Journal of Cultural Economics
https://doi.org/10.1007/s10824-020-09403-2

SHORT PAPER

An empirical analysis of price differences for male and female artists in the global art market

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Received: 9 February 2020 / Accepted: 28 October 2020

Abstract

We study prices paid at auction for artworks created by male and female artists, based on birth-identified sex, and how these prices have evolved over time. Artworks produced by female artists comprise less than 4% of art auction sales; after controlling for artwork characteristics, we find that artworks by female artists are 4.4% more expensive than artworks by male artists. In the top echelon of the art market—for sales above $1 million—artworks by male artists sell for 18.4% more than by female artists. The top 40 artists represent 40% of total market share; no female artist makes the top 40 ranking of artists in terms of total sales value at auction in the period under study, 2000–2017. However, for contemporary artists, our empirical results show that works by male artists sell for 8.3% more than their female counterparts. Overall, this study highlights significant price differences across birth-identified sex in the secondary market for fine art.

Keywords Art market · Auctions · Gender economics · Labour economics

We would like to thank Pierre-André Chiappori, Dakshina De Silva, Jonathan Feinstein, Raffi Garcia, William Goetzmann, Claudia Goldin, Kathryn Graddy, Michaela Pagel, Leonard Wolk, the seminar and conference participants at Bocconi University, Maastricht University, Sydney University, Monash University, ESSFT Gerzensee, the International Industrial Organization Conference, the Conference on Auctions, Competition, Regulation and Public Policy, the Annual Conference of the Society for Institutional & Organizational Economics, the Annual Meeting of the Financial Management Association, and the Yale Symposium on Art and Gender for valuable comments.

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Published online: 13 February 2021

JEL Codes J24 · J31 · J71 · Z11

1 Introduction

Artworks by female artists represent only 3% to 5% of major permanent collections in the USA and Europe (National Museum of Women in the Arts 2017), and this fraction is reflected in a similar percentage of artworks by female artists sold at auction globally; according to auction sales data from artnet, this is less than 4%. Historically there were far fewer female artists; however, in more recent generations roughly 50% of all Master of Fine Arts (MFA) holders are female in the USA. It has been noted that their share drops to 30% in commercial US galleries (National Museum of Women in the Arts 2017) and to 25% at art fairs (McAndrew 2018).

In this large-scale empirical study, we analyze how the fraction of male and female artists selling at auction has evolved over time and estimate the size of any relative price differences between these two groups, after controlling for conventional artwork characteristics. Our curiosity in the pricing of artworks across different birth identities is to further our understanding of whether there are any differences in artistic characteristics of female produced artworks. As the share of female produced artworks has significantly increased over time, this will be reflected in the art market more broadly.

We use auction data representing nearly the whole population of auction transactions in the time period between 2000 and 2017. We also employ a smaller primary (gallery) market data set to investigate how the share differs between the primary and the secondary (auction) market for male and female artists. We find that female-produced artworks have a lower price than male-produced artworks when we do not control for artwork characteristics. However, after controlling for conventional artwork characteristics, female-produced artworks trade at a higher average price. This is suggestive that the difference in prices is reflective of differences in artistic characteristics of female-produced artworks.

2 Data

2.1 Sample

Our dataset comprises almost the full population of global art auction transactions between 2000 and 2017 from artnet AG, covering over 1800 auction houses.[1,2] Auction sales characteristics include the auction house name, the sale date, the lot number, the auction house pre-sale estimate and the hammer price in US Dollars

[1] We exclude decorative art, antiques, ceramics, furniture, jewellery, and watches, since our focus is the fine art sector. The fine art category includes photography, prints and multiples, works on paper, paintings, installations, design objects and sculptures.

[2] This includes the largest auction houses such as Sotheby's, Christies, Poly International, Phillips, China Guardian and Dorotheum, as well as predominately online auction houses such as Heritage and Heffel. Transactions are required to have a minimum estimate of $500 to be included in the database.

before transaction costs. We deflate all prices using the US consumer price index using 2017 as our base year.[3] With respect to the artists' attributes, the database records name, date of birth, living status and nationality. At an artwork level, we have information on the title of the work, its size and object type. We categorize auction transactions into movements based on the birth year of the artist following the classification in the Tefaf (Pownall 2017) and the Art Basel and UBS Global Art Market Reports (McAndrew 2018), into Old Masters and Impressionists (1250--1874), Modern (1875--1910), Post War (after 1911 and deceased) and Contemporary (all living artists).[4]

Our variable of interest is the artists' birth sex. Since artnet's price database does not indicate the birth sex of the artists, we identified female artists by matching them to a number of name lists, and use name as a proxy for birth-identified sex. We use a list provided by the Museum of Modern Art that lists name and birth sex of 70,000 major artists. We use a probabilistic approach to match the remaining artist names to their likely birth sex based on name lists.[5] In order to ensure accuracy and increase the homogeneity of the artists in our sample in terms of opportunities such as access to education, we focus on Western artists who are based in Europe and North America.[6,7] We also drop observations where information on artwork size is missing.[8] Lastly, we exclude bought-in lots from our main analysis.[9] Our final sample consists of 2,677,190 auction transactions for 116,550 artists (Tables 1 and 2).

2.2 Descriptive statistics

Table 3 shows the summary statistics for auction prices for male and female artists, by artistic movement, object type, region and living status. The final column presents the difference between mean male and female prices. Overall, 96.1% (2,572,346) of all artworks sold at auction between 2000--2017 are attributed to

[3] The US consumer price index provided by the OECD: https://data.oecd.org/price/inflation-cpi.htm.

[4] The artworks where the artist's birth year was not available are subsumed under "other". We do not consider artists born before 1250. We acknowledge that there are alternative ways as to how one may classify artists into movements (e.g., by year of artwork creation).

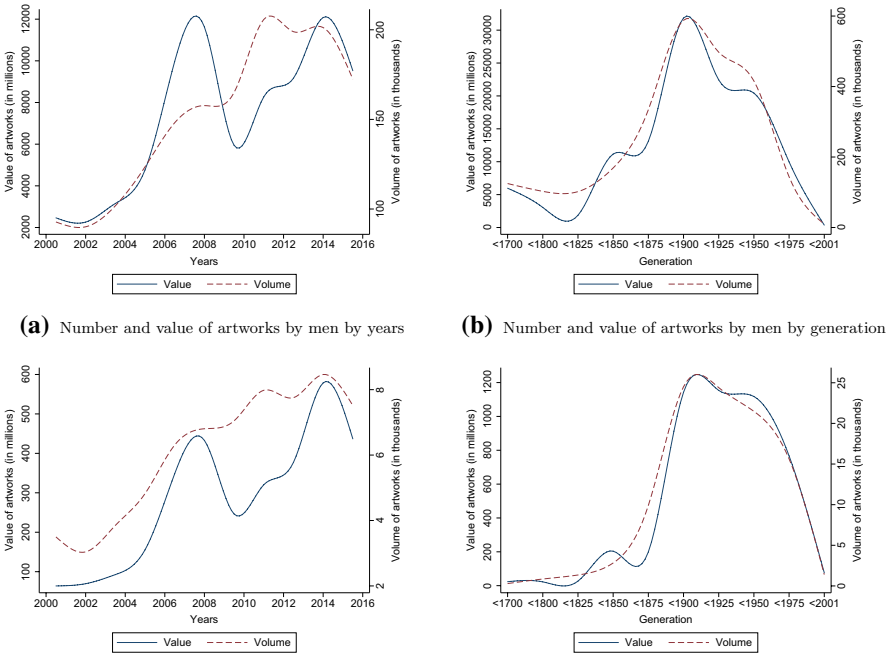
[5] We started from a list provided by MOMA (https://github.com/MuseumofModernArt/collection) which covers about 70,000 artists. For these 70,000 artists, we know their sex unambiguously. For the remaining names, we use a list for US baby names provided by the SSA (https://www.ssa.gov/oact/babynames/limits.html). Over 50% are identified with 90% precision or higher. We next use a list compiled by the German computer magazine Heise which covers European names (ftp://ftp.heise.de/pub/ct/listings/0717-182.zip.).

