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The auction market for artworks and their physical dimensions: Australia—1986 to 2009

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Abstract Within a hedonic pricing model, the preferences of Australian art purchasers are investigated. Emphasis is placed on the impact of an artwork's dimensions upon its auction price. A salient aspect of this is the first test of the 'golden ratio' hypothesis in a market situation. It is concluded that purchasers prefer paintings that deviate from the golden rule. The 'orientation' of works (portrait, landscape or square) as well as size also helps determine price. The impact of winning the Archibald portraiture prize (Australia's foremost art prize) is found to have significant and positive impacts on winning artists' prices. This suggests that purchasers are not fully informed. In addition, a previously unsuspected relationship between artwork dimensions and Archibald prize winners was found. As well as purchasers' preferences, the artists' choices of the dimensions of their artworks are considered.

Keywords Hedonic pricing · Artwork dimensions · Archibald prize

JEL Classification C23 · C33 · G11

1 Introduction

The characteristics of two-dimensional artworks (paintings, drawings and prints) that determine their prices at auction are investigated. Among those characteristics, other than area, the dimensions of such works have been ignored. Nonetheless, artwork dimensions present an avenue for investigating several neglected aspects of choice and price in the art market.

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A major element in understanding the art market has been the empirical determination of the role of the characteristics of individual artworks, as well as general economic conditions, in determining auction prices. That work has largely been accomplished using the hedonic pricing model (Chanel et al. 1994; de la Barre et al. 1994; Agnello and Pierce 1996; Higgs and Worthington 2005; Higgs 2010; Renneboog and Spaenjers 2011). Using this method, the list of characteristics found to be significant in determining artwork price is increasing. Such characteristics include the names of artists; living status; subject matter; medium of execution; size (area); auction houses and date of sale (see Buelens and Ginsburgh 1993; de la Barre et al. 1994; Agnello and Pierce 1996; Chanel et al. 1996; Renneboog and Van Houtte 2002; Higgs and Worthington 2005; Ursprung and Wiermann 2008; Higgs 2010; Renneboog and Spaenjers 2010; Renneboog and Spaenjers 2011; among others) are explored in many past studies. The repeat-sales method has been used to generate art price indices by Anderson 1974; Baumol 1986; Frey and Pommerehne 1989; Buelens and Ginsburgh 1993; Pesando 1993; Pesando and Shum 1999 and Mei and Moses 2002. The present work uses the hedonic pricing method.

Many hedonic pricing studies have also created art price indices and compared art returns to other financial assets. Buelens and Ginsburgh (1993); Mok et al. (1993); Agnello and Pierce (1996); Candela and Scorcu (1997); Renneboog and Van Houtte (2002); Higgs and Worthington (2005) and Renneboog and Spaenjers (2011) have variously produced price indices for English, Dutch, American, Chinese, Italian, Belgian, Australian and Russian art and Old Master, Impressionist and Modern paintings. In addition, Candela and Scorcu (1997); Pesando and Shum (1999); Mei and Moses (2002); Renneboog and Van Houtte (2002); Higgs and Worthington (2005); Renneboog and Spaenjers (2010); Goetzmann et al. (2011); Renneboog and Spaenjers (2011) compared returns of paintings to returns of financial assets.

This paper extends on past studies by incorporating physical dimensions of artworks as characteristics. These dimensions can also involve aesthetic considerations. In this context, the ‘golden ratio’ hypothesis is considered because of its significance and longevity in the Western art canon. If the golden ratio hypothesis holds, artworks conforming to golden ratio dimensions should command higher prices. Each artwork’s orientation, in terms of being either portrait or landscape oriented or square, is included as explanatory variables. But it is not just purchasers who make decisions about a work’s dimensions. Both the artists and the sellers of the works make such decisions. Nevertheless, these two groups are largely ignored in the literature, even though their supply decisions constrain the choices that can be made by potential purchasers.

Also, little considered are market imperfections, yet such imperfections clearly exist. A possible major imperfection is that purchasers are not perfectly informed. If purchasers are perfectly informed an artist winning, an art prize conveys no new information and should not add to the value of that artist’s work. Consequently, the impact of winning Australia’s best-known art prize, the Archibald, is considered. It is expected the award has a positive effect on a winner’s prices. Despite the light they can shed on the market for paintings, drawings and prints, art prizes have not previously been examined.

The structure of the paper is that Sect. 2 discusses dimensions as major characteristics of artworks. The distribution of the dimensions of works coming to auction is described. The golden ratio is then described. The role of artwork dimensions in determining artwork prices is briefly discussed. In Sect. 3, the model is specified. While conforming to the standard form of the hedonic pricing model, the explanatory variables are believed to be novel. The data set is described in Sect. 4. The empirical results, especially those relating to dimensions and the golden ratio, and market imperfections are presented and interpreted in Sect. 5. Conclusions are drawn in Sect. 6.

2 Artists' choices, artwork dimensions and the golden ratio

The distribution of the ratio of height to width of the sample of works is described (Fig. 1). That frequency distribution is complex and multi-modal. It indicates that artists make distinct choices among possible dimensions, that is, height and width. It also shows that most works sent to auction do not conform to the golden ratio. This has an enormous impact upon the choices that auction purchasers can make. Consequently, the reasons for artists' choices of dimensions are discussed as they are relevant to auction purchasers' decisions. It is also recognised that decisions of the owners sending works to auction intermediate between artists' decisions and secondary market's purchasers' decisions.

