

AGE-PRICE PROFILES FOR CANADIAN PAINTERS AT AUCTION

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Abstract

We conduct an empirical analysis of the effect on the auction price of a Canadian painting of the age of the painter at the time of creation of the painting. We consider several hundred artists, active over the entire history of Canadian art, who are pooled in the estimation of a hedonic regression in which a polynomial function in age enters as a regressor along with several other control variables. We then consider the possibility that the age-price relationship has changed over time by : (a) estimating separate age-price functions for three generational groups of artists - those born before 1880, between 1880 and 1920, and after 1920 and thus coming of age in the world of post-war “contemporary art” ; and (b) estimating a parameterization where the shape of the age-price profile is permitted to change continuously depending on the year of birth of the artist. Our principal result is that artists born more recently tend to “peak” earlier in their careers than those of previous generations. As pertaining to artists born after 1920, this result is consistent with the findings of Galenson (2000) for modern American painters, but we find that the phenomenon applies over longer periods of art history, and propose an interpretation based on demand-side changes in art markets brought about by economic and urban population growth.

1. INTRODUCTION

It is agreed among observers of art markets that the price commanded by the painting of a given artist can be highly dependent on the age of the artist at the time of creation of the work, and that the relation between age and price can vary across artists. Working with auction data, one can econometrically estimate the relation, using a hedonic regression in which other observable characteristics of the painting (such as size, genre, etc.) are controlled for. Conceptually, the results of such an analysis can be interpreted within the context of the age-productivity (or experience-productivity) model commonly estimated by labour economists (Mincer (1974)).

This line of enquiry is most closely associated with David Galenson, who, sometimes with co-authors, has undertaken several studies in which age-price profiles are estimated for major artists (see, for example, Galenson (2000, 2001) and Galenson and Weinberg (2000, 2001)). A related study for the individual case of Picasso is due to Czujack (1997), who found that the most highly valued Picassos at auction tend to be those from the Blue, Rose, and Cubist periods (1902-1915), while the least valuable are those produced after 1944.

The principal focus of the work of Galenson (2000, 2001) and Galenson and Weinberg (2000, 2001) is the possible existence of, and explanations for, changes in age-price profiles for different cohorts whose careers overlap during periods of particular art historical importance. Two examples of such periods are studied – nineteenth and early twentieth century Paris, and post-war New York City. In Paris, art historians describe a revolution in which the prevailing impressionist and post-impressionist styles, associated with such artists as Manet, Cézanne, Monet, and Gauguin, gave way to the fast-moving diversity of styles known as early modernism, as represented by, for example, Matisse, Dufy, Picasso, and Miro. The second period saw the birth of the contemporary New York “Art World”, where an earlier generation of abstract expressionists, including Philip Guston, Jackson Pollock, and Barnett Newman, were succeeded by a cohort characterized by a quickly-evolving diversity of styles, represented by painters such as Joan Mitchell, Andy Warhol, Sol LeWitt, and Philip Pearlstein.

The basic findings in these studies are that, in both historical periods, earlier generations are characterized by an age-price profile well to the right of that of younger generations, that is to say, that the members of earlier generations tend, on average, to “peak” later in their careers than do younger painters. These econometric results are obtained from the estimation of hedonic regressions which include polynomials in painters’ ages. Galenson (2000, 2001) and Galenson and Weinberg (2000, 2001) find that these results, obtained from auction prices, are consistent with the judgements of art historians as measured by the age distribution of pictures illustrated in art history textbooks for different artists.

In their interpretations of these empirical findings, Galenson et al devote most of their attention to the implications for the nature of artistic creativity exhibited by members of the different generations – in particular, that fundamental changes in the nature of art works being produced have occurred, favouring those artists who are disposed to problem solving and rapid innovation over those who produce in a more workmanlike or experimental fashion. This interpretation has attracted considerable attention in the intellectual community, many of it from non-economists, and not all of it favourable. Among economists, Galenson et al have been criticized for an analysis which is too one-sided, or “supply-side”, and which pays insufficient attention to various other explanatory factors, especially those associated with the “demand side” of the market (see, for example, Ginsburgh and Weyers (2006)).

It is not true that Galenson et al are unaware or neglectful of the importance of changes in demand in bringing about the observed changes in the age-price relationship. In Galenson and Weinberg’s (2000, p. 765) study of New York based painters, we read about the importance of a growing cadre of “pioneering galleries devoted to selling contemporary American art”, of the rise of influential young art critics such as Clement Greenberg, phenomena which helped stimulate a previously weak demand for the work of modern American painters. We also find a quotation from William Rubin, who noted that “by 1958...the art-buying public had become convinced that Americans could produce major painting...this work could be sold at prices that made an artist’s profession economically feasible”.

It is true, however, that in choosing to focus on the supply-side of the art market, much of potential interest to economists regarding the demand for fine art has been left unexamined. One could indeed argue that demand-side factors are of determining importance, and that the

arts, by their very nature, require a sufficiently large and affluent urban population in order to flourish. The existence of a critical mass of potential collectors with the wealth and leisure to devote considerable time and resources to art appreciation is necessary (if not sufficient) to support the critical mass of artists required for the existence of an “art scene” in which the interesting and fruitful development of original styles is possible. With growing income and urbanization, the conditions are present for the development of a demand for art; as galleries arise to market the art, and a growing number of young individuals are in a position to seriously entertain art as a career, the resulting thickening of the art market leads to competition on the supply side, in which innovation and novelty are factors by which an artist can become noticed. Collectors will turn to critics and other ‘experts’ to help identify the most promising artists. The more rapid the growth in the urban population and its wealth, the greater will be the increase in demand for fine art, the greater will be the entry of young artists into the market, and the more competition there will be among them to get a piece of the pie. The result is that the quantity of production among younger artists will increase, as will the likely quality, as the new artists jockey for the attention of the market. The growth in demand for artists will be associated with an expansion of training institutions such as art academies and university art departments, and the training of artists will be more concentrated in time, as the arts become more highly professionalized both in formation and practice, and artists seek to enter the market and capitalize on their training and talent with the minimum delay.

These remarks are not meant to provide a fully-articulated model of the art market; indeed, satisfying theoretical and empirical models of supply and demand for paintings are currently lacking in the literature. However, the importance of urban centres to the history of art is being studied (see, for example, Kelly and O’Hagan (2007)), and we can suggest as an important underlying cause of the phenomena identified by Galenson et al rapid economic and urban growth in the cities studied. In the American context, it would be of interest to learn if the shift to the left of the age-price profile was a one-time post-war event, or if was the culmination of a longer and more continuous historical process associated with a longer period of economic and urban growth in the United States.

Our objective in the present paper is to estimate age-price profiles for Canadian artists active over a lengthy period of Canadian history, and to see if evidence can be detected of continuous movement to the left of the relation. There are a few reasons why an application of such an analysis to the Canadian case may be of interest. First, the changes that occurred

in Canadian society and art in the post-war period are similar in many ways to the American case. We can thus verify whether or not the changes in career patterns of modern American artists identified by Galenson (2000, 2001) and Galenson and Weinberg (2000) are paralleled by the careers of modern Canadian painters. Second, as a young country, established in 1867, and which has seen rapid economic and urban growth almost continuously since its inception, Canada is an ideal test case for the hypothesis described above, viz. that economic and urban growth are associated with age-price profiles that slide to the left. Third, the art of painting is very important in Canada – the history of Canadian art extends almost to the beginning of the colonial period in the seventeenth and eighteenth centuries, there have been many important painters over the entire course of Canadian history, and there has been an active and healthy auction market for Canadian art for over forty years now, with abundant data being available.