[6] Asian artists, whose names are difficult to decode, account for less than 0.2% of artists in our sample and for 0.2% of sales. As a result, even in the unfortunate case of mis-classification, this should not affect our results. In cases where the name was unisex, we manually researched the identity of the artist. Instances where the artist consisted of more than one person were dropped from the sample.

[7] Whenever there were two nationalities attributed to an artist, the name was included in the sample if either nationality was European or North American.

[8] There are 58,166 transactions where information on size is missing.

[9] In auctions, a buy-in takes place when an artwork is not sold as it fails to meet the seller's reserve price. The buy-in rate in our sample is 37.73% which is in line with the commonly observed buy-in rates in auction sales.



(a) Number and value of artworks by men by years

(b) Number and value of artworks by men by generation

(c) Number and value of artworks by women by years

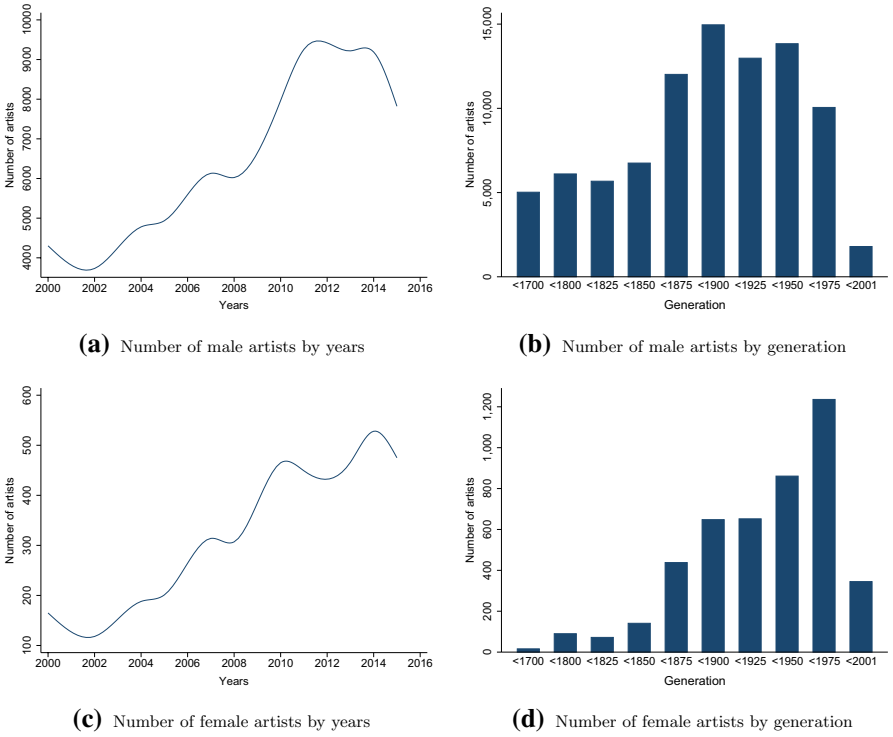
(d) Number and value of artworks by women by generation

Fig. 1 Evolution of sales by male and female artists. The year 2017 is omitted in Figures **a** and **c** as we only use the first four months of this year. Overall, there were 35,860 artworks by male and 1787 artworks by female artists in this year. The value of these artworks is $1,521,769,000 and $53,611,000, respectively. Due to missing data on the year of birth, not all artists could not be allocated to a generation. Figures **b** and **d** omit these artists. Overall, there are 89,888 artworks by male and 2199 artworks by female artists in this omitted category. The value of these artworks is $761,310,000 and $7,780,000, respectively.

male artists. Figure 1 shows that sales volumes have increased overall, with a larger relative increase for women. Over the sample period (Fig. 1a,c), sales of artworks by females increased by a multiple of 6.0, while sales of male artworks increased by a multiple of 2.8. Nevertheless, female artists remain a small fraction of the overall market in terms of both volume (4.2%) and value (5.0%). Over generations, sales numbers increased rapidly for artists born after 1875 (Fig. 1b,d). Again, this increase is more pronounced for female artists.

With respect to the number of artists, men dominate the auction market representing 95.2% of the artists sold at auction. While there are 110,938 male artists, there are only 5612 female artists. The proportion of female artists is highest for Contemporary art (9.3% are from female artists) and smallest for the Old Masters period (2.9%). Figure 2 shows the evolution of the number of distinct male and female artists over the sample period as well as over the generations (Fig. 2).[10] Whilst

[10] A generation is defined as 25 years.



(a) Number of male artists by years

(b) Number of male artists by generation

(c) Number of female artists by years

(d) Number of female artists by generation

Fig. 2 Evolution of number of male and female artists. The year 2017 is omitted in Figures **a** and **c** as we only use the first four months of this year. Overall, there were 6171 male and 167 female artists in 2017. Due to missing data on the year of birth, not all artists could not be allocated to a generation. Figures **b** and **d** omit these artists. Overall, 21,748 male and 1113 female artists could not be allocated to a generation

we observe an increasing trend in the number of recorded artists selling at auction between 2000 and 2017 for both male and female artists, the trend is much greater for the number of female artists; this is highlighted in Fig. 3, which graphs the ratio of the number of female artists to the number of male artists over the period under study (Fig. 3).

We find that while the average prices of female artworks are significantly below the average price for male artworks ($39,065 versus $45,614)[11], the median price of $3931 is higher for women than for men ($3649). This is also reflected in Fig. 4 which shows how these numbers have evolved over time and over generations of

[11] This is equivalent to an average price difference of 16.8% which is smaller than the unconditional discount of 47.6% documented by Adams et al. (2017). Consistent with this study, we also find a negative price difference (−8.3%) for female artists when we only consider contemporary artists or artworks selling for more than 1 million (−17.9%). It is likely that differences in sample compositions of our studies drive differences in results. Adams et al. (2017) use a sample of 1.5 million global auction transactions between 1970 and 2013 (62,442 artists). In their sample, female artists account for 16.9% of artists and for 6.9% of transactions; our focus is on Western artists names as a proxy for birth-identified sex.