Figure 1 shows the frequency distribution of the ratio of H/W where $H =$ height and $W =$ width of all 52,298 works in the data set by. It is noted that the measurements are for the external dimensions of the works, rather than the dimensions of the subject matter. Where $H/W < 1$, the works are described as 'landscape' oriented, although landscape need not be the subject matter. Where $H/W > 1$, works are 'portrait' oriented, although portraiture need not be the subject matter. Where $H/W = 1$, the work is 'square', so the frequency for 'square' works is

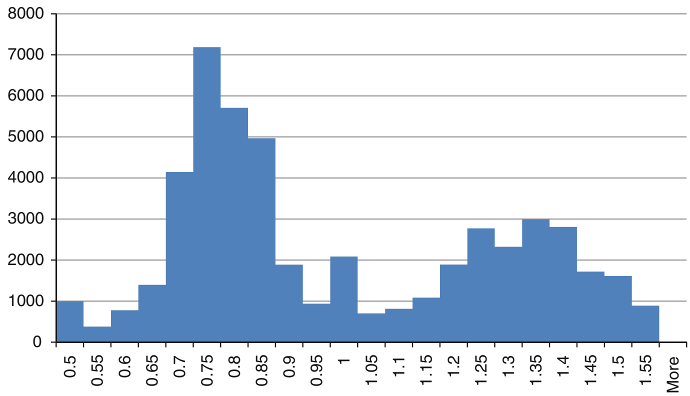

Fig. 1 Frequency distribution of height divided by width

necessarily at a point and not an interval. Figure 1 exhibits three major modes, with a fourth possible at $0.0 < H/W < 0.5$, that is, 'panoramic' ratios, suggesting the outcome of artists' conscious choices. The modality of the square works also suggests conscious choices by artists. To investigate this further, the two intervals either side of the point $H/W = 1$, that is, the intervals $\{0.95 < H/W < 1\}$ and $\{1 > H/W > 1.05\}$, were both disaggregated into further tenths. Examination of these two sets of smaller sub-intervals shows that the sub-intervals for dimensions very close to $H/W = 1$ were avoided compared to the sub-intervals further away from perfectly square. This is evidence that if artists either choose a precisely square format or distance their works' dimensions from it. Of the works in the data set, 54.27 % were landscape oriented, 41.74 % were portrait oriented and 3.99 % were exactly square. In addition, the frequency distribution of the portrait dimensions is far less peaked than that for landscape. These elements reflect the preferences of artists, but they may also reflect the influence of the market on artists.

The golden ratio has little supporting theory, but it is of interest because it belongs to a long established Western aesthetic tradition (Boselie 1992; Green 1995; Shortess et al. 1997; Silvia and Barona 2009). Thus, artists and architects are argued to have proportioned their works to golden ratio precepts since at least the classical Greek period (Green 1995). And, unusually for an aesthetic attribute, it can be measured. The golden ratio exists for an artwork if and only if: $H/W = (H + W)/H$ and $H, W > 0$ and $H > W$. This yields a unique solution for the ratio of H to W, the irrational number phi, $\Phi = 1.618034$ (Livio 2003). When $H > W$, the work has a portrait orientation. If $H < W$, it has a landscape orientation, with $H/W = (H + W)/W = 0.618034$. There are many studies of the golden ratio in the arts (Boselie 1992; Macrosson and Strachan 1997) and perception literature (Benjafield 2000; Boselie 1984; Green 1995; Ohta 1999; Russell 2000), some arguing that recognition of the golden ratio is innate. The empirical studies among these are all experimental, analysing choices in the absence of significant incentives. Such incentives exist in art auctions. The distribution and its' modalities in Fig. 1 indicate that whatever the incentives they face, (Australian) artists are not concerned with the golden ratio. The mode for landscape-oriented works is the interval 0.75–0.8, as opposed to the 0.60–0.65 interval that contains the golden ratio, $H/W = 0.618$. The portrait-oriented mode is the interval 1.35–1.4, whereas the golden ratio interval is $H/W > 1.55$, containing $H/W = 1.618$. Only a lexicographic preference ordering in which the golden ratio was dominant for all artists would see all works created conform to its proportions. Dimensions differ not only due to artists' preferences, but also due to idiosyncratic subject matter, or specific locations that dictate unusual dimensions. One such idiosyncratically dimensioned and portrait-oriented work in these data is a head and neck portrait of a giraffe by Whiteley. In general, it is expected that idiosyncratically dimensioned works will attract lower prices in a secondary auction market. So, not all works will adhere to one set of proportions. This means that even if the golden ratio hypothesis holds, we expect departures from it for artistic and other reasons. It is what purchasers are prepared to pay that illuminates preferences for the golden ratio and other dimensions.

3 Model specification

A standard form of the hedonic price equation is used:

$$Y_{kt} = f(X_{1kt}, \ldots, X_{mkt}, \ldots, X_{Mkt}, g(t)) + \varepsilon_{kt} \qquad (1)$$

where Y_{kt}, the dependent variable is the natural logarithm of the price of a work k ($k = 1, \ldots, K$) sold in year and quarter t ($t = 1, \ldots, T$), X_{mkt} are the measurable characteristics m ($m = 1, \ldots, M$) of a work k at time t, $g(t)$ is a function of time such as a price index and an error term $\varepsilon \sim N(0, \Sigma_k \otimes I_T)$.

The basic dependent variable is price paid by the successful bidder, Y_{kt}, equal to the auction hammer price plus buyer's premium. The buyer's premia are included as these differ from period to period and, most importantly, from auction house to house.

The explanatory variables fall into four groups. The first group relates to the artists, including each artist's name. An artist's name serves as a surrogate quality variable and to some degree with subject matter and genre. Binary dummy variables link each artist to a work, with the artist Coleman the reference category. Thus, in the Australian canon, artists such as Fred Williams, Brett Whiteley and Margaret Olley should have a positive impact on price compared to Coleman. If an artist is alive or dead at the time of the auction of each of his or her works, a dummy variable (DTH = 1 if deceased; DTH = 0 otherwise) is assigned. The role of death in determining an artist's prices has been studied elsewhere (e.g. Ekelund et. al. 2000; Higgs and Worthington 2005; Ursprung and Wiermann 2008; Renneboog and Spaenjers 2010; among others). Of the 70 artists, 31 died prior to the study period, 23 died during it, with 16 alive at its end.

Winning the Archibald prize (ACH = 1 if a winner prior to the auction of a work; ACH = 0 otherwise) is expected to have a positive impact on the artist's prices. It is believed no variable of this type has been included in any previous art price modelling, although Ginsburgh (2003) considered prizes when modelling recognition of quality in literature, movies and music. Australia is unusual, although not unique, in that some art prizes make national news, notably the Archibald. Associated with the Archibald (portraiture; founded 1921) are the Sulman prize (genre or murals; founded 1936) and the Wynn prize (landscape; founded 1897). The three prizes are announced simultaneously each year and reported in all mass media. Neither the Sulman nor the Wynn, nor winning the Archibald more than once were statistically significant, and so these variables were removed from the modelling.