The specific contributions of the paper are to estimate hedonic regressions, using data from auctions of Canadian art, in which we obtain age-price profiles for a large set of Canadian painters active over the entire history of the nation. We then estimate age-price profiles for three distinct “generations” of Canadian artists, in order to assess the presence of discrete historical “shifts” in the age-price profile. Finally, we estimate a hedonic regression in which the age-price profile is permitted to shift continuously as a function of the date of birth of the artist, this last being, to our knowledge, a methodological innovation in the literature. Our main finding is that economic and urban growth in Canada has indeed been accompanied by a continuing shift to the left of the age-price profile among Canadian painters.

2. DATA AND ECONOMETRIC MODEL

2.1 Data

Records of sales of Canadian paintings at auction from 1968 to 2007 were collected from Campbell (1970-75, 1980), Sotheby’s (1975, 1980) and Westbridge (1981-2008). Our data set includes results on sales for painters judged to be of significant interest from the standpoint of Canadian art history, this criterion being satisfied if a painter is mentioned in one of the major histories of Canadian art written by Harper (1977) or Reid (1973, 1988). We consider only oil and acrylic paintings, and only sales for which the auction house provides a secure attribution. For each painting, we recorded, in addition to the identity of the artist, the height and width,

the medium and support, the auction house, the date of sale, the genre of the picture, and, when available, the date of execution of the painting. The prices we use are hammer prices as reported in the aforementioned publications. The resulting data set, an expanded version of that used in the study of the investment properties of Canadian paintings by Hodgson and Vorkink (2004), contains 24,060 sales, of which date of execution was available for 9051¹. These latter form the sample on which the hedonic regressions reported below are based. We are left with 248 painters for which at least one dated painting is recorded, and they are listed in Appendix 1 in chronological order according to date of birth.

2.2 Econometric Model

We estimate three different specifications of a hedonic regression model, in all of which log price is regressed on the various painting-specific characteristics listed in the preceding subsection, with the fashion in which age enters the regression differing in the three cases. First, age is included through a polynomial function with all painters pooled together, regardless of date of birth. Second, we estimate the same polynomial model, but now with the painters partitioned according to the following three broad cohorts or generations: (1) those born up to 1880, (2) those born after 1880 and up to 1920, and (3) those born after 1920. Separate parameter estimates are computed for each cohort. The third model pools all the painters, but now adds to the polynomial in age the same polynomial, multiplied by the date of birth of the painter. This has the effect of allowing the polynomial function linking age to price to change continuously through time (according to date of birth), rather than to change in two discrete jumps as in the second specification.

Each of the three specifications can be written as special cases of the following general model:

¹ The data sources used do not provide date of execution information for every painting. This problem is especially bad for the relatively early auctions, for which date of execution is infrequently reported in the publications consulted. Also, certain artists rarely date their work, or only date relatively important works, with lesser works such as sketches being undated. Thus, even in recent sales at upscale auction houses, there may be works for which date of execution is not reported in the auction catalogue, and so will not be reported in our data sources. To get an idea of the magnitude of the problem, we chose at random, as a representative illustration, the catalogue for the 24 November 2006 sale at Heffel's. This is one of Canada's top auction houses, and their glossy, expensive catalogues contain extensive information on the works for sale, including essays by major art historians for certain lots. Nevertheless, for only 104 of the 153 oil or acrylic works on sale was date of execution reported in the catalogue.

$$(1) \quad y_i = x_i' \beta + g(z_i, \gamma) + u_i,$$

for $i = 1, \dots, n$ where y_i is the log price for sale i , the number of sales is n (equal to 9051 in our case), x_i is a vector of observations of k control variables (other than age), β is an unknown k -vector of parameters, z_i is the age of the painter at time of execution of painting i , g is a function whose form will be discussed in more detail below, γ is an unknown parameter vector, and u_i is a zero-mean disturbance, assumed to be independent of the regressors. The 234 regressors contained in the vector x include annual time period dummies, dummy variables for painter, auction house, medium and support, and genre, along with height, width, and surface area measures. Our concern in this paper is with the estimation and analysis of g , so we treat β as a nuisance parameter (see Hodgson and Vorkink (2004) for a more complete analysis of a hedonic regression similar to the one considered here).

The first specification we consider for g is a fourth-order polynomial in age:

$$(2) \quad g(z_i, \gamma) = \gamma_1 z_i + \gamma_2 z_i^2 + \gamma_3 z_i^3 + \gamma_4 z_i^4,$$

where $\gamma = (\gamma_1, \gamma_2, \gamma_3, \gamma_4)'$. In this version of the model, it is assumed that the parameters of the functional form are the same for all generations of Canadian painters, so that the function linking price to age is presumed constant across generations. Galenson and Weinberg (2000, 2001) estimate fourth-order polynomials in age for early twentieth century French artists, as well as for postwar American ones.

In the second place, we estimate a fourth-order polynomial in age, where the parameters are permitted to differ for the three cohorts of painters described above. We therefore have

$$(3) \quad g(z_i, \gamma) = \sum_{j=1}^3 (\gamma_{j1} z_i + \gamma_{j2} z_i^2 + \gamma_{j3} z_i^3 + \gamma_{j4} z_i^4) I(i \in \text{gen}(j)),$$

where $I(i \in \text{gen}(j))$ is an indicator function equal to one if the painter of painting i belongs to generation j , and equal to zero otherwise.

Finally, we estimate a quadratic function in age², supplemented with date-of-birth effects:

$$(4) \quad g(z_i, \gamma) = \sum_{j=1}^2 (\gamma_j z_i^j + \gamma_{j+2} z_i^j db_i)$$

where db_i is the year of birth of the painter associated with observation i ³.

Under all three specifications, the regression is linear and can be consistently estimated by ordinary least squares (OLS). However, the errors in a model such as this are generally not identically distributed normal (preliminary OLS estimates of the model under specifications (2) and (3) yielded Jarque-Bera (1980) normality statistics of 1671 and 1801, respectively), and so OLS will not be the maximum likelihood estimator and will be asymptotically inefficient. In particular, the presence of heteroskedasticity and non-normality in the errors suggests the use of an estimator that is robust to these departures from the canonical OLS assumptions. One could correct for the presence of heteroskedasticity in estimating the model by weighted least squares, which would be efficient if the weights were correctly estimated and the weighted errors normal. Both assumptions are, however, questionable. One could, for example, follow Galenson and Weinberg (2001) in weighting each observation by the standard deviation of realized prices for its painter, but this omits other possible sources of heteroskedasticity, such as the date of sale, as well as any non-normality that may be present. One could, in principle, deal with the first of these problems by weighting the observations by a nonparametric function of the regressors, but this introduces curse of dimensionality problems in the non-parametric estimation.

We opt to estimate all three versions of the regression using the semiparametric adaptive estimator developed by Bickel (1982). This estimator treats the errors as being independently and identically distributed (iid) from a distribution of unknown form, and is fully asymptotically efficient under general conditions. However, Hodgson (2000) shows that Bickel's (1982) estimator is robust to the presence of heteroskedasticity in the errors, and will

² A fourth order polynomial of this form was estimated, but yielded meaningless results, probably due to overparameterization. The quadratic was chosen due to its reduced number of parameters and simpler functional form.