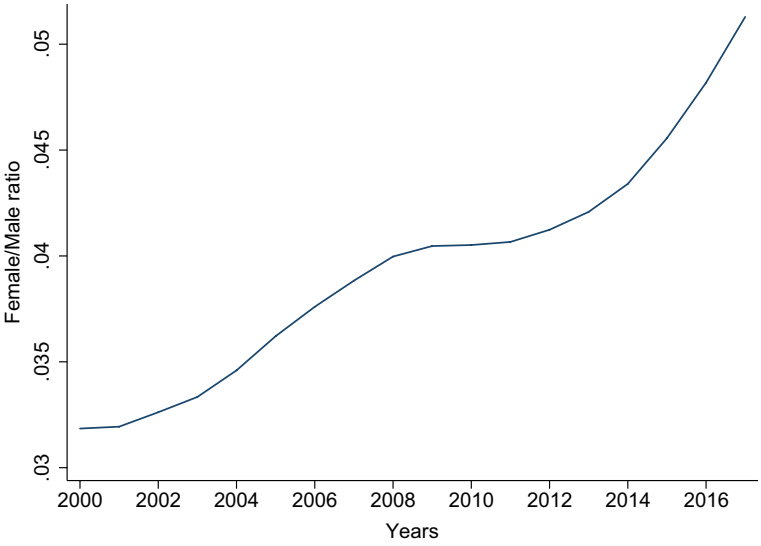


Fig. 3 Evolution female-to-male ratio

artists. In Fig. 4a we observe that mean artwork prices tend to be higher for men, whereas median prices (Fig. 4c) appear to be higher for women after 2002 with a widening gap after 2011. The hedonic price indices based on the respective year dummies in Fig. 5 in the Appendix show that sales prices of female artists have overall outperformed sales prices of male artists (Fig. 5a).

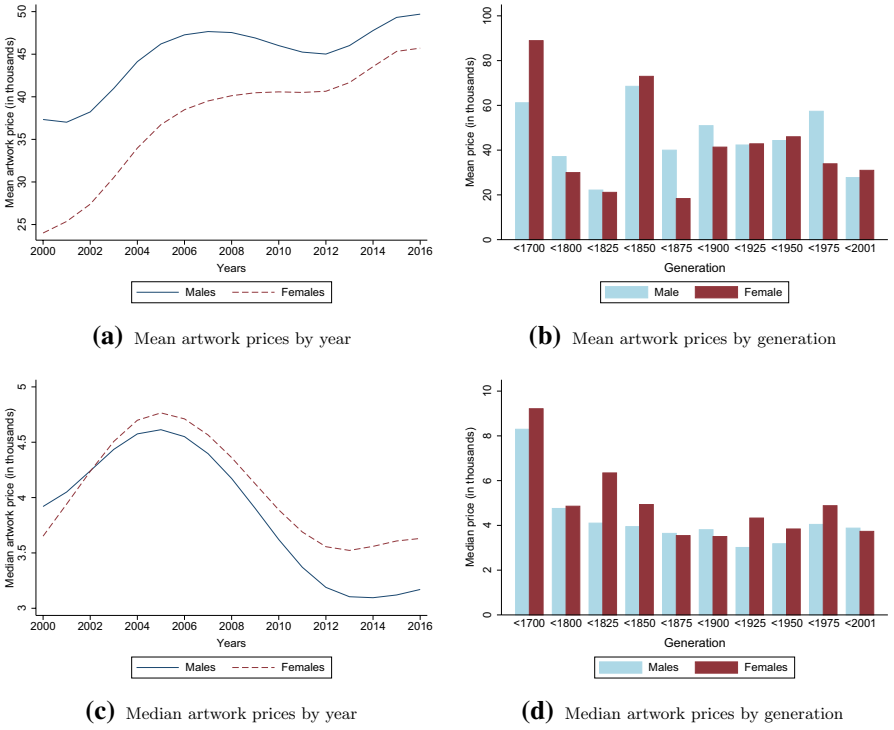
3 Empirical analysis

To examine whether artworks by men sell at the same price as women—all other things equal—and thus observe if the patterns in our summary statistics hold after controlling for characteristics, we analyze our data with the following basic model specification:

$$\log P_{it} = \alpha + \psi W_i + \beta X_i + \eta H_i + \tau_{t+}\epsilon_{it}, \quad i = 1, \ldots, N; \qquad t = 1, \ldots, T; \quad (1)$$

In this equation, $\log P_{it}$ indicates the log of the real price of an artwork, i, which is sold at a given time t.[12] $N = 2,677,190$ artworks in our sample over $T = 72$ seasons (Winter, Spring, Summer, and Autumn) between 2000 and 2017 (18 years). W_i denotes the birth-identified sex coefficient which is a dummy variable, denoted female, taking a value of 1 whenever the respective artist of a given artwork, i, is a woman. This regression specification estimates the differences between the actual sales price for an artwork of a female artist and the value of an artwork by a male

[12] We also conducted a robustness check where we used the nominal artwork price as our dependent variable. The results remain qualitatively in line with results reported in Table 4.



(a) Mean artwork prices by year

(b) Mean artwork prices by generation

(c) Median artwork prices by year

(d) Median artwork prices by generation

Fig. 4 Evolution of mean and median artwork prices for men and women. The year 2017 is omitted in Figures **a** and **c** as we only use the first four months of this year. Overall, the mean (median) value is \$42,436 (\$3681) for artworks by male and \$30,001 (\$4306) for artworks by female artists in this year. Due to missing data on the year of birth not all artists could not be allocated to a generation. Figures **b** and **d** omit these artists. Overall, the mean (median) value is \$8968 (\$1992) for artworks by male and \$3542 (\$1182) for artworks by female artists in this omitted category

artist with the same characteristics. All artwork characteristics are captured in X_i, a 1×276 vector that includes the object type (the base category is paintings), the auction house where it was sold and the size of the artwork.[13] H_i is a 1×5 vector that denotes the artist characteristics of a given artwork, i, including region of the artist's nationality (the base category is North America)[14] and a dummy for the living status of the artist at the time of the transaction (the base category is 'deceased').[15] τ represents time fixed-effects for the years 2000 until 2017. ψ, β and η are time-independent parameters. α is a constant term. Lastly, ϵ_{it} denotes the error term.

[13] In total, there are 1522 auction houses in our data set. Due to collinearity concerns, we subsumed auction houses below the 90th quantile in terms of number of transactions under "other". This resulted in 270 different categories.

[14] All countries are allocated into five regions: North America, Eastern Europe, Northern Europe, Southern Europe and Western Europe.

[15] Due to collinearity between the artist names and the female dummy, we exclude artist fixed effects from the regression in our main analysis.