The second group of explanatory variables is the physical characteristics of the works. The media employed are acrylic (*ACR*), charcoal (*CHA*), crayon (*CRA*), etching (*ETC*), gouache (*GCH*), lithography (*LTH*), pastel (*PAS*), pencil (*PEN*), oil (*OIL*) and watercolour (*WCO*). They are treated as dummy variables, the reference category being 'all other media', including mixed media (*MIX*). Oil is expected to have the largest positive impact on price, followed by its substitute, acrylic, both having characteristics of durability, permanency and colour fastness. Etching and lithography, allow editioning of copies of the same image, creating a lack of uniqueness and so should have estimated negative coefficients. More ephemeral and fugitive media, that is, charcoal, crayon, gouache, lithographs, pastels, pencil and watercolour, are expected to have a negative impact upon price. In addition, these media are usually rendered on paper and are more prone to deterioration and can be rendered more quickly and in greater numbers of works than oils and acrylics. Nonetheless, the largest group of works sold is oils (39.06 %), then etchings (10.18 %) and watercolour (9.83 %).

Physical characteristics also include the dimensions of the artworks. Among many possible expressions of the dimensions, only area (H x W) has normally been included as an explanatory variable (Anderson 1974; de la Barre et al. 1994; Agnello and Pierce 1996; Czujack 1997; Locatelli et al. 1999; Renneboog and Spaenjers 2010; among others). Size is usually represented as two explanatory variables: (a) surface area (ARE) = ($H \times W$) and (b) area squared (ASQ), that is, ASQ = ARE^2. The reason for use of a quadratic is that as size increases so price rises, but as size increases it becomes difficult for most houses to accommodate them. Thus, the expected signs are positive for ARE and negative for ASQ. Conversely, museum demand rises for the largest works as they tend to be an artist's more significant works—all the present artists are represented in public galleries—but these represent only a very small part of auction transactions. It is worthy of note that Australian houses are on average the largest in the World (James 2009).

Here, as well as ARE and ASQ, other measures are used to explore the impacts of an artwork's dimensions on its price. Specifically, this includes the impact of the deviation of the artwork's dimensions from the golden ratio upon its price. The basic measure of dimensions as shape is the ratio of height to width, with the variable HDW = H/W. Two dummy variables representing the major orientations, portrait (POR) and landscape (LAN), such that if HDW > 1 then for that artwork POR = 1 (POR = 0 otherwise) and if HDW < 1 for any artwork then for that artwork LAN = 1 (LAN = 0 otherwise), square works being the reference category. Assuming that the demand for generic Australian scenes, that is, landscapes, is the mainstay of the Australian art market the estimated coefficient on LAN is expected to be positive, and to have a higher value than the estimated coefficient on POR. Thus, it is being assumed that dummy variables LAN and POR act partly as highly aggregate proxies for the subject matter of the works. The dummy variables LAN and POR are also multiplied by ARE and ASQ to separately identify the effects of the size (LAN × ARE; LAN × ASQ; POR × ARE and POR × ASQ) on art prices on the two categories. This differentiates them from the size, that is, ARE and ASQ, of square artworks.

The golden ratio is treated as a null hypothesis such that purchasers exhibit a preference for the golden ratio. As the golden ratio can only apply to rectangular works, square works were excluded from the hypothesis test. This favours the golden ratio hypothesis in the sense that square works will not fit the hypothesis, but avoids the arbitrary inclusion of square works into either the portrait or landscape categories. Two measures of deviations of dimensions from the golden ratio are calculated, one each for portrait-oriented works and landscape-oriented works. For portrait-oriented works, GRPOR is calculated as GRPOR = $|[(H+W)/W] - \Phi|$. For landscapes, GRLAN is calculated as GRLAN = $|[(H+W)/H] - (\Phi - 1)|$. If the estimated coefficients for GRLAN and GRPOR cannot be rejected under the null hypothesis, it is concluded that artwork purchases are made according to the golden ratio. The absolute values are required because the values obtained from the deviations can be either positive or negative, potentially cancelling each other out. These definitions mean that the values of the estimated coefficients on these two variables should be negative if larger deviations from the golden ratio decrease price. It is important to note that the variables GRLAN and GRPOR are designed specifically as tests of the golden ratio hypothesis, rather than as purely explanatory variables. As their two tests are separate, they could be of different signs and of different levels of significance. Also, potentially affecting the test, extreme ratios will occur for specific purposes such as friezes, panoramas and full-length portraits—technical requirements override any preference for the golden ratio.

It was recognised that the two golden ratio variables, GRLAN and GRPOR, could do the work of omitted dimensional variables in explaining prices. To overcome this potential problem, a cubic polynomial of dimensions was employed, that is, the variables HDW, HDW^2 and HDW^3. In other words, when estimated in the same equation (Final Model, Table 2) as the golden ratio variables, they compete for explanatory significance. There were, of course, no specific expectations concerning the signs of estimated coefficients.

The third set of characteristics concerns the auction transactions. Characteristics of the auction include its date and the name of the auction house. These are Australian Art Auctions (*AUS*), Christies (*CHR*), Deutscher-Menzies (*DEU*), Lawson Menzies (*LAW*), Leonard Joel (*LEO*) and Sotheby's (*SOT*). The reference category is 'other auction houses'. The largest number of works was sold through Leonard Joel (19.37 %), probably because it specialises in prints. It was followed by Sotheby's (15.16 %) and Christies (12.87 %). Pesando (1993), de la Barre et al. (1994), Renneboog and Van Houtte (2002) and Higgs and Worthington (2005) among others have found that Christies and Sotheby's obtain systematically higher hammer prices than other houses. As with art prizes, this suggests a market in which sellers and purchasers are not fully informed.

The fourth variable set of is a quarterly Australian art price index (API) by Higgs (2010). This is included to eliminate any distortions due to asset price inflation. As opposed to the 96 dummy variables that would have been required to represent each time period, an art index is preferred as being distinctly more parsimonious. An alternative specification with quarter and year dummy variables, rather than the API, was also tested to ensure this did not affect estimated coefficients.