³ Our thanks to Bernard Fortin for suggesting the estimation of a model allowing for continuous drift in the parameters of the age-price profile.

adapt for the non-normality induced in the unconditional density of the errors by this heteroskedasticity. Furthermore, the usual standard error estimates proposed by Bickel (1982) are also robust. Thus, the adaptive estimator, though not fully asymptotically efficient in the presence of heteroskedasticity, nevertheless has powerful robustness properties, can provide a substantial efficiency gain relative to OLS, and is easy to compute, as described in Appendix 2. For other applications of this estimator to hedonic regressions, see Hodgson, Slade, and Vorkink (2006) and Hodgson and Vorkink (2004).

3. EMPIRICAL RESULTS

We begin by examining our results for the pooled group of all painters before looking at the breakdown by cohort. We can see from the first row of Table 1 that the average age of the painter at time of execution for the 9051 sold paintings in our sample is just over 50, with a standard deviation of 16. The estimates of the parameters of the fourth-order polynomial in age and associated standard errors are reported in the first row of Table 2. The R-squared is 0.798 and the chi-square statistic for joint significance of the age parameters 329.82. The implied age-price profile is graphed in Figure 1. The function rises rapidly to a peak age of 34, after which it gradually declines in an approximately linear fashion, with a work executed at the age of 60 fetching about 23% less than peak.

The results for the model estimated with artists partitioned by cohort are reported in Tables 1 and 2 and in Figures 2-4. The age distribution of paintings that are sold at auction (Table 1) differs significantly for the most recent generation (mean of 42.1 and standard deviation of 11.2), compared with the earlier ones (respective means of 48.9 and 53.7, with standard deviations of about 16). Although this result could be due in part to bias arising from the fact that some members of this latest cohort were alive and active for all or part of our sample period, it is robust to the joint truncation of the set of artists included to those born before 1935 and of the dates of sale to those after 1995. It suggests a number of hypotheses consistent with the notion that the generation born after 1920 is more likely to do its best work at a relatively early stage of life: (i) a decline in quality, originality, or financial remuneration of an artist's work will tend to lead to a decline in productivity measured by number of works

painted; (ii) an early period of frenetic productivity could lead to burnout; (iii) later works, if of lesser quality or historic interest, will be less demanded in the secondary (auction) market.

The differences between the age-price profiles for the different cohorts can be observed in Figures 2-4, which are based on parameter estimates reported in Table 2. This regression had an R-squared of 0.794, and the Wald statistics for joint significance of the age parameters, were, respectively by cohort, 34.80, 386.04, and 129.90. For the pre-1880 cohort (Figure 2), prices increase rapidly with age until about 35, after which they slowly increase to a peak age of 46, and then decline only very gradually thereafter. For the second cohort, born between 1880 and 1920, the function, plotted in Figure 3, peaks at 35 and then declines fairly rapidly, with a fall off of value of nearly 30% between the ages of 35 and 60. A Wald statistic with null hypothesis that the parameters of the first two cohorts are identical rejected strongly at 89.38. Again, the results for the post-1920 cohort are the most unique of the three. Here, we see that prices peak much earlier, at the age of 23, and then drop rapidly, by about 40%, between the ages of 25 and 50. The parameters for the third cohort are significantly different from those for both the first and second, with respective Wald statistics of 79.60 and 132.60.

A couple of apparent oddities in Figure 4 should be noted, viz., the seemingly very early peak age and the “hump” which appears after age 60. The former can be attributed to estimation error and/or to misspecification: of our 1653 observations for artists born after 1920, only 76 correspond to works produced by an artist aged under 26. The shape of the function in this zone will thus be largely an extrapolation of the functional form estimated with observations from older artists, and would therefore be hard to estimate precisely, even if a larger parameterization or nonparametric regression were specified. What the function as estimated with the bulk of our sample does tell us is that there is a steep downward gradient in price from the mid- to late twenties onward. Indeed, for all three cohorts, it could be argued that the differences in the slopes of the profiles after the peak age are more striking, and perhaps more interesting, than the differences in the peaks themselves. As for the “hump” after 60, this can be attributed to three late Colvilles that sold in auctions in 2005-2006 for over \$200,000 each, by far the most expensive of the 101 paintings in our post-1920 sample executed by artists over the age of 60.

The results of the estimation of model (4), in which date-of-birth effects are included, are reported in Table 3, and the age-price profile is illustrated in Figures 5-8 for four examples of

years of birth, at 35-year intervals from 1815 to 1920. The parameters for the date of birth effects are jointly significant, with a chi-squared statistic of 72.9. We can see from Figures 5-8 a clear shift to the left in the peak age as function of date of birth, as the peak age for an artist born in 1815 is about 55, for an artist born in 1850 is 50, and for an artist born in 1885 is around 30. As the date of birth moves to 1920, the function as estimated actually becomes convex and continually decreasing, with no peak. As the specification of structural change used here is very ad hoc, and because of the problems of estimating the profile for later artists alluded to in our discussion above of Figure 4, we are not overly troubled by the strange function illustrated in Figure 8. Even with the crude model of structural change employed here, we observe a clear and continual shift to the left of the age-price profile, consistent with the picture presented in Figures 1-4 and with our basic hypothesis.

4. ANALYSIS AND ART HISTORICAL CONSIDERATIONS

The shift to the left of the age-price profile found by Galenson (2000, 2001) and Galenson and Weinberg (2000, 2001) for modern American artists born before and after 1920 is confirmed in our analysis of Canadian artists born before and after 1920. The principal reasons for this shift, whatever they may be, are without doubt very similar in the two countries, as many of the general historical and economic forces occurring in the aftermath of World War II were felt similarly in the two countries. Much of the interpretation of trends in artistic creativity and production emphasized by Galenson et al for the American case are also applicable to Canadian artists, who were very much “plugged in” to the emerging New York art scene. The major Canadian modern art movements of this period arose in Toronto and Montreal, large and growing cities that were geographically close to New York City. Canadian artists were in direct contact with several of the leading European and American artists and critics based in New York during and just after the war, and in some cases had their work exhibited in New York and sold through galleries there.

So although our results for artists active in the post-war period would seem to be consistent with the “supply-side” interpretation of Galenson et al, in taking a longer view of the evolution of age-price profiles in Canadian art, and in discovering that the changes that occurred with the post-war generation seem to have been the culmination of a longer and more gradual shift to the left of the profiles, we believe that we have obtained evidence

supporting the proposition that a continuous development and maturation of the demand side of the market in a young and quickly growing country is also an essential factor generating the observed changes in the labour market for artists.

Total and urban population statistics for Canada for the period from 1851 to 1971, and reported at 20-year intervals, are provided in Table 4. It is evident from the figures that Canada grew very rapidly over the century 1871-1971 from a sparsely populated rural society to an overwhelmingly urban one. We maintain that this growth is an essential condition for the development of a vibrant art market permitting the existence of the artistic professions and making feasible the establishment of institutions devoted to the training of young people for entry to these professions.

