

Glass Ceilings in the Art Market ^{*}

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Abstract

Using unique data set consisting of the population of fine art auctions from 2000 to 2017 for Western artists, with over 2.7 million auction sales, 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, where 96.1% of auction sales are by male artists. This higher bar materializes in an average price premium of 4.4% for artworks by female artists at auction. Second, this premium is driven by a small number of women located at the top of the market, and manifests as a discount of 10% when we account for the number of artworks sold per artist. Third, the superstar effect, where a small number of individuals absorb the majority of industry rewards, prevails; 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 40% of the sales value are concentrated) are currently unattainable for female artists selling at auction – revealing a glass ceiling. Our study has important implications for industries characterized by a superstar effect and illustrating how market structure impacts gender equality.

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

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1 Introduction

Market structures characterized by the superstar effect where a few individuals absorb the majority of rewards can reinforce the lack of mobility of underrepresented market participants. In these so-called “winner-take-all” industries lesser talent is an imperfect substitute for higher talent and the gap in compensation can be disproportional to the gap in skill (Rosen, 1981). Eventually, the size of rewards will depend 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 of the distribution often earn less than they could have earned in alternative occupations. At the same time, consumers in these markets are often not able to perfectly evaluate the level of skill making meritocracy more difficult to achieve. As a result, higher quality standards might be applied to market participants for whom fewer track records are available and for whom it was historically more difficult to acquire legitimacy due to lower status characteristics.¹ Furthermore, information cascades and herding behavior where buyers imitate the decisions of preceding actors disregarding their own private information can result in market inertia (Banerjee, 1992; Bikhchandani et al., 1992). In summary, the extremely large competition for top ranks in combination with information asymmetries in these industries might inhibit underrepresented groups from progressing. This may lead to a glass ceiling for them as consumers try to minimize risk and avoid uncertainty in their consumption decisions.

In this large-scale empirical study, we are interested in whether the superstar effect encountered in the art market translates into barriers for female artists at auction. In particular, we investigate auction outcomes for artworks created by female and male artists and analyze whether the prevailing market structure impacts artwork prices and materializes in a glass ceiling for female artists at the top of the market.

The superstar effect is very well illustrated in the art market. The distribution of rewards in this industry is highly skewed with the largest profits concentrated at the top. According to the latest Art Basel and UBS art market report (McAndrew, 2018) only 1% of artists accounted for 64% of auction sales in terms of value in 2017. The heterogeneous nature of art as a good makes it difficult to evaluate its quality. The assessment criteria that make a good artist are not fully understood and involve a lot of subjectivity in judgment. These information asymmetries give an important role to the institutions in the art world (for instance, museums, art dealers, auction houses, art journalists

¹Lower status characteristics might refer for instance to age, education race or gender.

and curators) in identifying talent and in determining the superstars in the market. Since the birth of the modern art market in the mid-19th century in London little has change in terms of the identity of the key institutions, sales channels as well as the structure of the competitive landscape (De Silva et al., 2017). It is also documented that female artists are historically underrepresented in this industry. The eminent female art historian, Linda Nochlin, 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 in her 1971 landmark essay *Why Have There Been No Great Women Artists?*. Later 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). The share of female artists decreases gradually along the career ladder and indicating impaired mobility. While women do not display less interest in pursuing an artistic career than men do (about 50% of all Master of Fine Arts (MFA) holders are female in the US), their share drops to 30% in commercial US galleries (National Museum of Women in the Arts, 2017) and to 25% at art fairs (McAndrew, 2018). According to the National Museum of Women in the Arts (2017), nowadays, artworks by female artists represent only 3% to 5% of major permanent collections in the US and Europe. Furthermore, based on our data, female artworks at auctions make up less than 4%.

The auction market constitutes the secondary market for art where typically artworks are traded which were previously sold on the primary market (i.e. through galleries). This implies that these artworks have a resale value and are in demand by other buyers. The appearance of an artwork at auction signals professional recognition (Goetzmann et al., 2016). Therefore, artists who reach this stage are regarded as relatively established with their quality being certified by the market. Similar to individual wages these prices represent market value of an 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. Information on past auction results is frequently used by art collectors, experts, consultants and insurers as input to determine the value and future potential of an artist. Therefore, while prices fetched at auction do not directly accrue to the artists themselves they may have a large impact on their careers and can also feed back into gallery prices (Galenson and Weinberg, 2000).

Given the low representation of women in the art market, we expect the superstar effect to

create larger barriers for female artists with the result that they are less likely to reach the secondary (auction) market than male artists. However, conditional upon reaching this market, we predict that the artworks by female artists should either command a price premium or show no significant difference compared to prices for artworks created by male artists after controlling for quality. The rationale for a premium for female artworks might arise due to a (perceived or actual) stricter quality filter in earlier career stages which creates a higher bar for female artists. This has also recently been observed in a study involving a field experiment on a large online Q&A forum (Bohren et al., 2017) as well as for the case of the referee process in academic journals (Hengel, 2017) and patent applications (Jensen et al., 2018). As a result, a female artist will have to be on average better than a male artist in order to transit from the primary into the secondary market. However, if being traded on the secondary market is not sufficient to signal quality (i.e. in order to resolve uncertainty with respect to the ability and/ or the future potential of female artists) and establish legitimacy as an artist, a stricter quality standard might still be applied which should materialize in yet another hurdle along the career trajectory. In particular, we may see a glass ceiling arising at the top of the market meaning that female artists are less likely to reach the highest ranks than male artists. Higher standards for female have also recently empirically been observed within the context of online Q&A platforms (Bohren et al., 2017), patent applications (Jensen et al., 2018), the academic journal referee process (Hengel, 2017) as well as investment recommendations (Botelho and Abraham, 2017).

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. 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 2.6 million and 105,844 lots respectively). Furthermore, the data covers several art genres and media types allowing us to segment and homogenize sub-samples resulting in improved comparability. This auction sample allows us to compare the performance of female artists in the secondary market to the performance of male artists. Our focus is on the output (the artistic product) instead of on the input of labor as is often common practice in gender performance differential studies has the advantage that our results are less likely to be driven by differences in the individual characteristics of the artists.² Additionally, we

²For instance better negotiation and self-promotion skills.

are fortunate to also employ a unique primary (gallery) market data set to investigate the mobility between the primary and the secondary (auction) market for male and female artists. Access to the opaque dealer market data is extremely limited and has not been studied empirically within the art market literature. Lastly, to test for the presence of a glass ceiling specifically and to observe the upper tail of the price distribution where most of the rewards are concentrated, we perform a quantile regression analysis.

Our results reveal strong evidence for the presence of structural barriers faced by female artists in the market for fine art. First, we find that women are less likely to enter the secondary (auction) market. This selection bias may explain the average 4.4% price premium found for female artworks at auction. Second, this price premium is likely to be due to a supply squeeze caused by a small number of female artists located at the top 1% of the market. In particular, this effect can be attributed to female artists from older generations (mainly pre-1950's works of art) where institutional barriers for women pursuing artistic career were stronger. At the same time, we observe an increase in the share of contemporary artworks by women traded at auction. These artworks sell at a price discount of 8.3% compared to contemporary artworks by men. This provides evidence of lower barriers for female artists in recent time periods. However, we also show that market concentration is higher for women than for men accentuating stronger competition for top ranks among female artists. This implies that the superstar effect, where rewards are concentrated among a few individuals, appears to be even more prevalent 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 40% of the sales value is concentrated, appear out of 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 the 99.9th quantile of the price distribution. Assuming that talent is evenly distributed across gender the exclusion of women from the superstar league of the market points to important structural barriers for underrepresented groups in the market for fine art.

We complement the literature on the influence of a market structure characterized by the superstar effect on the performance of underrepresented groups in particular within the area of the cultural and creative industries. There is a lot of anecdotal evidence on gender inequality in the art world as well as surveys (Throsby and Mills, 1989; Throsby et al., 2003, 2010), case studies (Cowen,

1996; Reis, 1995a,b) and a few empirical studies (Adams et al., 2017; Cameron et al., 2017; Rengers, 2002) documenting performance differences between male and female artists. Findings stress the high underrepresentation, relatively lower sales revenues of female artists, as well as hurdles experienced by women that impede their careers. With the exception of Adams et al. (2017), the rather small employed sample sizes impact the strength and robustness of these results. As superstar markets are characterized by a skewed distribution of income, it is of particular importance to be able to analyze the tails of these distributions which calls for a critical sample size. For instance, using a sample of 4,434 fine art graduates from Yale University from 1891 until 2014, a recent study by (Cameron et al., 2017) provides partial empirical evidence of a higher bar for women. They show that while female artists experience more obstacles than men when entering the market, their artworks sell at a premium conditional on being traded in the market. This effect is mainly driven by pre-1983 graduates. The effect disappears for post-1983 graduates. Even though the authors use a rather small sample (auction results of 515 artists are examined) which is more likely to include higher skilled artists (given the quality of the Yale School of Art), our results are consistent with these findings. Another very recent larger empirical study by Adams et al. (2017) employs a sample of 1.5 million global transactions over a time period from 1970 until 2013 to study the performance of female artists at auction. The authors document an average discount of 47.6% for female artworks before adjusting for artist and artwork characteristics. This effect is moderated by the level of country-specific gender inequality. Our results might be different from their findings due to differences in the sample composition. Given that we have 2.7 million auction transactions over a period of 18 years (2000-2017) for Western artists only our data is more dense representing almost the entire population of auction transactions for this sub-set of artists during this time span. Furthermore, our focus is specifically the top end of the art market as opposed to average effects. There is some statistical support from other industries subject to superstar economics showing that women encounter a glass ceiling when they climb 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). However, these studies use salaries to investigate reward differentials which bears the risk of omitting individual characteristics such as negotiation skills that might explain the gap in salaries. Our focus on auction sales enables us to isolate any direct influence of the artist on prices.

Our results provide important lessons on the impact of market structures that result due to the prevalence of the superstar effect. It appears that the competitive pressure for high ranks paired with uncertainty about the level of skill leads to higher quality standards for underrepresented market participants and impairs their mobility. While we cannot provide evidence of the mechanism that causes the barriers that lead to the observed performance differences between male and female artists, we offer material input for a closer investigation of the underlying reasons.³ Our results can be extended to other 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 homogeneous groups.

The paper proceeds as follows: In section 2, we present our conceptual framework and formulate predictions which will be tested empirically. The data set is described in section 3. Section 4 is dedicated to the empirical analysis and results. We finish with some concluding remarks in section 5.

2 Conceptual Framework

Our conceptual framework combines the theory on statistical discrimination as laid out by Phelps (1972) and a demand externality whereby the marginal utility of one person undertaking an action is increased with number of other people engaging in the same behavior in order to explain how the superstar phenomenon can impact the performance of underrepresented groups in the market. In the context of this study, it will help us to formulate predictions concerning the performance of female artists at auction.

An artist’s career typically starts with completion of an art degree⁴ after which she seeks gallery representation. A gallery acts as an agent with the goal to create a market for the artist in exchange for a commission on the price of the sold artworks. This aligns the incentives of the artist and her dealer and makes the initial hiring process very crucial. A sign for the artist’s market establishment is that her artworks appear at auction sales (the (secondary) resale market) trading for prices not below

³One approach to disentangle the supply from the demand side would be to perform the analysis separately for common names where there is not doubt about the gender (e.g. Mary) and ambiguous names (e.g. Kim) where one would not have full certainty about the gender of the artist. However, it is not a plausible assumption that auction houses or auction participants are uninformed about the identity of the artist. For instance, auction catalogs typically provide some information about the artist using pronouns which disclose the gender of the artist.