Table 1 Top 50 male artists by value of sales

Rank	Artist	Movement	Total sales value in $	Total sales volume (market share (%))	Average price
1	Pablo Picasso	Modern	5,853,551,616 (4.99)	37,386 (1.45)	156,571
2	Andy Warhol	Postwar	4,931,258,880 (4.2)	19,028 (0.74)	259,158
3	Claude Monet	OldMasters	2,509,770,496 (2.14)	493 (0.02)	5,090,813
4	Gerhard Richter	Contemporary	2,128,574,336 (1.81)	3587 (0.14)	593,414
5	Francis Bacon	Modern	2,071,435,648 (1.77)	1372 (0.05)	1,509,793
6	Alberto Giacometti	Modern	1,661,223,808 (1.42)	1991 (0.08)	834,367
7	Jean-Michel Basquiat	Postwar	1,604,688,384 (1.37)	1308 (0.05)	1,226,826
8	Mark Rothko	Modern	1,589,495,040 (1.35)	142 (0.01)	11,200,000
9	Henri Matisse	OldMasters	1,384,500,224 (1.18)	5157 (0.2)	268,470
10	Roy Lichtenstein	Postwar	1,365,195,904 (1.16)	6429 (0.25)	212,350
11	Amedeo Modigliani	Modern	1,282,909,952 (1.09)	502 (0.02)	2,555,598
12	Marc Chagall	Modern	1,246,740,480 (1.06)	14,957 (0.58)	83,355
13	Joan Miró	Modern	1,195,891,584 (1.02)	14,781 (0.57)	80,907
14	Willem De Kooning	Modern	1,144,317,696 (0.98)	1272 (0.05)	899,621
15	Lucio Fontana	Modern	1,098,615,296 (0.94)	2772 (0.11)	396,326
16	Alexander Calder	Modern	1,088,666,752 (0.93)	5479 (0.21)	198,698
17	Pierre-Auguste Renoir	OldMasters	1,046,396,352 (0.89)	3,766 (0.15)	277,854
18	Zao Wou-Ki	Postwar	1,015,000,512 (0.87)	4045 (0.16)	250,927
19	Fernand Léger	Modern	1,005,042,112 (0.86)	2978 (0.12)	337,489
20	Cy Twombly	Postwar	850,141,376 (0.72)	881 (0.03)	964,973
21	Jeff Koons	Contemporary	848,892,096 (0.72)	1646 (0.06)	515,730
22	Paul Cézanne	OldMasters	791,902,080 (0.67)	697 (0.03)	1,136,158
23	Edgar Degas	OldMasters	771,783,232 (0.66)	1274 (0.05)	605,795
24	René Magritte	Modern	734,759,296 (0.63)	1519 (0.06)	483,713
25	Damien Hirst	Contemporary	705,134,592 (0.6)	3940 (0.15)	178,968
26	Egon Schiele	Modern	640,337,088 (0.55)	810 (0.03)	790,540
27	Yves Klein	Postwar	629,027,840 (0.54)	1008 (0.04)	624,036
28	Henry Moore	Modern	623,510,656 (0.53)	4350 (0.17)	143,336
29	Paul Gauguin	OldMasters	607,289,600 (0.52)	928 (0.04)	654,407
30	Camille Pissarro	OldMasters	604,985,536 (0.52)	1882 (0.07)	321,459
31	Vincent Van Gogh	OldMasters	597,029,632 (0.51)	153 (0.01)	3,902,155
32	Gustav Klimt	OldMasters	575,096,128 (0.49)	827 (0.03)	695,400
33	Edvard Munch	OldMasters	563,149,632 (0.48)	1695 (0.07)	332,242
34	Jean Dubuffet	Modern	553,278,464 (0.47)	2291 (0.09)	241,501
35	Wassily Kandinsky	OldMasters	505,244,672 (0.43)	1091 (0.04)	463,102
36	Auguste Rodin	OldMasters	501,098,080 (0.43)	1695 (0.07)	295,633
37	Christopher Wool	Contemporary	484,130,208 (0.41)	532 (0.02)	910,019
38	Lucian Freud	Postwar	482,981,248 (0.41)	553 (0.02)	873,384
39	Richard Prince	Contemporary	463,410,368 (0.39)	1066 (0.04)	434,719
40	Null Chu Teh-Chun	Postwar	463,145,696 (0.39)	1521 (0.06)	304,501
41	Kees Van Dongen	Modern	452,388,320 (0.39)	1719 (0.07)	263,170

Table 1 (continued)

Rank	Artist	Movement	Total sales value in $	Total sales volume (market share (%))	Average price
42	Salvador Dalí	Modern	381,447,968 (0.33)	10,991 (0.43)	34,705
43	Paul Signac	OldMasters	365,125,984 (0.31)	1267 (0.05)	288,182
44	Pierre Bonnard	OldMasters	358,641,664 (0.31)	1758 (0.07)	204,006
45	Chaïm Soutine	Modern	353,786,048 (0.3)	169 (0.01)	2,093,409
46	Peter Doig	Contemporary	351,808,064 (0.3)	612 (0.02)	574,850
47	Alfred Sisley	OldMasters	349,061,056 (0.3)	285 (0.01)	1,224,776
48	Ed Ruscha	Contemporary	343,948,960 (0.29)	2068 (0.08)	166,320
49	Jackson Pollock	Postwar	343,908,544 (0.29)	148 (0.01)	2,323,707
50	Donald Judd	Postwar	341,338,528 (0.29)	917 (0.04)	372,234

All prices are in constant 2017 $

3.1 Performance at auction

Table 4 reports the results of our baseline regression. The coefficient on the female dummy shows that, controlling for artwork characteristics, artworks by female artists are on average 4.4% more expensive than the artworks of male artists. All other coefficients are in line with expectations. Sculptures are the most expensive objects, while prints and multiples are least expensive relative to paintings. Artworks of artists from Southern Europe sell at higher prices.[16] Lastly, artworks of living artists sell for less (negative coefficient on the 'Alive' dummy variable). The R-squared of the regression is 0.42 which is within the usual range for hedonic models in the art market literature (Ashenfelter and Graddy 2002). We also run regressions for different types of art categories (Columns 2 to 6, Table 4). With the exception of two categories—1) Design and 2) Prints and Multiples—every object type has a positive coefficient associated with the female dummy. Paintings produced by female artists, the most prevalent type of object, are 15.5% more expensive than paintings with comparable characteristics that are controlled for in our regressions, produced by male artists.

We re-estimate the model for each artistic movement separately. Table 5 shows that the coefficient on the female dummy is positive and statistically significant for each movement with the exception of Contemporary art, where we observe a negative coefficient. The price difference on lots by Contemporary female artists, where we encounter a relatively larger proportion of women (9.3%), is −8.3%.[17]

[16] Highly renowned artists such as Picasso, Giacometti, Modigliani, Miro and Fontana, among many others are included in the category.

[17] To further homogenize our sample, we also consider every cohort (generation) of artists separately and run regressions for each generation of artists whereby one generation is defined as a time period of 25 years. The results are presented in Table 11 in Appendix. Consistent with the previous results, we observe a positive price difference for female lots for the generations active before the year 1850 and a negative price difference for more recent generations born after 1950.