Any artists active in the earlier stages of such a society would, due to lack of sufficient demand and training facilities, most likely be part-time or itinerant artists, with limited professional training. Only the ones most talented at the production of standard genres such as portraits or landscapes would have any market at all for their work, and it would be a market that would be discovered slowly, as, in the absence of a well-established network of art academies, galleries, critics, and practicing artists, the artist would have to largely find his own way in developing a personal style and in forging a client base. Indeed, the career of one of the very first “big names” in Canadian art, Cornelius Krieghoff (1815-1872), corresponds in many ways to this caricature (see Harper (1979) and Reid (1999)). For our purposes, the important thing to note is that the extreme thinness of the art market is largely responsible for the fact that such an artist would be likely to find his own market, and thus the style of painting most conducive to his individual talents, only relatively late in life, and, consequently, would be most productive in both quality and quantity at such a stage. We note that even an artist such as Emily Carr (1871-1945), born much later than Krieghoff, educated in France and England, and active well into the twentieth century, fits to some degree this profile. She lived most of her life in the city of Victoria, British Columbia, on the Pacific Coast. Victoria was a small city with very little opportunity for an ambitious young artist, and Carr, without a market for her art, essentially abandoned painting for several years, only resuming major artistic activity after the age of 50, when some of her early paintings attracted the attention of collectors and critics in the large eastern cities of Toronto, Montreal, and Ottawa. The work she created in her fifties and sixties, when she had finally found a market for her art, is generally considered to be her best (Thom et al (2006), Shadbolt (1979)).

5. CONCLUDING REMARKS

The results of the empirical analysis presented in this paper are consistent with the hypothesis that demographic and economic growth, particularly when concentrated in urban centres, can lead to changes in the life-cycle productivity patterns of fine artists, and, in particular, to increased productivity at relatively early ages. We have emphasized a demand-side explanation for this phenomenon, and have found that it is present in the history of Canadian art. We have estimated hedonic age-price profiles for three broadly defined cohorts of Canadian artists, and have extended the hedonic model to include a parameterization which allows for continual drift (as a function of date of birth) in the parameters of the age-price profile. In both cases, a continual drift to the left in the profile is observed as Canada rapidly evolved from a sparsely populated rural society to a wealthy and heavily urbanized modern one.

The reasoning presented in the Introduction to generate our main hypothesis is admittedly rather informal. Further theoretical and empirical elaboration of models of demand and supply in fine art markets would be desired, as would further investigation not only of the influence of demand factors on peak ages, but on the speed of decline of productivity after the peak age has been passed. We find that this speed is negatively related to the peak age, a phenomenon that merits further theoretical and empirical analysis.

The models of structural change in the age-price profile estimated here are essentially ad hoc and could be better elaborated in future work. We have considered the cases of discrete changes at more or less arbitrarily chosen break dates, as well as a drift model where the changes in the parameters are linear in time. As this latter is the first attempt of which we are aware to model such change, it could undoubtedly be improved upon.

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Table 1 – Average age at time of execution for paintings sold at auction, by cohort

Cohort	Number obs.	Average age	Standard deviation
All	9051	50.3	15.9
Pre-1880	2437	48.9	15.4
1880-1920	4961	53.7	16.4
Post-1920	1653	42.1	11.2

Table 2 – Hedonic regression: estimates of parameters of fourth-order polynomial in age, by cohort (standard errors in parentheses)

Cohort	Age	Age ²	Age ³	Age ⁴
All	0.196 (.0442)	-5.45×10^{-3} (1.37×10^{-3})	6.17×10^{-5} (1.80×10^{-5})	-2.54×10^{-7} (8.53×10^{-8})
Pre-1880	0.100 (.0794)	-1.73×10^{-3} (2.46×10^{-3})	1.01×10^{-5} (3.25×10^{-5})	-1.04×10^{-8} (1.54×10^{-7})
1880-1920	0.255 (.0587)	-6.66×10^{-3} (1.81×10^{-3})	6.95×10^{-5} (2.35×10^{-5})	-2.60×10^{-7} (1.10×10^{-7})
Post-1920	0.504 (.162)	$-.0196$ (5.65×10^{-3})	3.01×10^{-4} (8.42×10^{-5})	-1.61×10^{-6} (4.54×10^{-7})

Table 3 – Hedonic regression: estimates of parameters of quadratic in age for all artists with date-of-birth effects included

Regressor	Estimate	Standard error
Age	1.59	.233
Age ²	-0.0127	.00221
D.B. X Age	-8.39×10^{-4}	1.23×10^{-3}
D.B. X Age ²	6.66×10^{-6}	1.17×10^{-6}

Table 4 – Total and Urban Population of Canada, 1851-1971

Year	Total (millions)	Urban (millions)
1851	2.44	0.32
1871	3.74	0.72
1891	4.93	1.54
1911	7.22	3.28
1931	10.38	5.57
1951	14.01	8.63
1971	21.57	16.41

Source : Statistics Canada

APPENDIX 1 – LIST OF PAINTERS INCLUDED

(the painters included in our empirical study are listed here in chronological order according to year of birth, the latter being provided in parentheses along with the number of observed sales for each painter)

George Heriot (1766, 2), Robert Field (1769, 1), Antoine Sebastien Plamondon (1804, 3), James Duncan (1805, 1), Robert Whale (1805, 6), George Theodore Berthon (1806, 3), Robert Todd (1809, 1), Daniel Fowler (1810, 1), Paul Kane (1810, 3), Otto Jacobi (1812, 78), Cornelius Krieghoff (1815, 151), Theophile Hamel (1817, 3), William Sawyer (1820, 9), William Armstrong (1822, 2), William Cresswell (1822, 20), A.S. Falardeau (1822, 7), Napoleon Bourassa (1827, 1), Henri Perre (1828, 5), Ludger Ruelland (1828, 1), John O'Brien (1831, 2), Charles Caleb Ward (1831, 8), Lucius R. O'Brien (1832, 12), William Raphael (1833, 42), Marmaduke Matthews (1837, 10), John A. Fraser (1838, 5), Thomas Mower Martin (1838, 43), Frederick Arthur Verner (1839, 87), Henry Sandham (1841, 13), John Hammond (1843, 131), Frederic Martlett Bell-Smith (1846, 52), Allan Edson (1846, 18), John C. Forbes (1846, 7), Henri Julien (1846, 1), Robert Gagen (1847, 4), Wyatt Eaton (1849, 2), Robert Harris (1849, 43), William Cruikshank (1849, 2), J.W.L. Forster (1850, 8), William Brymner (1855, 25), Charles Huot (1855, 9), Homer Watson (1855, 29), Percey Woodcock (1855, 7), Horatio Walker (1858, 36), F.S. Coburn (1871, 243), Julian Seavey (1856, 4), Franklin Brownell (1857, 50), William Blair Bruce (1859, 15), Paul Peel (1860, 62), George Reid (1860, 71), Laura Muntz Lyall (1860, 24), J.M. Barnsly (1861, 25), Robert Holmes (1861, 1), William Atkinson (1862, 78), Archibald Browne (1862, 26), Henri Beau (1863, 21), William R. Hope (1863, 2), Carl Ahrens (1863, 16), Ozias Leduc (1864, 12), James Wilson Morrice (1865, 13), H. Ivan Neilson (1865, 2), Maurice Cullen (1866, 60), Joseph Franchere (1866, 9), Curtis Williamson (1867, 6), Ludger Larose (1868, 22), Joseph Saint-Charles (1868, 3), William Beatty (1869, 92), C.W. Jeffreys (1869, 4), Sophie Pemberton (1869, 9), Marc-Aurèle de Foy Suzor-Coté (1869, 129), Georges Delfosse (1869, 10), Emily Carr (1871, 73), Charles Gill (1871, 10), Edmund Morris (1871, 8), Fred Brigden (1871, 6), J.E.H. Macdonald (1873, 245), Tom Thomson (1877, 29), W.J. Wood (1877, 3), W.H. Clapp (1879, 32), W.P. Weston (1879, 104), Helen MacNicoll (1879, 9), John Russell (1879, 15), Clarence Gagnon (1881, 112), Fred Varley (1881, 35), Albert Robinson (1881, 98), A.Y. Jackson (1882, 717), W.J. Phillips (1884, 1), David Milne (1882, 78), Mabel May (1884, 25),