The art price hedonic regression equations for which the results are reported are below. They differ in their inclusion/exclusion of dimension variables and the golden ratio tests. Equation (2) represents the Final Model which includes all of the explanatory variables. For comparative purposes, the first regression (Model 1) excludes the HDW, HDW^2 and HDW^3 variables. The second regression (Model 2) excludes the GRLAN and GRPOR variables. The three sets of results therefore represent the three possible permutations of the pair of golden ratio hypothesis variables and the cubic polynomial set of ratio variables. All other dimensions-related variables are maintained in all three equations.

$$\begin{aligned}\mathrm{LNPCE}_{kt} = {} & \alpha_1 + \alpha_2\mathrm{ACH}_{kt} + \sum_{m=3}^{M}\alpha_m\mathrm{PER}_{mkt} + \beta_1\mathrm{LAN}_t + \beta_2\mathrm{POR}_t \\ & + \beta_3\mathrm{GRLAN}_{kt} + \beta_4\mathrm{GRPOR}_{kt} + \beta_5\mathrm{HDW}_{kt} + \beta_6\mathrm{HDW}_{kt}^2 + \beta_7\mathrm{HDW}_{kt}^3 \\ & + \beta_8\mathrm{ARE}_{kt} + \beta_9\mathrm{ASQ}_{kt} + \beta_{10}\mathrm{LAN}_{kt} \times \mathrm{ARE}_{kt} + \beta_{11}\mathrm{LAN}_{kt} \times \mathrm{ASQ}_{kt} \\ & + \beta_{12}\mathrm{POR}_{kt} \times \mathrm{ARE}_{kt} + \beta_{13}\mathrm{POR}_{kt} \times \mathrm{ASQ}_{kt} \\ & + \sum_{q=1}^{Q}\delta_q\mathrm{MED}_{qkt} + \sum_{r=1}^{R}\gamma_r\mathrm{HSE}_{rkt} + \lambda_1\mathrm{API}_{kt} + \varepsilon_{kt} \qquad (2)\end{aligned}$$

where α_i, β_i, δ_i, γ_i and λ_1 are parameter estimates of the implicit prices of the specified art characteristics, PER represents the set of the personal characteristics of the work, MED represents the medium of execution and HSE is the auction house, API the Australian art price index. All other variables are as previously defined.

4 The data

The data set comprises 52,298 individual auction sales between January 1986 and December 2009. The works are by 70 established Australian artists (Table 1). These artists were either born or lived mostly in Australia and mostly covered Australia related subject matter. The selection of the artists was based on discussions with art auctioneers, curators and dealers about which artists' works were sought after and which also sold regularly at auctions. This was to capture as long a time period as possible for which each artist's works appeared and covered a spectrum of art movements and genres. Thus, the works are intended to be highly heterogeneous with respect to period (very early nineteenth century to very early twenty-first century), subject matter, genre and medium. Examination of the data set revealed that every artist was represented in one or more of the collections of Australian national, state or regional public galleries. Eleven of the artists were Archibald winners. These artists form a very high proportion of the sales by value in Australian auctions. The records of all auction sales of all individual works of these artists in the six major Australian auction houses are from the Australian Art Sales Digest (2010). The data were then aggregated into quarters. Virtually, all these transactions are secondary sales consigned by domestic owners. Their reasons for consignment are not known. The price variable is the auction hammer price plus the buyer's premium, being 10–30 % above the hammer price depending on the auction house. The premium is included as it both increases the purchasers' outlay and is different between auction houses. Hammer price alone would be misleading. Pesando and Shum (1999), Locatelli Biey and Zanola (1999) and Zanola (2007) also include premium to the hammer price. Investigation of the works indicated no repeat sales, even of editioned prints such as lithographs and etchings. Consequently, neither repeat-sales methods (e.g. see Ashenfelter and Graddy 2003) nor panel data methods are appropriate. The dimensions are also from the Australian Art Digest (2010) and do not include frames or framing mattes.

Table 1 Descriptive statistics of price, area, HDW and works sold per artist

Description	Artists	Born	Died	Price ($)		Area (m^2)		HDW		Works sold
				Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Arkley, Howard	ARK	1951	1999	$56,450	$84,902	1.3782	1.2453	1.2982	0.4641	147
Ashton, John	ASH	1881	1963	$4,720	$6,571	0.1752	0.1527	0.8404	0.5837	682
Beckett, Clarice	BEC	1887	1935	$15,820	$17,651	0.1209	0.0601	0.8725	0.2246	186
Blackman, Charles	BLA	1928	–	$12,960	$43,871	0.4989	0.7592	1.0162	0.3646	3,288
Booth, Peter	BOO	1940	–	$11,734	$24,502	0.5122	0.9281	0.8718	0.3792	214
Boyd, Arthur	BYA	1920	1999	$82,936	$290,228	0.4752	0.5604	1.0218	0.3253	410
Boyd, David	BYD	1924	–	$29,330	$75,939	0.5422	0.7129	0.9669	0.2420	2,259
Boyd, Jamie	BYJ	1948	–	$7,167	$10,784	0.2723	0.2698	1.0569	0.3555	2,075
Boyd, Theodore Penleigh	BYT	1890	1923	$1,481	$1,553	0.6023	0.9047	0.8666	0.3278	193
Brack, Cecil John	BRA	1920	1999	$16,088	$35,156	0.2137	0.261	1.1682	0.7821	253
Buckmaster, Ernest	BUC	1897	1968	$5,603	$3,162	0.5064	0.2154	0.8759	0.2473	722
Bunny, Rupert	BUN	1864	1947	$46,776	$102,330	0.2771	0.386	0.9944	0.3739	420
Coburn, John	COB	1925	2006	$6,338	$14,221	0.5303	0.6651	0.9324	0.3431	1,141
Coleman, William	COL	1922	1993	$1,704	$2,249	0.1979	0.4098	1.1985	0.5407	907
Crooke, Ray	CRO	1922	–	$7,171	$9,882	0.3379	0.3649	0.8973	0.2708	1,853
Dargie, William	DAR	1912	–	$4,181	$13,114	0.2212	0.2365	0.9648	0.2766	184
Dickerson, Robert	DIC	1924	–	$7,259	$10,897	0.3578	0.4804	1.2448	0.2843	1,889
Dobell, William	DOB	1899	1970	$27,375	$66,917	0.1068	0.1752	0.9834	0.3698	431
Drysdale, George Russell	DRY	1912	1981	$58,271	$186,207	0.1648	0.2307	1.1227	0.3880	652
Duncan, George	DUN	1904	1974	$2,141	$3,203	0.2255	0.1609	0.9331	0.2475	111
Fairweather, Ian	FAI	1891	1974	$75,524	$132,756	0.3645	0.3269	1.0722	0.3268	137
Fizelle, Reginald Cecil	FIZ	1891	1964	$3,082	$10,603	0.1443	0.0859	0.8620	0.3121	106
Fox, Ethel	FOX	1872	1952	$26,676	$79,927	0.154	0.1314	0.8541	0.2245	271

