $r_t = \alpha + (\psi/H_{22,t})\ H_{1,t} + u_t$ with the following conditional variance parameterization: $H_t = C^T C + A^T u_{t-1} u_{t-1}^T A$. Standard errors in this panel are computed by taking the inverse of the Hessian.

that art has less systematic risk than the market, as evidenced by our estimates of β being less than one (0.042 for the annual data, and 0.251 for the semi-annual data). The β estimated on the semi-annual returns is statistically significantly different from zero at the 10% level, but the standard error on the annual β is too large to admit statistical significance. These results also are in contrast with findings of Goetzman (1993), who estimates that the β for the London art returns lies above 1 with strong statistical significance. Again, our results support the notion that portfolios of Canadian art pieces would have provided a strong diversification benefit to Canadian equity holders over the past 30 years given the low correlation between the two series and the similar average returns and risks of both art and equities. The small absolute values of the point estimates of α and their respective standard errors suggest that we fail to reject the unconditional CAPM. Caution again must be used in this interpretation of the coefficients and asymptotic t-tests, given the small data sets we use in our estimations. Consequently, we construct tests of market efficiency as found in Gibbons, Ross, and Shanken (1989) using the following formula:

$$\text{GRS} = (T-1)\left[1+\frac{\hat{\mu}_M}{\hat{\sigma}^2_M}\right]^{-1}\frac{\hat{\alpha}^2}{\hat{\sigma}^2_u}.$$
$$\sim F_{1,T-2}.$$

This test of market efficiency has an exact finite sample distribution under the assumption of normality, and given that our sample sizes are small, this test may provide better market efficiency tests than asymptotic t-tests. Panel A provides Jarque-Bera normality tests of the residuals from the unconditional CAPM regressions and indicates that normality appears to be a reasonable assumption. In the final column of panel A, the Gibbons, Ross, and Shanken (1989) statistics, denoted GRS, and their associated p-values indicate that we cannot reject the notion that our art index return behaviour is described by an unconditional CAPM.

A finding of $\alpha = 0$ can have a number of possible interpretations. The one posited above is that returns to the art market are adequately captured by the CAPM, and that only systematic risk is important for returns in this market. A second possibility is that there are returns not related to systematic risk, but that they are offset by the costs associated with art ownership (costs referred to earlier but that we have not explicitly attempted to measure). Among the pecuniary and non-pecuniary returns associated with art ownership that we have also not attempted to measure are the fees that may be obtainable through loans to gallery or museum exhibitions or through reproduction rights and the direct utility afforded by a picture to its owner. Another way of looking at it is in considering that, under the maintained hypothesis that the CAPM holds, the unmeasured costs and benefits of holding art referred to here balance one another exactly (since under the CAPM, any such imbalance would result in a non-zero α, positive if costs outweigh benefits and negative otherwise).

Estimation of the conditional CAPM using the semi-annual data, found in panel B of table 5, yields similar conclusions. The estimated α is both economically and statistically insignificant, suggesting that the conditional CAPM cannot be rejected by the data. An estimated value of .029 for φ is consistent with an annual equity premium of 5.9%, which is roughly equivalent to U.S. equity premiums estimated using stock market data over the same horizon. We do find that allowing second moments to move over time in an ARCH model adds little to the model. Specifically, the coefficients in the **C** matrix, which represent the unconditional portion of conditional covariances, are statistically significant, while the coefficients in the **A** matrix, which represent the conditional or time-varying portion of conditional covariances, are not significant. The insignificance of the time-varying nature of the conditional covariances is partially caused by our small data set and partially driven by the length of our returns. Most ARCH and GARCH modelling uses data of a higher frequency (daily, weekly, or monthly), and most research finds that the higher the frequency the richer the dynamics of second moments. Using semi-annual data, a low frequency of returns may cloud our ability to capture the dynamics of second moments. We also intend to further investigate the ability of general asset pricing models (consumption CAPM, multivariate factor models) to explain the movement of art returns, given the conditional CAPM results as well as the low R^2 and marginal significance of systematic risk in the unconditional estimations.