⁴Not all artists are completing university art programs. According to Davis (2016), out of the 500 most successful early-career artists 35% have no MFA degree and 12% are self-thought.

gallery level.⁵ The sellers at auction are typically composed of private individuals who previously acquired the artwork through a gallery. With the exception of liquidity sales (i.e. the famous death, disease and divorce), an artwork is usually put up for sale at auction if it has increased in value and if there is demand for this artist. There is an interdependence between the gallery and the auction market. Trends in auction sales reflect in gallery representation patterns and feed back into prices. At the same time, effective dealer marketing can boost the demand of an artist in the secondary market. Therefore, we will focus on the dealer's (art gallery's) and well as the buyer's perspective at auction in order to formulate predictions for how the superstar effect in which a small number of individuals dominate their domain will influence the performance of male and female artist in the market.⁶

In this conceptual framework profit-maximizing art galleries and buyers (the sources of utility for buyers will be discussed in more detail below) are unable to perfectly observe the ability of an artist and instead observe a noisy signal. In order to interpret the quality signal art galleries use an observable salient group characteristic (gender in this case) which is correlated with ability to proxy for the missing information. The rationale for why gender may be employed as lens to make inferences about ability is due to the historically lower status ascribed to women (Ridgeway, 2001). The distinctiveness of gender as attribute provides a large amount of differentiation between groups with little within-group variation (Hilton and Von Hippel, 1996). A posterior belief of the artist's ability will be formed using a prior (unbiased) belief about her gender's ability. If prior beliefs for male and female artists are not the same different quality standards will be applied to the two groups. A crucial element is that due to the superstar effect the relevant measure of group performance will be drawn from the top of the sales distribution at auction instead of the average. The social multiplier effect will come into play when explaining why there will be a glass ceiling for female artists at the top of the art market despite higher hiring standards in the primary market.

In both belief-based models that constitute the seminal contributions on statistical discrimination (Phelps, 1972; Arrow et al., 1973) hiring decisions are based on observing group identity, the group's past performance and a quality signal emitted by the employee. While in the framework of Arrow et al. (1973) group differences endogenously arise in equilibrium and the minority group is

⁵There are also instances in which artists sell directly through auction houses (Damien Hirst being a very prominent example). However, this is considered a risky strategy since only little control can be exerted over prices. Price stability is of utmost importance in the art market as prices proxy the quality of an artwork and future potential of an artist.

⁶Except for art dealers and collectors, museums and art critics can exert a major influence on the artist's career.

rationally discriminated due to self-fulfilling negative ex-ante beliefs of the employers, in the model by Phelps (1972) rational discrimination occurs due to imperfect information on employee ability with a (correct) more negative belief about the ability of the minority group. Female artists might indeed choose to underinvest in their skills upon observing the past performance of their female peers as predicted in Arrow et al. (1973). Yet, since the number of professional female artists shows an increasing trend (for the Arts, 2011) and given the fact that information asymmetries are a key obstacle within the art market we base our predictions upon the statistical discrimination model of Phelps (1972). Furthermore, we cannot exclude taste-based explanations as laid out by Becker (1957) for the underperformance of one group in the market. However, it is in our interest in this study to show that the superstar effect can evoke discrimination on rational grounds.

Art gallery hiring decision. In this study we cannot empirically observe the hiring decision of an art gallery. However, modeling this process is important in order to understand the performance of female and male artists at auction given that the gallery’s hiring decisions impact both supply and demand for artists in the secondary market. Public galleries sales figures are not available. Nevertheless, there is evidence that the proportion between male and female artists represented by galleries is unbalanced (ranging at around 30%) as opposed to the proportion among MFA graduates (National Museum of Women in the Arts, 2017).

Imagine a population of identical artists who completed an art education program and who are now seeking representation from a population of art galleries. While an art gallery cannot perfectly observe an artist’s ability, it can observe group identity $g \in \{F, M\}$ denoting male and female artists. An artist’s ability, a , is fixed and drawn from a normal distribution $N(\mu_g, \sigma_g^2)$. As auction results are public and art dealers have deep insights into other galleries we assume that art galleries hold correct beliefs about the true distribution of ability across gender within the population (i.e. μ_g is estimated without bias).⁷ Overall, galleries observe group identity and a noisy signal of ability, $\theta = q + \varepsilon$, where ε is a zero-mean error which is normally distributed with $N(0, \sigma_{\varepsilon, g}^2)$. In our case, this signal may be an artist’s track record consisting of previous grades on university program projects, shows and exhibitions, awards or other quality certifications. Art galleries will use the noisy signal, θ , to infer the expected value of q combining the information contained in her group identity and the artist’s track record. If the signal would be precise ($\varepsilon = 0$) information on group identity would not

⁷Bohren et al. (2017) also incorporate biased beliefs in their model of gender discrimination.

be required to determine an artist's ability. However, assessment criteria that make a good artist are not fully understood and involve a lot of subjectivity in judgment. This condition makes the art market highly susceptible to stereotyped thinking and reliance on past group related information. The art gallery will use the Bayes rule to form a posterior belief about the ability of an artists where ability and the signal are jointly normally distribution. The conditional distribution of q given θ is normal with a mean equal to the weighted average of the signal and the unconditional group mean:

$$E(q | \theta) = \frac{\sigma_g^2}{\sigma_\varepsilon^2 + \sigma_{\varepsilon,g}^2} \theta + \frac{\sigma_{\varepsilon,g}^2}{\sigma_g^2 + \sigma_{\varepsilon,g}^2} \mu_g, \quad (1)$$

$E(q | \theta)$ is strictly increasing in θ and σ_g meaning that higher signals and higher expected group ability result in a higher expected posterior ability of an artist. The precision of the signal ($\frac{\sigma_g^2}{\sigma_\varepsilon^2 + \sigma_{\varepsilon,g}^2}$) will determine how much weight is placed on the population averages versus the signal's value. With perfect information ($\varepsilon = 0$), an artist will only be evaluated based on her signal and discrimination will not arise. As mentioned above, given that an artist's ability cannot be broken down into objective measurable criteria it is highly likely that a considerable amount of weight is placed on population averages.

When relying on group averages in order to infer ability, two properties within the group distributions may lead to different prior beliefs which may result in differential standards in interpreting the artist's signals depending on group identity. First, an art gallery may (correctly) perceive that the male population of artists has on average higher ability than female artists ($\mu_F < \mu_M$). This will be the case if historically female artists underperformed male artists in terms of auction sales. A crucial element is that the superstar effect prevalent in the art market implies that the largest part of the sales value is concentrated among a small number of artist who are located at the higher part of the price distribution. The prices at the top which eventually reflect in art gallery prices are disproportional to the difference in rank between the artists. Therefore, art galleries will base their beliefs about group ability in terms of its past performance at right tail of this skewed distribution as opposed to its mean. In our context, this means that female artists will be subject to a disadvantage when there is imperfect information about their individual ability. Second, one group might not only have higher average ability but there is also the possibility of differences in the informativeness of the signals emitted by the two groups ($\sigma_{\varepsilon,F} > \sigma_{\varepsilon,M}$). In particular, this is highly likely to be the

case if one group (here women) was historically underrepresented within the artist population. Art galleries will have collected less information on women not being used to interacting with that group. As a result, galleries will attribute less confidence to a pre-market signal emitted by a female artist than by a male artists.⁸ The resulting effect of both sources of group differences (unequal abilities and precision of signals) is that female artists (the disadvantaged/minority group) will be subject to a higher threshold than male artists. In order to offset negative prior beliefs they will have to emit higher signals given equal underlying ability in order to be hired by an art gallery. This higher quality standard does not only imply that female artists will be represented by art galleries at a lower rate⁹ but also that conditional on being hired a female artists will on average be better than a male artists. While we do not model the supply side, it is also likely that higher standards for female artists leads to a self-selection among women whereby only the most talented and persistent women will pursue a professional artist career.¹⁰

Hypothesis 1 (H1). *Conditional on being traded in the market female artworks will sell on average at a premium relative to the artworks of male artists.*

Buyer’s purchasing decision. The buyers at auction sales are usually composed of private collectors, art dealers as well as institutional buyers such as museums. In particular for private collectors, purchasing motives may be driven by aesthetic, status and investment considerations. Recently, art has received a lot of attention for its suitability as a financial asset class.¹¹ It is reasonable to assume that after a certain monetary threshold the ability of the artwork to act as a store of value is likely to be an important element. While this threshold is subjective, we assume in our framework that the buyer derives utility from the artwork’s conspicuous consumption value (status) as well its financial return as suggested in Mandel (2009). Both motives imply that a buyer cares about the quality and future value appreciation of the artwork. Furthermore, we adapt the assumption that consumer demand is not independent but depends on the behavior of others. This introduces an externality or dis-functional utility to the buyer’s demand function. Similarly to the

⁸Bjerk (2008) considers both factors in his dynamic model showing that a sticky floor leads to a glass ceiling. In our case, in addition to a sticky floor (hiring by an art gallery), the minority group is also subject to a barrier at the top (at auction) due to the social multiplier effect.

⁹If talent is randomly distributed across gender by nature, fewer women will be able to meet this higher threshold.

¹⁰For instance, Breen and Garcia-Penalosa (2002) show that the anticipation of lower revenues leads to a self-selection among women which is responsible for gender segregation in occupations.

¹¹There is a rich literature investigating the risk and return profile of art including among other Ashenfelter and Graddy (2003); Baumol (1986); Goetzmann (1993); Mei and Moses (2002); Pesando (1993); ?.

case of the art galleries buyers cannot directly observe the ability of an artist (or the quality of the artwork) and are subject to information asymmetries. Therefore, the buyer will also make use of information contained in an artist’s group identity in order to evaluate her underlying ability.¹² In addition to group identity and the group’s past performance, art buyers at auction are aware of the hiring policy of art galleries which set higher quality standards for female artists. Moreover, a buyer at auction can also observe the purchasing behavior of all buyers before him. Given that as a result of the gallery’s hiring policy female artists are underrepresented in the market the buyer is more likely to observe a sale of an artwork by a male artist than by a female artist providing him with more information.

When information asymmetries with respect to the talent of an artist are present, following the crowd can be beneficial. First, herding may be rational when collecting own information involves substantial costs (Banerjee, 1992). Second, even if private information is available adopting the majority’s choice and ignoring own information can be risk reducing since being wrong when everyone else is wrong would be associated with a lower reputational cost than being wrong alone (Scharfstein and Stein, 1990). Making a mistake becomes costlier the capital that is at stake. Lastly, if appreciation is the source of utility from consuming art purchasing art which is consumed by a substantial number of people can increase consumption capital leading to an even higher demand for a particular artists (Adler, 1985; Stigler and Becker, 1977). The buyer will maximize the following utility function:

$$U^i = a_i - P + c_i(Z_{i,t-1}), \quad (2)$$

with $c_i > 0$. a_i is a random idiosyncratic taste-shock incorporating income and other taste parameters. P is the exogenous price of engaging in the sales transaction. Lastly, $Z_{i,t-1}$ is the proportion of the agent’s reference group buying an artwork of an artists of a particular gender at time $t - 1$. This means that the agent considers the external demand effect in the previous period. Therefore, the utility of agent i depends on her taste-shock, the cost of engaging in the transaction as well the proportion of her reference group engaging in the same transaction in the past period.

