

Glass Ceilings in the Art Market

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Abstract

Using a unique data set consisting of the population of fine art auctions from 2000 to 2017 for Western artists, we provide strong empirical evidence for a glass ceiling for female artists. First, we show that female artists are less likely to transition from the primary (gallery) into the secondary (auction) market. This glass ceiling results in a selection mechanism which is manifested in an average premium of 6% for artworks by female artists. Second, this premium is driven by a small number of women located at the top of the market and turns into a discount when we account for the number of artworks sold. The superstar effect, where a small number of individuals absorbs the majority of industry revenues, is amplified for the group of female artists. Third, at the top 0.1% of the market artworks by female artists are traded at a discount of 9%. Moreover, the very top 0.03% of the market, where 41% of the revenues are concentrated, are still entirely off limits for women. Overall, we find two glass ceilings for women pursuing an artistic career. While the first one is located at the starting point of a female artist's career, the second one can be found at the transition into the superstar league of the market and remains yet impermeable. Our study has wide-reaching implications for industries characterized by a superstar effect and a strong concentration of men relative to women.

KEYWORDS: Art market, Auctions, Gender economics, Labour economics

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1 Introduction

On October 29, 2017 the author of the prominent 1971 landmark essay *Why Have There Been No Great Women Artists?*, Linda Nochlin, passed away. The eminent female art historian was among the first ones to question the notion of the male genius and to draw attention to the issue of gender discrimination in the art world. Today, almost 50 years later, in our study we aim to question the relevance of this debate by focusing on art prices in the secondary art market.

A look into the list of the top 20 most expensive artworks sold at auction during 2016 as published by this year's Tefaf report¹ (Pownall, 2017) confirms the suspicion that none of these lots can be attributed to a female artist. The first female lot appears on rank 64. It is the work *Lake George Reflection* by Georgia O'Keeffe which was sold for \$12.9 million at Christie's in New York. In comparison, the most expensive lot was the painting *Meule* by Claude Monet which was sold for \$81.4 million at the same auction house. Art auctions are part of the secondary market. Prices fetched at auction indicate the resale or investment value of a particular artist. An artist's track record within the secondary market is highly visible to the public as opposed to prices in the primary dealer market. As a result, information on past auction results is frequently used by art collectors, experts and consultants as input to determine the value and future potential of an artist. In addition, the art market is characterized by the superstar effect, as laid out by Rosen (1981), where a small number of individuals absorbs most of the revenues. This implies that the rank of an artist is crucial in determining her share of industry rewards.

Discrimination occurs when a subgroup is treated differently or less favorably than members of a majority group with identical productive characteristics. While women do not display less interest in pursuing an artistic career than men do (more than half of all MFA holders are female according to National Museum of Women in the Arts (2017)), they appear to encounter challenges in establishing themselves as successful artists in the market. If female artists can be found in large numbers in classes of fine art colleges but not among art auction lots it may point to a well-known phenomenon in the professional world faced by women known as the glass ceiling. This intangible barrier prevents female professionals from achieving upper-level positions. However, conditions for women in the labor market in general have improved over time. In the US, the Equal Pay Act of 1963 aimed to abolish wage differences based on gender and the Civil Rights of 1964 outlawed sex

¹The Tefaf report is the annual art market report published by the The European Fine Art Foundation.

based discrimination in the labor market. In the art world, efforts have been made to raise attention for gender discrimination. For instance, in 1984 the Guerrilla Girls started to create awareness for sexual discrimination by pointing out the underrepresentation of female artists in the New York based Museum of Modern Art's exhibition *International Survey of Painting and Sculpture* where only 10% of all works were by female artists (The Guerrilla Girls, 2017). Nowadays, many museums dedicate separate exhibition space to female artists only (for instance the Brooklyn Museum or the Museum of Modern Art in New York). Nevertheless, according to the National Museum of Women in the Arts (2017), artworks by female artists constitute only three to five percent of major permanent collections in the U.S. and Europe.

Assuming that skill is equally distributed across the population, there should be no differences in quality between the commodity (artworks) produced by male and female artists. This suggests that a potential underrepresentation and value discount on art by women would be due to an inherent gender bias on the side of art collectors and the market in general. As most wealth is concentrated in male hands (Wealth-X, 2017) it is likely that the buyers of art are also still predominantly male and beliefs such as that "...There has never been a first-rank woman artist. (And that) Only men are capable of aesthetic greatness." as stated by the critic Brian Sewell (Johnson, 2008) might still be quietly held by a large part of the society. The result would be an unfounded entry barrier to the established artist market for female artists leading to market distortions.

In this paper, we are examining whether women are subject to gender discrimination in the secondary market for fine art. Building on the theory on the economics of superstars developed by Rosen (1981), we investigate the presence of a glass ceiling in a market characterized by a skewed distribution of rewards and a high concentration of men relative to women by evaluating prices of artworks traded at auction. This is the first comprehensive empirical study analyzing the performance of female visual artists compared to the performance of male artists in the secondary art market.

We complement the literature on gender wage differentials in the cultural and creative industries and contribute to the body of research on markets characterized by the superstar effect. While there is a lot of anecdotal evidence on gender discrimination in the art world, surveys (Throsby and Mills, 1989; Throsby et al., 2003, 2010), case studies (Cowen, 1996; Reis, 1995a,b) and empirical studies (Cameron et al., 2017; Rengers, 2002) on the performance differences between male and female artists, these are too limited in scale to draw conclusive results. Findings of these studies

stress the high underrepresentation, relatively lower sales revenues of female artists, as well as hurdles experienced by women that impede their careers. For instance, a recent study by (Cameron et al., 2017) provides empirical evidence using a sample of fine art graduates from Yale University that while female artists experience more obstacles than men when entering the market, their artworks are traded at a premium once established. Further, there is some empirical evidence from other industries characterized by the superstar effect showing that women are subject to a glass ceiling when they are climbing up the career ladder. This was found to be the case for top athletes (Kahn, 1991), movie stars (Bielby and Bielby, 1996; Lincoln and Allen, 2004), top executives (Bertrand and Hallock, 2001) and researchers (Barbezat and Hughes, 2005; Probert, 2005). Nevertheless, the majority of these studies suffer from rather small sample sizes impacting the strength and robustness of the results. As superstar markets are characterized by a skewed distribution of income, the human capital model as developed by Becker (1967, 1996); Mincer (1974) will not yield reliable results. Therefore, it is of particular importance to be able to analyze the tails of these distributions which calls for a critical sample size.

We have exclusive access to a unique auction data set representing nearly the whole population of global art auction transactions in the time period between 2000 and 2017. Further, we are also employing a unique primary (gallery) market data set. From this global database we consider only Western artists to facilitate an accurate identification of the gender of the artists. Overall, we have auction results of 110,938 male and 5,612 female artists (with 2,572,346 and 104,844 lots respectively). Furthermore, the data covers several art movements and media allowing us to segment and homogenize sub-samples resulting in better comparability. Another novelty is our focus on the output (the artistic product) instead of on the input of labor as it is common practice in gender discrimination studies (Becker, 2010). This implies that our results are driven by market demand as opposed to differences in the individual characteristics of the artists. We quantify the value discrepancy between female and male artists controlling for the quality of the artworks on artist and artwork level. The application of a Kalman filter enables efficient use of the data and highly increases the precision of the indices which are used to deflate sales prices. We correct for a potential selection bias arising from higher barriers for female artists in our data by applying a Heckman model using data from the primary (gallery) art market. We also perform a quantile regression analysis to test for the presence of gender discrimination particularly in the upper tail of the price distribution where

most of the revenues are concentrated.

Our results reveal strong evidence for the presence of a glass ceiling that is faced by female artists in the market for fine art. First, women are less likely to enter the secondary (auction) market which represents the first barrier for female artists. This selection bias results in a 6% price premium for female artworks. Second, this price premium likely to be due to a supply squeeze caused by a small number of female artists located at the top 1% of market. Further, we show that market concentration is higher for women than for men. The superstar effect, where the winner takes all, appears to be amplified for women. Third, we identify a second hurdle faced by female artists which is manifested in their exclusion from the superstar league of the market. In particular, the top 0.03% of the market, where 41% of the industry revenues are concentrated, are off-limits for women and is entirely occupied by men. This is supported by the quantile regression results which reveal that artworks by female artists are traded at a price discount of 9% in 99.9th quantile of the price distribution.

This is the first empirical study on gender discrimination of this scale within the cultural sector. Our highly robust results provide important implications for gender equality. Most importantly, our findings present strong evidence that female artists are discriminated against in the market based on their gender. This indicates that art market participants are still biased towards male artists and that the idea of the male artistic genius still prevails. These results call for more effort in creating equal opportunities for women who are aspiring an artistic career as well as in setting up initiatives which help accelerating a paradigm shift in the minds of art market participants. While the market for fine art is a specialized sector, our approach of examining the presence of a glass ceiling can be extended to the overall sphere of creative and cultural industries including performing arts, motion pictures, radio and television, printing and publishing as well as fashion and advertising. Our research design can also find valuable applications for occupational areas characterized by the superstar effect such as the high-end gastronomy, top sports, academia, journalism as well as for leadership positions in general which are still largely dominated by men.

The paper proceeds as follows: In section 2, we provide an overview of the current state of research with respect to gender discrimination in the art world. We present our conceptual framework in section 3. The data set is described in section 4. Section 5 is dedicated to the empirical analysis and results. We finish with some concluding remarks and implications in section 6.

2 The Gender Gap in the Art Market

There is a rich body of empirical literature within the domain of labor market economics providing evidence on the existence of a wage gap between men and women that is attributed to discrimination (Cohen, 1971; Fuchs, 1971; Goldin and Katz, 2007; Goldin, 2014; Goldin et al., 2017; Malkiel and Malkiel, 1973; Oaxaca, 1973). It implies that women are relatively underpaid compared to men given their observed skills set. While most studies come to the conclusion that gender wage discrimination exists, there are considerable differences with respect to the size of the gap (Jarrell and Stanley, 2004; Stanley and Jarrell, 1998; Weichselbaumer and Winter-Ebmer, 2005). In his meta analysis involving 55 empirical studies on gender wage discrimination, Stanley and Jarrell (1998) showed that the empirically established wage difference between men and women was in the ballpark of -2.7% to 91% resulting in an average of 31.8%. They further found that the magnitude of the wage discrimination is sensitive to the model specification, higher if the authors are men and that it exhibited a declining trend over time. While current studies by Goldin and Katz (2007); Goldin (2014) confirm an overall narrowing gap in earnings over the years due to an increase in the productive human capital of women relative to men, it is also shown that the gap diverges over the life cycle of the careers of men and women (Bertrand et al., 2010; Goldin et al., 2017).

Within the sphere of cultural and creative industries, empirical evidence for wage differences becomes sparse. In their longitudinal study on the careers of male and female actors, Lincoln and Allen (2004) found that female actors receive fewer roles than male actors even when controlling for the number of Academy Award nominations. Moreover, aging seemed to have a more detrimental effect on the women's acting careers rather than the male actors' career paths. This 'double jeopardy', the adverse interaction effect of gender and age on wage, was also empirically shown by De Pater et al. (2014) in their study on wage differences among top hollywood movie stars. Bielby and Bielby (1996) found similar results for the case of a sample of screenwriters over a period of 60 years. However, these results might not necessarily apply to the world of art. While the actor's aesthetics next to their acting skills are of importance in the film industry, it is less likely to be the case for the fine art market.

Due a lack of data, research on wage discrimination within the art market is mainly confined to surveys (Throsby and Mills, 1989; Throsby et al., 2003, 2010) and qualitative survey- or interview-based case studies (Pheterson et al., 1971; Piirto, 1991; Cowen, 1996; Kirschenbaum and Reis, 1997;

Brooks and Daniluk, 1998). In repeated surveys on the artist labor market in Australian, Throsby and Mills (1989); Throsby et al. (2003, 2010) found that the share of women has increased from 50% to 63% over the time period from 1983 until 2008. Further, they show that women feel more restrained in their work by having children. Reis (1995a,b) found in their studies that motherhood diverts time from creative endeavors and that a female artist's productivity peak is more likely to occur at a later age. The resulting income of female artists was found to be 38% below the income of male artists with a decreasing trend. In addition, women were found to be more often in the low income quantiles than men (44% and 35%) and less often in higher income quantiles (16% and 25%). However, these studies have very limited sample sizes and employ a broader definition of the artist profession by including performance artists and writers. For the case of US artists, Filer (1986) found that being female (married or unmarried) has a negative effect on earnings. Consistent with the findings above, Rengers (2002) reported that Dutch female visual artists sell their artworks for lower prices (about 30%) and are less represented by agents. The author explains this with the fact that female artists are on average younger and have less experience than men. Lastly, a case study involving 10 female artists with children by Kirschenbaum and Reis (1997) found that creative productivity was related to access to financial resources, spousal support, childbearing responsibility and recognition by teachers other significant persons. In addition, sales were influenced by the extent of the artist's self-confidence. Moreover, the expectation of inferior career chances leads women avoid certain professions resulting in gender segregation. Breen and Garcia-Penalosa (2002); Filippin and Ichino (2005) showed that the beliefs about once career prospects are updated based on the success probabilities of past generations leading to gender specific career choices. As a result, female success should be highest in areas where they found most incentives and least resistance.