4. Conclusions

Among the contributions of this study can be enumerated the facts that it is the first comprehensive econometric analysis of pricing and returns in the auction market for Canadian paintings, the first paper in the art pricing literature to adaptively estimate a hedonic regression (a fact that may also be of interest to econometricians working in the field of semi-parametric methods), and among the few to estimate a conditional capital asset pricing model for art returns. In estimating a hedonic regression for art prices over the period 1968–2001, we obtain estimated time series of prices and returns in the market, and a ranking of the top Canadian painters according to their individual market valuations. We feel that both sets of results may be of intrinsic interest to anyone interested in Canadian art.

In addition, we use the estimated returns to estimate and test unconditional and conditional versions of the capital asset pricing model. Our results here represent a contribution to the related literature that has the virtue of representing relatively 'independent' new evidence on these questions, since most previous work has been focused on European and American art. Our results are generally in line with the 'stylized facts' in the literature, viz. that art returns are generally lower than stock returns, although they are similarly variable, and that their betas with respect to the latter are small and positive. We find that extending the basic CAPM to a conditional model adds little to the analysis.

A number of extensions of this work are contemplated for future research. As mentioned above, considering returns at a more disaggregated level and possibly analysing individual artists are worth investigation, subject to sample size constraints. Also, an analysis of valuation as a function of an artist's age, along the lines of Galenson (2000) and as outlined in the text for the examples of Riopelle and Borduas, may be of interest.

Our analysis of returns has been carried out within the context of the simplest version of the CAPM and conditional CAPM models. It may also be of interest to consider more complicated multi-factor models, possibly including as factors measures of real economic activity and aggregate wealth (Macklem 1997), and perhaps more interestingly, measures of international art market movements. In particular, how closely do art price trends for Canadian art mimic those for American and European art? This line of analysis will also be subject to serious data constraints, however, since basic degrees-of-freedom considerations will limit the number of variables that can be included in any one model.

Appendix A: Bickel's (1982) adaptive estimator

The estimator is efficient under the assumption that the disturbances are independent and identically distributed (iid) with a density function $f(u)$ that is symmetric, so that $f(u)=f(-u)$. Using the OLS estimator $\widehat{\beta}$, compute the associated residuals $\widehat{u}_i = p_i - x_i'\widehat{\beta}$, $i = 1, \ldots, n$. For each residual $\widehat{u}_i$, $i = 1, \ldots, n$, one can use the remaining residuals to compute a kernel estimate of the level of the density f evaluated at $\widehat{u}_i$ as follows:

$$\widehat{f}_i(\widehat{u}_i) = \frac{1}{2(n-1)} \sum_{\substack{j=1,\\ j\neq i}}^{n} \left\{ K\left(\frac{\widehat{u}_i + \widehat{u}_j}{h_n}\right) + K\left(\frac{\widehat{u}_i - \widehat{u}_j}{h_n}\right) \right\},$$

where $K(\bullet)$ is a user-specified kernel weighting function and h_n is a user-specified bandwidth parameter that satisfies the asymptotic condition $h_n \to 0$ as $n \to \infty$.[9] We will also require the following estimate of the first derivative of f:

$$\widehat{f}_i'(\widehat{u}_i) = \frac{1}{h_n 2(n-1)} \sum_{\substack{j=1,\\ j\neq i}}^{n} \left\{ K'\left(\frac{\widehat{u}_i + \widehat{u}_j}{h_n}\right) + K'\left(\frac{\widehat{u}_i - \widehat{u}_j}{h_n}\right) \right\}.$$

We then have the estimated (negative of the) score of f, evaluated at $\widehat{u}_i$:

$$\widehat{\psi}_i(\widehat{u}_i) = \frac{\widehat{f}_i'(\widehat{u}_i)}{\widehat{f}_i(\widehat{u}_i)},$$

where some trimming conditions may need to be specified in the computation of $\widehat{\psi}_i$, depending on the kernel employed.[10]