¹²Since information on male artists tends to be more salient (Cameron et al., 2017) one might also imagine a scenario in which buyers hold biased beliefs due a representativeness heuristic. For the sake of our analysis we assume that buyers hold unbiased beliefs about the distribution of ability among male and female artists.

An important implication is that price increases do not result in falling demand since the additional utility from external consumption creates a bandwagon effect that keeps the demand high. While we do not specify the unique sources of the utility derived from the consumption of others, the point we want to stress is that the additional utility gained from the increased consumption of other market participants might prevent the mitigation of statistical discrimination despite the on average higher quality of female lots and can potentially dominate a high signal. The resulting glass ceiling for female artists is then not necessarily an indicator for a distaste for female artists as the utility from increased consumption can dominate a high quality signal. As a result there will be an imperfect substitution between men and women and equally talented male and female artists will not have the same chance of becoming superstars. This might lead to inertia and a persistent underrepresentation of women among superstars in the art market as the advantage of one group over another accumulates over time making it difficult to catch up.

Hypothesis 2 (H2). *Conditional on gallery representation female artists are less likely to be traded at auction.*

Hypothesis 3 (H3). *Female artworks will sell on average at a discount relative to the artworks of male artists at the top of the price distribution at auction.*

3 Data

3.1 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.¹³ Artnet collects all global 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 totaling 6,140,774 auction transactions. We exclude installations. The market for installations is slightly different from

¹³Decorative Art includes among other antiques, ceramics, furniture, jewelry, and watches.

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 comprehensiveness 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 representation since the millennium.

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. We deflate all prices using the US consumer price index (CPI) provided by the OECD using 2017 as our base year.¹⁴ With respect to the artists' attributes, the database records name, date of birth, living status and nationality. At an artwork level, we have information on the title of the work, its size and object type. Additionally, we categorize all auction transactions into movements based on the birth year of the artist. Consistent with the classification in the Tefaf report (Pownall, 2017), 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. It is important to mention that while we have artists in our sample from different artistic movements and generation, we observe their sales only in the time period from 2000 until 2017. This implies that while opportunities for these artists differed across time, we do not expect the perceptions of buyers with regard to gender performance differences to vary too much during the period of the past 17 years.

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. 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, the name 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). We combined two name lists provided by the US Social Security Administration¹⁵ and the German computer magazine Heise¹⁶. The former list contains North American baby names, while the latter provides a name dictionary with a focus on

¹⁴The employed consumer price index can be found under <https://data.oecd.org/price/inflation-cpi.htm>.

¹⁵The list is available at <https://www.ssa.gov/oact/babynames/limits.html>.

¹⁶The list is available at <ftp://ftp.heise.de/pub/ct/listings/0717-182.zip>.

European names by country. 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 were 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.¹⁷ 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 such a study.

Additionally, we have exclusive access to primary market data provided by Artnet. Primary market data identifies which artists are represented by which galleries and is highly confidential 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. It 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. Due to disclosure limitations, we pool the data and treat it as a cross-section instead of a panel. In total, there are 1,281 galleries in Artnet's international gallery network representing 15,121 unique 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 (contemporary) 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 differentials within our sample based on univariate analysis.

3.2 Descriptive Statistics

Table 1 illustrates the extent of the concentration within the secondary market based on our data for the whole sample period (2000 until 2017). It depicts for different shares of the market (in terms of value) and the percentages (numbers) of artists who account for it. First, the market is highly concentrated with only 2.2% of the artists accounting for 90% of overall sales. Second, artwork sales of female artists amount to only 3.4% of the total auction market. Third, whereas the female segment

¹⁷In 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.

is smaller in size it is more concentrated than the male market. While 19.9% of all male artists are responsible for 99% of the sales value, only 15.5% of all female artists occupy this share within their respective segment. These numbers suggest that the art auction market resembles a superstar market where rewards are concentrated among a few individuals. This appears to be amplified for the segment of female artists.

Table 2 shows the summary statistics for auction prices for men and women with detailed statistics by artistic movement, object type, region and living status. The last column presents the difference between mean male and female prices. Overall, 96.1% (2,572,346) of all artworks sold at auction can be attributed to male artists. Hence, the proportion of female artworks in terms of volume is slightly higher (3.9%) than their share in terms of value (3.4%) in our sample. 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. 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 contemporary artworks 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. The proportion is highest for Contemporary art (9.3% are female) and smallest for the Old Masters period (2.9% are female). 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 is that while the average prices of female artworks are significantly below the average price for male artworks (\$39,065 versus \$45,614), the median price is with \$3,931 higher for women than for men (\$3,649). This is also reflected in Figure 3 which shows how these numbers have evolved over time and through generations of artists. In Figure 3(a) we can observe that mean artwork prices tend to be higher for men, whereas median prices (3(c)) appear to be higher for women after 2002 with a widening gap after 2011. The hedonic price indices based on the respective time (year) dummies for both genders in Figure A1 in the Appendix show that sales of female artists have overall outperformed male artists (1(a)). However, this seems to be driven by artists from older generations (in particular Postwar female artists) since the financial performance of contemporary female artist (1(b)) appears to be significantly worse than the performance of contemporary male artists.

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

In terms of national residency, it is noteworthy that mean artwork prices of female artists are slightly higher in North America (\$58,929 versus \$58.234) and significantly higher in Eastern Europe (\$68.258 versus \$40.758). Only in Western Europe median prices for female artists are lower than for male artists.

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 both living

and deceased female artists fetch significantly higher mean and median prices than artworks by male living and deceased artists.

Lastly, 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 \$392,962,816 the highest selling female artists, Joan Mitchell, does not reach the sales value of any of the male artists in the top 25.

In summary, the univariate analysis reveals three important facts about gender differences in the secondary art market. First, with a share of less than 4% female artists are extremely underrepresented but relatively more concentrated in terms of sales value in the secondary art market. Second, median prices appear to be higher for women. This might be indicative of a selection mechanism where a higher bar is applied to female artists admitting only the most talented ones. Third, it appears that those women, who do break through the initial barrier to the market, still lag behind top male artists in terms of sales value. In the following section, we will perform an in-depth multivariate analysis in order to investigate the presence of structural barriers for female artists in the secondary art market.

4 Empirical Analysis

4.1 Auction Participation

Starting at the art gallery level, we hypothesize that female artists are less likely to enter the secondary art market than men. As shown in the descriptive statistics, female artists are highly underrepresented in the secondary market with a share of less than 4%. 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 between these two career stages. 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.

If an artist is present in the primary data set, it means that this artist is represented by at least one gallery during the sample period. Having gallery representation is the first crucial step in an artist's

career after the completion of an art education program. A gallery provides the artist with access to its network of buyers as well as marketing activities to improve her visibility in the art market. While galleries can represent emerging as well as more established artists, good representation is particularly important for new, unknown artists. Auctions are predominantly considered the secondary market. Reasons for selling an artwork at auction can be liquidity related (the famous disease, death and divorce) or the fact that an artwork has increased in market value. In the latter case the owner wishes to realize this positive financial return. Hence, if an artist is not traded at auction it might be suggestive of an insufficient value appreciation and/ or demand to make it attractive for its owner to sell.

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 contemporary primary market sample are also present in our main (auction) sample of living artists. Table 3 shows that out of 4,180 male artists, 96.9% (4,050 artists) can also be found in the secondary market. However, only 7.0% (40 artists) out of the 574 female artists did not make this transition. The difference in proportions test is statistically significant at 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 within this sample. 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 would suggest that there is a selection mechanism in place which admits female artists with certain attributes to the market. These may be the most talented and persistent women in the sample. If this is the case, we should observe a negative coefficient conditional on being a female artist. In order to analyze the mobility of women in a multivariate setting, we employ a probit model on the entire primary market sample with a binary dependent variable indicating whether an artist from the gallery sample is traded at auction. The model takes the following form:

$$Z_j = \alpha_1 + \delta_1 D_j + \lambda_1 A_j + \epsilon_{1j}, \quad (3)$$

where Z_j is a binary variable that takes the value 1 if an artist j participates at auction and 0 otherwise 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 a value 1 whenever the respective artists is a woman. A_j is a 1×92 vector that denotes the artist characteristics including the artist’s nationality¹⁸, 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.¹⁹

The result of the probit model is shown in Table 4. It provides evidence for a small but statistically significant 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 coefficient on the female dummy indicates that given their characteristics, female artists are 2.2% less likely to participate at auction compared to men. For example, a female artist might have interrupted her artistic career which would negatively impact the market demand for her existent artworks. This can also be the result of self-selection whereby female artists decide to cease their artistic endeavors in anticipation of less success. It could also be the case that galleries underinvest in female artists as they estimate their likelihood to succeed as lower. An alternative explanation might that buyers of female artworks differ from other other buyers with respect to their buying motive. These buyers could prefer to hold on to their purchases being less interested in realizing financial returns. While we cannot exclude this alternative explanation, there is currently little theoretical ground to support such a conjecture.

Overall, the magnitude of the chance with which female artists are less likely to transit from the primary into the secondary market (-2.2%) appears to be low and provides evidence of increased equality between genders in recent years. However, it is worth keeping in mind that this estimate is on the lower bound given that we are only considering contemporary artists who are represented by US galleries. It is also worth mentioning that Artnet’s gallery network does not capture the whole population of galleries. Our gallery sample consists of 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 represent the top of the market and have a larger chance 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

¹⁸Nationality 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.

¹⁹In 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.

market is likely to be higher. Another concern is that the relationship between gallery representation and the auction participation works in the opposite direction and that good auction results lead to a higher probability of being represented by a gallery. Nevertheless, this would still not explain why women have a lower chance of being represented by a gallery given their auction performance.

4.2 Performance at Auction

In the previous section we have found that based on our gallery sample female artists are less likely to progress from the primary into the secondary market. We will now turn to our main (auction) sample to investigate the overall performance of female artists on artwork level at auction. The basic regression model has the following specification,

$$\log P_{it} = \alpha + \psi W_i + \beta X_i + \eta H_i + \tau_t + \epsilon_{it}, \quad i = 1, \dots, N; \quad t = 1, \dots, T; \quad (4)$$

where $\log P_{it}$ indicates the log of the real 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.²⁰ 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)²¹ 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 in our main analysis. τ represents time fixed-effects for the years 2000 until 2017. ψ , β and η are time-independent parameters. α is a constant term. Lastly, ϵ_{it} denotes the error term.

Table 5 reports the regression results when estimating parametrs using the OLS methodology. While the first two specification involve the full sample using the real and the nominal price as the

²⁰In 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.

²¹All countries are split into five regions: North America, Eastern Europe, Northern Europe, Southern Europe and Western Europe.

dependent variable, we also run separate regressions for all four movement sub-samples with the real price as the dependent variable. The highly statistically significant female dummy coefficient in our base regressions shows that artworks by female artists are on average 4.4% 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 mechanism whereby female artists that make it to the secondary art market are on average better than male artists. It could also 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 as Picasso, Modigliani, Miro and Fontana originate from there. Lastly, there is a premium on deceased artists. The R-squared of the regression is 0.42 which is within the usual range for hedonic models in the field of art market economics (Ashenfelter and Graddy, 2002). All coefficients remain unchanged independent of whether the nominal or the real artwork price is used as the dependent variable.