Gender discrimination becomes most apparent when, given equal quality of the artworks, a female artist's work is judged to be inferior than a male artist's work. In an experiment conducted by Pheterson et al. (1971) 120 college women had to evaluate the quality of a number of paintings. Half of the subjects was told that the artist was male and the other half that the artist was female. While in one scenario subjects were judging artworks of contest entrants, in the second scenario subjects were evaluating the quality of artworks of contest winners. In case of contest entrants, female paintings received a poorer judgment, while in the case of contest winner, women received equally high judgments as men. A potential explanation is that the likelihood for men to succeed

is higher, which results in lower valuation for non-established female artists but overvaluation for established women who made it despite lower probability of success. The finding indicates that women encounter obstacles during their establishments as artists due to gender-related prejudicial attitudes specifically by other women. This is not the case for already recognized accomplishments pointing to a vicious circle for aspiring female artists in that unbiased valuation will only take place upon public certification. These findings are in line with the experimental study by Goldin and Rouse (2000) where female musicians were more likely to be hired in blind auditions for symphony orchestras. Similarly, Cowen (1996) reports that the market actually did not discriminate female artists and that female artists often fetched higher prices during their lifetimes than male artists did. He argues that that it was the personal environment that discouraged women to acquire the required skill to become good artists. There is anecdotal evidence showing that established female artists such as Frida Kahlo, Georgia O’Keeffe, Lee Krasner or Helen Frankthaler all enjoyed important support from influential artist fathers, teachers or husbands. It facilitated their entry into the world of art through access to relevant artistic circles. Many significant female artists indeed entered the market due to marriage or birthright (Cowen, 1996; Piirto, 1991). Several studies report that it is harder for women to find access to critical informal networks and social circles as these are often “old boys networks” (Ruth Eikhof and Warhurst, 2013; Gill, 2002; Gregory, 2009) and also benefit to lower extent from these than men do (Forret and Dougherty, 2004). These results are in line with a recent working paper by Cameron et al. (2017). Based on a sample of over 4,000 Yale School of Art graduates, the authors show that while female artist experience more difficulties entering the market they reach higher sales prices at auction conditional on accessing this market. They conclude that it is gender discrimination on institutional as opposed to market level that holds women back from pursuing artistic careers.

The domain of professional sports is similar to the art market in the sense that it is also characterized by the superstar effect where a few top performers are able to extract most of the earnings in the industry. However, compared to the art market performance criteria are more transparent and therefore evaluation is expected to be merit-based leaving less space for discrimination. Nevertheless, remuneration for male and female athletes seems to be unequal as found in a study by Kahn (1991) for the case of top tennis players. The author showed that despite higher market values of female top players, as proxied by television ratings, prize money for men was higher than for women.

In summary, empirical evidence in the art market literature on gender-based salary differentials is mixed. Overall, it appears that women especially encounter barriers in entering the market. While there is some evidence that gender discrimination decreases once women establish themselves as artists, so far a lack of data inhibited the development of a clear understanding of gender effects in the art market.

The following section will present our conceptual framework based on which we form our predictions.

3 Conceptual Framework

In this study, we are interested as to whether female artists are discriminated in the secondary market for fine art. In forming our hypotheses, we draw from empirical findings in the labor market literature as well as the theory on the economics of superstars by Rosen (1981).

The art market is known to be characterized by the superstar effect. Developed by Rosen (1981), it describes the phenomenon where a small number of individuals absorbs the largest part of the revenues within one industry. This market concentration leads to a skewed distribution of revenues with extremely large rewards at the top. It is also known as the “winner-take-all” effect and results from imperfect substitution between goods where lesser talent is an improper substitute for higher talent. This leads to compensation that is disproportional to the amount of talent so that the gap between the rewards for the few most talented and the incrementally less talented is too large to be justified by the difference in talent or skill. As a result, the size of revenues depends more on rank than on talent. As stated by Frank and Cook (2013), in “winner-take-all” markets sellers who are not located in the top distribution often earn less than they could have earned in alternative occupations. Another important attribute of markets characterized by the superstar effect is that consumers are often not able to perfectly evaluate talent and skill and rely on external validation. In addition to the artist profession, examples of occupations which are subject to the superstar effect include chefs, movie stars, comedians, musicians, athletes and researchers.

Our first hypothesis results from empirical findings in the literature that women are reported to experience difficulties in gaining foothold in the art market (Cameron et al., 2017; Cowen, 1996; Pheterson et al., 1971) and generally lack a support system necessary to accelerate career mobility (Cowen, 1996; Forret and Dougherty, 2004; Piirto, 1991). In addition, it is found that the anticipation

of a lower probability of success (Breen and Garcia-Penalosa, 2002; Filippin and Ichino, 2005) as well as childbearing obligations (Kirschenbaum and Reis, 1997) lessen the attractiveness of pursuing a career as a professional artists for women. Therefore, we expect that female artists in our sample are less likely to enter the secondary art market than men. The secondary art market represents the resale market where mostly already established artists are traded. It is only rarely the case that auctions are used for first-time sales since their public nature makes prices more difficult to control as opposed to gallery sales. The effect of this barrier should be a selection mechanism in which potentially only the most persistent and/or most talented female artists are admitted to the auction market. This selection should not be present for the male artist sub-sample. Therefore, our second hypothesis is that female lots are on average traded at a price premium compared to male lots given the quality of the artworks.

However, since the art market is subject to the superstar effect, we expect that it will also apply to the sub-population of female artists. Combining the superstar effect with the selection mechanism mentioned above, we should expect the concentration among female artists to be higher than the concentration in the male segment. In particular, we should observe a top consisting of a small number of female artist who are considered to be the most talented in the market and for whom most buyers will compete. This upper quantile should absorb the majority of the industry rewards and be competitive in terms of revenues and prices with the male segment. The price premium described in the paragraph above could be the outcome of a supply squeeze where demand for the artworks of these few most talented female artists is not satisfied. This is not expected to be the case for women located in lower parts of the distribution where revenues are expected to lag behind the revenue levels of men. This would be in line with notion described by Rosen (1981) where the rank is decisive for the share of revenues that can be absorbed.

Lastly, empirical evidence from industries characterized by the superstar effect including top sports (Kahn, 1991), high-level executives (Bertrand and Hallock, 2001), movie actors (Bielby and Bielby, 1996; Lincoln and Allen, 2004) and academia (Barbezat and Hughes, 2005; Probert, 2005) showed that the top end of these markers are still populated by men. Given that the art market is described as a “winner-take-all” market, we test for a second barrier for female artists which is located at the very top end of the overall revenue distribution. Price levels achieved at this layer of the market should be unattainable for female artists which would imply that the notion of the male

artistic genius is still the predominant paradigm within society.

Overall, we test the presence of two obstacles throughout the career paths of female artists. The first one is a glass ceiling that is expected to appear at the transition from an emerging to an established artist. This should result in a selection mechanism and a higher concentration of female artists at the top of the market. We expect the second ceiling to emerge at the top end of the auction market where most revenues are concentrated and where price levels reached by certain male superstar artist remain out of reach for female artists.

4 Data

4.1 Sample

The data set employed in this study was provided by Artnet AG (Artnet thereafter). The Berlin-based company is an online platform offering trading as well as research and analytic services within the art market. Their price database dates back to the year 1989 and has over ten million price quotation records.² Artnet collects all art auction transactions which reach a hammer price equal to 500 US Dollars and above. As a result, our data set can be considered to represent the population of art auction transactions worldwide.

In this analysis, we focus on the fine art sector. The category includes photography, prints and multiples, works on paper, paintings, installations, design objects and sculptures amounting to 6,140,774 auction transactions. In order to increase the homogeneity of our sample, we exclude installations. The market for installations is slightly different from the market for other more traditional object types as installations are more difficult to maintain, store and exhibit for collectors. Furthermore, as Artnet gradually increased the comprehension of its price database between 1989 and 2000, we restrict our sample period to the years 2000 (January) to 2017 (April) resulting in a very high degree of completion.

The database provides information on transaction characteristics including the name of the auction house and its location, the date of the sale, the lot number, the price estimate of the auction house and the hammer price in US Dollars before transaction costs. With respect to the artists' attributes, the database records her name, date of birth, living status and nationality. On artwork

²Decorative Art includes among other antiques, ceramics, furniture, jewelry, and watches.

level, we have information on the title of the work, its size and object type (as mentioned above). Additionally, we categorize all auction transactions into movements based on the birth year of the artist. Consistent with the classification in the Tefaf report, we distinguish between Old Masters and Impressionists (1250-1874), Modern (1875-1910), Post War (after 1911 and deceased) and Contemporary (all living artists). The artworks where the artist's birth year was not available are subsumed under "other". We do not consider artists born before 1250.

Our variable of interest is the artist's gender. Since Artnet's price database does not indicate the gender of the artists, we identified female artist by matching them to a name list containing female names. The list was compiled from various national statistics records and contains overall 17,885 unique females names. In order to ensure accuracy and increase the homogeneity of the artists in our sample in terms of opportunities such as access to resources and education, we focus on Western artists who are based in Europe and North America (the US and Canada). Whenever there were two nationalities attributed to an artist, she was included in the sample if either of the nationalities was European or North American (e.g. the male artist Zao Wou-Ki who is French-Chinese). In cases where the name was unisex (e.g. Jessy, Joan and Kim), we manually researched the identity of the artist. Instances where the artist consisted of more than one person (e.g. Christo and Jeanne-Claude) were dropped from the sample.

As a result, we are left with a sample size of 4,387,393 observations. We drop observations where information on the dimension (size) of the object is missing which is the case for 58,166 transactions. Lastly, we exclude bought-in lots from our main analysis.³ Our final sample consists of 2,677,190 auction transactions. To the best of our knowledge, this represents the largest and most comprehensive art market auction transaction sample so far employed in a study.

In order to deflate prices, we created separate price indices based on hedonic variables for every artistic movement, object type and gender combination. By segmenting our sample based on these three levels, we obtain very homogenous subsamples which minimize the measurement error. The base year for all indices is 2017. Due to a lack of sufficient data, typically indices of annual and semi-annual frequencies are employed in art market research. The OLS estimator does not exploit the information provided in adjacent time periods resulting in a large variance when only few observations

³In 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% (1,622,019 observations) which is in line with the commonly observed buy-in rates in auction sales.

are available. This leads to unstable estimators for the time dummy coefficients which are used to construct the indices. Following the approach in Bocart and Hafner (2012), we apply a combination of a maximum likelihood estimation (MLE) and a Kalman filter to construct a more stable estimator than the OLS estimator. The MLE-Kalman estimator facilitates a more efficient use of the data and allows us to develop indices of quarterly frequency. Employing a Bayesian approach, the MLE-Kalman filter uses past information to update and smoothen the estimator, assuming a particular dynamic process for the data. In order to obtain the time dummy coefficients used to create the index, the MLE-Kalman estimation is applied to the residuals of the hedonic OLS regression.⁴ The idea is to partition the composite error term of the OLS regression into a time fixed-effect and an error term. All indices are de-seasonalized using the LOESS methodology as suggested in Cleveland and Devlin (1988).^{5,6} Figure A1 in the Appendix provides exemplary indices for paintings which constitute the most frequent object type in our sample.⁷

Additionally, we have exclusive access to primary market data provided by Artnet. Primary market data is proprietary and therefore difficult to obtain. As a provider of art market services, Artnet provides also an online platform for art galleries to sell their work. This data set will be applied to examine the presence of entry barriers into the secondary market for female artists. The data set contains the name of the galleries and the names of the artists they represent as well as the artist's year of birth over the time period from 2000 until 2017. In total, there are 1,281 galleries in Artnet's international gallery network representing 15,121 artists. Again, we only focus on Western artists. Furthermore, as we are interested in the transition from the primary to the secondary market we restrict our sample to the population of living artists. This leaves us with an overall sample of 4,754 artists.

The following subsection will introduce the properties of our data set and provide some first evidence for gender effects within our sample based on univariate analysis.

⁴The hedonic variables used as explanatory variables include the auction house dummies, a dummy for the living status of the artist (dead or alive), the dimensions of the artwork and the dummies for the season when the sale took place. A separate regression was performed for every combination between movement (five levels), object type (six levels) and gender (two levels).

⁵Art auctions are typically concentrated in the spring and autumn in order to ensure presence of collectors.

⁶LOESS is a non-parametric regression technique which locally fits models to a subset of the sample.

⁷All indices are available upon request.

