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ABSTRACT

The literature on hedonic price indices, such as the adjacent art price index, often uses a logarithmic transformation of the price data to deal with the non-normality. However, this creates the problem of retransforming the predictions back to an economically meaningful scale. This paper investigates the impact of dealing with the retransformation problem for estimates of art market returns. The empirical results show how failure to allow for retransformation may result in a biased price index.

Key words: Retransformation; heteroskedasticity; Picasso; hedonic prices.

JEL classification: C6, D2, Z1.

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1. Introduction

In recent years many papers have discussed the hedonic estimation of prices for art collectibles and measured their dynamics using hedonic price indices (see e.g., Ginsburgh and Throsby, 2006). To deal with the non-normality of art prices many of these studies use a log-linear specification for the hedonic models and indices. However, to our knowledge, the problem of retransforming predictions back to an economically meaningful scale in order to compute the art price index has been ignored in this literature. To address this problem, this paper investigates the effects on estimates of art market returns of a modified version of Duan's (1983) smearing factor. Empirical results show how failure to control for retransformation issues will result in biased estimates of the price index.

2. Modelling framework

A set of quality characteristics $z_{i,k}^{t} = 1,...,K,$ is identified for a regression of the log price of painting i, with $i = 1,...,N$, sold at time t, with $t = 1,...,T$ on its k-characteristics and a set of dummy variable d_i^t, which are equal to 1 in period t and zero otherwise, such that:

$$\log(p_i^t) = \alpha + \sum_{k=1}^{K} \beta_k z_{i,k}^t \sum_{t=2}^{T} \delta_\tau d_i^t + \varepsilon_i^t \qquad (1)$$

where α is the intercept; the β_i^t can be interpreted as (implicit) prices of the various characteristics describing the painting; the $\boldsymbol{d_i^t}$ can interpreted as a measure of the component of prices that is not attributable to the identified characteristics, which can be used as an estimate of the pure price change; and ε_i^t is a random error term. The error term is assumed to have a zero conditional mean but the other moments of its distribution may be functions of the regressors z and d, for example there may be heteroskedasticity on the log-scale.

The quality of a painting is defined in terms of its characteristics and a regression of prices on these characteristics, along with the time dummies, holds quality constant.This enables the construction of constant-quality price indices. In particular, the adjacent quality-adjusted price index of a painting between period t and s, $PI^{t,s}$, for any given set of characteristics, z, is equal to (Triplett, 2006):

$$
\begin{aligned}
PI^{t,s} &= \frac{E\left[p_i^t \mid z,d\right]}{E\left[p_i^s \mid z,d\right]} \\
&= \frac{\exp\left(\hat{\alpha}+\sum_{k=1}^{K}\hat{\beta}_k z_{i,k}+\hat{\delta}^t\right)}{\exp\left(\hat{\alpha}+\sum_{k=1}^{K}\hat{\beta}_k z_{i,k}+\hat{\delta}^s\right)} \frac{E\left[\exp\left(\varepsilon_i^t\right) \mid z,d\right]}{E\left[\exp\left(\varepsilon_i^s\right) \mid z,d\right]} \\
&= \frac{\exp\left(\hat{\delta}^t\right)}{\exp\left(\hat{\delta}^s\right)} \frac{E\left[\exp\left(\varepsilon_i^t\right) \mid z,d\right]}{E\left[\exp\left(\varepsilon_i^s\right) \mid z,d\right]}
\end{aligned}
\qquad (2)
$$

Whenever a change in quality occurs it is taken care of by the associated characteristics, and the quality-adjusted price change will be captured by the product of the exponential of the regression coefficient of the time dummy variable and the conditional expectation of the exponential of the unobserved error term. This second term, which is the source of the retransformation bias, has been neglected in the literature on hedonic art price indexes.

In order to correct for this retransformation bias, Duan's (1983) nonparametric smearing estimator can be applied, this estimates the conditional expectation of $\exp(\varepsilon_i^t)$ by its sample mean. However, as the error on the log-scale of art prices is expected to be heteroskedastic, a variant of the standard Duan estimator has been adopted (see Manning, 1998). This calculates a separate smearing factor for each year, such that:

$$
\begin{aligned}
&PI^{t,s} = \frac{\varphi^t}{\varphi^s}\exp\left(\hat{\delta}^t-\hat{\delta}^s\right) \\
&\textit{where} \\
&\varphi^t = \frac{1}{N^t}\sum_{i=1}^{N}\exp\left(\log(p_i^t)-\hat{\alpha}-\sum_{k=1}^{K}\hat{\beta}_k z_{i,k}-\hat{\delta}^t\right) = \frac{1}{N^t}\sum_{i=1}^{N}\exp\left(\hat{\varepsilon}_i^t\right)
\end{aligned}
\qquad (3)
$$

3. Data and Results

The dataset consists of 716 Picasso paintings sold at auction worldwide during the period 1988-2005. The data set is collected from the 2006 edition of the Art Price Index on CD-Rom. It contains records of paintings sold at the world's major auctions. Prices are gross of the buyers and sellers' transaction fees paid to auction houses and are expressed in US dollars, deflated using US CPI prices (2000=100). Variables included in the study are size, media, saleroom, style periods (Czujack, 1997); and year of sale. Table 1 reports descriptive statistics for the variables used in the analysis.