Table 1 continued

Description	Artists	Born	Died	Price ($)		Area (m^2)		HDW		Works sold
				Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Friend, Donald	FRI	1915	1989	$5,804	$10,590	0.2195	0.1974	1.0357	0.3831	1,652
Fullbrook, Samuel	FUL	1922	2004	$12,047	$12,977	0.2244	0.2324	1.0308	0.3449	194
Garrett, Thomas	GAR	1879	1952	$2,609	$1,723	0.0822	0.0369	0.8597	0.2170	784
Gascoigne, Rosalie	GAS	1917	1999	$37,954	$63,288	0.5894	0.9533	1.0522	0.4635	34
Gleeson, James Timothy	GLE	1915	2008	$7,689	$17,629	0.2545	0.7499	1.1398	0.3074	796
Glover, John	GLO	1767	1849	$54,613	$230,592	0.3151	0.3148	0.7073	0.1197	168
Gould, John	GOU	1804	1881	$836	$1,844	0.1793	0.0337	1.2661	0.3629	586
Gruner, Elioth	GRU	1882	1939	$21,571	$23,513	0.1131	0.1248	0.8887	0.2715	317
Hart, Kevin Charles Pro	HAR	1928	2006	$4,009	$5,434	0.2173	0.2864	0.9341	0.3320	3,034
Hester, Joy	HES	1920	1960	$14,646	$31,341	0.1382	0.1345	1.1727	0.4262	100
Heysen, Hans	HYH	1877	1968	$12,372	$21,775	0.1253	0.1162	0.8417	0.2316	1,161
Heysen, Nora	HYN	1911	2003	$7,446	$9,171	0.2013	0.1518	1.1357	0.2529	139
Hodgkinson, Frank	HOD	1919	2001	$1,623	$2,631	0.5599	0.6077	0.9809	0.3917	318
Jackson, James Ranalph	JAC	1882	1975	$8,463	$11,458	0.2102	0.131	0.7881	0.2173	506
Kelly, John	KEL	1965	–	$32,374	$35,389	0.7346	0.8265	0.9603	0.7359	166
Kngwarreye, Emily	KNG	1910	1996	$36,493	$68,061	1.3521	1.1964	1.2913	0.4564	441
Larter, Richard	LAR	1929	–	$5,250	$5,150	1.2653	1.0011	1.3190	0.3757	164
Lindsay, Lionel	LNL	1874	1961	$563	$607	0.0467	0.123	1.0928	0.4748	2,192
Lindsay, Norman	LNN	1879	1969	$8,346	$20,000	0.0981	0.1099	1.2018	0.3224	3,500
Long, Sydney	LON	1871	1955	$6,375	$13,672	0.1319	0.375	0.8799	0.3468	697
Maguire, Tim	MAG	1958	–	$21,928	$44,960	1.0693	1.4616	0.9703	0.2875	205
McCubbin, Frederick	MCC	1855	1917	$137,108	$305,226	0.2388	0.3337	0.8005	0.3155	210
Namatjira, Albert	NAM	1902	1959	$14,129	$10,682	0.1000	0.0379	0.8009	0.4465	616

Table 1 continued

Description	Artists	Born	Died	Price ($)		Area (m^2)		HDW		Works sold
				Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Nolan, Sydney	NOL	1917	1992	$17,242	$61,774	0.508	0.7207	0.9992	0.3193	3,142
Olley, Margaret	OLL	1923	–	$23,323	$23,002	0.4792	0.2932	0.8919	0.2781	337
Olsen, John	OLS	1928	–	$16,675	$48,798	0.587	0.9139	1.0983	0.3765	1,631
Perceval, John	PER	1923	2000	$23,693	$51,729	0.376	0.3099	0.9525	0.3056	773
Preston, Margaret	PRE	1875	1963	$24,342	$38,068	0.1384	0.1694	1.0720	0.2137	291
Proctor, Althea	PRO	1879	1966	$3,178	$4,111	0.0951	0.0704	1.0938	0.4539	264
Pugh, Clifton	PUG	1924	1990	$5,780	$10,107	0.5319	0.4403	0.9275	0.3124	864
Rankin, David	RAN	1946	–	$3,093	$3,821	1.1977	1.3941	1.0406	0.3946	491
Rees, Lloyd	REE	1895	1988	$14,328	$36,796	0.2221	0.2434	0.8149	0.2289	1,078
Roberts, Thomas William	RBT	1856	1931	$39,229	$64,131	0.1707	0.247	1.0125	0.4788	199
Robinson, William	ROB	1936	–	$66,490	$97,679	0.8437	0.8262	0.8632	0.3001	158
Russell, John Peter	RUS	1859	1930	$88,797	$219,761	0.1707	0.1459	0.8422	0.2344	165
Sawrey, Hugh	SAW	1923	1999	$7,689	$8,359	0.4719	4.1053	0.8667	0.2009	773
Shead, Garry	SHE	1942	–	$17,613	$38,436	0.4221	0.6689	1.0119	0.2948	477
Smart, Frank Jeffrey	SMA	1921	–	$71,758	$109,860	0.2995	0.2496	0.8787	0.3419	392
Smith, Grace Cossington	SMI	1892	1984	$28,069	$39,160	0.1507	0.1041	1.1542	0.2627	239
Storrier, Tim	STO	1949	–	$17,618	$30,767	0.915	1.0438	0.8350	0.3889	639
Streeton, Arthur	STR	1867	1943	$52,371	$107,411	0.2509	0.5024	0.8693	0.4375	692
Thomas, Rover	THO	1926	1998	$65,142	$110,754	1.1608	1.2891	0.8499	0.3749	241
Tjapaltjarri, Clifford	TJA	1932	2002	$33,636	$164,809	1.5504	3.7212	1.2324	0.6098	227
Tucker, Albert	TUC	1914	1999	$41,725	$94,348	0.3838	0.3807	0.8792	0.2514	305
Whiteley, Brett	WHI	1939	1992	$52,500	$199,957	0.5823	0.7615	1.1712	0.4810	1,392
Williams, Frederick	WIL	1927	1982	$56,702	$166,303	0.3942	0.5555	1.0156	0.3608	754