4.2 Descriptive Statistics

Table 1 shows the summary statistics for auction prices for men and women with detailed statistics by artistic movement, object type, region and living status. Overall, 96.1% (2,572,346) of all artworks sold at auction can be attributed to male artists. The total size of the market in terms of value amounts to \$125.7 billion. Of this amount, \$121.0 billion can be attributed to male and \$4.7 billion to female artists. This proportion is in line with the overall share of female artists and their artworks in the sample. correct with female to all ratio. Figure 1 shows how the total sales value and volume developed for both genders over the sample period as well as over different generations. We chose these two dimensions since while attitudes toward gender might not have changed profoundly over the last 17 years, the market might perceive gender differently across artist generations due to the improvement of conditions for women pursuing an artistic career. As shown in Figures 1(a) and 1(c) sales volumes have clearly increased for men and women with a larger relative increase for women. While female artists increased sales volume by a multiple of 1.95 (from 3,714 artworks in 2000 to 7,247 artworks in 2016), male artists increased sales by a multiple of 1.68 (from 97,807 artworks in 2000 to 164,936 in 2016). Similarly, total sales values have increased for both genders despite a dip following the financial crisis. Here, the relative improvement for female artists is even more evident. From the year 2000 until 2017, female artists increased sales value by a multiple of 6.0 while male artists only increased sales by a multiple of 2.8. Nevertheless, female artists remain a small fraction of the overall market in terms of volume and value (4.2% in terms of volume and 5.0% in terms of value in 2016). For both genders, sales numbers highly increased for artists born after 1875 as depicted in Figures 1(b) and 1(d). This is more pronounced for female artists and is likely to reflect a higher supply of Modern artworks as compared to Old Masters and points to lower entry barriers for female artists born in later generations.

With respect to the number of artists, men clearly dominate the auction market occupying 95.2% of the market. While there are 110,938 male artists, there are only 5,612 female artists. Figure 2 shows the evolution of the number of male and female artists during the sample period and over generations. From Figures 2(a) and 2(c) which depict the number of distinct male and female artists in every year, we can observe that there is an increasing trend for both groups over the years. However, the trend is stronger for the female sub-group with an almost three-fold increase from 165 artists in 2000 to 456 artists in 2016. The number of male artists at auction per year less than

doubled from 4,303 to 7,815 artists over the same time period. As a result, the male-to-female ratio improved by 40% over time from 0.03 in 2000 to 0.05 in 2017 (see Figure A2 in the Appendix). This trend is also reflected in Figure 2(d) which shows a steady increase in the number of female artists over the generations with a clear peak for the generation that was born between 1975 and 2000. The number of male artists remains rather stable for the generations born after the year 1875. The rising market entry by female artists points to a potential improvement in conditions and higher market acceptance making the artist profession more attractive for women.

An interesting observation with respect to auction prices is that while the average price for artworks by female artists is below the average price for male artworks (\$45,215.8 versus \$47,030), the median price is with \$4,138 higher for women than for men (\$3,648). Figure 3 shows how these numbers have evolved over time and through generations of artists. A very intriguing pattern can be observed in Figure 3(a). Starting with a gap of \$9,309 in average artwork prices in the year 2000, female artists catch up and overtake male artists in 2013 with an average artwork price of \$58,528 for female art versus \$48,138 for male art. This trend continues with a widening gap until the end of the sample period. Another noteworthy fact is that median prices for female artworks outperformed male median prices throughout the sample period with a widening gap culminating at a difference of \$760 in 2017 as shown in Figure 3(c). Overall, these observations hint to the fact that the composition of artworks sold by female artists might be different in terms of quality than the selection of artworks sold by male artists.

With respect to different artistic movements, female artists can be found in higher numbers in newer eras (Contemporary and Post War). There is a clear increasing trend for number of female artists from the Old Masters and Impressionists era (595 female artists) to the Contemporary movement (2,031 artists). Male artists are more equally split across all four movements with the highest number of artists in the Post War era.

Paintings are most frequent object type in our data set for both genders while Photographs are the least frequent object type. Mean artwork prices are lower for women for Design objects and Works on Paper while median prices are lower for Design objects and Prints and Multiples.

In terms of national residency, it is noteworthy that only in Western Europe the mean and median prices for female artists are lower than for male artists. In Eastern Europe the mean price for artworks by women is with \$85,259 almost twice as high as the mean price for artworks by male

artists (\$42,926).

With respect to living status, the share of artworks by deceased artists is lower for the female sub-sample (64.9%) than for the male sub-sample (78.5%). Furthermore, artworks by living female artists fetch higher median prices than artworks by male living artists (\$4,927 versus \$3,156).

Tables A1 and A2 in the Appendix provide an overview of the top 25 male and female artists and reveal some first insights on the rank of female artists in the market. With a sales value of \$390,077,952 the highest selling female artists, Joan Mitchell, does not reach the sales value of the male artists in the top 25.

In summary, the univariate analysis has revealed three important facts about gender differences in the secondary art market. First, with a share of only 5% female artists are extremely underrepresented in the secondary art market. Second, median prices appear to be higher for women. This might be indicative of a selection mechanism which impedes access to the market for female artists admitting only the most talented ones. Third, it appears that those women, who do break through the initial glass ceiling/ invisible barrier to the market, still lag behind top male artists in terms of sales revenue. In the following section, we will perform an in-depth multivariate analysis in order to investigate the presence of potential discrimination against female artists in the secondary art market.

5 Empirical Analysis

5.1 Selection into the Art Market

As previously described, in this study, our key interest is to test whether female artists experience gender-based discrimination in the market for fine art.

We focus on the secondary art market where mainly established artists are traded. Our first hypothesis is that female artists are less likely to enter this market than men. As shown in the descriptive statistics, female artists are highly underrepresented in the secondary market with a share of 5%. At the same time, it is reported that the number of female students pursuing MFA degrees is not below the number of men. This indicates that there appears to be a large drop out rate of women at the stage of market entry. However, it might be the case that not all students attending fine art schools are interested in pursuing professional careers as artists. Therefore, in order to make

conclusions with respect to the mobility of female artists, we need to observe the share of women present in the primary market where less established and younger artists are represented by galleries.

In order to determine how many male and female artists move from the gallery to the auction market, we check whether the artists in the primary market sample are also present in our main (auction) sample. Table 2 shows that out of 4,180 male artists, 96.9% (4,050 artists) made it into the secondary market. However, only 93.0% (534 artists) out of the 574 female artists made this transition. The difference in proportions test is statistically significant on a 1% significance level. It is also notable that the share of women decreases from 13.7% in the primary market to 11.6% in the secondary market. This amounts to a drop of 15%. The result of this univariate analysis provides us with a first evidence for a barrier that precludes female artists from entering into the secondary market.

The fact that female artists are not as likely to reach the secondary market as male artists suggests that there is a selection mechanism in place which admits only the most talented female artists to the market. If this is the case, we should observe an overall higher sales turnover for female artists. However, if there is a selection bias in place, the positive effect should disappear when the selection bias is taken into account. Descriptive statistics in Table 2 show overall higher mean total sales value for men (\$4.2 million versus \$2.2 million). However, a standard deviation of \$12 million for the sales value of female artists is very large. The total sales value is defined as the sum of the value of all sold lots at auction over the sample period (2000 to 2017) per artists in 2017 US Dollars. In order to analyze the performance of women in a multivariate setting and to control for a potential selection bias, we employ a Heckman sample selection correction as in Heckman (1977) on the entire primary market sample with the log of the total sales as our dependent variable. The model takes the following form:

$$Z_j = \alpha_1 + \delta_1 D_j + \lambda_1 A_j + \epsilon_{1j}, \quad (1)$$

$$\log S_j = \alpha_2 + \delta_2 D_j + \lambda_2 A_j + \kappa C_j + \epsilon_{2j}, \quad j = 1, \dots, N_a; \quad (2)$$

where equation (1) is the selection equation and equation (2) is the outcome equation. Z_j is a binary variable that takes the value 1 if an artist j participates at auction and 0 otherwise. $\log S_j$

is the log of the total deflated sales value for each artist j from the population of $N_a = 4754$ living artists in our sample. D_j denotes the discrimination coefficient which is a gender dummy taking the value 1 whenever the respective artist is a woman. Artist j ' specific transaction characteristics are captured in C_j , a 1×2 vector containing the log of the total sales volume per artist and the artist's buy-in rate. The former is defined as the total number of artworks sold over the sample period. A_j is a 1×92 vector that denotes the artist characteristics including the artist's nationality⁸, his or her year of birth as well as a dummy for every gallery an artist is represented by as a gallery's reputation is known to have a high impact on an artist's success.⁹ δ_1 , δ_2 , λ_1 , λ_2 and κ are parameters of the model. α_1 and α_2 are constant terms. $\log S_j$ is only observed if Z_j equals 1. Following Heckman procedure, we assume that ϵ_{1j} and ϵ_{2j} are error terms which follow a bivariate normal distribution from which can be derived a scale parameter σ and a correlation coefficient ρ . While we do not make use of any exclusion restrictions (all variables in the selection model (equation (1)) are also included in the outcome model (equation (2))), we rely on the non-linearity of the data to identify the model. The correction term will not be perfectly correlated with the covariates since the Mills ratio is estimated using a non-linear probit model.

The results of the selection and outcome model are shown in Table 3. The first important observation is derived from the results of the selection model. It provides evidence for a barrier for female artists at the transition from the primary into the secondary market. The presented coefficients in the selection model are the marginal effects at the mean. The negative and statistically significant coefficient on the female dummy indicates that given their characteristics, female artists are 2.5% less likely to participate at auction compared to men. Furthermore, the correlation coefficient ρ is relatively large and highly statistically significant. This implies that there is indeed a correlation between the error terms of the selection and the outcome model resulting in an upward bias in the coefficient on the female dummy. In other words, female artists who transition into the auction market are different than the average female artists in the sample. Nevertheless, even after correcting for the selection bias, the female dummy is positive and highly statistically significant in the outcome model. The marginal effect of the female dummy at the mean is 0.163. This means that the market

⁸Nationality is defined on country level and includes all countries in Europe and North America totaling to 53 countries. Due to collinearity concerns, 5 of these nationalities were included in the regression model.

⁹In order to avoid overparameterization, galleries that represented less than 100 artists were subsumed under the category 'others'. This resulted in 23 gallery dummies. Due to collinearity concerns, 9 of these galleries were included in the regression model.

is willing to pay a premium of 16.3% for female lots resulting in higher sales revenues for women than for men.

It is worth mentioning that Artnet’s gallery network does not capture the whole population of galleries. It is likely that our gallery sample is rather biased towards more successful artists as being a member of an online gallery network requires resources smaller galleries might not possess. As a result, it might be the case that the artists in our gallery sample are more likely to progress into the secondary market. This implies that our findings are on the conservative side and that the actual share of female artists not transitioning into the secondary market is even likely to be higher.

In order to complement the artist level regression, we also perform a regression on artwork level using our main auction sample. Our basic regression model has the following specification,

$$\log P_{it} = \alpha + \psi W_i + \beta X_i + \eta H_i + \epsilon_{it}, \quad i = 1, \dots, N; \quad t = 1, \dots, T; \quad (3)$$

where $\log P_{it}$ indicates the log of the deflated price of an artwork i , which is sold at a given time t . $N = 2,677,190$ artworks in our sample over $T = 72$ seasons between 2000 and 2017. W_i denotes the discrimination coefficient which is a gender dummy taking a value of 1 whenever the respective artists 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 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 are paintings), the auction house where it was sold and the size of the artwork.¹⁰ 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)¹¹ and a dummy for the living status of the artist at the time of the transaction (the base category is deceased). Due to collinearity between the artist names and the gender dummy, we exclude artist fixed effects from the regression. As we have deflated all prices using our self-constructed indices, we also do not make use of time fixed-effects. ψ , β and η are time-independent parameters. α is a constant term. Lastly, ϵ_{it} denotes the error term.

Table 4 reports the regression results when estimating parameters using the OLS methodology.

¹⁰In total, there are 1,522 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.

¹¹All countries are split into five regions: North America, Eastern Europe, Northern Europe, Southern Europe and Western Europe.

The highly statistically significant female dummy coefficient in our base regression (column (1)) shows that artworks by female artists are on average 5.9% more expensive than the artworks of male artists given the quality of the artworks. While this difference appears to be rather small, this depicts merely the average effect. It is also consistent with findings by Bertrand and Hallock (2001) who studied gender salary differentials for the case of top executives. This result implies that there is a premium on artworks created by women which is supportive evidence for the presence of a selection bias whereby female artists that make it to the secondary art market are on average better. It could be indicative of a potential supply squeeze. Due to the limited supply of high-quality female artworks, collectors are willing to pay a premium for these lots.

All other coefficients are in line with expectations. Sculptures are the most expensive objects, while prints and multiples display the highest discount relative to paintings. Artworks of artists from Southern Europe sell highest. This is not surprising given that many of the top artists such Picasso, Modigliani, Miro and Fontana originate from there. Lastly, there is a premium on deceased artists. The R-squared of the regression is 0.4 which is within the normal range for hedonic models in the field of art market economics (Ashenfelter and Graddy, 2002). Due to some instances of missing data we excluded the birth year of the artists as an explanatory variable in our main specification. However, as shown in column (2), the covariate has a coefficient of zero and its inclusion does not contribute to the explanatory power of the model.

Another way to increase the R-squared and to better control for the unobserved quality characteristics of the artworks which are not explicitly captured by our hedonic variables, would be to modify the dependent variable (the artwork price) by dividing it by the mid-point of the auction house pre-sale estimate. This way, we would analyze whether gender can explain the deviation of the final hammer price from the auction house price estimate. However, this would assume that auction house estimates are unbiased measures of quality. We believe that this is unlikely given that auction house experts incorporate buyer preferences and tastes in their valuations of the artworks. In addition, there are over 1,500 auction houses in our sample with diverging valuation procedures. Furthermore, in this study we are interested whether a gender bias is present in the overall art market and not only on institutional level.¹²

¹²We performed a regression using the model specification in equation (3) with the log of the price scaled by the auction house pre-sale estimate as the dependent variable. The female dummy coefficient is still positive and highly statistically significant with a magnitude of 2.5%. This means that buyers are willing to pay a premium above the auction house pre-sale estimate in case of female lots. The full regression results are available upon request.