Lawren S. Harris (1885, 118), Emily Coonan (1885, 1), Arthur Lismer (1885, 289), John Lyman (1886, 18), Charles H. Scott (1886, 11), Hortense Gordon (1887, 12), Mabel Lockerby (1887, 4), Bertram Brooker (1888, 11), Randolph Hewton (1888, 113), Frank Johnston (1888, 129), Marc-Aurèle Fortin (1888, 71), Frank Carmichael (1890, 54), Lemoine Fitzgerald (1890, 24), Eric Goldberg (1890, 1), Adrien Hebert (1890, 30), Sarah Robertson (1891, 6), Rodolphe Duguay (1891, 23), Edwin Holgate (1892, 53), Aleksandre Bercovitch (1893, 2), Kathleen Morris (1893, 12), Fritz Brandtner (1896, 15), Louise Gadbois (1896, 64), Prudence Heward (1896, 6), Liliás Torrance Newton (1896, 5), Andre Bieler (1896, 46), Ernst Lindner (1897, 8), J.W.G. Macdonald (1897, 39), Anne Savage (1898, 18), A.J. Casson (1898, 441), Paraskeva Clark (1898, 24), Yvonne McKague Housser (1898, 39), Robert W. Pilot (1898, 256), Charles Comfort (1900, 62), Jack Humphrey (1901, 15), Alexandra Luke (1901, 2), Will Ogilvie (1901, 5), Isabel McLaughlin (1903, 14), Carl Schaefer (1903, 32), Jean-Paul Lemieux (1904, 124), Louis Muhlstock (1904, 12), Goodridge Roberts (1904, 133), Pegi Nichol Macleod (1904, 10), Paul-Emile Borduas (1905, 54), William Leroy Stevenson (1905, 11), Illingworth Kerr (1905, 209), Maxwell Bates (1906, 134), Alfred Pellan (1906, 31), Marian Scott (1906, 15), Jori Smith (1907, 49), Henri Masson (1907, 226), Ernst Neumann (1907, 15), B.C. Binning (1909, 15), Jack Bush (1909, 62), Jack Shadbolt (1909, 109), Gordon Webber (1909, 6), Marion Nicholl (1909, 9), Lawren P. Harris (1910, 3), Philip Surrey (1910, 31), Leon Bellefleur (1910, 114), Stanley Cosgrove (1911, 232), Miller Brittain (1912, 5), Kate Graham (1913, 4), E.J. Hughes (1913, 94), John Korner (1913, 8), John Hall (1914, 7), Jean Dallaire (1916, 50), Fernand Leduc (1916, 10), Albert Dumouchel (1916, 11), Walter Yarwood (1917, 6), Louis de Niverville (1917, 2), Jacques de Tonnancour (1917, 46), Gordon Smith (1919, 49), Michael Snow (1919, 4), William Perehudoff (1919, 22), Alex Colville (1920, 10), Gershon Iskowitz (1921, 23), Ray Mead (1921, 11), Clark McDougall (1921, 7), Jack Nichols (1921, 1), Pierre Gauvreau (1922, 12), Robert Varvarande (1922, 5), Jean McEwen (1923, 91), Jean-Paul Riopelle (1923, 256), Bruno Bobak (1923, 12), Donald Jarvis (1923, 5), Marcelle Ferron (1924, 66), Tom Hodgson (1924, 11), Harold Town (1924, 78), Marcel Barbeau (1925, 28), Ronald Bloore (1925, 4), Patterson Ewen (1925, 15), Denis Juneau (1925, 2), Rodolphe de Repentigny (1926, 6), Roy Kiyooka (1926, 3), Kenneth Lochead (1926, 16), Arthur McKay (1926, 2), Kazuo Nakamura (1926, 32), William Ronald (1926, 54), Gerald Scott (1926, 1), Takao Tanabe (1926, 37), Tony Tascona (1926, 2), Dorothy Knowles (1927, 47), Jean-Paul Mousseau (1927, 7), William Kurelek (1927, 59), Jean-Paul Jerome (1928, 18), Francoise Sullivan (1928, 1), Jean Goguen (1928, 2), Hugh Mackenzie (1928, 1), Daphne Odjig (1928, 17), Toni Onley (1928, 61), Louis Belzile (1929,

15), Rita Letendre (1929, 63), Allen Sapp (1929, 81), Suzanne Bergeron (1930, 1), Fernand Toupin (1930, 52), Jack Chambers (1931, 4), Graham Coughtry (1931, 7), Joyce Wieland (1931, 3), Edmund Alleyn (1931, 44), Claude Tousignant (1932, 5), Norval Morriseau (1932, 125), Dennis Burton (1933, 13), John Meredith (1933, 19), Guido Molinari (1933, 16), Ted Godwin (1933, 10), Charles Gagnon (1934, 2), Tony Urquhart (1934, 11), Yves Gaucher (1934, 3), Richard Gorman (1935, 14), Christopher Pratt (1935, 6), Gordon Rayner (1935, 4), Ivan Eyre (1935, 6), Alex Janvier (1935, 12), Mary Pratt (1935, 15), Otto Rogers (1935, 10), Tom Forrestall (1936, 10), Doug Haynes (1936, 8), Christiane Pflug (1936, 1), Claude Breeze (1938, 4), Guy Monpetit (1930, 2), Brian Fisher (1939, 1), Jacques Hurtubise (1939, 9), Paul Fournier (1939, 9), Ken Danby (1940, 1), Joseph Drapell (1940, 5), John Boyle (1941, 1), Esther Warkov (1941, 2), Michael Morris (1942, 3), Harold Klunder (1943, 3), Ron Martin (1943, 7), Carl Ray (1943, 4), Michael Forster (1943, 17), David Bolduc (1945, 14), Daniel Solomon (1945, 3), Bruce St. Clair (1945, 2), Ric Evans (1946, 1), Alex Cameron (1947, 1), Erik Gamble (1950, 1)

APPENDIX 2 – BICKEL’S (1982) ADAPTIVE ESTIMATOR

We consider estimation of a linear regression model

$$y_i = w_i' \delta + u_i,$$

where δ is the parameter vector to be estimated. The estimator is efficient under the assumption that the disturbances are iid with a density function $f(u)$ that is symmetric, so that $f(u) = f(-u)$. Using the OLS estimator $\hat{\delta}$, compute the associated residuals

$$\hat{u}_i = y_i - w_i' \hat{\delta}, i = 1, \dots, n.$$

For each residual $\hat{u}_i, i=1, \dots, n$, one can use the remaining residuals to compute a kernel estimate of the level of the density f evaluated at \hat{u}_i as follows :

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

where K is a kernel function (we use the standard normal density in our empirical application) and h is a bandwidth parameter that converges to zero as the sample size n goes to infinity (in practice, we use the rule-of-thumb plug-in bandwidth mentioned by Silverman (1986, p. 45)).

We also have the following estimate of the first derivative of f :

$$\hat{f}_i'(\hat{u}_i) = \frac{1}{h2(n-1)} \sum_{\substack{j=1 \\ j \neq i}}^n \left\{ K'\left(\frac{\hat{u}_i + \hat{u}_j}{h}\right) + K'\left(\frac{\hat{u}_i - \hat{u}_j}{h}\right) \right\}.$$

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

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

where some trimming conditions may need to be specified in the computation of $\hat{\psi}_i$.