[TABLE 1 ABOUT HERE]

Table 2 displays the results of the OLS estimate of hedonic log-price equation (1). Standard errors of the coefficients have been computed using the Huber-White heteroskedasticity-robust procedure. According to the set of physical characteristics in the regression model greater financial value is placed both on larger size, with decreasing returns to size, and on oil works executed on canvas, while prices decrease for mixed techniques. The set of explanatory variables related to the sale characteristics of the works show that auctions at Christie's and Sotheby's increase prices over other auction houses. The final set of variables relates to the different style periods. Works executed before 1954 command higher prices.

[TABLE 2 ABOUT HERE]

Time dummy variable coefficients are then used to compare the un-smeared price index with the smeared price index. Calculating a separate smearing factor for each year (Table 3) as in eq.(3), the results for the two indices are reported in Figure 1. This comparison casts doubt on the capacity of the standard index to estimate the correct return from an investment in Picasso paintings. During the period the un-smeared estimate lies both above and below the smeared estimate without any obvious regularity to the bias.

[TABLE 3 ABOUT HERE]

[FIGURE 1 ABOUT HERE]

In order to focus on the bias generated by ignoring the retransformation problem, issue Figure 2 shows the percentage differences between the smeared and un-smeared estimates over the time. These range from -22.3 up to +32.7 per cent, signalling that there may be a substantial bias in the empirical literature on art price indices. Moreover, to the extent that the art market is influenced by these indices, the issue of retransformation may lead to market failure.

[FIGURE 2 ABOUT HERE]

5. Conclusion

This paper investigates the problem of retransforming predictions back to an economically meaningful scale when art price indices are calculated from log-scale regressions. The empirical results show how failure to deal with retransformation may result in a biased price index, potentially creating misleading information upon which choices are made in the financial art markets.

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TABLE 1. Descriptive statistics

	Mean	Std. Dev.	Description
price	2,122,799	5,984,123	Price of painting
size	.5171	.5275	Area
size2	.5452	1.1117	Squared area
canvas	.7251	.4467	Oil on canvas
panel	.0580	.2340	Oil on panel
mixed	.0557	.2294	Mixed technique
other_tech	.1896	.3922	Other techinques (omitted category)
chrilon	.1505	.3578	Sold at Christie's London
chriny	.2666	.4424	Sold at Christie's New York
sothlon	.1458	.3530	Sold at Sotheby's London
sothny	.2868	.4525	Sold at Sotheby's New York
othauc	.1256	.3316	Sold at other auction houses (omitted category)
style1	.0564	.2309	Childhood and Youth (1881-1901)
style2	.0184	.1344	Blue and Rose Period (1902-1906)
style3	.0589	.2356	Analytical and Synthetic Cubism (1907-1915)
style4	.1055	.3074	Camera and Classicism (1916-1924)
style5	.1043	.3058	Juggler of the Form (1925-1936)
style6	.1595	.3664	Guernica and the 'Style Picasso' (1937-1943)
style7	.1472	.3546	Politics and Art (1944-1953)
style8	.3497	.4772	The Old Picasso (1954-1973) (omitted category)
d88	.0140	.1174	1988 dummy
d89	.0475	.2128	1989 dummy
d90	.0670	.2503	1990 dummy
d91	.0182	.1336	1991 dummy
d92	.0335	.1801	1992 dummy
d93	.0517	.2215	1993 dummy
d94	.0461	.2098	1994 dummy
d95	.0642	.2454	1995 dummy
d96	.0517	.2215	1996 dummy
d97	.0768	.2665	1997 dummy
d98	.1271	.3333	1998 dummy
d99	.0824	.2752	1999 dummy
d00	.0475	.2128	2000 dummy
d01	.0503	.2187	2001 dummy
d02	.0531	.2243	2002 dummy
d03	.0349	.1837	2003 dummy
d04	.0601	.2378	2004 dummy
d05	.0377	.1906	2005 dummy