It might be the case that the quality of the artworks systematically differs between male and female artists due to unequal opportunities - in particular due to unequal access to education. In order to control for this possibility, we perform a robustness check using a time period where access to education for women should have improved because of legislative changes in the law in the United States. In 1972, the US Congress has approved to add Title IV to the Civil Rights Act of 1964. It was renamed the Patsy Mink Equal Opportunity in Education Act in 2002. This law aimed to ban gender based discrimination from educational programs. At that time, it had particularly important implications for the area of collegiate athletics (U.S. Department of Education, 1972). We expect this regulatory change to also have an effect on women aspiring careers as artists. In our analysis, this should result in a lower effect of the gender dummy on artwork price. In order to test this proposition, we re-estimate the model specified in equation (3) using OLS methodology for the sub-sample of US artists born after 1966 as it is likely that these artists were schooled in the US after the age of five. While not all artists who have the US nationality were schooled in the US (the nationality might have been obtained at a later point in their lives) such regulatory changes may initiate an overall shift in a society's mindset. As we focus on a certain nationality and birth year, we exclude the region and alive dummy from this regression.

The results of this regression analysis can be found in Table A3. As compared to the baseline regression in Table 4, the coefficient on the female dummy more than doubled in magnitude to 14.2%. This indicates that for later generations, where opportunities for men and women were presumably became more equal, the premium for artworks by women is even more pronounced supporting our baseline result.

Tables A4, A5, A6 and A7 in the Appendix provide detailed results for model specifications focusing on movement, object type, region and the generation of the artist separately. One notable observation from these more granular models can be found in the regressions focusing on generations (Table A7). Comparing different generations of artists, we find that there seems to be a larger premium on female artworks for artists born before 1850. Further, a discount is found for female artworks for the generation born between 1875 and 1900 which corresponds to Modern art. Overall, the premium is smaller for younger artists born after 1900. This pattern implies that the selection mechanism appeared to be particularly strong for generations where relatively less support was provided for women pursuing artistic careers. Given the gender dummy coefficient of 5.9% in our

baseline regression in Table 4, it also implies this result is driven by younger artists in our sample.

Overall, the analysis in this section yields two important findings. First, it appears that women are less likely to transit from the primary into the secondary market. This impaired mobility is suggestive of a selection mechanism that admits only the most persistent and/or most talented female artists to the auction market. Second, there is a premium on artworks for those women who break through this initial hurdle/ glass ceiling, both on artist as well as on artwork level. This might be the consequence of the selection bias and a limited supply of high-quality female lots. However, given the low amount of female artists and the superstar effect in the art market, our conjecture is that the premium is driven by a small number of female artists whose artworks demand very large prices. These top artists could be causing a supply squeeze as in a “winner-take-all” market demand will be concentrated on these few individuals. A potentially skewed distribution of revenues is not taken into account by OLS estimation which focuses on the average effect. Therefore, the next section will take a closer look at the distribution of revenues for male and female artists.

5.2 Distribution of Rewards

The analysis above showed that the share of female artists decreased as they moved from the primary into the secondary market. This entry barrier appears to have caused a selection bias in the population of female artists. The result is that it looks like women outperform men in terms of prices fetched at auction. However, we hypothesize that this average effect results from a supply squeeze for the most popular female artists who attract the highest demand. These women constitute the superstars in the “winner-take-all” market and drive the observed average premium. Results on artwork level are distorted if a large amount of artworks is sold by a small amount of female artists located on the top of the price distribution.

Table 5 depicts the distribution of lots of female artists. We can see that as many as 25% of the female lots sold at auction stem from only 0.84% (47) of the artists which however account for 74.0% of the overall value of female lots. Further, only 2.55% (143) of all female artists account for 50% of the transacted lots and for 90.6% of the overall value. Lastly, three quarters of all lots come from 8.68% (487) of the female artists totaling to 99.5% of the whole sales value in the female sub-group. Indeed, it seems that a very small number of female artists dominates the art market in terms of value and volume. Therefore, the artwork level OLS is likely to be not informative about the true

performance of female artists at auction.

In order to correct for the large number of lots by the most expensive artists, we estimate equation (3) using weighted-least-squares (WLS). The applied weights equal the inverse of the square root of the total number of artworks sold per artist at auction throughout the sample period. The results of the WLS regression are presented in Table 6. As expected, the female dummy coefficient turns negative and now yields an average discount of 8.3% on female lots given the characteristics of the artworks. This result lends supportive evidence for the conjecture that the positive coefficients on artwork and artist level derived in the previous section are due to the presence of a small number of very popular female artists who attract the largest demand and the highest prices from collectors in a “winner-take-all” market.

As in the previous section, we perform a robustness check for the sub-sample of US artists born after 1966. Due to the approval of the Equal Employment Opportunity Act of 1972 in the US, opportunities should have improved for female workers which should result in a lower effect of the gender dummy on artwork prices. The results of the regression are presented in Table A8. The discount on female lots increases to 13.3%. This suggests that a stronger protection of female rights resulting in converging opportunities for both genders did not contribute to a lower impact of gender on artwork prices at auction.

Given that women are less likely to gain access to the secondary art market resulting in an upward bias and the fact that the art market is a “winner-take-all” market, we investigate the concentration among the female sub-segment of the market. Table 7 shows the percentages of male and female artists at every quantile of the sales value distribution on artist level. As defined in the section above, the sales value equals the sum of the value of all sold lots throughout the sample period per artist. The most interesting observation is that the female sub-market is more concentrated at the top (top 10%) and less concentrated at the bottom (bottom 50%) than the male sub-market. The latter effect becomes more amplified the further we move down the sales value distribution. While an expected share of 10.1% (5,568) of the male artists can be found in the top 10% of the sales value distribution, only 8.1% (259) of the female artists are located there. At the 50th quantile of the sales value distribution, only a total of 40.7% of the female artists can be found as opposed to an expected share of 50%. Moving further down the sales value distribution, 9.78% of all male and as many as 14.42% of the female artists are situated at the bottom 10% of the sales value distribution. Overall,

this implies that female artists are more likely be found at the bottom of the revenue distribution. The superstar effect wherein a small number of individuals absorbs all industry rewards (Rosen, 1981) applies even more to the female sub-group than to the male segment.

The key implication of the results in this section is that the expected revenues for a female artist at auction are below what a male artist can expect to earn. In order to benefit from the industry rewards, a woman must make it to the top of the market. This effect is more amplified for female than for male artists.

5.3 The Superstar Effect

Having established that female artist are more likely to be found in the lower tail of the value distribution and are more concentrated at the top, we hypothesize that there is another barrier for women located near the climax of the career path. In particular, we test whether female artists are subject to a second glass ceiling by still being excluded from the very top end of the market where the largest revenues are concentrated.

Table 7 does not only exemplify the concentration of revenues within the female sub-segment, but also provides first critical evidence for a second barrier for female artists in the market. In the 99.97th quantile of the sales value distribution no single female artist can found. This quantile corresponds to a market share of 41% in terms of value which entirely accrues to a core of 34 top male artists. As the most expensive female artist, Joan Mitchell, can be found in the 99.96th quantile. With \$390 million in total sales, she is ranked 47th in the list of top artists.

Furthermore, Table 8 shows for different quantiles of the sales value distribution the respective brackets for male and female artists as well as the number of artists per bracket. The key takeaway is that the sales value is significantly lower for female artists than for male artists in every quantile with exception of 99th quantile where the sales value bracket is \$9,258,646 for male artists and \$13,565,304 for female artists. However, at the very top, namely at the 99.91th quantile, the sales value per artist for men elevates again above the sales value level of women. Moving from \$9.3 million in the 99th quantile to 199.1 \$million in the 99.1th quantile, is a sizable jump. At this revenue level 99 male artists and a mere of 5 female artists can be encountered. While the overall 1:20 male-to-female ratio is preserved at this quantile, the increase in revenues is disproportional. It represents the part of the distribution where the superstars of the art market are located who absorb the largest chunk of the

revenues. This univariate artist level analysis shows that in order to reach and overshoot the sales level of male artists, a woman needs to be at the top of the distribution. At the same time, she is precluded from entering the league of the superstars of the art market which appears to be reserved for the male population of artists.

In the following step, we aim to investigate whether taking into account the skewed distribution of prices in the art market will open up a more granular view on gender differences in the art market. Capitalizing on our comprehensive data set that allows us to dig into the tails of the price distribution, we estimate parameters of equation (3) with a quantile regression technique as laid out by Koenker and Bassett Jr (1978). Quantile regression models consider every price segment separately focusing on parts of the distribution other than the conditional expectation. Table 9 presents the regression results and offers a very clear perspective on gender effects in our sample and are in line with the findings from the univariate analysis. For illustration, the female dummy coefficient is plotted in Figure 4. In the lowest quantile, female artists are traded at a small discount of 2.6%. This represents the lower tail of the price distribution where relatively more women than men are located. It also can be seen as representative of the first barrier in which female artists experience difficulties in entering the secondary market. This lower segment consists of many artists with a single auction sale. Therefore, it might include the sub-population of artists who do not manage to establish themselves as artists in the market trading at a discount. After the 25th quantile, we observe a premium on female artworks which steadily increases from 4.2% to 10.1% in the 95th quantile. The coefficient located at the 99th quantile, close to the top of the market, is with 3.4% small in size and low in statistical significance. At this level, it appears that the market does not differentiate based on gender. However, at the 99.9th quantile, which represents the very top of the secondary art market, a high discount of 9.2% on prices for female artworks emerges. This is supportive evidence for the presence of a second glass ceiling that precludes women from participating in the high-end of the art market.

Statistical analysis cannot be used to directly compare the quality of different artworks. Instead, it relies on aggregate bidder demand to provide a signal of the quality of the artworks. Even though we have a comprehensive data set that is representative of the population of artist, we cannot exclude the possibility that there are omitted variables which are valued by collectors and are important determinants of quality and which are currently being picked up by the gender dummy. Given that

our regressions explain about 40% to 60% of the variation in the price, we are faced with some quality characteristics of the artworks that we do not observe. However, we control for a number of variables that are likely to be correlated with the gender including the origin and living status of the artist, as well as the movement and object type of the artwork. Furthermore, even though Nochlin (1971) argues that topics are rather similar within artistic periods as opposed to within gender, other potential explanatory variables that could be correlated with the female dummy are certain colors or themes. For instance, it could be the case that female artists are more likely to focus on family as a theme of their artworks. These topics might in turn be valued higher or lower by the market. As these variables should be artist specific, we make use of a two-stage regression. We perform this analysis in two steps due to the correlation between the artist and the gender dummies. In the first step we include artist fixed-effects in our regression on the logarithm of the real price in addition to the other hedonic variables specified in equation (3). We extract the residuals from this regression and run a second regression where the residual is the dependent variable and the gender dummy is the independent variable. The results are reported in the Appendix in Table A9 and show that even after considering the artist as an explanatory variable, the gender dummy is still highly statistically significant. With exception of a premium in the 5th quantile and a discount for female artworks already appearing in the 99th quantile, the pattern of the coefficients along the quantiles is consistent with the findings in Table 9. However, as previously mentioned, the gender dummy and the artist are correlated variables. Therefore, the results of this two-step residual regression are not entirely accurate.

Overall, the preceding analysis showed that at the very top of the market the idea of the male artistic genius still prevails and that female artists are disadvantaged in the secondary market for fine art.

6 Concluding Remarks

This is the first comprehensive study to provide strong empirical evidence for a glass ceiling for women in the art market, using a sample of data that is only fractionally smaller than the true population. Access to such a full and comprehensive database of transactions enables us to accurately describe and analyse the influence of gender in this market. Using the population of art auction transactions for Western artists as well as a proprietary primary (gallery) market data set over the

time period from 2000 to 2017, we show that 50 years after the pioneering essay *Why Have There Been No Great Women Artists?* by the feminist art historian Linda Nochlin (1971) not much has changed for women aspiring a career as a visual artist. The size of our data set allows us to investigate the tails of the price distribution which are characteristic of the art market and which reveal the most meaningful insights with respect to gender effects.

First, we show that female artists are subject to higher entry barriers than men when transitioning from the primary (gallery) to the secondary (auction) market. Specifically, results from the Heckman selection model show that women are less likely to progress from the primary to the secondary market. This hurdle represents the first glass ceiling and is manifested in a strong underrepresentation of women as well as larger average sales values and higher prices for artworks by female artists. While the share of women in art schools acquiring MFA degrees is reported to be equal to the share of men, we encounter a proportion of only 13.7% in our primary art market sample of living artists which decreases to 11.6% in the secondary market. Overall, across movements and generations, female artists make up only a share of 5% in terms of number of artists as well as number of lots. As empirically shown by Breen and Garcia-Penalosa (2002), it appears that the anticipation of lower revenues might discourage women from pursuing professional artistic careers leading them to drop out of the market. The result may be a selection bias which allows only the best female artists to enter the secondary art market. Therefore, we observe an average price premium of 6% on artwork level for female artists. These findings are in line with the most recent working paper by Cameron et al. (2017) who find a premium for female artworks within a sample of Yale graduates.