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

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

and

$$\hat{\Phi}_n = \hat{\Omega} n^{-1} \sum_{i=1}^n w_i w_i',$$

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

$$\tilde{\delta} = \hat{\delta} + \hat{\Phi}_n^{-1} \hat{S}_n.$$

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

$$\sqrt{n}(\tilde{\delta} - \delta) \xrightarrow{d} N(0, \Phi^{-1}),$$

where the asymptotic covariance matrix Φ^{-1} is consistently estimated by $\hat{\Phi}_n^{-1}$.

REFERENCES

- Bickel, P. 1982. On adaptive estimation. *Annals of Statistics* 10: 647-671.
- Campbell, H. 1970-1975. *Canadian Art Auction Record 1969-1974*, vols 1-6. Toronto: Canadian Antiques and Fine Arts; and Montreal: Bernard Amtmann.
- Campbell, H. 1980. *Canadian Art Auctions, Sales, and Prices, 1976-1978*. Don Mills, Ont.: General.
- Czujack, C. 1997. Picasso paintings at auction, 1963-1994. *Journal of Cultural Economics* 21:229-247.
- Galenson, D.W. 2000. The careers of modern artists. *Journal of Cultural Economics* 24:87-112.
- Galenson, D.W. 2001. *Painting Outside the Lines*. Harvard.
- Galenson, D.W., and Weinberg, B.A. 2000. Age and quality of work: The case of modern American painters. *Journal of Political Economy* 108:761-777.
- Galenson, D.W., and Weinberg, B.A. 2001. Creating modern art: The changing careers of painters in France from impressionism to cubism. *American Economic Review* 91:1063-1071.
- Ginsburgh, V. and Weyers, S. 2006. Creativity and life cycles of artists. *Journal of Cultural Economics* 30:91-107.
- Harper, J.R. 1977. *Painting in Canada: A history (2nd ed.)*. Univ. of Toronto.
- Harper, J.R. 1979. *Krieghoff*. Univ. of Toronto.

Hodgson, D.J. 2000. Unconditional pseudo-maximum likelihood and adaptive estimation in the presence of conditional heterogeneity of unknown form. *Econometric Reviews* 19:175-206.

Hodgson, D.J., Slade, B.A., and Vorkink, K. 2006. Constructing commercial indices: A semiparametric adaptive estimator approach. *Journal of Real Estate Finance and Economics* 32:151-168.

Hodgson, D.J. and Vorkink, K. 2004. Asset pricing theory and the valuation of Canadian paintings. *Canadian Journal of Economics* 37:629-655.

Jarque, C. and Bera, A. 1980. Efficient tests for normality, homoskedasticity, and serial independence of regression residuals. *Economics Letters* 6:255-259.

Kelly, E. and O'Hagan, J. 2007. Geographic clustering of economic activity : The case of prominent western visual artists. *Journal of Cultural Economics* 31 :109-128.

Mincer, J. 1974. *Schooling, Experience, and Earnings*. Columbia University Press.

Reid, D. 1973. *A Concise History of Canadian Painting*. Toronto: Oxford.

Reid, D. 1988. *A Concise History of Canadian Painting (2nd ed.)*. Toronto: Oxford.

Reid, D. 1999. *Kriehoff : Images of Canada*. Toronto: Douglas & McIntyre.

Shadbolt, D. 1979. *The Art of Emily Carr*. Toronto: Douglas & McIntyre.

Silverman, B.W. 1986. *Density Estimation for Statistics and Data Analysis*. London: Chapman and Hall.

Sotheby's. 1975. *Canadian Art at Auction, 1968-1975*. Toronto: Sotheby's.

Sotheby's. 1980. *Canadian Art at Auction, 1975-1980*. Toronto: Sotheby's.

Thom, I. et al. 2006. *Emily Carr : New Perspectives on a Canadian Icon*. Toronto: Douglas & McIntyre.

Westbridge, A.R. 1981-2008. *Canadian Art Sales Index, 1977-2007*. Vancouver: Westbridge.