Table 2 Top 50 female artists by value of sales

Rank	Artist	Movement	Total sales value in $ (market share (%))	Total sales volume (market share (%))	Average price
1	Joan Mitchell	Postwar	392,962,816 (9.59)	641 (0.61)	613,046.50
2	Georgia O'Keeffe	Modern	211,702,064 (5.17)	117 (0.11)	1,809,419.00
3	Louise Bourgeois	Postwar	197,968,512 (4.83)	649 (0.62)	305,036.20
4	Agnes Martin	Postwar	193,711,040 (4.73)	296 (0.28)	654,429.20
5	Cindy Sherman	Contemporary	140,606,176 (3.43)	1269 (1.21)	110,800.80
6	Barbara Hepworth	Modern	135,153,952 (3.3)	616 (0.59)	219,405.80
7	Tamara De Lempicka	Modern	127,470,128 (3.11)	313 (0.3)	407,252.80
8	Natalia Sergeevna Goncharova	Modern	127,109,512 (3.1)	731 (0.7)	173,884.40
9	Mary Cassatt	OldMasters	88,247,688 (2.15)	832 (0.79)	106,066.90
10	Helen Frankenthaler	Postwar	79,406,904 (1.94)	1100 (1.05)	72,188.09
11	Bridget Riley	Contemporary	78,610,368 (1.92)	818 (0.78)	96,100.70
12	Berthe Morisot	OldMasters	76,978,256 (1.88)	258 (0.25)	298,365.30
13	Eileen Gray	Modern	75,399,800 (1.84)	187 (0.18)	403,207.50
14	Gabriele Münter	Modern	67,722,952 (1.65)	449 (0.43)	150,830.60
15	Niki De Saint Phalle	Postwar	67,633,304 (1.65)	1849 (1.76)	36,578.32
16	Maria Helena Vieira Da Silva	Modern	62,461,532 (1.53)	683 (0.65)	91,451.73
17	Elisabeth Frink	Postwar	56,816,528 (1.39)	1212 (1.16)	46,878.32
18	Camille Claudel	OldMasters	47,351,292 (1.16)	115 (0.11)	411,750.40
19	Julie Mehretu	Contemporary	39,050,448 (0.95)	117 (0.11)	333,764.50
20	Marie Laurencin	Modern	37,916,940 (0.93)	1633 (1.56)	23,219.19
21	Germaine Richier	Modern	36,489,668 (0.89)	207 (0.2)	176,278.60
22	Charlotte Perriand	Modern	36,297,372 (0.89)	1270 (1.21)	28,580.61
23	Sonia Delaunay	Modern	35,823,440 (0.87)	2414 (2.3)	14,839.87
24	Zinaida Evgenievna Serebryakova	Modern	35,679,896 (0.87)	130 (0.12)	274,460.80
25	Elizabeth Peyton	Contemporary	34,532,152 (0.84)	305 (0.29)	113,220.20
26	Jenny Saville	Contemporary	33,717,704 (0.82)	67 (0.06)	503,249.30
27	Lee Krasner	Modern	32,803,988 (0.8)	125 (0.12)	262,431.90
28	Louise Nevelson	Modern	31,701,858 (0.77)	995 (0.95)	31,861.16
29	Eva Hesse	Postwar	31,495,010 (0.77)	67 (0.06)	470,074.80
30	Rosemarie Trockel	Contemporary	29,649,818 (0.72)	370 (0.35)	80,134.64
31	Leonora Carrington	Postwar	29,199,762 (0.71)	368 (0.35)	79,347.18
32	Diane Arbus	Postwar	27,909,234 (0.68)	680 (0.65)	41,042.99
33	Cady Noland	Contemporary	27,686,520 (0.68)	50 (0.05)	553,730.40
34	Line Vautrin	Postwar	27,666,570 (0.68)	1390 (1.33)	19,904.01
35	Käthe Kollwitz	OldMasters	27,358,426 (0.67)	3287 (3.14)	8,323.22
36	Tauba Auerbach	Contemporary	24,741,638 (0.6)	115 (0.11)	215,144.70
37	Elaine Sturtevant	Postwar	24,650,568 (0.6)	109 (0.1)	226,152.00
38	Paula Rego	Contemporary	22,420,256 (0.55)	279 (0.27)	80,359.34

Table 2 (continued)

Rank	Artist	Movement	Total sales value in $ (market share (%))	Total sales volume (market share (%))	Average price
39	Grandma Moses	OldMasters	20,810,438 (0.51)	228 (0.22)	91,273.85
40	Alexandra Exter	Modern	20,683,992 (0.51)	214 (0.2)	96,654.17
41	Paula Modersohn-Becker	Modern	20,028,110 (0.49)	227 (0.22)	88,229.56
42	Barbara Kruger	Contemporary	17,710,106 (0.43)	207 (0.2)	85,556.07
43	Sherrie Levine	Contemporary	16,430,324 (0.4)	153 (0.15)	107,387.70
44	Remedios Varo	Modern	16,238,367 (0.4)	42 (0.04)	386,627.80
45	Lisa Yuskavage	Contemporary	16,097,871 (0.39)	121 (0.12)	133,040.30
46	Alice Neel	Modern	16,033,746 (0.39)	119 (0.11)	134,737.40
47	Ruth Asawa	Postwar	15,410,404 (0.38)	79 (0.08)	195,068.40
48	Tracey Emin	Contemporary	15,272,947 (0.37)	485 (0.46)	31,490.61
49	Mary Fedden	Postwar	14,461,859 (0.35)	1098 (1.05)	13,171.09
50	Angelika Kauffmann	OldMasters	14,241,870 (0.35)	323 (0.31)	44,092.48

All prices are in constant 2017 $.

The post-war era yields the largest positive price difference (+14.9%) for artworks by female artists. This movement is associated with a number of highly recognized female artists (i.e., Agnes Martin, Helen Frankenthaler and Joan Mitchell).

Lastly, we investigate the persistence of the difference in performance found in our baseline regression for the period since the Millennium. We split our data into four different time periods for which we run separate regressions (Table 6). For all four periods, a positive price difference for female lots persists ranging from +1.9% to +7.4%. This effect is robust across different object types and over time.

3.2 The top end

Table 7 shows that after the 99.97th quantile, which represents the top 40 artists in terms of total sales value, there are no women. This quantile corresponds to a market share of 40% in terms of value. To more closely analyze differences in the prices for male and female artists at the top end of the market, we create a sub-sample for artworks selling for more than $1 million at auction (denoted as mega transactions).[18] We perform a separate analysis for the full sample (columns 1 and 2) and the contemporary sub-sample (columns 3 and 4). Controlling for artwork characteristics,

[18] As a result, in the subsequent regression, the left-hand-side variable is censored. We also performed a nonparametric test by running a quantile regression where we obtained consistent results (available upon request).