Second, we provide empirical evidence that the superstar effect which is characteristic of the art market is more prevalent within the group of female artists than within the male segment. The observed average price premium for female artworks turns into a 8% price discount after correcting for the number of lots per artist. This means that the observed price premium is driven by a small number of female artists who are responsible for a large number of expensive lots. We find that the top end of the market is more concentrated in female sub-sample than in the male sub-sample. These women are responsible for the price premium potentially causing a supply squeeze for their limited amount of lots. Furthermore, relatively more female than male artists are located in the lower tail of value distribution. In every quantile of the distribution, the total sales value for men is higher than the one for women with exception of the 99th quantile. This means that unless a

female artist reaches the top, her revenues will remain below the revenue level of a male artist in the secondary art market. This has also been shown for the case of women in top executive positions and for women in higher salary quantiles in general (Bertrand and Hallock, 2001; Garcia et al., 2001; Kuhn, 1987). The finding that the female sub-segment is more concentrated is novel within the labor market literature on gender differentials and opens up a new ground for discussion with respect to prevalent competitive dynamics among women within one occupational field.

Third, we reveal that the top of the art market is dominated by a core of male artists which constitutes the second barrier for female artists. In terms of total sales values, the 99.97th quantile which corresponds to 41% of the market by value is entirely occupied by male artists where no single women can be found. This is supported by the quantile regression results which show that within the 99.9th quantile a discount of 9% for female artworks emerges. While the first hurdle is overcome by some female artists, this second barrier still appears to be too strong to be permeated. This result is in line with empirical findings in other industries where the superstar effect prevails including the market for top athletes (Kahn, 1991), movie stars (Bielby and Bielby, 1996; Lincoln and Allen, 2004), high-level executives (Bertrand and Hallock, 2001) and researchers (Barbezat and Hughes, 2005; Probert, 2005).

Overall, it appears that art market participants still discriminates based on the gender of an artist on many levels. As Rosen (1981) argued, it is not the distribution of talent but the distribution of opportunities in society that matters. While the first glass ceiling which exists at the transition from the emergence to the establishment of an artist might be of institutional nature, the second barrier is related to market taste and is so far unbreakable. Over the years, the art market has grown substantially with rising rewards for artists located at the top as manifested by ever increasing auction records. However, these rewards still appear to be concentrated among a core that purely consist of male artists. At the very high end of the market, collectors are reluctant to pay as much for an artwork conditional on the artist being female as compared to an artists being a man. Assuming that skill is randomly distributed within society and that female artists are not genetically inferior to male artists, such a behavior points to a gender bias which is still embedded in the heads of art market participants. The largest share of the global wealth is still held by men (Wealth-X, 2017). If the wealthy buyers of art are indeed predominantly male, art purchases reflect male tastes. As an increasing number of women move into the realms of high-net-worth individuals (HNWIs), we may

see a taste shift occurring.

Our study provides important lessons for gender differentials in labor market outcomes. In light of recent events related to gender discrimination across a large range of industries, this study provides strong empirical evidence for the case of the art market. It appears that men and women do not enjoy the same opportunities even in Western democratic societies with many anti-discrimination laws in place. While legal regulations were an important step in establishing gender equality, it seems that the prevailing outdated notion of the male genius is more difficult to replace. It is left for future research to investigate which initiatives are most effective in creating equal opportunities and creating a shift in the society.

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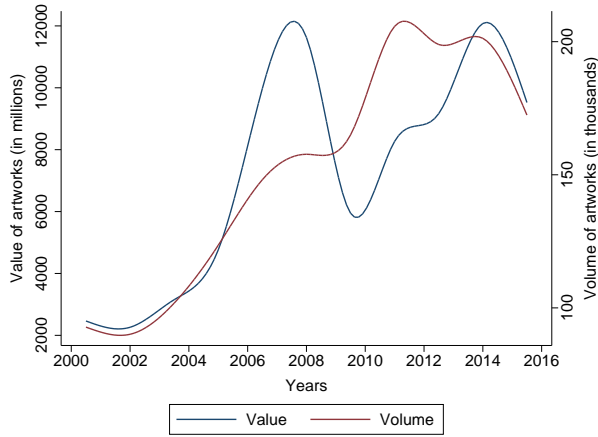
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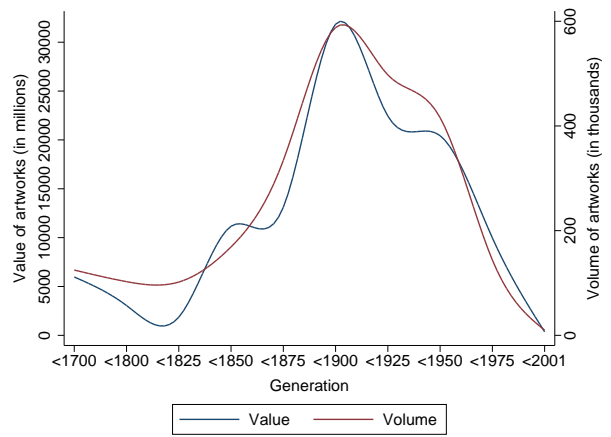
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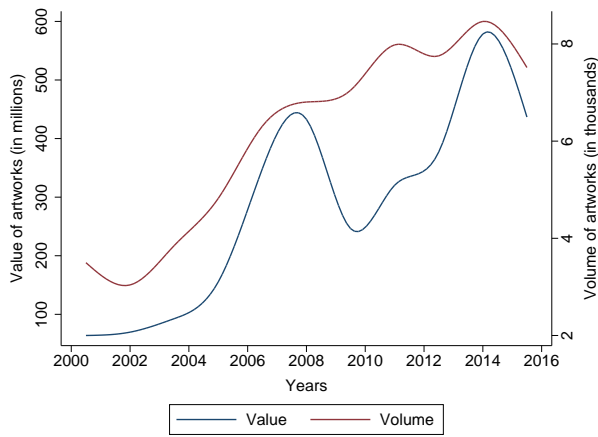
Figures



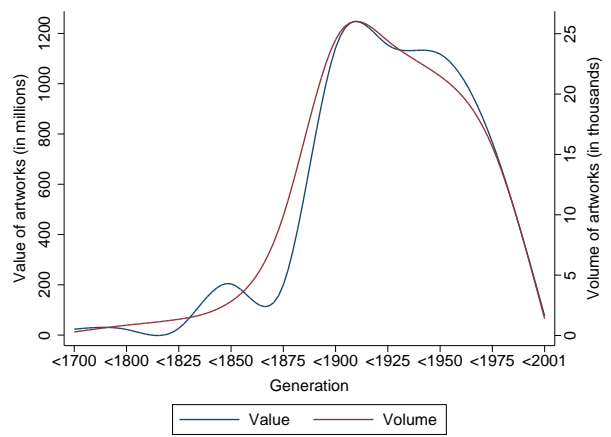
(a) Number and value of artworks by men by years



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



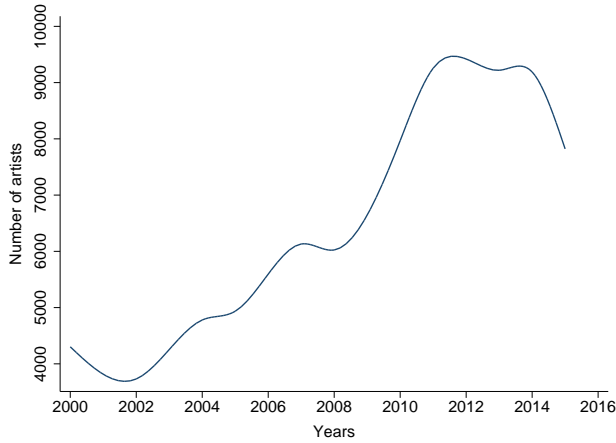
(c) Number and value of artworks by women by years



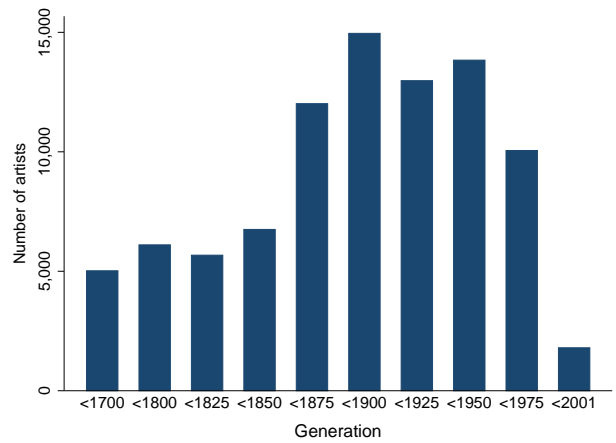
(d) Number and value of artworks by women by generation

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 1,787 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 2,199 artworks by female artists in this omitted category. The value of these artworks is \$761,310,000 and \$7,780,000 respectively.

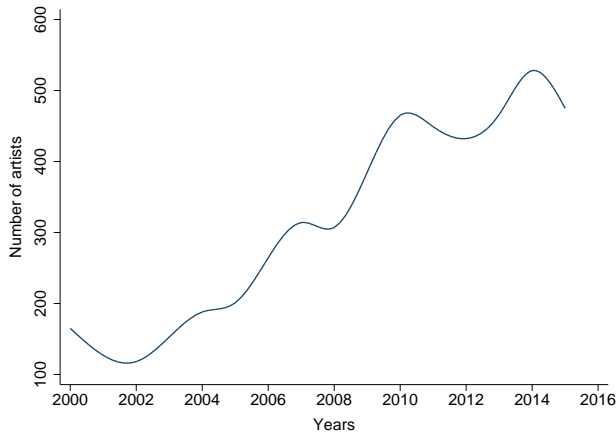
Figure 1: Evolution of sales by male and female artists



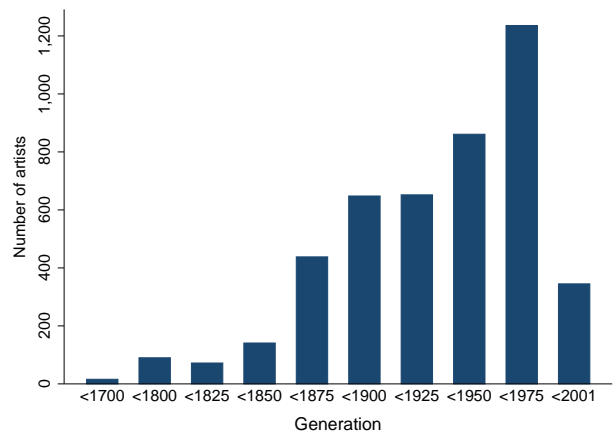
(a) Number of male artists by years



(b) Number of male artists by generation



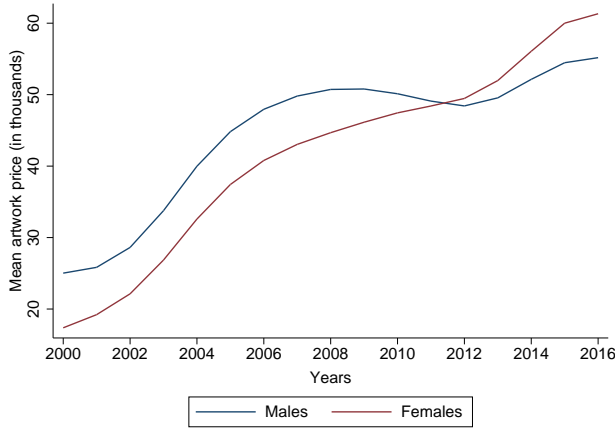
(c) Number of female artists by years



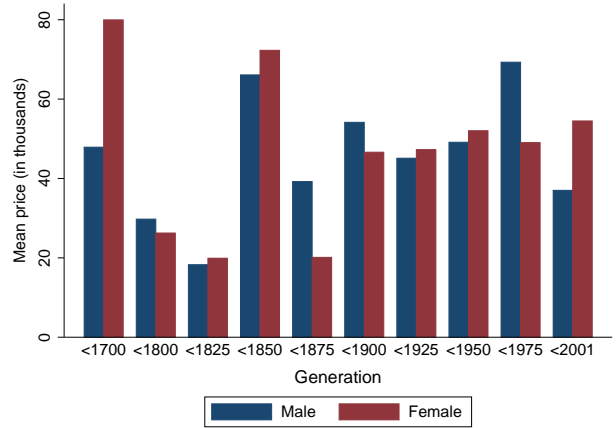
(d) Number of female artists by generation

The year 2017 is omitted in Figures a) and c) as we only use the first four months of this year. Overall, there were 6,171 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 1,113 female artists could not be allocated to a generation.