Fig. 1 – Age–Price Profile, All Painters

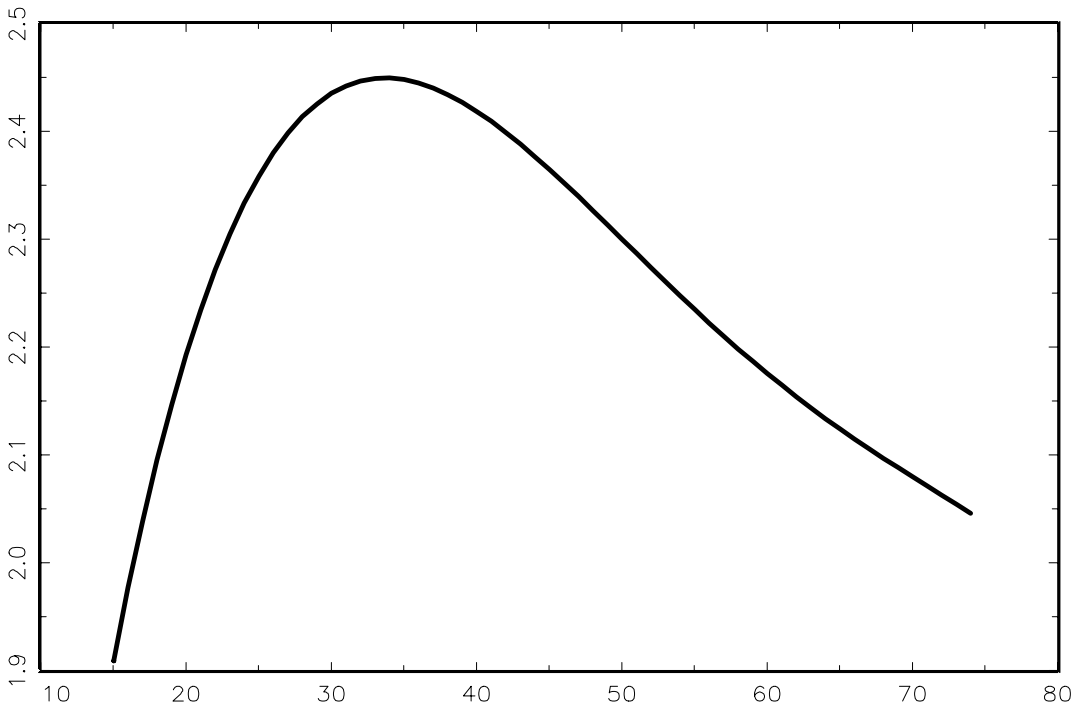


Fig. 2 – Age–Price Profile, pre-1880

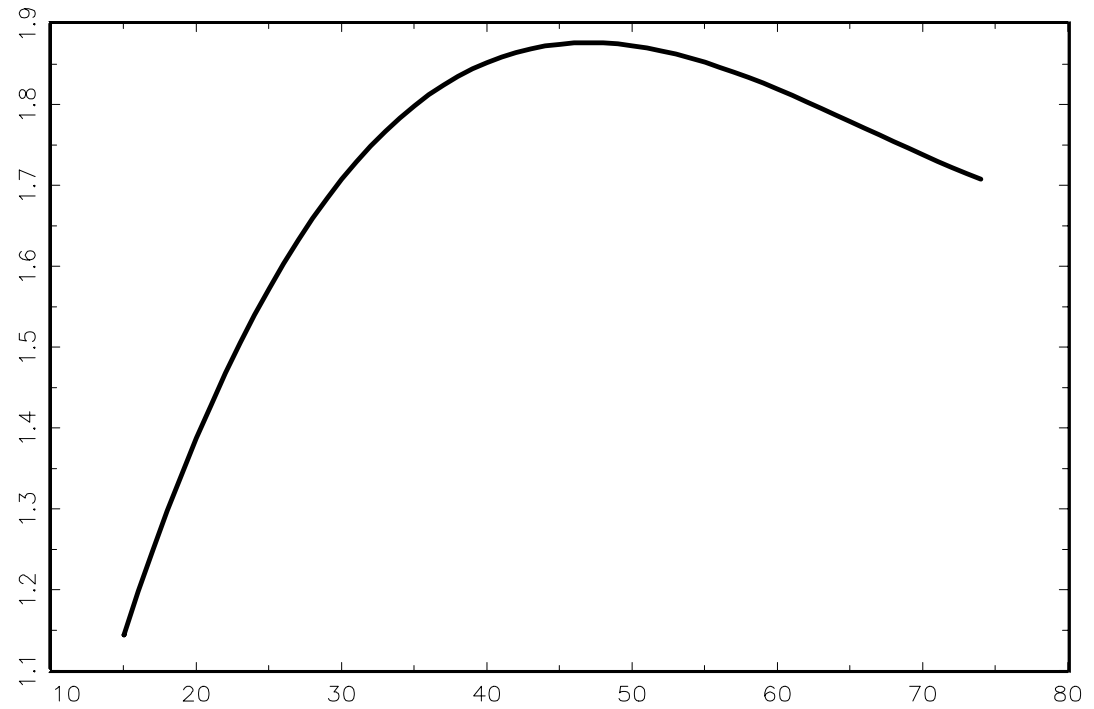


Fig. 3 – Age–Price Profile, 1880–1920

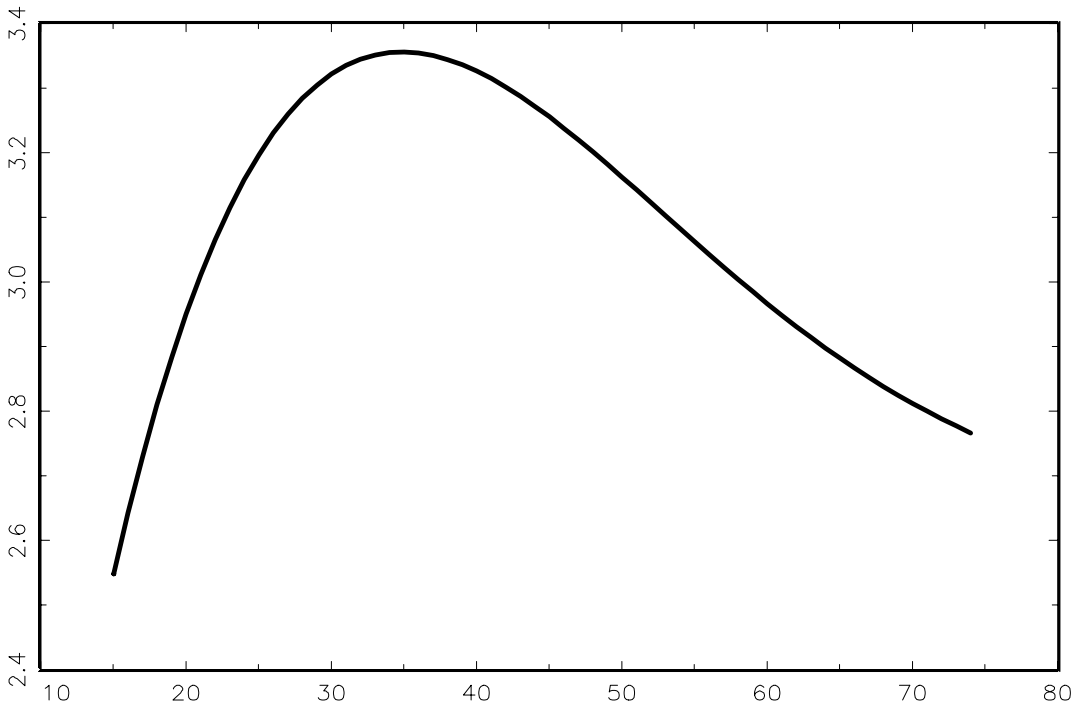


Fig. 4 – Age–Price Profile, post-1920

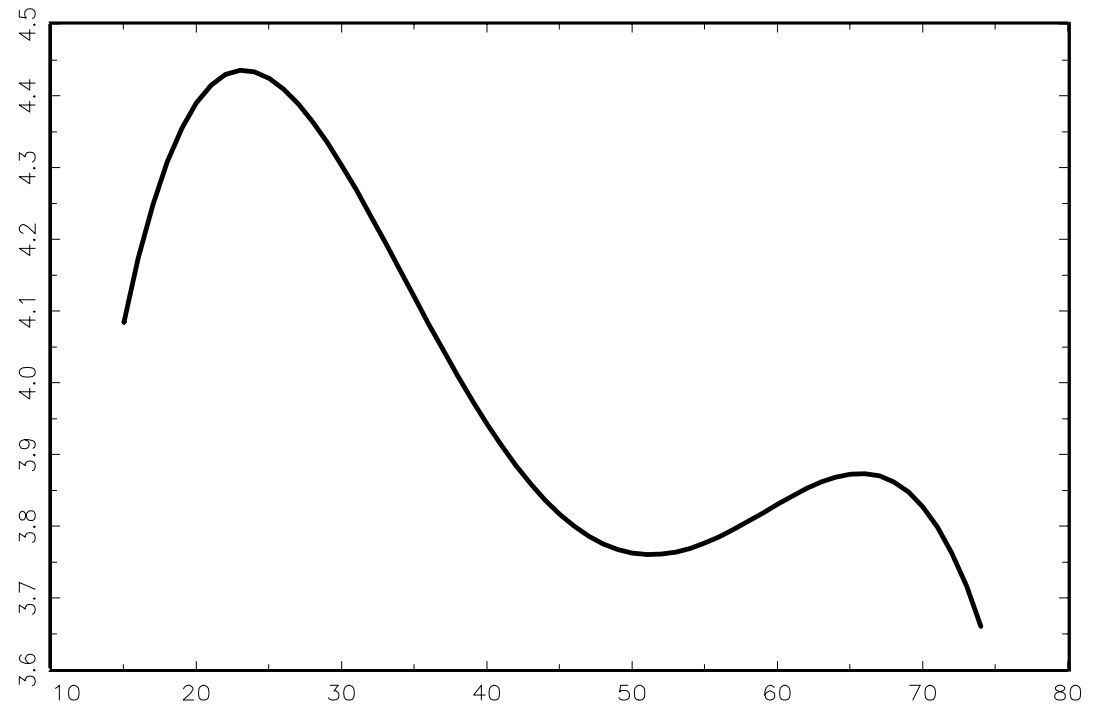


Fig. 5 – Age–Price Profile with Date of Birth Effects (1815)