The sample score vector and information matrix of the likelihood function can be approximated, respectively, by the following semiparametric estimators:

$$\widehat{S}_n = -n^{-1} \sum_{i=1}^{n} x_i \widehat{\psi}_i(\widehat{u}_i)$$

and

9 See Silverman (1986) for a good introduction to the topic of non-parametric density estimation.

10 We use a normal kernel with the rule-of-thumb bandwidth of Silverman (1986). Although trimming is theoretically required to calculate $\widehat{\psi}_i$, we elect not to trim, owing to the large size of our sample (Monte Carlo evidence prevented by Hsieh and Manski 1987 and Hodgson 1998, 1999 show that adaptive estimators with normal kernels behave well with very little trimming for sample sizes in the 100–200 range).

$$\widehat{\mathcal{I}}_n = \widehat{\Omega} n^{-1} \sum_{i=1}^{n} x_i x_i',$$

where $\widehat{\Omega} = n^{-1} \sum_{i=1}^{n} \widehat{\psi}_i(\widehat{u}_i)^2$. The adaptive estimator $\widetilde{\beta}$ is then computed using the following one-step Newton-style adjustment of the OLS estimator $\widehat{\beta}$:

$$\widetilde{\beta} = \widehat{\beta} + \widehat{\mathcal{I}}_n^{-1} \widehat{S}_n.$$

Under conditions specified by Bickel (1982), $\widetilde{\beta}$ will be consistent and asymptotically normal,

$$\sqrt{n}\left(\widetilde{\beta} - \beta\right) d \rightarrow^{d} N(0, \mathcal{I}^{-1}),$$

where the asymptotic covariance matrix $\mathcal{I}^{-1}$ is consistently estimated by $\widehat{\mathcal{I}}_n^{-1}$.

Appendix B: Painters

The following is a list of all 152 painters included in our study, in alphabetical order. The three numbers given in parentheses for each artist represent, respectively, the number of observations, the dummy parameter estimate for the painter, and the associated standard error:

William Armstrong (10, −2.5288, 0.1719); William E. Atkinson (10, −2.9040, 0.0669); Marcel Barbeau (28, −2.8138, 0.1058); Maxwell Bates (169, −1.9513, 0.0528); William Beatty (350, −1.5475, 0.0333); Henri Beau (84, −2.0644, 0.0625); Frederic Marlett Bell-Smith (237, −1.5492, 0.0396); Louis Belzile (21, minus;3.5003, 0.1202); Aleksandre Bercovitch (20, −3.2828, 0.1228); William Berczy (2, 1.2258, 0.3817); George Theodore Berthon (4, −2.3420, 0.2708); B.C. Binning (16, −1.0550, 0.1429); Ronald Bloore (7, −2.5194, 0.2093); Paul-Emile Borduas (56, 0.6804, 0.0748); Joseph Bouchette (3, −3.9160, 0.3130); Fritz Brandtner (41, −1.8293, 0.0874); Miller Brittain (4, −2.1444, 0.2835); Bertram Brooker (33, −1.9075, 0.0958); Archibald Browne (115, −3.1804, 0.0534); Franklin Brownell (102, −1.7625, 0.0570); William Blair Bruce (23, −1.9855, 0.1143); William Brymner (107, −1.5099, 0.0550); Dennis Burton (14, −3.2367, 0.1463); Jack Bush (35, −1.3777, 0.0937); Oscar Cahen (3, −1.5984, 0.3170); Frank Carmichael (68, 1.1390, 0.0676); Emily Carr (182, 0.7177, 0.0489); A.J. Casson (579, 0.0700, 0.0290); Jack Chambers (2, −0.9730, 0.3843); W.H. Clapp (43, −1.8069, 0.0844); Paraskeva Clark (34, −2.1551, 0.0945); Alex Colville (5, −0.0304, 0.2436); Charles Comfort (105, −1.5519, 0.0553); Stanley Cosgrove (709, −1.1038, 0.0275); Graham Coughtry (5, −3.1163, 0.2452); William Cresswell (25, −2.0739, 0.1097); Maurice Cullen (204, −0.1570, 0.0414); Jean Dallaire (54, −0.7721, 0.0760); Rodolphe de Repentigny (8, −1.0488, 0.1930); James Duncan (2, 0.9118, 0.3831); Wyatt Eaton (5, −1.7262, 0.2431); Allan Edson (70, −2.0339, 0.0674); Marcelle Ferron (63, −2.2649, 0.0731); Lemoine Fitzgerald (63, −0.7250, 0.0712); Tom Forrestall (15, −1.6062, 0.1973);