Table 1 continued

Description	Artists	Born	Died	Price ($)		Area (m^2)		HDW		Works sold
				Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	
Withers, Walter	WTH	1854	1914	$20,450	$42,690	0.1189	0.129	0.8221	0.3434	263
Total				$17,257	$72,633	0.3609	0.813	0.9894	0.3512	52,298

HDW is height divided by width

Table 1 also presents sample means and standard deviations for price, area, height divided by width (HDW) and number of works sold per artist. In terms of area, only seven out of 70 artists (10 %) produced artworks that on average exceeded one square metre. The majority of these artworks were created for the walls of domestic houses as opposed to art galleries. For orientation, HDW, there is a higher percentage of landscapes (40 out of 70 artists—57 %) when compared to portraits. This presumably reflects both the preferences of the artists and the influence of the art market on the artists.

5 Empirical results

Some clear patterns emerge from the estimation. These include results commonly seen in the literature, notably the impact of individual artists, death, the medium used and the auction house. These results are stable across all estimated equations. The results for dimensions are then considered, including the golden ratio. In addition, a serendipitous result that indicates a relationship between the dimensions of works and Archibald prize winners is briefly examined.

The empirical results are in Table 2 for the three versions of the model. The estimated coefficients; standard errors; *p* values and percentage changes are detailed in columns 2–5 for Model 1; columns 6–9 for Model 2 and columns 10–13 for the Final Model.

The null hypothesis of no heteroskedasticity in the least squares residuals was initially rejected using White's (1980) test (results can be provided upon request). These tests ranged between F statistic = 60.8497, p value = 0.0000 to F statistic = 61.2029, p value = 0.0000. The standard errors and p values incorporated White's (1980) corrections for unknown forms of heteroskedasticity. For all three models, the adjusted R^2 were in the band 0.7157 to 0.7160. While high for cross-sectional data, this is weakened by the degrees of freedom offered by the very large data set.

The inclusion of higher orders of HDW (i.e. HDW^2 and HDW^3) as well as the interactions of LAN and POR with ARE and ASQ terms almost inevitably creates multicollinearity with variance inflation factors (VIF) exceeding the value of ten (results can be provided upon request). In essence, a VIF greater than ten indicates the presence of potentially harmful collinearity. The three models are re-estimated with and without the collinear dimensional variables, and it is evident that multicollinearity only affects the dimensional variables. Other estimates remain stable.

The impact of the artists on prices conformed to expectations based on knowledge of the Australian art market. Only, Boyd (Jamie), Duncan, Hodgkinson and Rankin had estimated coefficients that lack statistical significance across all three equations. The great majority of the artist dummy variables were statistically significant at the 1 % level. Artists most in favour during the study period were Fairweather, Gascoine and Thomas, while most out of favour were Buckmaster, Crooke and Dargie. Note that these artists are judged against this group of seventy, rather than their standing in the market as a whole. The rankings of artists remain

Table 2 The empirical results

Variable	Model 1				Model 2				Final Model			
	Estimated coefficient	Standard error	*p* value	Percentage change	Estimated coefficient	Standard error	*p* value	Percentage change	Estimated coefficient	Standard error	*p* value	Percentage change
CON	3.7756	0.0455	0.0000	43.6232	3.6535	0.0629	0.0000	38.6101	3.4726	0.0785	0.0000	32.2204
ACH	1.5946	0.0628	0.0000	4.9263	1.6468	0.9022	0.0680	5.1902	1.5979	0.9018	0.0764	4.9428
DTH	0.2082	0.0168	0.0000	1.2314	0.2084	0.0168	0.0000	1.2317	0.2081	0.0168	0.0000	1.2313
LAN	0.1968	0.0333	0.0000	1.2175	0.2713	0.0329	0.0000	1.3116	0.2888	0.0389	0.0000	1.3348
POR	−0.3098	0.0802	0.0001	0.7336	0.1136	0.0333	0.0006	1.1203	−0.7317	0.1462	0.0000	0.4811
GRLAN	0.3701	0.0751	0.0000	1.4479					0.1720	0.0805	0.0325	1.1877
GRPOR	0.3726	0.0645	0.0000	1.4515					0.6820	0.1128	0.0000	1.9777
HDW					0.1744	0.0520	0.0008	1.1906	0.3729	0.0745	0.0000	1.4520
HDW^2					−0.0706	0.0151	0.0000	0.9319	−0.0754	0.0164	0.0000	0.9274
HDW^3					0.0038	0.0009	0.0000	1.0038	0.0034	0.0009	0.0002	1.0034
ARE	0.1484	0.0095	0.0000	1.1600	0.1483	0.0084	0.0000	1.1599	0.1485	0.0084	0.0000	1.1601
ASQ	−0.3206	0.0375	0.0000	0.7257	−0.3204	0.0318	0.0000	0.7258	−0.3210	0.0317	0.0000	0.7254
LAN*ARE	−0.0788	0.0097	0.0000	0.9243	−0.0786	0.0085	0.0000	0.9244	−0.0785	0.0084	0.0000	0.9245
LAN*ASQ	0.3144	0.0375	0.0000	1.3695	0.3143	0.0318	0.0000	1.3692	0.3149	0.0317	0.0000	1.3701
POR*ARE	−0.0645	0.0100	0.0000	0.9375	−0.0640	0.0085	0.0000	0.9380	−0.0645	0.0085	0.0000	0.9376
POR*ASQ	0.3045	0.0375	0.0000	1.3560	0.3043	0.0318	0.0000	1.3556	0.3049	0.0317	0.0000	1.3566
ACR	1.0871	0.0360	0.0000	2.9657	1.0898	0.0321	0.0000	2.9738	1.0908	0.0321	0.0000	2.9767
CHA	0.6473	0.0309	0.0000	1.9104	0.6400	0.0321	0.0000	1.8965	0.6444	0.0321	0.0000	1.9048
CRA	0.4090	0.0523	0.0000	1.5053	0.4021	0.0571	0.0000	1.4950	0.4081	0.0571	0.0000	1.5040
ETC	−0.4140	0.0178	0.0000	0.6610	−0.4088	0.0168	0.0000	0.6645	−0.4143	0.0168	0.0000	0.6608
GCH	1.1653	0.0308	0.0000	3.2069	1.1632	0.0331	0.0000	3.2002	1.1664	0.0330	0.0000	3.2105
LTH	−0.6664	0.0192	0.0000	0.5135	−0.6687	0.0191	0.0000	0.5123	−0.6676	0.0191	0.0000	0.5130