Male and female artists in different time periods were subject to different conditions especially with respect to access to education and the general acceptance of women as creators of cultural goods and part of the workforce. Assuming societal barriers as the only source of performance differences between men and women, our base regression results might pick up unobserved quality difference between the artworks produced due to unequal opportunities granted to women. For instance, less support for female artist in the Old Masters movement could have led to an even higher bar for women during this time period reinforcing a potential selection mechanism. In turn, this would imply that women who succeeded to pursue careers as professional artists had to be on average better than male artists resulting in a higher demand for these lots. As opportunities and beliefs held in society with respect to gender roles have shifted throughout time, the selection mechanism is expected to become less pronounced resulting in a convergence in the supplied quality between artworks produced by men and women in later time periods. As a result, any observed performance

differences at auction between the genders are expected to be to a lesser extent due to factors related to differences in access to opportunities.

In order to test this hypothesis, we estimate the model specified in equation (4) for each artistic movement separately. The last four specifications in Table 5 present the results. Interestingly, the coefficient on the female dummy is positive and statistically highly significant for each movement with the exception of Contemporary art where we observe a negative and statistically significant coefficient. The Post War Era yields the largest premium (14.9%) for female artworks. While it is difficult to imagine that opportunities were worse for female artists in the mid-20th century than in the mid-19th century, it could be the case that this era produced a small number of female artist considered large superstars (e.g. Agnes Martin, Helen Frankenthaler and Joan Mitchell) for which competition among buyers is high. The discount on contemporary female lots is more likely to be driven by a gender bias present in the market given the improved opportunities for women pursuing an artistic career manifested in a relatively higher proportion of women in this period (9.3%). However, it is also indicative of a lower bar and a larger demand for female art whereby also artworks of lesser quality enter the secondary market.²²

Even though our data set contains artworks created by artists in different time periods, all sales of these works take place over a time period of about 18 years (2000 to 2017). While we do not expect large shifts in the market attitude towards female artists or strong differences in the quality of the artworks by men and women available in the market, we are interested in investigating the persistence of the difference in performance between the genders found in our baseline regression in Table 5 across time. We split our data into four different time periods for which we run separate regressions. The results are shown in Table 6. For all four periods a premium for female lots persists ranging from 1.9% to 7.4%. The premium appears to be smaller for the years after 2010. However, this might be due an increased supply of artworks in the market in later years by female artists (see Figures 2(a) and 2(c)). Since we observed a discount on female Contemporary lots (Table 6), Table 7 separately reports the results for the sub-sample of Contemporary artworks for the four time periods. Interestingly, it appears that the discount on female lots intensifies throughout time. While the marginally statistically significant discount amounts to 3.5% in the period from 2000 until 2004,

²²To provide further homogenize our sample, we also consider every cohort of artist separately and run regressions for each generation of artists whereby one generation is defined by a time period of 25 years. The results are presented in Table A3 in the Appendix. Consistent with the previous results, we observe a premium on female lots for the generations active before the year 1850 and a discount for more recent generations born after 1950.

it increases to 12.6% for the years from 2015 until 2017. These result also reject the participation rate hypothesis which states that extreme performance outcomes are less likely for women for statistical reasons as they are fewer in number. It aims to explain why women are excluded from top ranks in occupations with a high concentration of men. However, as our results show, increasing the ratio of women or lowering their barriers to entry does not defeat a gender gap in performance. This suggests that these additional female artists fall into the lower price quantiles lowering the average performance and could be interpreted as a sign of lower barriers for female artists.

A potential concern is that the performance of female artists might be different due to a lower productivity of women. A certain supply of artworks needs to circulate in the market in order to satisfy demand in case of a price appreciation. While we do not have an overview over all artworks ever created by every artists in our sample, we compared the amount of artworks sold by each artist per year. These are typically listed in a catalogue raisonné which would need to be obtained for every artist on our sample. Table 8 shows that the mean annual sales volume is a lot higher for male artists (105 versus 38). However, this appears to be driven by some male artists who have an extremely large trading volume (e.g. Picasso) since median yearly sales volumes are very close to each other (14 versus 16). Furthermore, in terms of trading frequency female artists appear slightly more liquid than male artists with an average of 165 days (versus 177 days for men) in between two consecutive sales. A frequent reason underlying the gender gap is found to be the woman's child-rearing responsibilities (Reis, 1995a,b). In order to closer investigate this potential for a difference in performance we estimate the model specified in equation (4) for the sample of contemporary artists and include a binary variable which is equal to one if the artists is 40 years old or above at the time of the transaction. We also interact this variable with our female dummy. Indeed, Table A4 in Appendix shows that being above 40 years old has a positive effect on price and that this effect is stronger for women than for men. As a result, motherhood and the risk of a career break might be a potential concern for collectors.

Another way 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.²³ This way, we would analyze whether gender can explain the auction house's estimation error which is

²³Before an auction takes place, auction houses typically publish a catalogue listing all lots that will be for sale with their own estimated value of these lots.

equal to 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. Lastly, in this study we are interested whether a gender bias is present in the overall art market and not only on institutional level. For robustness, we performed a regression using the model specification in equation (4) with the log of the price scaled by the auction house pre-sale estimate as the dependent variable. The summary statistics in Table A5 in the Appendix show that the auction house estimation error is on average higher for male artworks (2.43 versus 1.78). Proportionally, the share of undervalued artworks are slightly higher for women than for men (and vice versa). The results of the OLS regression can be found in Table A6 in the Appendix. The female dummy coefficient together with most of the other coefficients on our hedonic variables becomes statistically insignificant. This means that auction houses are on average able to provide a reliable estimate of the value of an artwork and account for a potential gender bias among buyers.

The artist’s identity is known to be the strongest predictor of artwork prices capturing important not directly observable quality characteristics such as an artist’s reputation. However, given that gender is a none time-variant characteristic of an artists, a gender dummy cannot be included together with artist fixed-effects in the same regression model. In order to incorporate the information contained in the artist’s identity we repeat the regression model specified in equation (4) with artist fixed-effects instead of the gender dummy.²⁴ We then test for differences in the means of the distribution of male and female artist fixed-effect coefficients. Figure 4 shows the density distribution of the male and female artist coefficient. The graph clearly highlights the dominance of the female distribution of the fixed-effect coefficient. The unreported two sample Kolmogorov-Smirnov test for equality of distribution provides statistically significant evidence that the male artist coefficient distribution is smaller than the artist coefficient distribution.²⁵

Overall, the analysis in this section yields two important findings. First, it appears that women

²⁴Due to computational limitations we only allocate individual artist dummies to artists for which there are at least 45 sales transactions. This corresponds to the 25th percentile in the sales volume distribution per artist. All other artists are subsumed under two IDs (one for male and one for female artists. This results in 9,584 distinct male and 366 distinct female artists.

²⁵The results of this test are available upon request.

are less likely to transit from the primary into the secondary market. While small in magnitude, this impaired mobility is suggestive of a selection mechanism that sets a higher bar for women and 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. This might be the consequence of the higher bar and a limited supply of high-quality female lots. This effect is in particular driven by artworks of older generations where different possibilities for men and women prevailed. At the same time, we observe an increasing discount over time for Contemporary female lots which suggests lower barrier for women in recent times. Given the underrepresentation of female artists and the superstar effect in the art market, our conjecture is that the premium observed for older generations of artists 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 around these few individuals. Further, a potentially skewed distribution of sales 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 sales for male and female artists.

4.3 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 traded at auction. 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 9 depicts the distribution of lots of male and female artists. Overall, we can see that a smaller number of female artists accounts for a relatively larger amount of lots in terms of volume and value than it is case for male lots. For instance, 95% of the female lots sold at auction stem from 36.7% of female artists accounting for 99.5% of the overall value of female lots. For the male sample, 95% of all lots are covered by 40.0% of the male artists who absorb 99.0% in terms of artwork value. Given the difference in the concentration between the male and the female market, 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 (4) 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. This transformation results in an equal weight for every artists in our sample. The results of the WLS regression are presented in Table 10. As expected, the female dummy coefficient turns negative and now yields an average discount of 10% on female lots given the characteristics of the artworks. Again, this result remains unchanged when the nominal price is employed as the dependent variable. This finding lends supportive evidence for the conjecture that the positive coefficients on artwork level derived in the previous section is 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 different sub-samples consisting of the four artistic movements. The discount on female lots observed in base specification seems to be driven by Post War and Contemporary lots which yield a female dummy coefficient of -13.1% and -4.2% respectively. While the price discount becomes smaller compared to the OLS baseline regression in Table 5 for Contemporary female artists, it flips the sign for the case of women attributed to the Post War era. It appears that particularly in this movement buyers compete for a very small number of female superstars (such as Joan Mitchell and Agnes Martin) with a large discount for the average female artist active during this period. The Post War era is characterized by abstract geometric forms which might more likely be associated with male attributes. The relative reduction in the magnitude of the discount for Contemporary female lots implies that this movement in particular dominated by a number of women with a large amount of lower priced artworks which are less desired by buyers. However, even if we take this distribution into account, the discount persists. The female dummy coefficient for Modern lots is negative but statistically indistinguishable from zero. Female Old Masters lot retain a premium, however the coefficient is only statistically significant on a 10% level. Thus, it appears that the premium found in the previous section is likely to be driven by a supply squeeze for a few superstar female artists in the case of Post War art while it was due to a higher quality standard in the case of Old Master works.

As an additional robustness check and in order to account for outlier sales, we split our sample into a sub-sample including only mega transactions (defined as artworks that yielded above \$1 million

at auction) and a second sub-sample which excludes these large transactions. The regression results for the baseline OLS model and the WLS model can be found in Tables A7 and A8 in the Appendix. It appears that the observed discount for female artworks is driven by lower sales for very high priced items. When adjusting for the number of artworks sold per artist which are considered mega transactions (WLS regression) the performance gap between men and women becomes statistically insignificant.

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 further investigate the concentration within the female segment of the market. Table 11 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% (5,650) of the male artists can be found in the top 10% of the sales value distribution, only 7.5% (178) of the female artists are located there. At the 50th quantile of the sales value distribution, only a total of 38.9% of the female artists can be found as opposed to an expected share of 50.6%. Moving further down the sales value distribution, 9.7% of all male and as many as 15.9% 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 sales 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.²⁶

4.4 The Superstar Effect

If being traded in the secondary market is not sufficient to signal quality and legitimacy for female artists, we expect that should materialize in a glass ceiling on the top of the market where the largest

²⁶In unreported results we also performed a Wilcoxon-Mann-Whitney test based on the average auction price for male and female artists. This non-parametric test does not rely on a normal distribution of the dependent variable. The results suggest that there is a statistically significant difference between the underlying distributions of the average price of male and female artists. The sum of the female ranks was lower while the sum of the male ranks was higher than expected. Thus the male group had higher rank. However, the difference in the distribution of average prices is not statistically significantly different between the two groups for the sub-sample of contemporary artists. The results of these tests are available upon request.

rewards are concentrated.