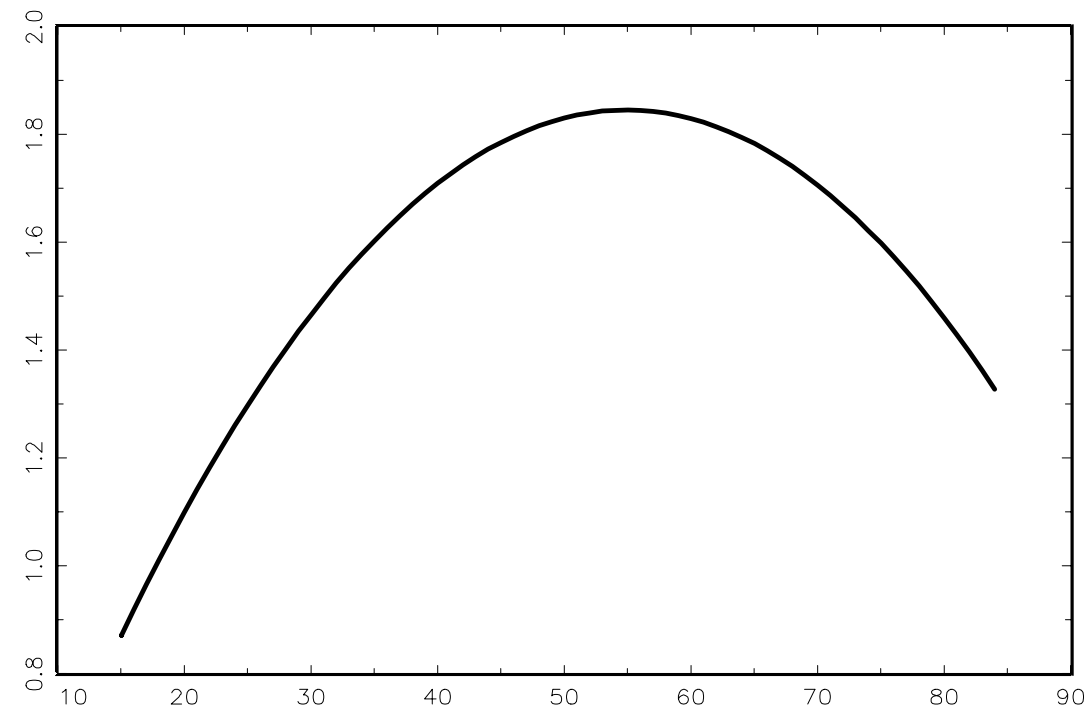


Fig. 6 – Age–Price Profile with Date of Birth Effects (1850)

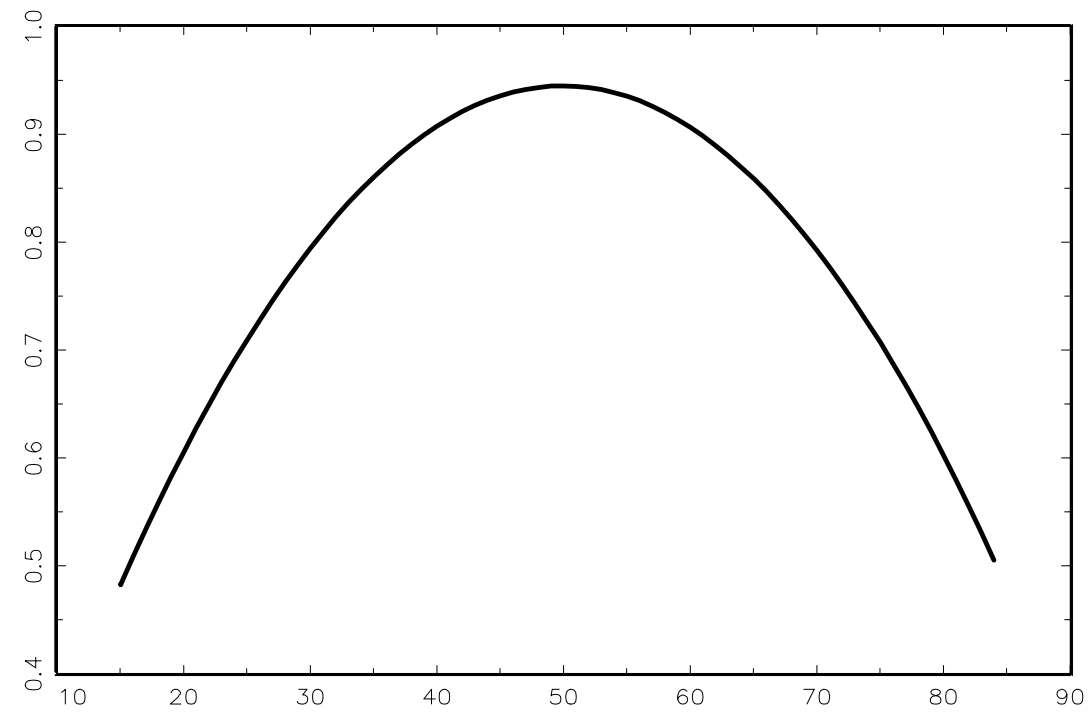


Fig. 7 – Age–Price Profile with Date of Birth Effects (1885)

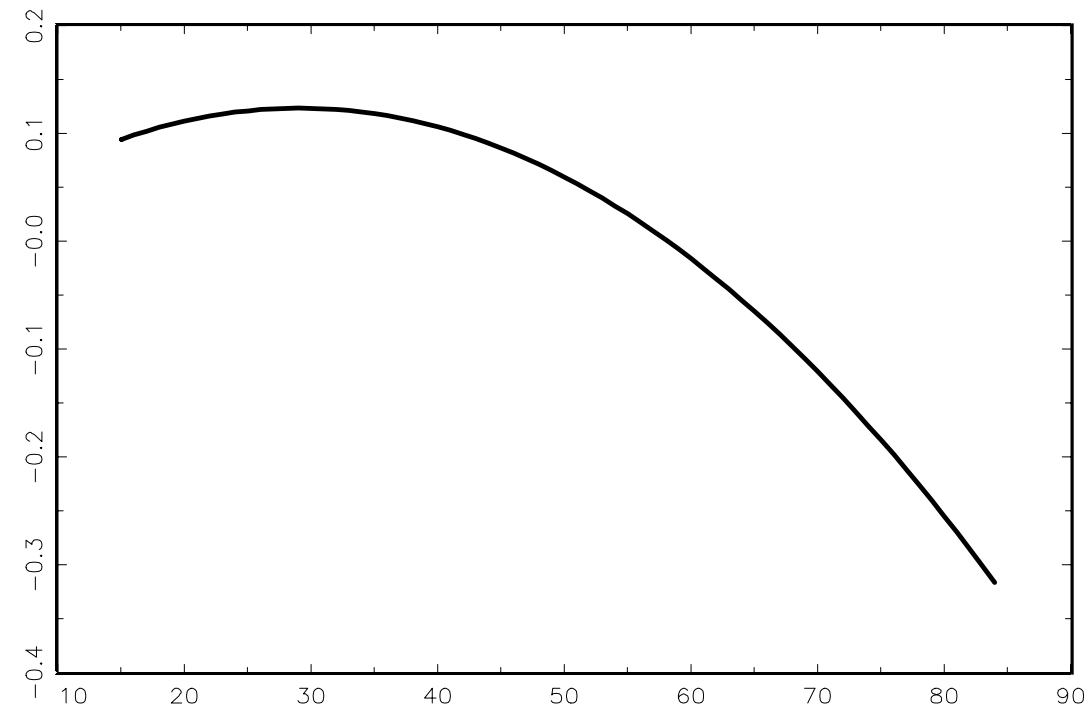


Fig. 8 – Age–Price Profile with Date of Birth Effects (1920)