Table 2 continued

Variable	Model 1				Model 2				Final Model			
	Estimated coefficient	Standard error	*p* value	Percentage change	Estimated coefficient	Standard error	*p* value	Percentage change	Estimated coefficient	Standard error	*p* value	Percentage change
MIX	1.0537	0.0296	0.0000	2.8682	1.0542	0.0294	0.0000	2.8698	1.0537	0.0294	0.0000	2.8682
OIL	1.8859	0.0183	0.0000	6.5925	1.8915	0.0143	0.0000	6.6291	1.8852	0.0143	0.0000	6.5876
PAS	1.0394	0.0313	0.0000	2.8276	1.0349	0.0316	0.0000	2.8149	1.0384	0.0316	0.0000	2.8247
PEN	0.1532	0.0233	0.0000	1.1656	0.1499	0.0222	0.0000	1.1617	0.1530	0.0222	0.0000	1.1654
WCO	1.0475	0.0195	0.0000	2.8505	1.0472	0.0182	0.0000	2.8495	1.0465	0.0182	0.0000	2.8476
AUS	−0.1892	0.0199	0.0000	0.8276	−0.1882	0.0225	0.0000	0.8285	−0.1893	0.0225	0.0000	0.8275
CHR	0.7249	0.0146	0.0000	2.0646	0.7260	0.0139	0.0000	2.0667	0.7249	0.0139	0.0000	2.0645
DEU	0.6489	0.0142	0.0000	1.9134	0.6493	0.0146	0.0000	1.9143	0.6483	0.0146	0.0000	1.9124
LAW	0.1746	0.0186	0.0000	1.1907	0.1735	0.0191	0.0000	1.1895	0.1740	0.0191	0.0000	1.1900
LEO	0.0710	0.0116	0.0000	1.0736	0.0715	0.0123	0.0000	1.0741	0.0707	0.0123	0.0000	1.0733
SOT	0.7414	0.0148	0.0000	2.0989	0.7419	0.0134	0.0000	2.0999	0.7413	0.0134	0.0000	2.0987
API	0.0043	0.0001	0.0000	1.0043	0.0043	0.0001	0.0000	1.0043	0.0043	0.0001	0.0000	1.0043
R^2	0.7164				0.7163				0.7166			
Adjusted R^2	0.7159				0.7157				0.7160			
F statistic	1331.9260				1317.5190				1293.7150			
p value	0.0000				0.0000				0.0000			

The sixty-nine artists' dummy variables are included in the three models but the estimated coefficients are not presented much the same across all three estimated equations. The estimated coefficients for the sixty-nine artists' dummy variables (Coleman is the reference category) are omitted from Table 2 and can be supplied on request. In all equations, the estimated coefficient for works by artists who are dead at the time of auction (*DTH*) is positive, statistically significant at the 1 % level and virtually identical.

In line with expectations, works in oil (*OIL*) are the most valued, followed by gouache (*GOU*) and acrylic (*ACR*). As acrylic and oil would appear to be the closer substitutes, it is surprising that gouache commands higher prices than acrylics and is not explained. As expected lithographs (*LTH*) and etchings (*ETC*) have negative coefficients, existing in multiple copies from editioned print runs as do the more fugitive and fragile media.

In the Final Model, the estimated coefficients on auction houses indicate that auctions at Sotheby's (*SOT*), Christies (*CHR*) and Deutscher-Menzies (*DEU*) achieve higher hammer price plus premium prices by 2.0987, 2.0645 and 1.9124 %, respectively, over other auction houses. The results for auction houses are similar in all equations. Outside Australia, Pesando (1993), de la Barre et al. (1994), Agnello and Pierce (1996), and Renneboog and Van Houtte (2002) typically found that Sotheby's fetched higher prices than Christies and, in turn, they both commanded higher prices than other houses.

The remaining results relate to dimensions of the works, including the golden ratio. Included are the size of the work, area (ARE) and area squared (ASQ). This is disaggregated into separate landscape, portrait and square components. For square works, the reference category for orientation, there is a significant positive coefficient on ARE and a significant negative coefficient of ASQ, consistent with other studies. For both the landscape and the portrait categories, the adjustments LAN × ARE and POR × ARE have a negative sign, while the squared components, LAN × ASQ and POR × ASQ, have a positive sign, and this is stable across the three different equations. This is consistent with large Australian house sizes, households perhaps being less deterred by large size than others.

The intercept terms for LAN and POR are significant at the 1 % level, across all three equations. The positive coefficient on LAN indicates that landscape dimensioned works are preferred to portrait and square works. However, as already noted, this need not represent a pure orientation effect as it will also relate to subject matter. Note, however, that the sign of POR changes in the second equation, interacting with the cubic polynomial of the dimension ratio HDW.