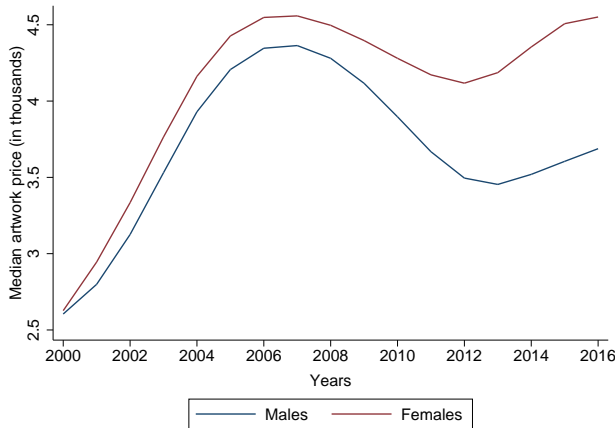
Figure 2: Evolution of number of male and female artists



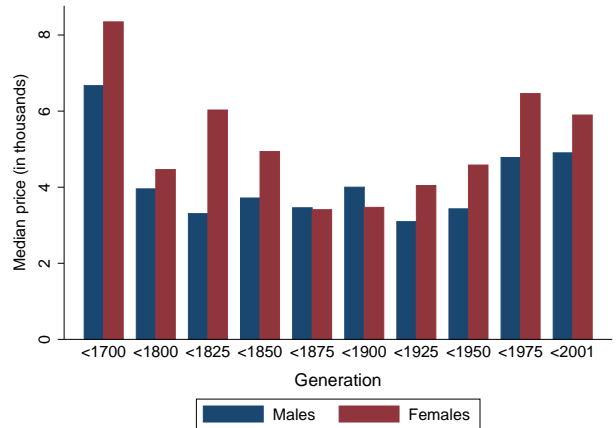
(a) Mean artwork prices by year



(b) Mean artwork prices by generation



(c) Median artwork prices by year



(d) Median artwork prices by generation

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 (\$3,681) for artworks by male and \$30,001 (\$4,306) 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 \$8,968 (\$1,992) for artworks by male and \$3,542 (\$1,182) for artworks by female artists in this omitted category.

Figure 3: Evolution of mean and median artwork prices for men and women

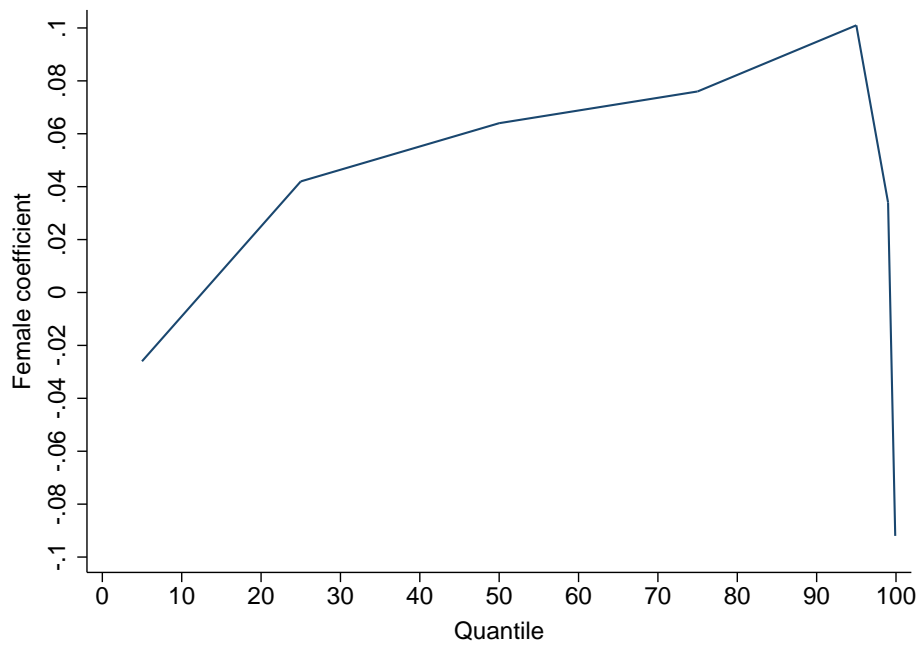


Figure 4: Coefficient on female dummy in quantile regression

Tables

Table 1: Summary statistics for men and women

| Price | Men | | | | Women | | | |
|----------------------------------|-----------|----------|----------|-------------|---------|-----------|-----------|-----------|
| | N | N artist | mean | sd | N | N artists | mean | sd |
| Overall | 2,572,346 | 110,938 | 47,029.8 | 735,892.7 | 104,844 | 5,612 | 45,215.8 | 396,124.3 |
| Buy-in rate* | | | 0.378 | 0.376 | | | 0.361 | 0.034 |
| Movement | | | | | | | | |
| Contemporary | 388,070 | 19,917 | 47,659.7 | 567,640.8 | 30,434 | 2,031 | 42,076.8 | 295,648.1 |
| Postwar | 532,238 | 34,173 | 41,418.8 | 651,382.2 | 24,280 | 1,863 | 54,697.9 | 431,210.4 |
| Modern | 819,923 | 21,281 | 55,228.7 | 957,919.0 | 34,920 | 961 | 47,430.0 | 489,967.9 |
| Old Masters & Impressionists | 525,405 | 19,806 | 47,204.0 | 683,676.1 | 13,781 | 595 | 30,961.9 | 251,112.9 |
| Other | 306,710 | 15,761 | 33,752.9 | 379,097.9 | 1,429 | 162 | 34,315.6 | 116,236.9 |
| Object type** | | | | | | | | |
| Design | 212,709 | 9,250 | 14,594.5 | 82,026.0 | 11,141 | 521 | 11,396.2 | 115,610.4 |
| Sculptures | 169,704 | 15,306 | 79,252.8 | 1,041,910.0 | 8,132 | 807 | 104,803.9 | 589,807.7 |
| Paintings | 1,132,403 | 78,184 | 75,900.5 | 4,562.4 | 33,064 | 3,663 | 84,211.9 | 602,817.5 |
| Works on paper | 453,729 | 36,161 | 24,382 | 2,992.9 | 16,477 | 1,646 | 20,287.5 | 106,720.2 |
| Prints and multiples | 477,203 | 15,050 | 9,953.1 | 192,335.3 | 19,371 | 711 | 19,371.0 | 183,783.4 |
| Photographs | 126,598 | 6,822 | 20,303.6 | 114,461.9 | 16,659 | 603 | 28,187.8 | 170,605.4 |
| Region | | | | | | | | |
| North America | 545,239 | 24,641 | 62,209.0 | 4,101.0 | 34,751 | 1,727 | 68,689.4 | 562,193.9 |
| Northern Europe | 463,192 | 19,162 | 31,052.0 | 2,969.2 | 25,195 | 1,310 | 32,671.7 | 273,858.0 |
| Western Europe | 1,099,021 | 44,143 | 43,263.4 | 3,498.3 | 35,243 | 1,673 | 26,500.9 | 170,791.1 |
| Southern Europe | 337,164 | 14,049 | 58,264.5 | 4,373.8 | 4,040 | 329 | 29,137.7 | 141,946.2 |
| Eastern Europe | 127,730 | 8,943 | 42,926.3 | 4,421.9 | 5,615 | 573 | 85,259.3 | 657,077.4 |
| Living status at time of sale | | | | | | | | |
| Deceased | 2,018,743 | 65,760 | 49,143.7 | 3,791.3 | 68,033 | 2,263 | 48,262.3 | 446,730.4 |
| Alive** | 553,603 | 47,175 | 39,321.3 | 3,156.1 | 36,811 | 3,454 | 39,585.4 | 279,352.6 |

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.

**Multiple attributions for a single artist are possible.

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

Table 2: Summary statistics for men and women: primary market sample

| Variables | Men | | | Women | | |
|---------------------------|---------------|-----------|------------|-----------|-----------|------------|
| | N | mean | sd | N | mean | sd |
| Auction participation | 4,180 (4,050) | 0.969*** | 0.174 | 574 (534) | 0.930*** | 0.255 |
| Total sales value (in \$) | 4,050 | 4,239,555 | 51,800,000 | 534 | 2,241,322 | 12,000,000 |
| Total sales volume | 4,050 | 89.736 | 296.240 | 534 | 61.391 | 164.991 |
| Buy-in rate | 4,050 | 0.367 | 0.216 | 534 | 0.350 | 0.221 |
| Year of birth | 4,180 | 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 3: Artist level regression results - Heckman selection model (primary market)

| Variables | Auction participation | Log of sales value |
|----------------------------|-----------------------|----------------------|
| | Selection model | Heckman model |
| Female | -0.025*** (0.007) | 0.116** (0.053) |
| Log of sales volume | | 1.480*** (0.012) |
| Buy-in rate | | -3.008*** (0.076) |
| Year of birth | -0.001*** (0.000) | 0.021*** (0.001) |
| Artist Nationality Effects | Yes | Yes |
| Gallery Effects | Yes | Yes |
| Artist Effects | No | No |
| Observations | 4,754 | 4,754 |
| ρ | | 0.842*** (0.030) |
| Lambda | | 0.975 (0.041) |

Standard errors in parentheses. $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

The selection model shows the marginal effects at the mean.

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

Table 4: Artwork level OLS regression results

| Variables | Log of price | |
|-----------------------|----------------------|----------------------|
| | (1) | (2) |
| Female | 0.059*** (0.004) | 0.061*** (0.004) |
| Design | -0.076*** (0.003) | -0.060*** (0.004) |
| Photographs | -0.447*** (0.004) | -0.461*** (0.004) |
| Prints & multiples | -0.808*** (0.002) | -0.820*** (0.002) |
| Sculpture | 0.420*** (0.004) | 0.427*** (0.004) |
| Works on paper | -0.378*** (0.002) | -0.381*** (0.002) |
| Eastern Europe | 0.064*** (0.005) | 0.049*** (0.005) |
| Northern Europe | -0.305*** (0.003) | -0.317*** (0.003) |
| Southern Europe | 0.143*** (0.003) | 0.120*** (0.003) |
| Western Europe | -0.074*** (0.003) | -0.100*** (0.003) |
| Alive | -0.285*** (0.002) | -0.197*** (0.002) |
| Year of birth | | -0.000*** (0.000) |
| Log of size | 0.183*** (0.001) | 0.185*** (0.001) |
| Auction house Effects | Yes | Yes |
| Observations | 2,677,190 | 2,590,103 |
| R-squared | 0.392 | 0.394 |
| Auction house Effects | Yes | Yes |
| Artist Effects | No | No |

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

In column (3) the real price is divided by the midpoint of the auction house pre-sale estimate.

The base category for the object type is paintings.

The base category for the region is North America.

Table 5: Distribution of lots for female artists

| Share of lots | Share of artists | Share of value |
|---------------|------------------|----------------|
| 25% | 0.84% (47) | 73.98% |
| 50% | 2.55% (143) | 90.57% |
| 75% | 8.68% (487) | 97.81% |
| 90% | 24.91% (1,398) | 99.53% |
| 95% | 43.46% (2,439) | 99.85% |
| 104.844 | 5,612 | 4,740,606,976 |

Table 6: Weighted least squares regression

| Variables | Log of price |
|-----------------------|----------------------|
| Female | -0.083*** (0.011) |
| Design | 0.357*** (0.011) |
| Photographs | -0.346*** (0.011) |
| Prints & multiples | -0.661*** (0.010) |
| Sculpture | 0.513*** (0.010) |
| Works on paper | -0.335*** (0.006) |
| Eastern Europe | 0.273*** (0.012) |
| Northern Europe | -0.050*** (0.009) |
| Southern Europe | 0.469*** (0.011) |
| Western Europe | 0.122*** (0.008) |
| Alive | -0.343*** (0.005) |
| Log of size | 0.147*** (0.002) |
| Auction house Effects | Yes |
| Artist Effects | No |
| Observations | 2,677,190 |
| R-squared | 0.332 |

Robust 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.

The weights are based on the number of observations per artist.