Table 11 does not only exemplify the concentration of sales 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 be found. This quantile corresponds to a market share of 40% in terms of value which entirely accrues to a core of 40 top male artists. As the most expensive female artist, Joan Mitchell, can be found in the 99.96th quantile. With \$393 million in total sales, she is ranked 43rd in the list of top artists.

Furthermore, Table 12 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 \$9,342,266 for male artists and \$12,382,016 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 176.8 \$million in the 99.1th quantile, is a sizable jump. At this sales 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 sales values 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 rewards. Lastly, we compare the distribution of maximum (record) artwork prices achieved by male and female artists. Figure 5 highlights how in particular at the top of the price distribution men overshoot women. 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 (4) 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 13 provides an overview of the number of male and female artworks located in every price quantile. Only 67 artwork by women

lie above the 99.9th quantile yielding prices above \$4.4 million. Table 14 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 6. In the lowest quantile, there is no significant differences in terms of prices between male and female artists. After the 25th quantile, we observe a premium on female artworks which steadily increases from 4.5% to 6.7% in the 95th quantile. A discount of 1.8% emerges for artworks by female artists at the 99th quantile and amplifies to 9.1% at the 99.9th quantile, which represents the very top of the secondary art market. This is supportive evidence for the presence of a glass ceiling that precludes women from participating in the high-end of the art market.

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 themes in 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 (4). 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 the coefficient in the 99.9th quantile which is indistinguishable from zero, the pattern of the coefficients along the quantiles is consistent with the findings in Table 14. However, as previously mentioned, the gender dummy and the artist are correlated variables. Therefore, the results of this two-step residual regression are to be viewed with caution.

Overall, the preceding analysis showed that at the very top of the market the idea of the male artistic genius still prevails. The “winner-take-all” effect in the art market appears to create a structure which precludes female artists from reaching the top of the market.

5 Concluding Remarks

This is the first large-scale study to provide strong empirical evidence for how a market structure characterized by the superstar effect can impact the career mobility of an underrepresented group. Using a sample of data that is only fractionally smaller than the true population enables us to accurately describe and analyze gender performance differences in the secondary market for fine art. The analysis goes beyond establishing the average effect of being a woman on the price of artworks. Instead, we closely look into the upper tail of the sales value and price distributions where most of the rewards are concentrated.

First, we show that female artists are still highly underrepresented in the primary (gallery) as well as in the secondary (auction) market. 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 contemporary artists which decreases to 11.6% in the secondary market. Overall, across movements and generations, female artists make up only a share of less than 4% in terms of number of artists as well as number of lots. This appears to be the result of higher entry barriers for women than men when transitioning from the primary to the secondary market. Specifically, probit model results show that women are 2.2% less likely to progress into the secondary market. This provides supporting evidence of a higher quality standard applied to female artists. In line with the higher bar explanation, we observe an average price premium of 4.4% on artwork level for female artists which is driven by artists of older generations where opportunities were less equal presumably allowing only the best and most persistent women to pursue an artistic career. These findings are consistent with the most recent working paper by Cameron et al. (2017) who find a premium for female artworks traded at auction within a sample of Yale graduates. A higher bar for women was also found in recent studies within the area of academia where journal papers abstracts by women had to be better written than the abstracts of male authors (Hengel, 2017) and science where patent application by women were found to be subject to higher scrutiny (Jensen et al., 2018). Furthermore, (Bohren et al., 2017) found that women are subject to higher standards in an online Q&A platform when no task history certifying their reputation is available. At the same time, our results show that the share of contemporary female artist has increased and that they are subject to a price discount. This might be indicative of lower entry barriers for women in recent years.

Second, we provide empirical evidence that the superstar effect which is a 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 10% price discount after correcting for the number of lots per artist. This discount is driven by Post War and Contemporary artists and implies that the observed price premium is due to a small number of female artists who account for a large share of expensive lots. Additionally, we find that the top end of the market is more concentrated in female sub-sample than in the male sub-sample. The women located at the top of the sales distribution appear to be responsible for the price premium and potentially cause a supply squeeze for their limited amount of lots. Furthermore, relatively more female than male artists are located in the lower tail of the 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 implies that unless a female artist reaches the top, her sales will remain below the sales 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).

Third, we reveal that the top end of the art market is still dominated by a core of male artists. In terms of total sales values, the 99.97th quantile which corresponds to 40% 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 of the price distribution a discount of 9% for female artworks emerges. 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) and might be the result of the given market structure which prevents the mobility of a historically underrepresented group. It appears that being traded in the secondary market is not sufficient for a female artist to signal quality and establish legitimization.

Overall, our results suggest that gender still plays an important role in the art market. While the art industry has grown substantially over time with increasing rewards for artists located at the top of the market as documented by the recent Art Basel and UBS Art Market Report (McAndrew, 2018), these rewards are still concentrated among a core that purely consist of male artists. While initially women are subject to higher quality standards at the very high end of the market, prices

are lower for an artwork conditional on the artist being female as compared to an artists being male. This can lead to a self-selection mechanism for female artists. The anticipation of lower sales might discourage women from pursuing professional artistic careers leading them to drop out of the market. Only female artists with the lower opportunity costs and highest talent might be willing to remain in the market. While this might be efficient, there is no explanation why the same filter is not applied to the population of male artists. On the other hand, we show that the number of artworks by women traded in the secondary market has increased. The price discount on female contemporary lots can be interpreted as a sign that the bar for female artist to enter the market became lower over the years and demand for their lots has increased.

Our study provides important lessons for gender differentials in labor market outcomes within markets characterized by the superstar effect. Our results suggest that an inertia towards existing market structures can hamper the mobility of historically underrepresented groups. While in other occupational areas (e.g. orchestra auditions) blinding the identity of the individuals has mitigated gender inequality this is less feasible in the art market. Part of an artwork's value is constituted by its historical value which is difficult to detach from an artist's identity. Therefore, it is important that institutions in the art world deviate from the current paradigm in order to establish gender equality. At the same time such non-conformance needs to be made worthwhile for institutions giving also an important role to policymakers. Recent trends such a growing number of women among high-net-worth-individuals increasing the share of female art buyers, as well media attention and interest in female artists by major museums might contribute to an alleviation of the situation. With a higher representation of female artists, art dealers and buyers will be more confident about the quality of artworks created by women. Less reliance on historical group statistics will be necessary.

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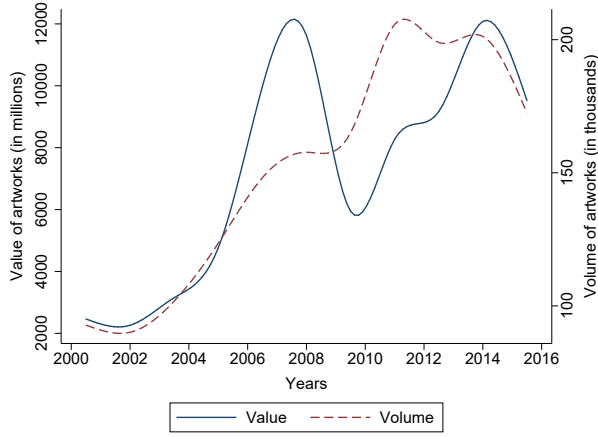
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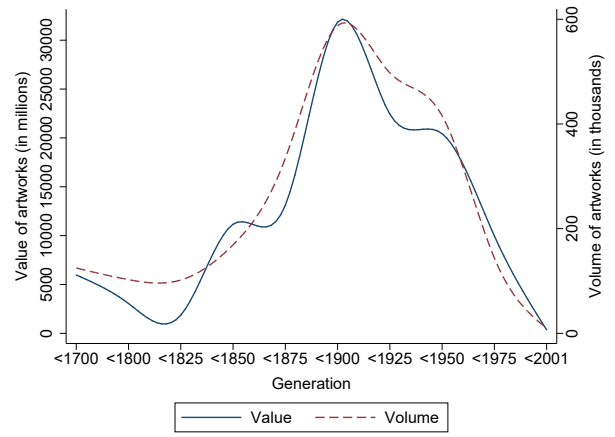
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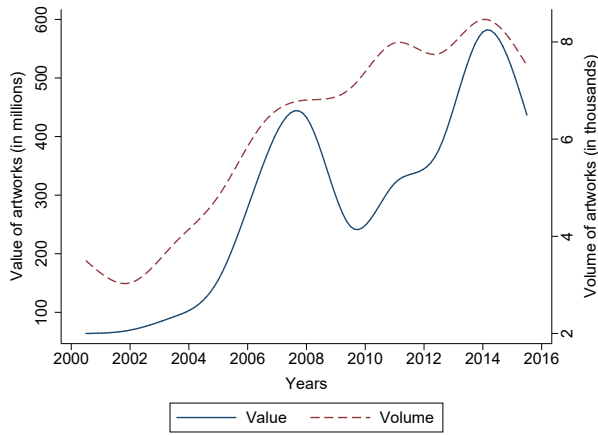
Figures



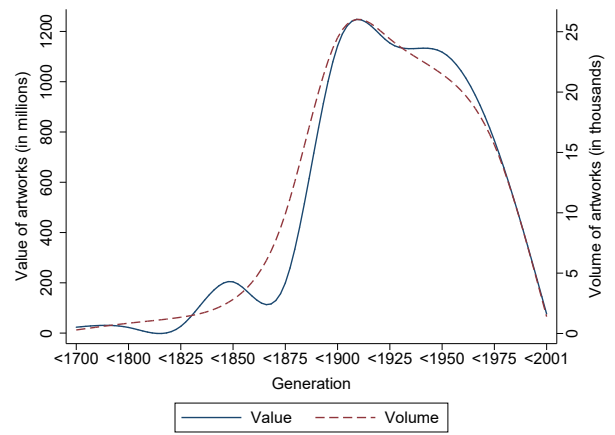
(a) Number and value of artworks by men by years



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



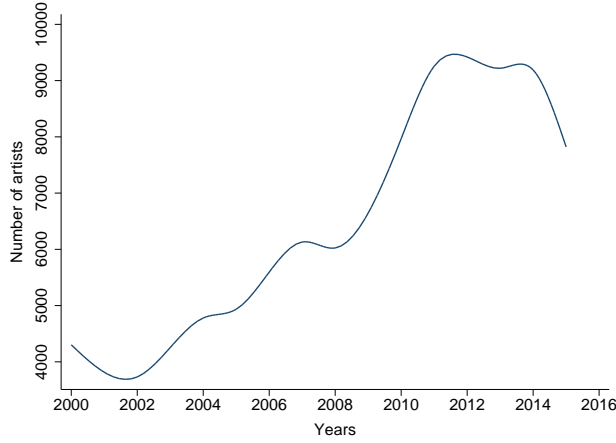
(c) Number and value of artworks by women by years



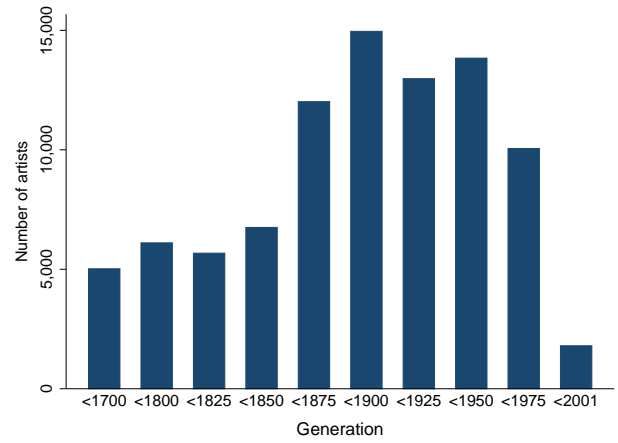
(d) Number and value of artworks by women by generation

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.