Daniel Fowler (1, −2.0596, 0.5422); Joseph Franchere (108, −2.1790, 0.0558); John A. Fraser (10, −1.6450, 0.1718); Louise Gadbois (117, −3.5359, 0.0600); Charles Gagnon (2, −0.9240, 0.3826); Clarence Gagnon (234, 0.0592, 0.0389); Pierre Gauvreau (15, −1.2929, 0.1418); Charles Gill (22, −2.8866, 0.1172); Eric Goldberg (36, −2.5217, 0.0922); Hortense Gordon (24, −2.7891, 0.1125); Richard Gorman (6, −3.1351, 0.2227); Theophile Hamel (11, −1.3427, 0.1647); Lawren P. Harris (5, −2.3675, 0.2421); Lawren S. Harris (364, 0.8866, 0.0329); Robert Harris (127, −1.7755, 0.0512); Prudence Heward (40, −2.0050, 0.0869); Randolph Hewton (123, −1.7887, 0.0590); William G.R. Hind (2, 0.0984, 0.3827); Tom Hodgson (11, −3.1535, 0.1664); Edwin Holgate (104, −0.2250, 0.0552); William R. Hope (4, −3.4231, 0.2705); Yvonne McKague Housser (86, −2.1649, 0.0613); Jack Humphrey (38, −1.7479, 0.0936); Charles Huot (44, −1.9976, 0.0843); Jacques Hurtubise (7, −2.1691, 0.2056); Gershon Iskowitz (17, −2.1881, 0.1335); A.Y. Jackson (1246, 0, 0); Otto Jacobi (102, −1.8244, 0.0565); C.W. Jeffreys (12,−1.5110, 0.1574); Jean-Paul Jerome (28, −3.4884, 0.1048); Frank Johnston (701,−0.8889, 0.0273); Paul Kane (7, 0.1248, 0.2053); Roy Kiyooka (1,−3.8628, 0.5407); Dorothy Knowles (43, −2.0714, 0.0861); Cornelius Krieghoff (472, 1.0400, 0.0311); Ludger Larose (24, −2.5270, 0.1129); Fernand Leduc (4,−1.1838, 0.2705); Ozias Leduc (41, −0.6804, 0.0866); Joseph Legare (8, −1.2237, 0.1919); Jean-Paul Lemieux (142, 0.1061, 0.0491); Ernst Lindner (8, −1.4078, 0.1924); Arthur Lismer (429, −0.3445, 0.0307); Kenneth Locchead (8, −1.9923, 0.1927); Alexandra Luke (2, −1.9796, 0.3824); John Lyman (77, −1.2186, 0.0641); J.E.H. MacDonald (406, 0.0672, 0.0326); Jock MacDonald (38, −1.0214, 0.0899); Thomas Mower Martin (264, −2.3458, 0.0382); Marmaduke Matthews (21,−2.4633, 0.1199); Jean McEwen (72, −2.3342, 0.0706); Isabel McLaughlin (11,−2.5150, 0.1639); Ray Mead (7, −2.4424, 0.2066); John Meredith (14, −2.2113, 0.1462); David Milne (98, 0.7502, 0.0579); Guido Molinari (6, −1.8016, 0.2254); James Wilson Morrice (191, 0.7704, 0.0427); Edmund Morris (40,−2.3422, 0.0874); Jean-Paul Mousseau (6, −2.7993, 0.2212); Louis Muhlstock (51,−2.7717, 0.0785); Kazuo Nakamura (27, −2.2942, 0.1059); H. Ivan Neilson (4,−3.2622, 0.2706); Lilias Torrance Newton (8, −2.7501, 0.1924); Jack Nichols (2,−3.0500, 0.3823); John O'Brien (3, −1.2969, 0.3121); Lucius R. O'Brien (24,−1.3425, 0.1122); Will Ogilvie (22, −2.7436, 0.1194); Paul Peel (78, −0.1055, 0.0645); Alfred Pellan (64, −0.9243, 0.0708); Sophie Pemberton (12, −2.5541, 0.1591); Antoine Plamondon (8, −1.8052, 0.1923); Christopher Pratt (3, 0.5187, 0.3120); William Raphael (80, −1.6400, 0.0631); Gordon Rayner (2, −4.3117, 0.3854); George Reid (90,−2.3449, 0.0603); Jean-Paul Riopelle (150, 0.3102, 0.0485); Goodridge Roberts (609,−0.6468, 0.0292); Sarah Robertson (37,−1.7654, 0.0912); William Ronald (38, −2.8152, 0.0924); Jean-Baptiste Roy-Audy (1, 0.3384, 0.5398); Joseph Saint-Charles (40, −2.9836, 0.0887); Henry Sandham (50, −2.2059, 0.0786); Carl Schaefer (27, −1.0083, 0.1056); Charles H. Scott (21, −2.7520, 0.1211); Marian Scott (18, −3.4891, 0.1292); Jack Shadbolt (67, −1.5123, 0.0712); Gordon A. Smith (75, −2.4670, 0.0687); Jori Smith (69, −2.7141, 0.0686); Michael Snow (1,−3.1115, 0.5407); Francoise Sullivan (1, −3.5141, 0.5400); Philip Surrey (97,−1.4724, 0.0580); Marc-Aurele de Foy Suzor-Cote (236, −0.4487, 0.0392); Tom Thomson (95, 1.7381, 0.0578); Robert Todd (3, −1.6705, 0.3123); Fernand Toupin (43, −3.0129, 0.0897); Harold Town (41, −2.2172, 0.0897); Tony Urquhart (10,−2.5434, 0.1719); Fred Varley (121, 0.2981, 0.0519); Frederick Arthur Verner (97,−0.3233, 0.0583); Adolph Vogt (8, −1.8144, 0.1922); Horatio Walker (79, −1.1572, 0.0633); Homer Watson (248, −1.2998, 0.0389); Gordon Webber (3, −3.0030, 0.3132); W.P. Weston (93, −1.1653, 0.0620); Robert Reginald Whale (39, −2.1395, 0.0897); Joyce Wieland (1, −2.6118, 0.5401); Curtis Williamson (36, −3.0842, 0.0920); Walter Yarwood (7, −2.4214, 0.2056)