Table 3 Summary statistics for men and women

	Men					Women					
Price	N	N artist	mean	median	sd	N	N artists	mean	median	sd	Δ in means (\%)
Overall	2,572,346	110,938	45,614	3648	686,070	104,844	5612	39,065	3931	330,635	−16.8***
Buy-in rate*			0.378	0.376	0.027			0.361	0.361	0.034	-4.7%
Movement											
Contemporary	388,070	19,917	38,025	3146	432,129	30,434	2031	28,502	4011	170,396	−33.4***
Postwar	532,238	34,173	41,047	3090	635,913	24,280	1863	54,262	4121	405,305	24.4***
Modern	819,923	21,281	51,358	3542	860,069	34,920	961	41,332	3701	409,739	−19.5***
Old Masters & Impressionists	525,405	19,806	48,503	3776	678,067	13,781	595	29,921	3928	223,868	−62.1
Other	306,710	15,761	38,641	5743	494,310	1429	162	34,316	5418	135,044	-12.6%
Object type**											
Design	212,709	9250	12,848	3269	67,873	11,141	521	19,934	4009	17,703	35.5***
Sculptures	169,704	15,306	70,600	5032	852,476	8132	807	88,341	11,419	483,140	20.1***
Paintings	1,132,403	78,184	75,343.8	4903.5	951,020.9	33,064	3663	72,025	5142	486,108	−4.6***
Works on paper	453,729	36,161	24,543	3090	315,271	16,477	1646	18,470	3797	93,931	−32.9***
Prints and multiples	477,203	15,050	2117	2241	172,222	19,371	711	6630	1895	100,688	68.1***
Photographs	126,598	6822	15,477	3572	76,292	16,659	603	20,475	5125	107,243	24.4***
Region											
North America	545,239	24,641	58,234	3946	803,389	34,751	1727	58,929	4525	467,225	11.8***
Northern Europe	463,192	19,162	29,560	3033	593,016	25,195	1310	27,827	3625	263,459	-6.2%
Western Europe	1,099,021	44,143	43,114	3571	594,711	35,243	1673	24,473	3394	140,217	−76.2***
Southern Europe	337,164	14,049	57,251	4246	912,561	4040	329	25,012	5695	111,384	−128.9***
Eastern Europe	127,730	8943	40,758	4247	453,220	5615	573	68,258	4258	491,061	40.3***
Living status at time of sale											
Deceased	2,018,743	65,760	49,159	3893	748,360	68,033	2263	44,659	3941	390,600	−10.1***

Table 3 (continued)

	Men					Women					
Price	N	N artist	mean	median	sd	N	N artists	mean	median	sd	Δ in means (\%)
Alive**	553,603	47,175	32,686	2864	380,340	36,811	3454	28,728	3909	170,957	−13.8***

All prices are in constant 2017 $.

*The buy-in rate is the share of lots of all lots offered per artist that is not sold at auction.

In total, 156,761 male lots and 59,258 female lots were bought in.

**Multiple attributions for a single artist are possible.

***The difference in mean prices between men and women is statistically significant on a 1% significance level

Table 4 Artwork level OLS regression results

Variables	Log of real price						
	Full sample	Paintings	Works on paper	Prints & multiples	Photographs	Design	Sculpture
Female	0.044***	0.155***	0.165***	−0.053***	0.056***	−0.459***	0.242***
	(0.004)	(0.007)	(0.010)	(0.008)	(0.009)	(0.011)	(0.015)
Design	−0.219***						
	(0.003)						
Photographs	−0.688***						
	(0.004)						
Prints & multiples	−0.918***						
	(0.002)						
Sculpture	0.330***						
	(0.003)						
Works on paper	−0.409***						
	(0.002)						
Eastern	0.014***	−0.028***	−0.083***	0.146***	−0.062***	0.315***	−0.015
Europe	(0.005)	(0.007)	(0.010)	(0.013)	(0.014)	(0.022)	(0.018)
Northern	−0.272***	−0.406***	−0.480***	−0.064***	−0.277***	−0.087***	0.079***
Europe	(0.003)	(0.006)	(0.008)	(0.006)	(0.012)	(0.009)	(0.014)
Southern	0.149***	0.018***	0.151***	0.271***	−0.226***	0.061***	0.053***
Europe	(0.003)	(0.006)	(0.009)	(0.005)	(0.018)	(0.009)	(0.012)
Western	−0.043***	−0.141***	−0.098***	−0.088***	0.007	0.204***	−0.204***
Europe	(0.003)	(0.005)	(0.007)	(0.004)	(0.007)	(0.008)	(0.010)
Alive	−0.381***	−0.366***	−0.238***	−0.225***	−0.188***	−0.384***	−0.352***
	(0.002)	(0.003)	(0.005)	(0.004)	(0.007)	(0.006)	(0.007)
Log of size	0.181***	0.288***	0.220***	0.061***	0.254***	0.099***	0.168***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.003)	(0.001)	(0.002)

Table 4 (continued)

Variables	Log of real price						
	Full sample	Paintings	Works on paper	Prints & multiples	Photographs	Design	Sculpture
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Auction house effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R−squared	0.422	0.436	0.372	0.390	0.463	0.349	0.461
Observations	2,677,190	1,165,467	470,206	496,574	143,257	223,850	177,836

Heteroscedasticity-consistent standard errors standard errors in parentheses.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

The base category for the object type is paintings.

The base category for the region is North America

Table 5 Artwork level OLS regression results—by movement

Variables	Log of real price			
	Old Masters	Modern	Post-war	Contemporary
Female	0.100***	0.045***	0.149***	−0.083***
	(0.011)	(0.007)	(0.008)	(0.007)
Design	−0.012	−0.199***	−0.261***	−0.168***
	(0.009)	(0.006)	(0.006)	(0.009)
Photographs	−0.707***	−0.788***	−0.718***	−0.494***
	(0.014)	(0.007)	(0.008)	(0.007)
Prints & multiples	−0.897***	−1.017***	−0.962***	−0.804***
	(0.006)	(0.004)	(0.005)	(0.006)
Sculpture	0.322***	0.406***	0.341***	0.393***
	(0.008)	(0.007)	(0.007)	(0.007)
Works on paper	−0.379***	−0.383***	−0.371***	−0.325***
	(0.005)	(0.004)	(0.005)	(0.006)
Eastern Europe	0.441***	0.168***	−0.528***	−0.359***
	(0.010)	(0.007)	(0.011)	(0.012)
Northern Europe	−0.228***	−0.130***	−0.497***	−0.057***
	(0.008)	(0.006)	(0.006)	(0.007)
Southern Europe	0.107***	0.539***	−0.228***	−0.085***
	(0.010)	(0.006)	(0.007)	(0.008)
Western Europe	0.010	0.120***	−0.284***	−0.100***
	(0.006)	(0.005)	(0.005)	(0.006)
Alive			−0.370***	
			(0.004)	
Log of size	0.186***	0.144***	0.188***	0.240***
	(0.001)	(0.001)	(0.001)	(0.001)
Year Effects	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes
Auction house	Yes	Yes	Yes	Yes
R-squared	0.420	0.417	0.437	0.483
Observations	539,186	854,843	556,518	418,504

Heteroscedasticity-consistent standard errors standard errors in parentheses.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

The base category for the object type is paintings.