TABLE 2. Hedonic regression results

	Coef.	Robust Std. Err.
Physical characteristics		
area	0.0004***	0.0000
area2	-1.13e-08***	1.02e-09
canvas	0.3853***	0.1161
panel	-0.2831	0.2208
mixed	-1.0101***	0.2855
Sale characteristics		
chrilon	0.3823***	0.1406
chriny	0.4037***	0.1401
sothlon	0.3231**	0.1455
sothny	0.5995***	0.1371
Style characteristics		
style1	1.6199***	0.2042
style2	2.2112***	0.3544
style3	1.8137***	0.1816
style4	0.9535***	0.1180
style5	1.2625***	0.1207
style6	0.9340***	0.1232
style7	0.2699***	0.1090
Year dummies	[incl.]	
cons	10.1389***	0.2154
R-squared	0.64	

Note: ***, **, * significance at .01, .05, and .10 respectively

TABLE 3. Estimates of smearing factors

	Smearing factor
d88	1.2216
d89	1.1883
d90	1.4520
d91	1.1282
d92	1.3874
d93	1.3047
d94	1.7316
d95	1.6501
d96	1.5572
d97	1.5777
d98	1.8095
d99	1.6935
d00	1.6123
d01	1.4645
d02	1.5459
d03	1.2256
d04	1.3234
d05	1.3188

FIGURE 1. Comparison between un-smeared and smeared prices indices

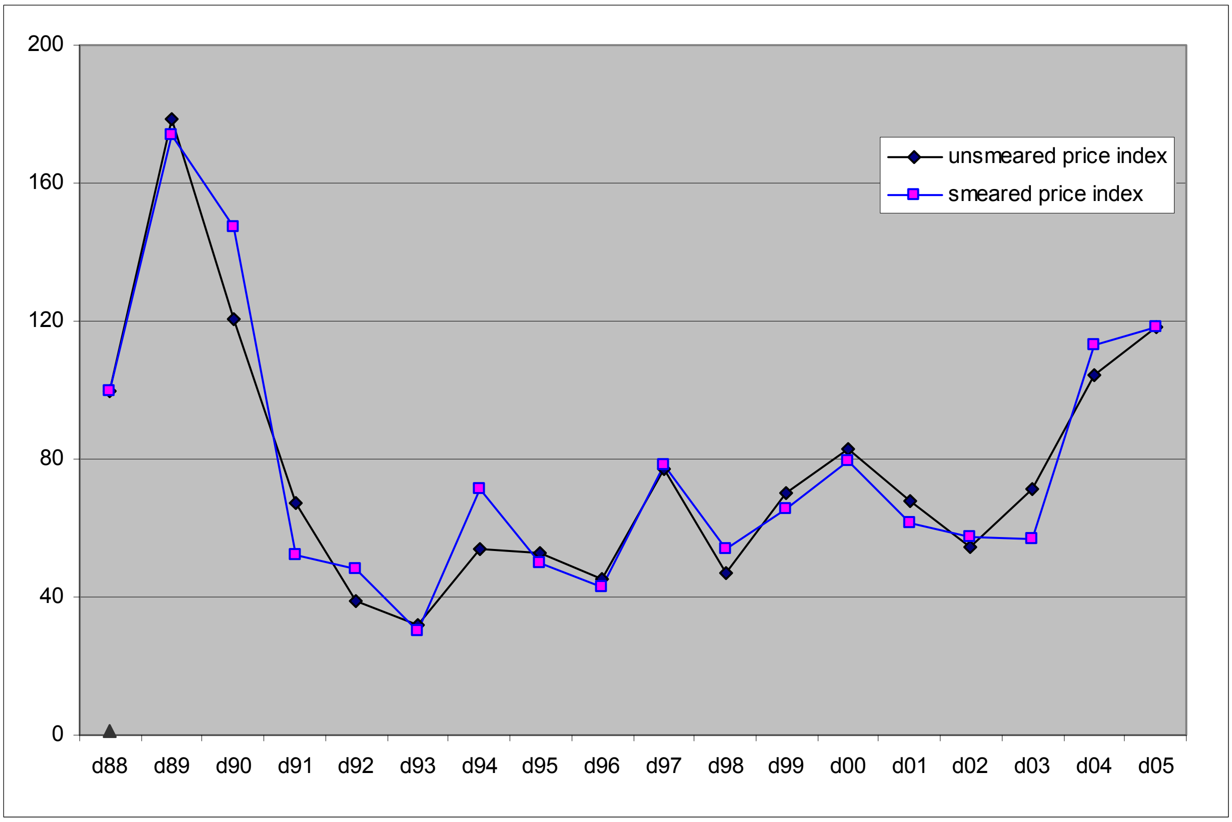

FIGURE 2. Percentage difference between smeared and unsmeared price indices