Table 7: Quantiles for men and women

| Quantile | Total sales value (\$) | Men | | Women | |
|-------------------|------------------------|-----------------|------------|----------------|------------|
| | | N artists | Cumulative | N artists | Cumulative |
| >99.97% | | 0.0003% (34) | 0.0003% | 0.0000% (0) | 0.0000% |
| <99.97% | 450,444,288 | 0.0001% (11) | 0.0004% | 0.0002% (1) | 0.0002% |
| <99.96% | 369,162,784 | 0.0005% (55) | 0.0009% | 0.0005% (3) | 0.0007% |
| <99.1% | 196,938,560 | 0.89% (982) | 0.98% | 1.14% (79) | 1.48% |
| <99% | 9,529,019 | 4.04% (4,486) | 5.02% | 3.14% (176) | 4.62% |
| <95% | 957,773 | 5.08% (5,634) | 10.10% | 3.46% (194) | 8.07% |
| <90% | 305,898 | 15.20% (16,867) | 25.30% | 10.96% (615) | 19.03% |
| <75% | 50,112 | 25.17% (27,992) | 50.47% | 21.67% (1,216) | 40.70% |
| <50% | 8,660 | 24.91% (27,637) | 75.38% | 26.73% (1,500) | 67.43% |
| <25% | 2,082 | 14.84% (16,464) | 90.22% | 18.16% (1,019) | 85.58% |
| <10% | 806 | 4.92% (5,462) | 95.15% | 6.50% (365) | 92.09% |
| <5% | 541 | 4.85% (5,384) | 100.00% | 7.91% (444) | 100.00% |
| Total sales value | 125,717,446,656 | | | | |

Table 8: Group-specific quantiles for men and women

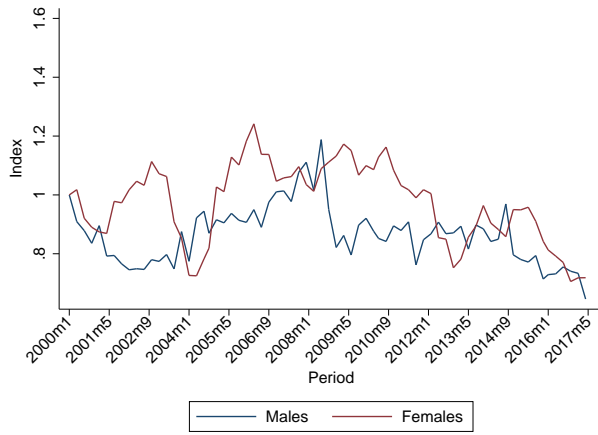
| Quantile | Men | | Women | |
|-------------------|------------------------|-----------|------------------------|-----------|
| | Total sales value (\$) | N artists | Total sales value (\$) | N artists |
| >99.91% | | 99 | | 5 |
| <99.91% | 199,062,592 | 1,010 | 186,889,456 | 51 |
| <99% | 9,258,646 | 4,437 | 13,565,304 | 224 |
| <95% | 963,328 | 5,548 | 820,916 | 281 |
| <90% | 311,344 | 16,640 | 195,287 | 842 |
| <75% | 51,394 | 27,735 | 27,410 | 1,403 |
| <50% | 8,880 | 27,734 | 5,085 | 1,403 |
| <25% | 2,127 | 16,642 | 1,396 | 841 |
| <10% | 820 | 5,547 | 614 | 282 |
| <5% | 549 | 5,546 | 420 | 280 |
| Total sales value | 120,976,834,560 | | 4,740,606,976 | |

Table 9: Quantile regression results

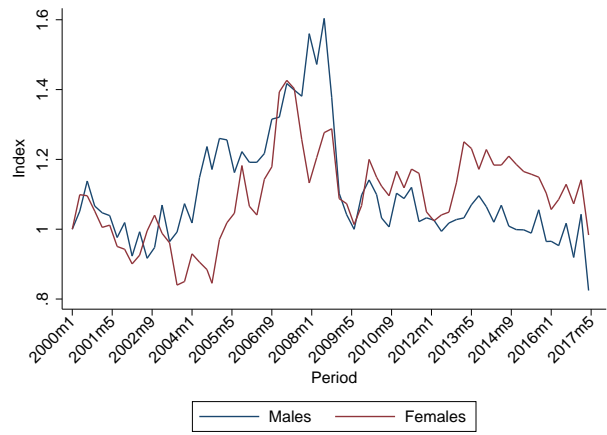
| Variables | Log of price | | | | | | |
|-----------------------|----------------------|---------------------|---------------------|---------------------|---------------------|-------------------|---------------------|
| | q5 | q25 | q50 | q75 | q95 | q99 | q99.9 |
| Female | -0.026*** (0.000) | 0.042*** (0.000) | 0.064*** (0.000) | 0.076*** (0.000) | 0.101*** (0.000) | 0.034* (0.059) | -0.092** (0.043) |
| Auction House Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Region Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Alive Dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Size Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Artist Effects | No | No | No | No | No | No | No |
| Observations | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 |

P-values based on bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

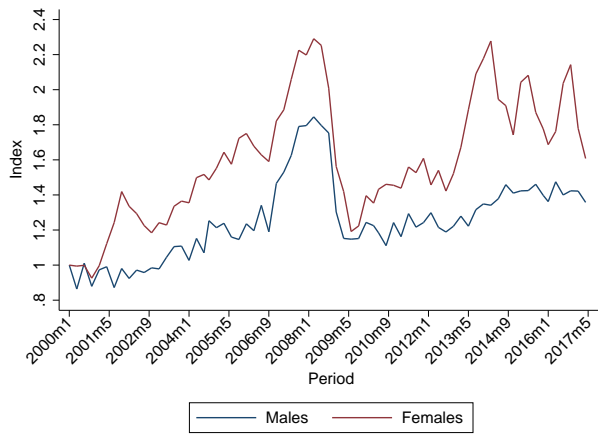
Appendix



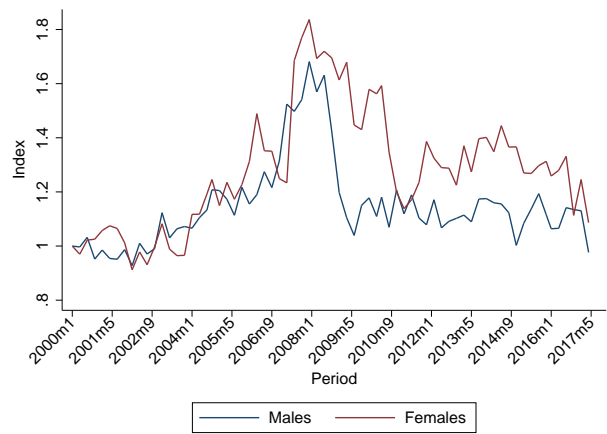
(a) Index for paintings - Contemporary



(b) Index for paintings - Post War



(c) Index for paintings - Modern



(d) Index for paintings - Old Masters and Impressionists

Figure A1: Index for paintings by movement

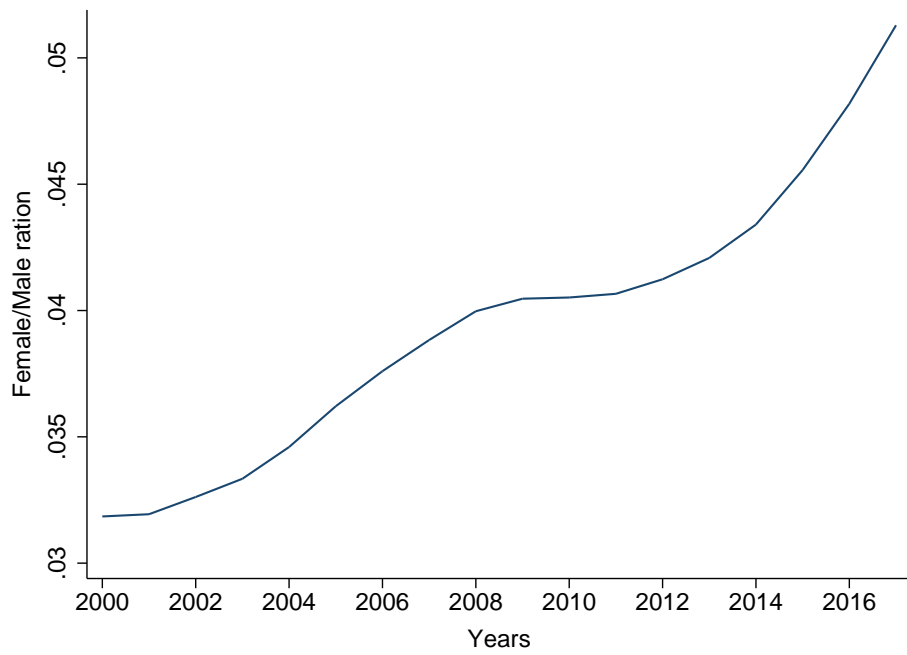


Figure A2: Evolution female-to-male ratio

Table A1: Top 25 male artists by value of sales

| Rank | Artist | Origin | Total sales value in \$ (market share) | Total sales volume (market share) | Buy-in rate |
|------|-----------------------|-----------------|--|---|----------------|
| 1 | Pablo Picasso | Southern Europe | 6,234,162,688 (5.15%) | 37,386 (1.45%) | 0.247 |
| 2 | Andy Warhol | North America | 4,944,984,064 (4.09%) | 19,028 (0.74%) | 0.310 |
| 3 | Gerhard Richter | Western Europe | 2,631,161,344 (2.17%) | 3,587 (0.14%) | 0.255 |
| 4 | Claude Monet | Western Europe | 2,454,644,416 (2.03%) | 493 (0.02%) | 0.197 |
| 5 | Francis Bacon | Northern Europe | 2,369,815,040 (1.96%) | 1,372 (0.05%) | 0.235 |
| 6 | Alberto Giacometti | Western Europe | 1,984,626,304 (1.64%) | 1,991 (0.08%) | 0.309 |
| 7 | Mark Rothko | North America | 1,714,187,648 (1.42%) | 142 (0.01%) | 0.184 |
| 8 | Jean-Michel Basquiat | North America | 1,625,287,552 (1.34%) | 1,308 (0.05%) | 0.288 |
| 9 | Henri Matisse | Western Europe | 1,348,156,288 (1.11%) | 5,157 (0.20%) | 0.302 |
| 10 | Roy Lichtenstein | North America | 1,334,994,432 (1.10%) | 6,429 (0.02%) | 0.247 |
| 11 | Amedeo Modigliani | Southern Europe | 1,334,220,672 (1.09%) | 502 (0.58%) | 0.344 |
| 12 | Marc Chagall | Western Europe | 1,319,881,600 (1.05%) | 14,957 (0.57%) | 0.294 |
| 13 | Joan Miró | Southern Europe | 1,273,512,064 (1.03%) | 14,781 (0.21%) | 0.285 |
| 14 | Alexander Calder | North America | 1,240,659,200 (1.00%) | 5,479 (0.05%) | 0.238 |
| 15 | Lucio Fontana | Southern Europe | 1,213,464,704 (1.00%) | 2,772 (0.11%) | 0.266 |
| 16 | Willem De Kooning | North America | 1,205,838,976 (0.92%) | 1,272 (0.06%) | 0.272 |
| 17 | Jeff Koons | North America | 1,108,363,904 (0.87%) | 1,646 (0.12%) | 0.296 |
| 18 | Fernand Léger | Western Europe | 1,054,615,616 (0.85%) | 2,978 (0.16%) | 0.354 |
| 19 | Zao Wou-Ki | Western Europe | 1,022,537,984 (0.83%) | 4,045 (0.15%) | 0.206 |
| 20 | Pierre-Auguste Renoir | Western Europe | 1,007,937,984 (0.77%) | 3,766 (0.15%) | 0.309 |
| 21 | Damien Hirst | Northern Europe | 935,925,248 (0.71%) | 3,940 (0.03%) | 0.406 |
| 22 | Cy Twombly | North America | 855,804,160 (0.64%) | 881 (0.06%) | 0.765 |
| 23 | René Magritte | Western Europe | 772,205,824 (0.62%) | 1,519 (0.03%) | 0.235 |
| 24 | Paul Cézanne | Western Europe | 755,820,864 (0.59%) | 697 (0.05%) | 0.299 |
| 25 | Edgar Degas | Western Europe | 716,723,904 (0.59%) | 1,274 (0.17%) | 0.295 |

All prices are in constant 2017 \$.

Table A2: Top 25 female artists by value of sales

| Rank | Artist | Origin | Total sales value in \$ (market share) | Total sales volume (market share) | Buy-in rate |
|------|------------------------------|-----------------|--|---|----------------|
| 1 | Joan Mitchell | North America | 390,077,952 (8.23%) | 641 (0.61%) | 0.213 |
| 2 | Georgia O'Keeffe | North America | 247,289,024 (5.22%) | 117 (0.11%) | 0.204 |
| 3 | Louise Bourgeois | North America | 213,115,504 (4.50%) | 649 (0.62%) | 0.289 |
| 4 | Cindy Sherman | North America | 198,720,272 (4.19%) | 1,269 (1.21%) | 0.268 |
| 5 | Barbara Hepworth | Northern Europe | 196,938,560 (4.15%) | 616 (0.59%) | 0.146 |
| 6 | Agnes Martin | North America | 186,889,456 (3.94%) | 296 (0.28%) | 0.249 |
| 7 | Natalia Sergeevna Goncharova | Eastern Europe | 170,325,248 (3.59%) | 731 (0.70%) | 0.463 |
| 8 | Tamara De Lempicka | Eastern Europe | 155,940,592 (3.29%) | 313 (0.30%) | 0.357 |
| 9 | Bridget Riley | Northern Europe | 132,993,840 (2.81%) | 818 (0.78%) | 0.189 |
| 10 | Mary Cassatt | North America | 84,284,360 (1.78%) | 832 (0.79%) | 0.296 |
| 11 | Gabriele Münter | Western Europe | 80,562,760 (1.70%) | 449 (0.43%) | 0.231 |
| 12 | Helen Frankenthaler | North America | 79,292,240 (1.67%) | 1,100 (1.05%) | 0.253 |
| 13 | Berthe Morisot | Western Europe | 78,504,968 (1.66%) | 258 (0.25%) | 0.340 |
| 14 | Maria Helena Vieira Da Silva | Western Europe | 71,507,552 (1.51%) | 683 (0.65%) | 0.320 |
| 15 | Julie Mehretu | North America | 67,251,968 (1.42%) | 117 (0.11%) | 0.328 |
| 16 | Camille Claudel | Western Europe | 64,525,668 (1.36%) | 115 (0.11%) | 0.275 |
| 17 | Niki De Saint Phalle | Western Europe | 63,479,844 (1.34%) | 1,849 (1.76%) | 0.361 |
| 18 | Elisabeth Frink | Western Europe | 56,891,788 (1.20%) | 1,212 (1.16%) | 0.186 |
| 19 | Jenny Saville | Northern Europe | 55,605,668 (1.17%) | 67 (0.06%) | 0.295 |
| 20 | Elizabeth Peyton | North America | 54,067,756 (1.14%) | 305 (0.29%) | 0.343 |
| 21 | Germaine Richier | Western Europe | 51,364,992 (1.08%) | 207 (0.20%) | 0.310 |
| 22 | Rosemarie Trockel | Western Europe | 48,283,824 (1.02%) | 370 (0.35%) | 0.375 |
| 23 | Diane Arbus | North America | 46,413,028 (0.98%) | 680 (0.65%) | 0.352 |
| 24 | Tauba Auerbach | North America | 44,928,216 (0.95%) | 115 (0.11%) | 0.354 |
| 25 | Cady Noland | North America | 43,953,368 (0.93%) | 50 (0.05%) | 0.296 |

All prices are in constant 2017 \$.