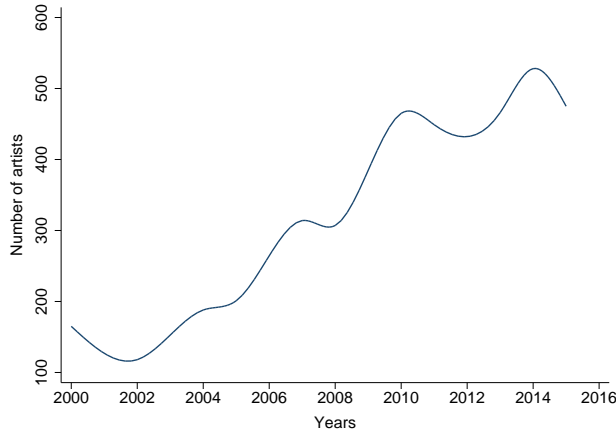
Figure 1: Evolution of sales by male and female artists



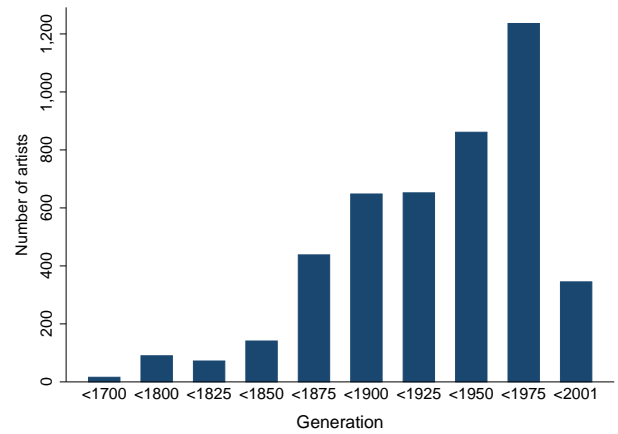
(a) Number of male artists by years



(b) Number of male artists by generation



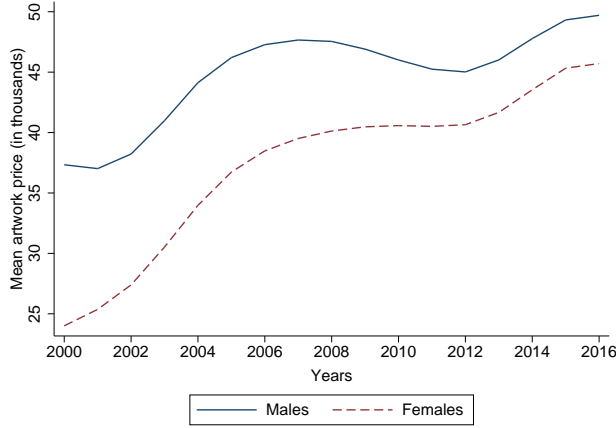
(c) Number of female artists by years



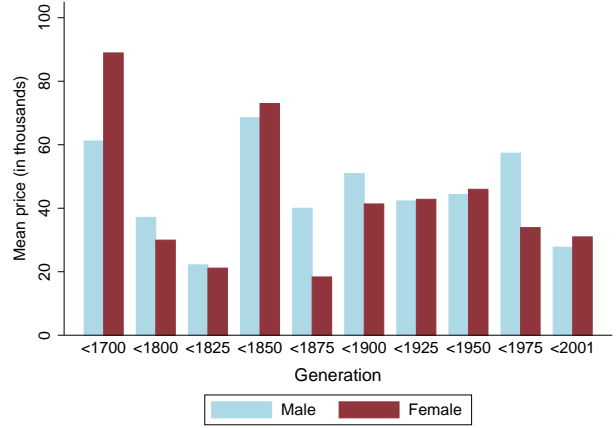
(d) Number of female artists by generation

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.

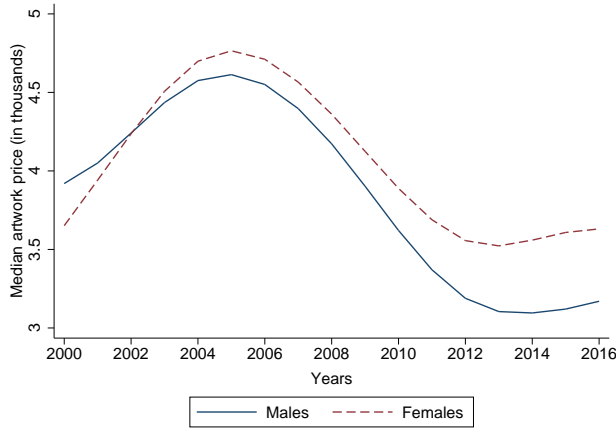
Figure 2: Evolution of number of male and female artists



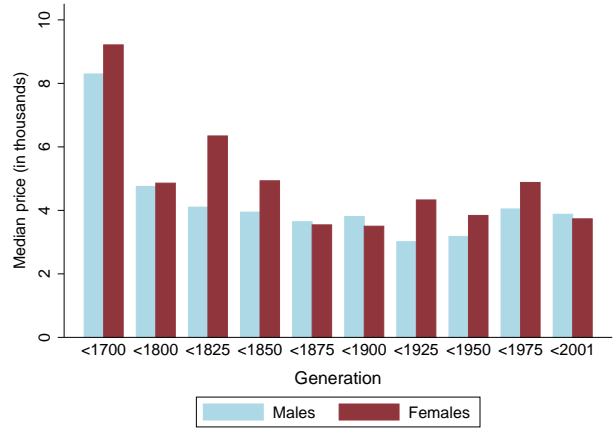
(a) Mean artwork prices by year



(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

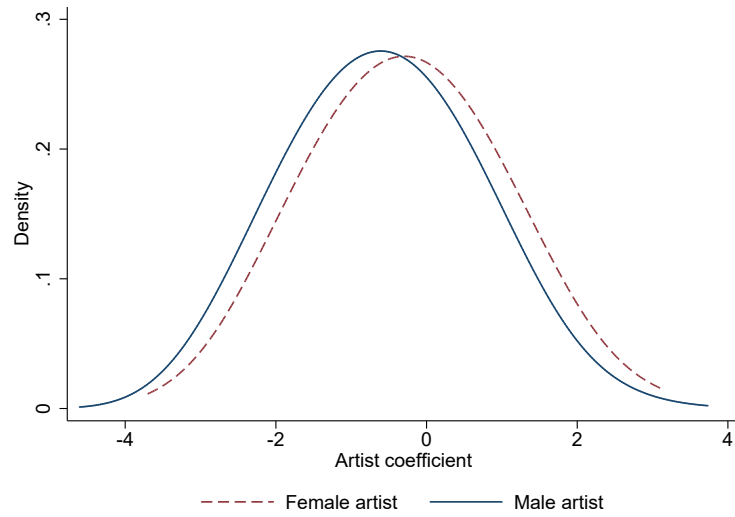


Figure 4: Density distribution of the artist fixed-effect coefficient for male and female artists

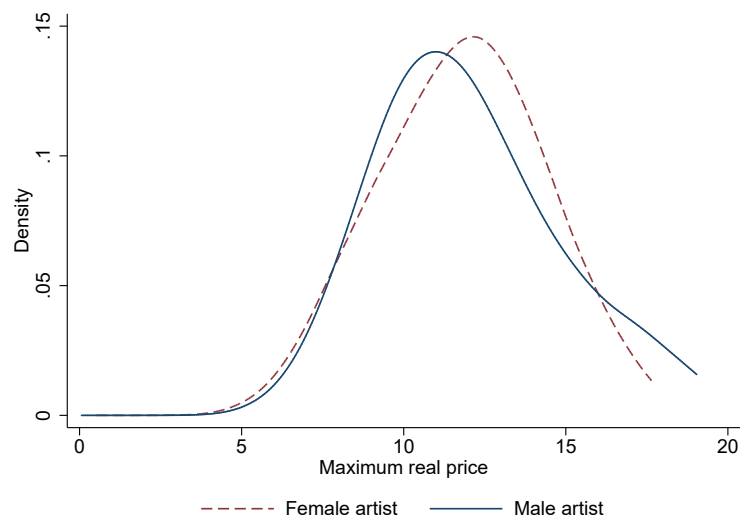


Figure 5: Distribution of maximum prices for male and female artists

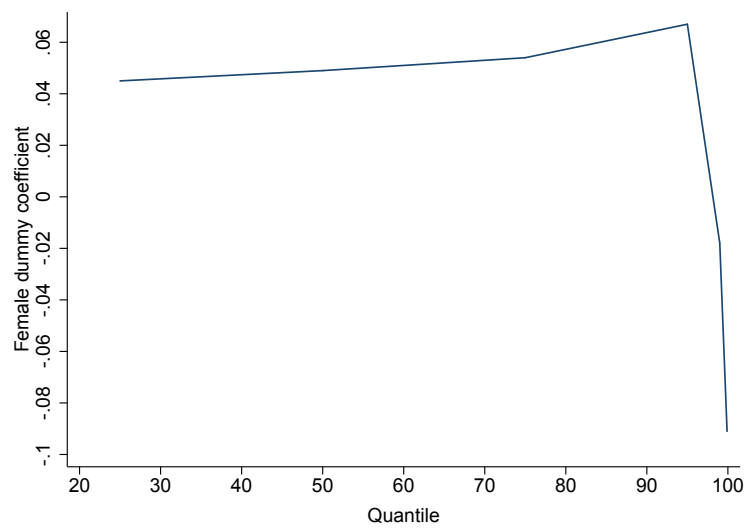


Figure 6: Coefficient on female dummy in quantile regression

Tables

Table 1: Concentration in the auction market (2000-2017)

Share (number) of artists	Share of market value				Total value
	50%	75%	90%	99%	
All artists	0.07% (80)	0.43% (497)	2.18% (2,563)	19.67% (22,926)	\$121.4bn
Male artists	0.07% (73)	0.41% (453)	2.16% (2,401)	19.89% (22,065)	\$117.3bn
Female artists	0.27% (15)	0.89% (50)	2.41% (135)	15.54% (872)	\$4.1bn