The base category for the region is North America.

There are 189 photographs in the Old Masters sample

the regression results in Table 8 show that within the price category of $1 million and above, artworks created by men sell at prices, on average 18.4% higher, than the works of women. The price difference is 17.9% higher when we consider the sub-sample of contemporary artists.

Table 6 Artwork level OLS regression results—by time period

Variables	Log of real price			
	2000–2004	2005–2009	2010–2014	2015–2017
Female	0.074***	0.069***	0.019***	0.039***
	(0.009)	(0.007)	(0.006)	(0.013)
Design	−0.425***	−0.207***	−0.200***	−0.186***
	(0.021)	(0.007)	(0.005)	(0.011)
Photographs	−0.945***	−0.722***	−0.563***	−0.570***
	(0.009)	(0.007)	(0.006)	(0.014)
Prints & multiples	−1.175***	−1.074***	−0.736***	−0.661***
	(0.005)	(0.004)	(0.004)	(0.009)
Sculpture	0.406***	0.444***	0.289***	0.190***
	(0.008)	(0.007)	(0.005)	(0.011)
Works on paper	−0.439***	−0.448***	−0.378***	−0.346***
	(0.005)	(0.004)	(0.004)	(0.008)
Eastern Europe	−0.016	0.140***	0.000	−0.138***
	(0.012)	(0.008)	(0.007)	(0.015)
Northern Europe	−0.260***	−0.264***	−0.247***	−0.273***
	(0.007)	(0.006)	(0.005)	(0.011)
Southern Europe	0.242***	0.188***	0.095***	0.083***
	(0.007)	(0.006)	(0.005)	(0.011)
Western Europe	0.012**	−0.049***	−0.048***	−0.084***
	(0.006)	(0.005)	(0.004)	(0.009)
Alive	−0.487***	−0.397***	−0.357***	−0.279***
	(0.005)	(0.004)	(0.003)	(0.007)
Log of size	0.201***	0.204***	0.167***	0.147***
	(0.001)	(0.001)	(0.001)	(0.002)
Year effects	Yes	Yes	Yes	Yes
Season effects	Yes	Yes	Yes	Yes
Auction house effects	Yes	Yes	Yes	Yes
R-squared	0.452	0.443	0.424	0.402
Observations	496,923	756,668	1,026,029	209,830

Heteroscedasticity-consistent standard errors standard errors in parentheses.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

The base category for the object type is paintings.

The base category for the region is North America

3.3 Auction participation

So far, we have only considered the (secondary) auction market which represents the market for established artists. To investigate potential sources of the observed differences in prices paid for male and female generated artworks, we look at the (primary) gallery market, which impacts an artist's chance to be represented at auction. A gallery provides the artists with access to its network of buyers and promotes them. We

Table 7 Quantiles by total sales value for men and women

		Men		Women	
Quantile	Total sales value ($)	N artists	Cumulative	N artists	Cumulative
> 99.97%		0.03% (40)	0.03%	0.00% (0)	0.00%
< 99.97%	452,388,320	0.01%(17)	0.05%	0.02% (1)	0.02%
< 99.96%	351,808,064	0.04% (43)	0.08%	0.05% (3)	0.07%
< 99.1%	176,461,520	0.90% (994)	0.98%	1.19% (67)	1.27%
< 99%	9,461,848	4.05% (4490)	5.03%	3.06% (172)	4.33%
< 95%	982,622	5.09% (5650)	10.12%	3.17% (178)	7.50%
< 90%	312,493	15.24% (16,908)	25.36%	10.23% (574)	17.73%
< 75%	50,209	25.19% (27,949)	50.56%	21.19% (1189)	38.92%
< 50%	8604	24.92% (27,644)	75.48%	26.60% (1493)	65.52%
< 25%	2089	14.82% (16,442)	90.30%	18.55% (1041)	84.07%
< 10%	814	4.90% (5435)	95.20%	6.99% (392)	91.05%
< 5%	545	4.80% (5326)	100.00%	8.95% (502)	100.00%
Total sales value	121,431,023,957				

use artnet's gallery database covering representation for 4754 contemporary artists. Table 9 shows that out of 4180 male artists, 96.9% (4050 artists) can also be found in the auction market sample. However, only 93% (534 artists) out of the 574 female artists made this transition.[19] We analyze the likelihood of women to move from the primary into the secondary market in a multivariate setting using a Probit model on the primary market sample. The binary dependent variable indicates whether an artist from the gallery sample is traded at auction. We include the female dummy and control for artist's nationality, birth year and a dummy for every gallery an artist is represented by. The coefficient on the female dummy indicates that female artists are 2.2% less likely to participate at auction compared to their male counterparts (Table 10).[20]

4 Concluding remarks

Our study shows that females comprise less than 4% of art auction sales, as identified by their birth sex. Furthermore, we show that artworks by females are, on average, sold for 4.4% more than artworks by males, after controlling for artwork and artist characteristics. These findings are consistent with a recent study by Cameron et al. (2017) who find a premium for female artworks traded at auction within a small sample of Yale graduates. At the same time, we provide evidence of average lower prices for the artworks of contemporary female artists as well as for artworks selling at the top-end of the market. Overall this analysis highlights how the share of females, as observed by birth-identified sex, is gaining in market share as the market evolves, and subsequently that price

[19] The difference in proportions test is statistically significant at a 1% level.

[20] The presented coefficients are the marginal effects at the mean.

Table 8 Artwork level OLS regression results—mega transactions

Variables	Log of real price			
	Full sample	Full sample	Contemporary	Contemporary
	Mega transactions	Excl. mega transactions	Mega transactions	Excl. mega transactions
Female	−0.184***	0.046***	−0.179**	−0.053***
	(0.033)	(0.004)	(0.073)	(0.007
Design	−0.317***	−0.192***	−0.316	−0.146***
	(0.068)	(0.003)	(0.250)	(0.009)
Photographs	−0.333***	−0.627***	−0.361***	−0.445***
	(0.074)	(0.004)	(0.075)	(0.006)
Prints & multiples	−0.265***	−0.869***	−0.350***	−0.759***
	(0.060)	(0.002)	(0.131)	(0.006)
Sculpture	−0.028	0.318***	0.050	0.385***
	(0.022)	(0.003)	(0.041)	(0.007)
Works on paper	−0.229***	−0.381***	−0.315***	−0.300***
	(0.025)	(0.002)	(0.081)	(0.006)
Eastern Europe	0.004	0.021***	0.058	−0.337***
	(0.034)	(0.004)	(0.146)	(0.011)
Northern Europe	0.076***	−0.256***	−0.101**	−0.052***
	(0.025)	(0.003)	(0.045)	(0.007)
Southern Europe	0.136***	0.142***	−0.268***	−0.078***
	(0.022)	(0.003)	(0.064)	(0.008)
Western Europe	−0.281***	−0.368***	0.197***	−0.104***
	(0.019)	(0.002)	(0.041)	(0.006)
Alive	−0.487***	−0.397***		
	(0.005)	(0.004)		
Log of size	0.084***	0.169***	0.096***	0.228***
	(0.005)	(0.001)	(0.012)	(0.001)
Year effects	Yes	Yes	Yes	Yes
Season effects	Yes	Yes	Yes	Yes
Auction house effects	Yes	Yes	Yes	Yes
R-squared	0.095	0.410	0.138	0.472
Observations	15,881	2,661,309	2270	416,234

Heteroscedasticity-consistent standard errors standard errors in parentheses

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Mega transactions are defined as transaction above $1,000,000 in real 2017 USD.