Table A3: Artwork level OLS for US artists born after 1966

| Variables | Log of price |
|-----------------------|----------------------|
| Female | 0.142*** (0.030) |
| Design | 0.073*** (0.024) |
| Photographs | -0.223*** (0.027) |
| Prints & multiples | -0.339*** (0.027) |
| Sculpture | 0.166*** (0.027) |
| Works on paper | -0.107*** (0.024) |
| Log of size | 0.163*** (0.005) |
| Auction house Effects | Yes |
| Artist Effects | No |
| Observations | 33,471 |
| R-squared | 0.442 |

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1
The base category for the object type is paintings.

Table A4: OLS regression by artistic movement

| Variables | Log of price | | | |
|-----------------------|----------------------|----------------------|----------------------|------------------------------|
| | Contemporary | Postwar | Modern | Old Masters & Impressionists |
| Female | 0.055*** (0.008) | 0.112*** (0.008) | -0.078*** (0.007) | 0.121*** (0.011) |
| Design | -0.340*** (0.010) | -0.091*** (0.007) | -0.091*** (0.006) | 0.154*** (0.009) |
| Photographs | -0.377*** (0.007) | -0.546*** (0.008) | -0.490*** (0.008) | -0.517*** (0.014) |
| Prints and multiples | -0.811*** (0.006) | -1.002*** (0.005) | -0.889*** (0.004) | -0.845*** (0.007) |
| Sculpture | 0.436*** (0.007) | 0.442*** (0.007) | 0.536*** (0.007) | 0.214*** (0.009) |
| Works on paper | -0.324*** | -0.304*** | -0.403*** | -0.407*** |
| Eastern Europe | -0.329*** (0.012) | -0.501*** (0.011) | 0.199*** (0.008) | 0.471*** (0.010) |
| Northern Europe | -0.074*** (0.007) | -0.523*** (0.007) | -0.158*** (0.007) | -0.245*** (0.008) |
| Southern Europe | -0.111*** (0.008) | -0.244*** (0.007) | 0.549*** (0.006) | 0.107*** (0.011) |
| Western Europe | -0.124*** (0.006) | -0.311*** (0.005) | 0.109*** (0.005) | 0.004 (0.006) |
| Alive | | -0.448*** (0.004) | -0.589*** (0.020) | |
| Log of size | 0.242*** (0.001) | 0.191*** (0.001) | 0.145*** (0.001) | 0.184*** (0.001) |
| Auction house Effects | Yes | Yes | Yes | Yes |
| Artist Effects | No | No | No | No |
| Observations | 418,504 | 556,518 | 854,843 | 539,186 |
| R-squared | 0.457 | 0.419 | 0.393 | 0.403 |

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 A5: OLS regression by object type

| Variables | Log of price | | | | | |
|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | Paintings | Works on paper | Prints & multiples | Photographs | Design | Sculpture |
| Female | 0.162*** (0.007) | 0.172*** (0.010) | -0.066*** (0.008) | 0.047*** (0.009) | -0.460*** (0.011) | 0.248*** (0.015) |
| Eastern Europe | -0.005 (0.007) | -0.066*** (0.011) | 0.149*** (0.014) | -0.058*** (0.015) | 0.309*** (0.022) | -0.006 (0.019) |
| Northern Europe | -0.431*** (0.006) | -0.525*** (0.008) | -0.112*** (0.006) | -0.301*** (0.012) | -0.066*** (0.009) | 0.079*** (0.014) |
| Southern Europe | 0.000 (0.006) | 0.123*** (0.009) | 0.259*** (0.006) | -0.243*** (0.018) | 0.084*** (0.009) | 0.030** (0.013) |
| Western Europe | -0.163*** (0.005) | -0.124*** (0.007) | -0.144*** (0.005) | -0.035*** (0.008) | 0.222*** (0.008) | -0.223*** (0.010) |
| Alive | -0.349*** (0.003) | -0.227*** (0.005) | -0.227*** (0.004) | -0.194*** (0.007) | -0.386*** (0.006) | -0.354*** (0.007) |
| Log of size | 0.290*** (0.001) | 0.223*** (0.002) | 0.065*** (0.001) | 0.273*** (0.003) | 0.098*** (0.001) | 0.169*** (0.002) |
| Auction house Effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Artist Effects | No | No | No | No | No | No |
| Observations | 1,165,467 | 470,206 | 496,574 | 143,257 | 223,850 | 177,836 |
| R-squared | 0.419 | 0.356 | 0.312 | 0.412 | 0.337 | 0.446 |

Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1

The base category for the region is North America.

Table A6: OLS regression by region

| Variables | Log of price | | | | |
|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|
| | North America | Northern Europe | Western Europe | Southern Europe | Eastern Europe |
| Female | 0.067*** (0.008) | 0.142*** (0.008) | -0.037*** (0.007) | 0.259*** (0.020) | 0.101*** (0.017) |
| Design | -0.409*** (0.009) | 0.027*** (0.007) | 0.060*** (0.005) | -0.430*** (0.010) | 0.156*** (0.027) |
| Photographs | -0.463*** (0.007) | -0.348*** (0.012) | -0.466*** (0.007) | -0.552*** (0.018) | -0.646*** (0.018) |
| Prints and multiples | -0.924*** (0.005) | -0.594*** (0.006) | -0.893*** (0.004) | -0.753*** (0.007) | -0.807*** (0.015) |
| Sculpture | 0.399*** (0.008) | 0.733*** (0.009) | 0.351*** (0.005) | 0.322*** (0.010) | 0.458*** (0.018) |
| Works on paper | -0.376*** (0.006) | -0.371*** (0.005) | -0.357*** (0.003) | -0.390*** (0.007) | -0.500*** (0.009) |
| Alive | -0.351*** (0.004) | -0.119*** (0.004) | -0.256*** (0.003) | -0.398*** (0.006) | -0.557*** (0.010) |
| Log of size | 0.213*** (0.001) | 0.172*** (0.001) | 0.181*** (0.001) | 0.162*** (0.002) | 0.222*** (0.003) |
| Auction house Effects | Yes | Yes | Yes | Yes | Yes |
| Artist Effects | No | No | No | No | No |
| Observations | 579,990 | 488,387 | 1,134,264 | 341,204 | 133,345 |
| R-squared | 0.396 | 0.395 | 0.385 | 0.434 | 0.407 |

Standard errors in parentheses. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

The base category for the object type is paintings.

Table A7: OLS regression by generation of artist

| Variables | Log of price | | | | | | | | | | |
|-----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|----------------------|-----------|
| | <1700 | <1800 | <1825 | <1850 | <1875 | <1900 | <1925 | <1950 | <1975 | <2001 | |
| Female | 0.496*** (0.071) | 0.192*** (0.042) | 0.300*** (0.032) | 0.398*** (0.024) | 0.015 (0.013) | -0.088*** (0.009) | 0.020** (0.008) | 0.175*** (0.009) | -0.017 (0.011) | 0.080** (0.034) | |
| Design | 0.189** (0.094) | 0.539*** (0.049) | 0.563*** (0.042) | 0.233*** (0.018) | 0.151*** (0.011) | -0.048*** (0.008) | -0.139*** (0.007) | -0.321*** (0.009) | -0.226*** (0.017) | -0.034 (0.056) | |
| Photographs | -0.790** (0.381) | -0.346*** (0.107) | -0.151*** (0.021) | -0.566*** (0.026) | -0.504*** (0.017) | -0.526*** (0.010) | -0.410*** (0.008) | -0.593*** (0.008) | -0.302*** (0.010) | -0.337*** (0.037) | |
| Prints and multiples | -0.852*** (0.013) | -1.067*** (0.013) | -0.840*** (0.019) | -0.936*** (0.014) | -0.802*** (0.008) | -0.876*** (0.005) | -0.978*** (0.005) | -1.068*** (0.006) | -0.711*** (0.011) | -0.617*** (0.043) | |
| Sculpture | 0.369*** (0.026) | 0.166*** (0.019) | 0.182*** (0.017) | 0.242*** (0.015) | 0.250*** (0.011) | 0.523*** (0.009) | 0.570*** (0.008) | 0.377*** (0.007) | 0.506*** (0.012) | 0.115*** (0.043) | |
| Works on paper | -0.601*** (0.013) | -0.467*** (0.009) | -0.402*** (0.010) | -0.475*** (0.009) | -0.348*** (0.006) | -0.390*** (0.005) | -0.355*** (0.005) | -0.367*** (0.006) | -0.248*** (0.010) | -0.326*** (0.038) | |
| Eastern Europe | 0.419** (0.206) | 0.128*** (0.050) | 0.613*** (0.032) | 0.547*** (0.020) | 0.456*** (0.012) | 0.175*** (0.009) | -0.152*** (0.011) | -0.462*** (0.012) | -0.399*** (0.020) | -0.404*** (0.047) | |
| Northern Europe | 0.086 (0.194) | -0.551*** (0.021) | -0.699*** (0.019) | -0.217*** (0.013) | -0.248*** (0.010) | -0.172*** (0.008) | -0.231*** (0.007) | -0.484*** (0.008) | 0.068*** (0.011) | -0.212*** (0.040) | |
| Southern Europe | 0.516*** (0.193) | -0.072*** (0.022) | -0.201*** (0.028) | 0.178*** (0.018) | 0.085*** (0.013) | 0.623*** (0.007) | 0.038*** (0.007) | -0.296*** (0.008) | -0.193*** (0.015) | -0.320*** (0.061) | |
| Western Europe | 0.528*** (0.193) | -0.306*** (0.021) | -0.346*** (0.018) | 0.048*** (0.012) | -0.012 (0.008) | 0.074*** (0.006) | -0.032*** (0.006) | -0.362*** (0.006) | -0.222*** (0.010) | -0.344*** (0.038) | |
| Alive | | | | | | | | | | | |
| Log of size | 0.131*** (0.003) | 0.225*** (0.002) | 0.229*** (0.003) | 0.205*** (0.003) | 0.179*** (0.002) | 0.146*** (0.001) | 0.185*** (0.001) | 0.224*** (0.001) | 0.288*** (0.002) | 0.226*** (0.008) | |
| Auction house Effects | Yes No | Yes No | Yes No | Yes No | Yes No | Yes No | Yes No | Yes No | Yes No | Yes No | Yes No |
| Artist Effects | 125,023 | 103,448 | 103,135 | 171,749 | 343,970 | 612,586 | 521,910 | 437,473 | 159,572 | 11,237 | |
| Observations | 0.388 | 0.383 | 0.379 | 0.429 | 0.396 | 0.395 | 0.388 | 0.451 | 0.505 | 0.584 | |
| R-squared | | | | | | | | | | | |

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 A8: Weighted least squares regression for US artists born after 1966

| Variables | Log of price |
|-----------------------|----------------------|
| Female | -0.133*** (0.044) |
| Design | 0.511*** (0.047) |
| Photographs | -0.134*** (0.044) |
| Prints & multiples | -0.416*** (0.046) |
| Sculpture | 0.232*** (0.041) |
| Works on paper | -0.103*** (0.033) |
| Log of size | 0.089*** (0.008) |
| Auction house Effects | Yes |
| Artist Effects | No |
| Observations | 33,471 |
| R-squared | 0.278 |

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The base category for the object type is paintings.

The weights are based on the number of observations per artist.

Table A9: Quantile regression on OLS residual

| Variables | OLS residual | | | | | | |
|--------------|---------------------|---------------------|---------------------|---------------------|--------------------|--------------------|------------------|
| | q5 | q25 | q50 | q75 | q95 | q99 | q99.9 |
| Female | 0.046*** (0.000) | 0.056*** (0.000) | 0.074*** (0.000) | 0.141*** (0.000) | 0.115*** (0.00) | -0.032* (0.076) | 0.013 (0.776) |
| Observations | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 | 2,677,190 |

P-values based on bootstrapped standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

The residual is based on a linear regression of the object type, auction house, season, region, alive dummy, artists dummies and size are regressed on the logarithm of the artwork price .