Table 2: Summary statistics for men and women

Price	Men				Women				Δ in means		
	N	N artist	mean	median	sd	N	N artists	mean		median	sd
Overall	2,572,346	110,938	45,614	3,648	686,070	104,844	5,612	39,065	3,931	330,635	16.8%***
Buy-in rate*			0.378	0.376	0.027			0.361	0.361	0.034	4.7%
Movement											
Contemporary	388,070	19,917	38,025	3,146	432,129	30,434	2,031	28,502	4,011	170,396	33.4%***
Postwar	532,238	34,173	41,047	3,090	635,913	24,280	1,863	54,262	4,121	405,305	-24.4%***
Modern	819,923	21,281	51,358	3,542	860,069	34,920	961	41,332	3,701	409,739	24.4%***
Old Masters	525,405	19,806	48,503	3,776	678,067	13,781	595	29,921	3,928	223,868	62.1%***
& Impressionists											
Other	306,710	15,761	38,641	5,743	494,310	1,429	162	34,316	5,418	135,044	12.6%
Object type**											
Design	212,709	9,250	12,848	3,269	67,873	11,141	521	19,934	4,009	17,703	-35.5%***
Sculptures	169,704	15,306	70,600	5,032	852,476	8,132	807	88,341	11,419	483,140	-20.1%***
Paintings	1,132,403	78,184	75,343.8	4,903.5	951,020.9	33,064	3,663	72,025	5,142	486,108	4.6%***
Works on paper	453,729	36,161	24,543	3,090	315,271	16,477	1,646	18,470	3,797	93,931	32.9%***
Prints and multiples	477,203	15,050	2,117	2,241	172,222	19,371	711	6,630	1,895	100,688	-68.1%***
Photographs	126,598	6,822	15,477	3,572	76,292	16,659	603	20,475	5,125	107,243	-24.4%***
Region											
North America	545,239	24,641	58,234	3,946	803,389	34,751	1,727	58,929	4,525	467,225	-11.8%***
Northern Europe	463,192	19,162	29,560	3,033	593,016	25,195	1,310	27,827	3,625	263,459	6.2%
Western Europe	1,099,021	44,143	43,114	3,571	594,711	35,243	1,673	24,473	3,394	140,217	76.2%***
Southern Europe	337,164	14,049	57,251	4,246	912,561	4,040	329	25,012	5,695	111,384	128.9%***
Eastern Europe	127,730	8,943	40,758	4,247	453,220	5,615	573	68,258	4,258	491,061	-40.3%***
Living status											
at time of sale											
Deceased	2,018,743	65,760	49,159	3,893	748,360	68,033	2,263	44,659	3,941	390,600	10.1%***
Alive**	553,603	47,175	32,686	2,864	380,340	36,811	3,454	28,728	3,909	170,957	13.8%***

All prices are in constant 2017 \$.

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

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

**Multiple attributions for a single artist are possible.

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

Table 3: 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
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 4: Auction participation - Artist level regression results (primary market)

Variables	Auction participation
	Probit model
Female	-0.022*** (0.006)
Year of birth	-0.001*** (0.000)
Artist Nationality Effects	Yes
Gallery Effects	Yes
Artist Effects	No
Observations	4,754

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

The probit model shows the marginal effects at the mean.

The primary market sample consists of

Western, contemporary artists only.

Table 5: Artwork level OLS regression results

Variables	Log of real price					
	Real price	Nominal price	Old Masters	Modern	Post War	Contemporary
Female	0.044*** (0.004)	0.044*** (0.004)	0.100*** (0.011)	0.045*** (0.007)	0.149*** (0.008)	-0.083*** (0.007)
Design	-0.219*** (0.003)	-0.219*** (0.003)	-0.012 (0.009)	-0.199*** (0.006)	-0.261*** (0.006)	-0.168*** (0.009)
Photographs	-0.688*** (0.004)	-0.688*** (0.004)	-0.707*** (0.014)	-0.788*** (0.007)	-0.718*** (0.008)	-0.494*** (0.007)
Prints & multiples	-0.918*** (0.002)	-0.918*** (0.002)	-0.897*** (0.006)	-1.017*** (0.004)	-0.962*** (0.005)	-0.804*** (0.006)
Sculpture	0.330*** (0.003)	0.330*** (0.003)	0.322*** (0.008)	0.406*** (0.007)	0.341*** (0.007)	0.393*** (0.007)
Works on paper	-0.409*** (0.002)	-0.409*** (0.002)	-0.379*** (0.005)	-0.383*** (0.004)	-0.371*** (0.005)	-0.325*** (0.006)
Eastern Europe	0.014*** (0.005)	0.014*** (0.005)	0.441*** (0.010)	0.168*** (0.007)	-0.528*** (0.011)	-0.359*** (0.012)
Northern Europe	-0.272*** (0.003)	-0.272*** (0.003)	-0.228*** (0.008)	-0.130*** (0.006)	-0.497*** (0.006)	-0.057*** (0.007)
Southern Europe	0.149*** (0.003)	0.149*** (0.003)	0.107*** (0.010)	0.539*** (0.006)	-0.228*** (0.007)	-0.085*** (0.008)
Western Europe	-0.043*** (0.003)	-0.043*** (0.003)	0.010 (0.006)	0.120*** (0.005)	-0.284*** (0.005)	-0.100*** (0.006)
Alive	-0.381*** (0.002)	-0.381*** (0.002)			-0.370*** (0.004)	
Log of size	0.181*** (0.001)	0.181*** (0.001)	0.186*** (0.001)	0.144*** (0.001)	0.188*** (0.001)	0.240*** (0.001)
Observations	2,677,190	2,677,190	539,186	854,843	556,518	418,504
R-squared	0.422	0.419	0.420	0.417	0.437	0.483
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes	Yes	Yes

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 6: Artwork level OLS regression results – by time period

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

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 7: Artwork level OLS regression results – by time period (contemporary sample)

Variables	Log of real price			
	2000-2004	2005-2009	2010-2014	2015-2017
Female	-0.035* (0.020)	-0.040*** (0.014)	-0.093*** (0.011)	-0.126*** (0.022)
Design	-0.504*** (0.061)	-0.135*** (0.019)	-0.126*** (0.013)	-0.194*** (0.028)
Photographs	-0.583*** (0.018)	-0.514*** (0.013)	-0.435*** (0.010)	-0.520*** (0.023)
Prints & multiples	-1.061*** (0.015)	-0.993*** (0.011)	-0.659*** (0.009)	-0.654*** (0.018)
Sculpture	0.488*** (0.021)	0.471*** (0.015)	0.399*** (0.011)	0.271*** (0.022)
Works on paper	-0.249*** (0.017)	-0.313*** (0.012)	-0.309*** (0.009)	-0.375*** (0.018)
Eastern Europe	-0.286*** (0.040)	-0.221*** (0.023)	-0.384*** (0.017)	-0.489*** (0.033)
Northern Europe	-0.091*** (0.019)	0.056*** (0.014)	-0.093*** (0.010)	-0.102*** (0.021)
Southern Europe	0.050** (0.024)	0.033** (0.016)	-0.211*** (0.012)	-0.120*** (0.025)
Western Europe	0.034** (0.017)	-0.055*** (0.012)	-0.165*** (0.009)	-0.141*** (0.019)
Log of size	0.257*** (0.004)	0.265*** (0.003)	0.234*** (0.002)	0.205*** (0.004)
Observations	44,731	106,980	185,573	43,267
R-squared	0.538	0.496	0.498	0.443
Year Effects	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes

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 8: Frequency of trading at auction

Variables	Men			Women		
	mean	median	sd	mean	median	sd
Average number of sales (per year)	105	14	329	38	16	55
Average time between consecutive sales (in days)*	177	42	402	165	33	398

*Excludes artists who had only one transaction (amounting to 31.6% of male and 41.1% of female artists.

Table 9: Concentration of lots for male and female artists

Share of lots	Men		Women	
	Share of artists	Share of value	Share of artists	Share of value
25%	0.30% (336)	51.69%	0.37% (21)	23.62%
50%	2.09% (2,316)	78.40%	1.66% (93)	65.65%
75%	8.87 % (9,838)	93.39%	6.56% (368)	93.36%
90%	23.96% (26,585)	97.99%	20.31% (1,140)	98.77%
95%	39.95% (43,318)	98.99%	36.72% (2,061)	99.54%
	110,938	117,335,262,644	5,612	4,095,761,313

All prices are in constant 2017 \$.

Table 10: Weighted least squares regression results

Variables	Log of real price					
	Real price	Nominal price	Old Masters	Modern	Post War	Contemporary
Female	-0.100*** (0.010)	-0.100*** (0.010)	0.049* (0.029)	-0.010 (0.021)	-0.131*** (0.020)	-0.042*** (0.016)
Design	0.229*** (0.011)	0.229*** (0.011)	0.500*** (0.034)	0.458*** (0.023)	0.230*** (0.019)	0.318*** (0.023)
Photographs	-0.376*** (0.011)	-0.376*** (0.011)	-0.183*** (0.041)	-0.360*** (0.029)	-0.347*** (0.022)	-0.202*** (0.015)
Prints & multiples	-0.672*** (0.009)	-0.672*** (0.009)	-0.758*** (0.026)	-0.522*** (0.017)	-0.564*** (0.019)	-0.503*** (0.020)
Sculpture	0.437*** (0.010)	0.437*** (0.010)	0.649*** (0.023)	0.604*** (0.021)	0.348*** (0.018)	0.513*** (0.016)
Works on paper	-0.342*** (0.006)	-0.342*** (0.006)	-0.392*** (0.012)	-0.219*** (0.011)	-0.271*** (0.013)	-0.195*** (0.013)
Eastern Europe	0.247*** (0.012)	0.247*** (0.012)	0.560*** (0.028)	0.290*** (0.023)	0.260*** (0.023)	-0.013 (0.022)
Northern Europe	-0.003 (0.009)	-0.003 (0.009)	-0.104*** (0.019)	-0.116*** (0.023)	0.072*** (0.016)	0.002 (0.019)
Southern Europe	0.493*** (0.011)	0.493*** (0.011)	0.405*** (0.024)	0.194*** (0.025)	0.541*** (0.021)	0.084*** (0.021)
Western Europe	0.153*** (0.008)	0.153*** (0.008)	-0.023 (0.017)	-0.063*** (0.017)	0.265*** (0.016)	-0.038** (0.017)
Alive	-0.359*** (0.005)	-0.359*** (0.005)			-0.132*** (0.009)	
Log of size	0.138*** (0.002)	0.138*** (0.002)	0.202*** (0.004)	0.133*** (0.004)	0.095*** (0.003)	0.175*** (0.003)
Observations	2,677,190	2,677,190	539,186	854,843	556,518	418,504
R-squared	0.362	0.354	0.378	0.316	0.332	0.356
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes	Yes	Yes

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 11: Quantiles by total sales value for men and women

Quantile	Total sales value (\$)	Men		Women	
		N artists	Cumulative	N artists	Cumulative
>99.97%		0.03% (40)	0.03%	0.00% (0)	0.00%
<99.97%	452,388,320	0.01% (17)	0.05%	0.02% (1)	0.02%
<99.96%	351,808,064	0.04% (43)	0.08%	0.05% (3)	0.07%
<99.1%	176,461,520	0.90% (994)	0.98%	1.19% (67)	1.27%
<99%	9,461,848	4.05% (4,490)	5.03%	3.06% (172)	4.33%
<95%	982,622	5.09% (5,650)	10.12%	3.17% (178)	7.50%
<90%	312,493	15.24% (16,908)	25.36%	10.23% (574)	17.73%
<75%	50,209	25.19% (27,949)	50.56%	21.19% (1,189)	38.92%
<50%	8,604	24.92% (27,644)	75.48%	26.60% (1,493)	65.52%
<25%	2,089	14.82% (16,442)	90.30%	18.55% (1,041)	84.07%
<10%	814	4.90% (5,435)	95.20%	6.99% (392)	91.05%
<5%	545	4.80% (5,326)	100.00%	8.95% (502)	100.00%
Total sales value	121,431,023,957				