References

Arnason, H.H. (1986) *History of Modern Art*, 3rd ed. (Englewood Cliffs, NJ: Prentice-Hall)

Banz, R. (1981) 'The relation between return and market value of common stocks,' *Journal of Financial Economics* 9, 3–18

Baumol, W.J. (1986) 'Unnatural value: or art investment as floating crap game,' *American Economic Review* 76, 10–14

Bryan, M. (1985) 'Beauty and the bulls: the investment characteristics of paintings,' *Economic Review of the Federal Reserve Bank of Cleveland* 1, 2–10

Campbell, H. (1973–75) *Canadian Art Auction Record 1971–1974*, vols 3–6 (Montreal: Bernard Amtmann)

Campbell, H., ed. (1980) *Canadian Art Auctions, Sales and Prices, 1976–1978* (Don Mills, ON: General)

Campbell, J., W. Lo, and A.C. MacKinlay (1997) *The Econometrics of Financial Markets* (Princeton, NJ: Princeton University Press)

Caves, R.E. (2000) *Creative Industries: Contracts between Art and Commerce*. (Cambridge, MA: Harvard University Press)

Chanel, O., L.A. Gérad-Varet, and V. Ginsburgh (1996) 'The relevance of hedonic price indexes: the case of paintings,' *Journal of Cultural Economics* 20, 1–24

Czujack, C. (1997) 'Picasso paintings at auction, 1963–1994,' *Journal of Cultural Economics* 21, 229–47

Engle, R. (1982) 'Autoregressive conditional heteroskedasticity with estimates of the variance of UK inflation,' *Econometrica* 50, 987–1008

Engle, R., and K. Kroner (1995) 'Multivariate simultaneous generalized ARCH,' *Econometric Theory* 11, 122–50