The tests for the golden ratio hypothesis were unexpected. The estimated positive coefficients indicate higher secondary auction market prices for deviations from the golden ratio. This is despite the fact that square works of art do not fit with the golden ratio hypothesis and excluding them from tests of the golden ratio hypothesis increased the chance of acceptance. Similarly, the linear weighting on deviations favoured the acceptance of the golden ratio by minimising the impact of large deviations in the hypothesis test. The rejection of the golden ratio hypothesis is therefore strengthened. This means that Australian purchasers prefer works whose dimensions deviate from the golden ratio. Reinforcing this result, the presence of the cubic polynomial of the HDW ratio does not substantively affect either of the golden ratio estimated coefficients, although it slightly reduces their significance levels. Certainly, the golden ratio hypothesis is rejected at the 1 % level for all model specifications. Nonetheless, a strong note of caution is required given the sample's distribution of dimensions shown in Fig. 1. In that distribution, the golden ratio dimensions are in the outer tails of the distribution. In principle, this should not affect the results. However, it may do so if, for example, there is an omitted variable mis-specification. The HDW cubic polynomial was designed to overcome this possibility—to pick up any nonlinearities in the relationship between the dimensional ratio and price not accounted for by the two highly specific and linear variables designed to test the golden ratio hypothesis. Consequently, there were no prior expectations for the signs of the HDW polynomial's coefficients.

For eleven artists, an unexpected consequence of inclusion of the HDW cubic polynomial was that the level of significance of their estimated coefficients fell (Table 2). The artists are Buckmaster, Bunny, Crooke, Dargie, Dobell, Fullbrook, Heysen (Nora), Olsen, Pugh, Robinson and Whiteley. Their estimated coefficients changed only marginally, symptomatic of multicollinearity. Despite this, the simple correlation coefficients between each of the eleven artists and the HDW variables had a maximum absolute value less than 6 %. All but one artist in this group, Bunny, won the Archibald prize. Only one of the Archibald prize winners in this study, Shead, was not in this group of eleven. The Archibald prize (ACH) variable coefficient also fell in significance from the 5 to 10 % level in the presence of the HDW cubic polynomial. Conversely, the POR dummy variable, potentially relevant to Archibald winning portraitists, was not affected, although it was by the presence of the golden ratio variable GRPOR. These results indicate complex interactions between at least some artists, their choice of dimensions for their works, the Archibald prize and the preferences of secondary auction customers. A tentative suggestion is that Archibald winners, compared to most portraitists, work on a large scale [although this is not completely borne out by the means of the areas of their works in this sample—see Table 1: Area (m^2)]. If area is regressed against Archibald prize, the significant estimated coefficient is 1.1 which suggests that for winners of the Archibald prize, the area of their works increases on average by 1.1 square metres. Shead, the sole Archibald winner not in the eleven, is a figurative and portrait painter who works on a small scale compared to the other Archibald winners. Conversely, Bunny, a highly regarded figurative and portrait painter, the only non-Archibald winner in the group of eleven often painted on a very large scale. The impact of the cubic polynomial on the significance of the Archibald prize variable, albeit it minor, seems to result from such relationships, but its precise nature remains unclear.

Finally, a comparison is made between the estimated coefficients (standard error and *p* value) for the Final Model with the API and the inclusion of the dummy variables of quarter and year. As an example, the estimated coefficients for GRLAN and GRPOR are, respectively, 0.1777 (0.0802 and 0.0268) and 0.6908 (0.1125 and 0.0000) with the dummy variables as compared to the API are, respectively, 0.1720 (0.0805 and 0.0325) and 0.6820 (0.1128 and 0.0000). These results indicate no significant difference in the corresponding estimated coefficients.

6 Concluding remarks

The argument that purchasers do not purchase an object in isolation from their domestic situation and physical surroundings is a starting point for investigating artwork dimensions. Previously, only one aspect of artwork dimensions, area, has been examined. The present results support the view that artwork dimensions are an important and complex influence on prices, and that they interact with other variables.

Nonetheless, the golden ratio hypothesis was found completely lacking in increasing prices paid in the Australian secondary art market. Indeed, the results indicate an aversion to golden ratio dimensions. This is a striking and unexpected result. However, given the longevity of the golden ratio hypothesis, its importance in aesthetics and its use in experimental testing in the perception sciences, this will not be the last test of this hypothesis. However, it is noted that the distribution of dimensions within the sample can be argued to mitigate against a result that favoured the golden ratio hypothesis.

In this context, one aspect of dimensions is the orientation of a work as ‘landscape’, ‘portrait’ or ‘square’. The results show a premium is paid for works that are landscape oriented. Although the landscape orientation is only imperfectly associated with landscape subject matter, it is suggested that many purchasers inside Australia have a preference for traditional, generic Australian landscapes. Conversely, in the ‘first-owner’ market, there can be specific commission requirements, such as subject matter and dimensions, with portraiture often related in specific ways to the original purchaser, commissioning families and organisations. Such works lose their specificity value on the secondary market. In the auction market, their price will be correspondingly lower.

Of course, a premium for talented artists’ works does carry over into the secondary market. The empirical results for the positive impacts of the Archibald portraiture prize on winning artists’ auction prices are consistent with this view. This result, as well as results for the impacts of auction houses, is also consistent with the market being imperfectly informed. A striking relationship appeared between the Archibald prize winners as a group and the addition of the cubic polynomial in the height-to-width ratio. Only two artists, Bunny and Shead, were exceptions to this. While an unexpected result, it fits with the argument that dimensions are important. At this stage, only a tentative interpretation is possible—that the Archibald winners paint portraits on a large scale (most Archibald portraits are on a large scale).

Overall, the results indicate that artwork dimensions contribute markedly to art market prices and do so in a complex and previously unexplored manner.

In this context, this work uniquely considers the distribution (of the dimensions) of works in the sample. Certainly, the distribution of the works constrains the choices that can be made by potential purchasers. It also reflects aspects of the supply side in that it represents choices made by artists and by owners consigning works to auction. The complexity of the sample distribution (of dimensions) also indicates not only a more cautious interpretation of the present results, but also for the mass of previous research where the sample distribution has not been noted.

Also, suggesting caution is the possible presence of sample selection bias (usual in hedonic art pricing models but not always noted) as the data comprise only actual transactions and ignores 'buy-ins' (unsold items whose hammer prices have not met the sellers' reserve prices). Future research is to acquire a longer data set to include these transactions for analysis. For future research, the overall sample may be divided into sub-samples belonging to specific artistic and historical periods, a feasible proposition over the limited historical period of saleable Australian art.

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