The base category for the object type is paintings.

The base category for the region is North America

differences observed between male and female artworks are reflected in a difference in artistic characteristics of female produced artworks. Our results call for further investigation into the supply and demand factors that prevail in the market that might explain observed differences in prices paid for male and female produced artworks.

Table 9 Summary statistics for men and women: primary market sample

Variables	Men			Women		
	N	Mean	SD	N	Mean	SD
Auction participation	4180 (4050)	0.969***	0.174	574 (534)	0.930***	0.255
Total sales value (in $)	4050	3,381,389	41,400,000	534	1,536,746	8,015,190
Year of birth	4180	1955	15.622	574	1958	14.990

The primary market sample consists of Western, contemporary artists only.

***The difference in proportions of the auction participation rates between men and women is statistically significant on a 1% significance level.

All prices are in constant 2017 $

Table 10 Auction participation—artist-level regression results (primary market)

Variables	Auction participation Probit model
Female	−0.022***
	(0.006)
Year of birth	−0.001***
	(0.000)
Artist nationality effects	Yes
Gallery effects	Yes
Observations	4754

Heteroscedasticity-consistent standard errors standard errors in parentheses.

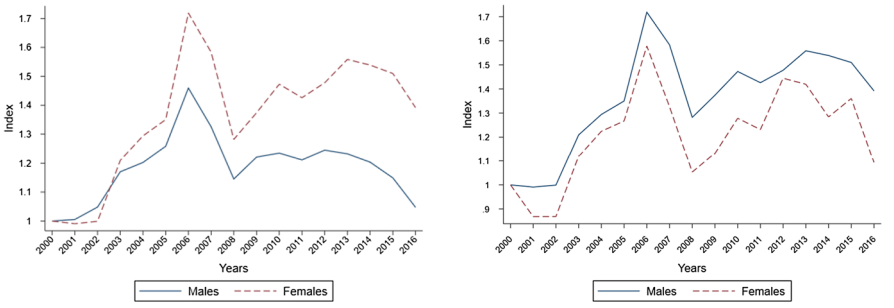
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

The probit model shows the marginal effects at the mean.

The primary market sample consists of Western, contemporary artists only

Appendix

See Fig. 5 and Table 11.



(a) Index for female and male artists - Full sample **(b)** Index for female and male artists - Contemporary sample

Fig. 5 Price index for female and male artists

Table 11 Artwork level OLS regression results—by generation of artist

Variables	Log of real price									
	<1700	<1800	<1825	<1850	<1875	<1900	<1925	<1950	<1975	<2001
Female	0.358***	0.058	0.125***	0.340***	0.008	−0.008	0.124***	0.080***	−0.105***	−0.097***
	(0.069)	(0.041)	(0.031)	(0.024)	(0.013)	(0.008)	(0.008)	(0.008)	(0.011)	(0.033)
Design	−0.668***	−0.292***	0.045	0.049***	−0.012	−0.171***	−0.248***	−0.312***	−0.068***	0.180***
	(0.092)	(0.048)	(0.041)	(0.017)	(0.011)	(0.007)	(0.007)	(0.009)	(0.016)	(0.055)
Photographs	−0.708*	−0.469***	−0.231***	−0.775***	−0.689***	−0.787***	−0.658***	−0.756***	−0.406***	−0.461***
	(0.371)	(0.105)	(0.020)	(0.026)	(0.017)	(0.010)	(0.008)	(0.008)	(0.010)	(0.037)
Prints and multiples	−1.267***	−1.441***	−1.154***	−0.999***	−0.851***	−1.003***	−1.010***	−1.025***	−0.742***	−0.738***
	(0.013)	(0.012)	(0.019)	(0.014)	(0.008)	(0.005)	(0.005)	(0.005)	(0.010)	(0.042)
Sculpture	0.225***	0.061***	0.118***	0.352***	0.354***	0.400***	0.452***	0.314***	0.483***	0.103**
	(0.026)	(0.019)	(0.017)	(0.014)	(0.011)	(0.008)	(0.008)	(0.007)	(0.012)	(0.042)
Works on paper	−0.601***	−0.467***	−0.402***	−0.475***	−0.348***	−0.390***	−0.355***	−0.367***	−0.248***	−0.326***
	(0.013)	(0.009)	(0.010)	(0.009)	(0.006)	(0.005)	(0.005)	(0.006)	(0.010)	(0.038)
Eastern Europe	0.392*	0.119**	0.567***	0.513***	0.427***	0.134***	−0.182***	−0.499***	−0.431***	−0.399***
	(0.201)	(0.049)	(0.031)	(0.020)	(0.012)	(0.009)	(0.010)	(0.012)	(0.019)	(0.046)
Northern Europe	0.060	−0.537***	−0.659***	−0.209***	−0.224***	−0.145***	−0.221***	−0.476***	0.058***	−0.197***
	(0.189)	(0.020)	(0.018)	(0.013)	(0.010)	(0.008)	(0.007)	(0.007)	(0.010)	(0.039)
Southern Europe	0.491***	−0.085***	−0.183***	0.174***	0.089***	0.607***	0.027***	−0.294***	−−0.168***	−0.300***
	(0.188)	(0.021)	(0.027)	(0.018)	(0.013)	(0.007)	(0.007)	(0.008)	(0.014)	(0.059)
Western Europe	0.500***	−0.299***	−0.327***	0.055***	−0.008	0.081***	−0.022***	−0.335***	−0.212***	−0.322***
	(0.188)	(0.020)	(0.017)	(0.011)	(0.008)	(0.006)	(0.006)	(0.006)	(0.010)	(0.038)
Alive							−0.079***	−0.322***	−0.659***	
							(0.005)	(0.004)	(0.013)	
Log of size	0.133***	0.224***	0.229***	0.206***	0.182***	0.147***	0.182***	0.222***	0.287***	0.220***
	(0.003)	(0.002)	(0.003)	(0.003)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.008)

Table 11 (continued)

Variables	Log of real price									
	<1700	<1800	<1825	<1850	<1875	<1900	<1925	<1950	<1975	<2001
Year effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Auction house effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.455	0.440	0.415	0.445	0.413	0.419	0.412	0.481	0.533	0.589
Observations	125,023	103,448	103,135	171,749	343,970	612,586	521,910	437,473	159,572	11,237

Heteroscedasticity-consistent standard errors standard errors in parentheses.

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

The base category for the object type is paintings. The base category for the region is North America

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