Fama, E., and K. French (1992) 'The cross-section of expected returns,' *Journal of Finance* 47, 427–65

Fama, E., and K. French (1993) 'Common risk factors in he returns on stocks and bonds,' *Journal of Financial Economics* 33, 3–56

Fama, E., and J. MacBeth (1973) 'Risk, return, and equilibrium: empirical tests,' *Journal of Political Economy* 71, 607–36

Flôres, R., V. Ginsburgh, and P. Jeanfils (1999) 'Long- and short-term portfolio choices of paintings,' *Journal of Cultural Economics* 23, 193–210

Galenson, D.W. (2000) 'The careers of modern artists: evidence from auctions of contemporary art,' *Journal of Cultural Economics* 24, 87–112

Gibbons, M., S. Ross, and J. Shanken (1989) 'A test of the efficiency of a given portfolio,' *Econometrica* 57, 1121–52

Goetzman, W.N. (1993) 'Accounting for taste: art and the financial markets over three centuries,' *American Economic Review* 83, 1370–76
Grampp, W.D. (1989) *Pricing the Priceless* (New York: Basic Books)
Gyourko, J., and E. Nelling (1996) 'Systematic risk and diversification in the equity REIT market,' *AREUEA Journal* 24, 493–515
Hodgson, D.J. (1998) 'Adaptive estimation of cointegrating regressions with ARMA errors,' *Journal of Econometrics* 85, 231–267
— (1999) 'Adaptive estimation of cointegrated models: Simulation evidence and an application to the forward exchange market,' *Journal of Applied Econometrics* 14, 627–50
Hsieh, D.A., and C.F. Manski (1987) 'Monte Carlo evidence on adaptive maximum likelihood estimation of a regression,' *Annals of Statistics* 15, 541–51
Jarque, C.M., and A.K. Bera (1980) 'Efficient tests for normality, homoskedasticity, and serial independence of regression residuals,' *Economics Letters* 6, 255–9
Lintner, J. (1965) 'The valuation of risky assets and the selection of risky investments in stock portfolios and capital budgets,' *Review of Economics and Statistics* 47, 13–37
Locatelli-Biey, M., and R. Zanola (2002) 'The sculpture market: an adjacent year regression index,' *Journal of Cultural Economics* 26, 65–78
Macklem, T. (1997) 'Aggregate wealth in Canada,' *Canadian Journal of Economics* 30, 152–68
Mei, M., and M. Moses (2002) 'Art as an investment and the underperformance of masterpieces,' *American Economic Review* 92, 1656–68
Newey, W., and K. West (1987) 'A simple positive semi-definite heteroscedasticity and autocorrelation consistent covariance matrix,' *Econometrica* 55, 703–8
Pesando, J.E. (1993) 'Art as an investment: the market for modern prints,' *American Economic Review* 83, 1075–89
Pesando, J.E., and P.M. Shum (1999) 'The returns to Picasso's prints and to traditional financial assets, 1977 to 1996,' *Journal of Cultural Economics* 23, 183–92
Reid, D. (1973) *A Concise History of Canadian Painting* (Toronto: Oxford University Press)
Reitlinger, G. (1961) *The Economics of Taste* (London: Barrie and Rockcliff)
Sharpe, W. (1964) 'Capital asset prices: a theory of market equilibrium under conditions of risk,' *Journal of Finance* 19, 425–442
Silverman, B. (1986) *Density Estimation for Statistics and Data Analysis* (London: Chapman and Hill)
Sotheby's (1975) *Canadian Art at Auction, 1968–1975* (Toronto: Sotheby's & Co. Canada)
— (1980) *Canadian Art at Auction, 1975–1980* (Toronto: Sotheby's Parke Bernet Canada)
Stein, J.P. (1977) 'The monetary appreciation of paintings,' *Journal of Political Economy* 85, 1021–35
Valsan, C. (2002) 'Canadian versus American art: what pays off and why,' *Journal of Cultural Economics* 26, 203–216
Westbridge, A.R. (1981–2002) *Canadian Art Sales Index, 1977–2001* (Vancouver: Westbridge)