Table 12: 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%	176,750,048	1,010	135,153,952	51
<99%	9,342,266	4,437	12,382,016	224
<95%	992,138	5,547	724,759	281
<90%	318,364	16,641	168,534	842
<75%	51,854	27,735	23,281	1,403
<50%	8,801	27,734	4,557	1,403
<25%	2,147	16,640	1,288	841
<10%	831	5,546	581	281
<5%	554	5,549	403	281
Total sales value	117,335,262,644		4,095,761,313	

Table 13: Quantiles for artwork prices for men and women

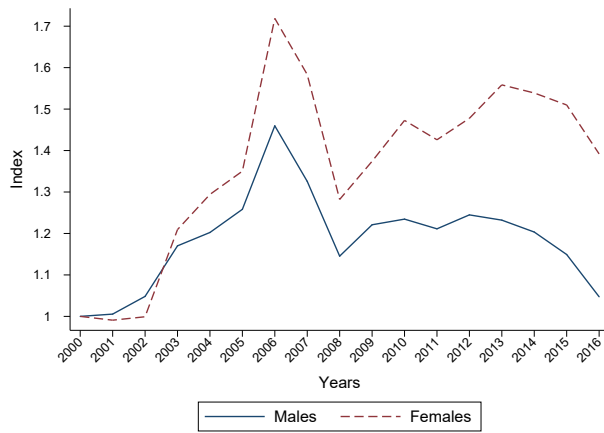
Quantile	Price (\$)	No. of male artworks	No. of female artworks
>99.9%		2,607	67
<99.9%	4,382,047	23,099	998
<99%	606,033	102,447	4,641
<95%	103,541	512,642	22,582
<75%	12,808	643,428	26,084
<50%	3,930	643,252	26,016
<25%	1,512	644,871	24,456

Table 14: Quantile regression results

Variables	Log of real price					
	q25	q50	q75	q95	q99	q99.9
Female	0.045*** (0.000)	0.049*** (0.000)	0.054*** (0.000)	0.067*** (0.000)	-0.018*** (0.000)	-0.091*** (0.000)
Auction House Effects	Yes	Yes	Yes	Yes	Yes	Yes
Region Effects	Yes	Yes	Yes	Yes	Yes	Yes
Alive Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Size Effects	Yes	Yes	Yes	Yes	Yes	Yes
Artist Effects	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

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

Appendix



(a) Index by gender - Full sample



(b) Index by genders - Contemporary sample

Figure A1: Price index by gender

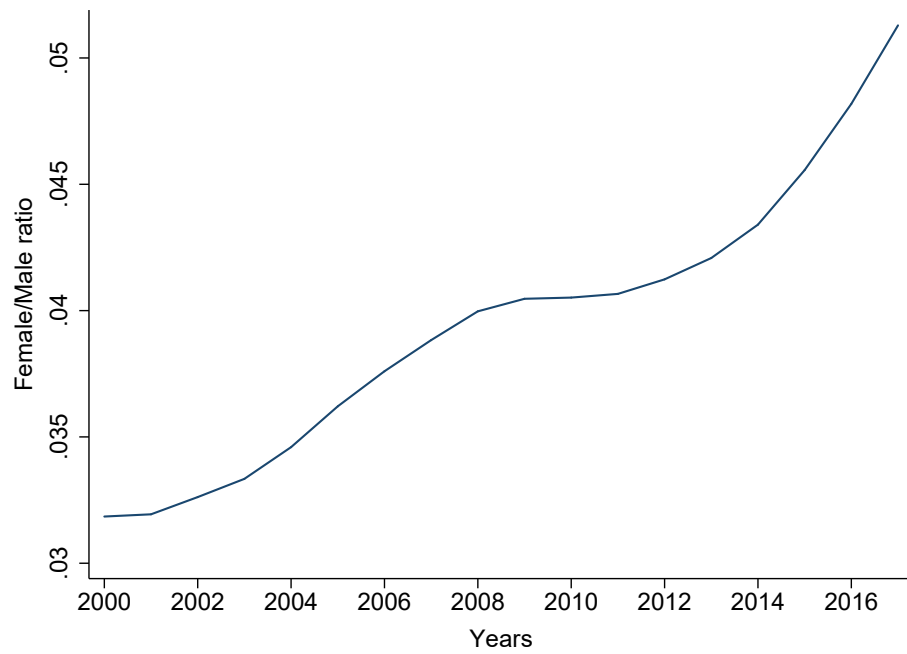


Figure A2: Evolution female-to-male ratio

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	5,853,551,616 (4.99%)	37,386 (1.45%)	0.247
2	Andy Warhol	North America	4,931,258,880 (4.20%)	19,028 (0.74%)	0.310
3	Claude Monet	Western Europe	2,509,770,496 (2.14%)	493 (0.02%)	0.197
4	Gerhard Richter	Western Europe	2,128,574,336 (1.81%)	3,587 (0.14%)	0.255
5	Francis Bacon	Northern Europe	2,071,435,648 (1.77%)	1,372 (0.05%)	0.235
6	Alberto Giacometti	Western Europe	1,661,223,808 (1.42%)	1,991 (0.08%)	0.309
7	Jean-Michel Basquiat	North America	1,604,688,384 (1.37%)	1,308 (0.05%)	0.288
8	Mark Rothko	North America	1,589,495,040 (1.35%)	142 (0.01%)	0.184
9	Henri Matisse	Western Europe	1,384,500,224 (1.18%)	5,157 (0.20%)	0.302
10	Roy Lichtenstein	North America	1,365,195,904 (1.16%)	6,429 (0.02%)	0.247
11	Amedeo Modigliani	Southern Europe	1,282,909,952 (1.09%)	502 (0.58%)	0.344
12	Marc Chagall	Western Europe	1,246,740,480 (1.06%)	14,957 (0.57%)	0.294
13	Joan Miró	Southern Europe	1,195,891,584 (1.02%)	14,781 (0.21%)	0.285
14	Willem De Kooning	North America	1,144,317,696 (0.98%)	1,272 (0.06%)	0.272
15	Lucio Fontana	Southern Europe	1,098,615,296 (0.94%)	2,772 (0.11%)	0.266
16	Alexander Calder	North America	1,088,666,752 (0.93%)	5,479 (0.05%)	0.238
17	Pierre-Auguste Renoir	Western Europe	1,046,396,352 (0.89%)	3,766 (0.15%)	0.309
18	Zao Wou-Ki	Western Europe	1,015,000,512 (0.87%)	4,045 (0.15%)	0.206
19	Fernand Léger	Western Europe	1,005,042,112 (0.86%)	2,978 (0.16%)	0.354
20	Cy Twombly	North America	850,141,376 (0.72%)	881 (0.06%)	0.765
21	Jeff Koons	North America	848,892,096 (0.72%)	1,646 (0.12%)	0.296
22	Paul Cézanne	Western Europe	791,902,080 (0.67%)	697 (0.05%)	0.299
23	Edgar Degas	Western Europe	771,783,232 (0.66%)	1,274 (0.17%)	0.295
24	René Magritte	Western Europe	734,759,296 (0.63%)	1,519 (0.03%)	0.235
25	Damien Hirst	Northern Europe	705,134,592 (0.60%)	3,940 (0.03%)	0.406

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	392,962,816 (9.59%)	641 (0.61%)	0.213
2	Georgia O'Keeffe	North America	211,702,064 (5.17%)	117 (0.11%)	0.204
3	Louise Bourgeois	North America	197,968,512 (4.83%)	649 (0.62%)	0.289
4	Agnes Martin	North America	193,711,040 (4.73%)	296 (0.28%)	0.249
5	Cindy Sherman	North America	140,606,176 (3.43%)	1,269 (1.21%)	0.268
6	Barbara Hepworth	Northern Europe	135,153,952 (3.30%)	616 (0.59%)	0.146
7	Tamara De Lempicka	Eastern Europe	127,470,128 (3.11%)	313 (0.30%)	0.357
8	Natalia Sergeevna Goncharova	Eastern Europe	127,109,512 (3.10%)	731 (0.70%)	0.463
9	Mary Cassatt	North America	88,247,688 (2.15%)	832 (0.79%)	0.296
10	Helen Frankenthaler	North America	79,406,904 (1.94%)	1,100 (1.05%)	0.253
11	Bridget Riley	Northern Europe	78,610,368 (1.92%)	818 (0.78%)	0.189
12	Berthe Morisot	Western Europe	76,978,256 (1.88%)	258 (0.25%)	0.340
13	Eileen Gray	Northern Europe	75,399,800 (1.84%)	184 (0.18%)	0.326
14	Gabriele Münter	Western Europe	67,722,952 (1.65%)	449 (0.43%)	0.231
15	Niki De Saint Phalle	Western Europe	67,633,304 (1.65%)	1,849 (1.76%)	0.361
16	Maria Helena Vieira Da Silva	Western Europe	62,461,532 (1.53%)	683 (0.65%)	0.320
17	Elisabeth Frink	Western Europe	56,816,528 (1.39%)	1,212 (1.16%)	0.186
18	Camille Claudel	Western Europe	47,351,292 (1.16%)	115 (0.11%)	0.275
19	Julie Mehretu	North America	39,050,448 (0.95%)	117 (0.11%)	0.328
20	Marie Laurencin	Western Europe	37,916,940 (0.93%)	1,633 (1.56%)	0.452
21	Germaine Richier	Western Europe	36,489,668 (0.89%)	207 (0.20%)	0.310
22	Charlotte Perriand	North America	36,297,372 (0.89%)	1,270 (1.21%)	0.367
23	Sonia Delaunay	Western Europe	35,823,440 (0.87%)	2,414 (0.23%)	0.412
24	Zinaida Evgenievna Serebryakova	Eastern Europe	46,413,028 (0.87%)	130 (0.12%)	0.272
25	Elizabeth Peyton	North America	34,532,152 (0.84%)	305 (0.29%)	0.343

All prices are in constant 2017 \$.

Table A3: Artwork level OLS regression results - by generation of artist

Variables	Log of real price									
	<1700	<1800	<1825	<1850	<1875	<1900	<1925	<1950	<1975	<2001
Female	0.358*** (0.069)	0.058 (0.041)	0.125*** (0.031)	0.340*** (0.024)	0.008 (0.013)	-0.008 (0.008)	0.124*** (0.008)	0.080*** (0.008)	-0.105*** (0.011)	-0.097*** (0.033)
Design	-0.668*** (0.092)	-0.292*** (0.048)	0.045 (0.041)	0.049*** (0.017)	-0.012 (0.011)	-0.171*** (0.007)	-0.248*** (0.007)	-0.312*** (0.009)	-0.068*** (0.016)	0.180*** (0.055)
Photographs	-0.708* (0.371)	-0.469*** (0.105)	-0.231*** (0.020)	-0.775*** (0.026)	-0.689*** (0.017)	-0.787*** (0.010)	-0.658*** (0.008)	-0.756*** (0.008)	-0.406*** (0.010)	-0.461*** (0.037)
Prints and multiples	-1.267*** (0.013)	-1.441*** (0.012)	-1.154*** (0.019)	-0.999*** (0.014)	-0.851*** (0.008)	-1.003*** (0.005)	-1.010*** (0.005)	-1.025*** (0.005)	-0.742*** (0.010)	-0.738*** (0.042)
Sculpture	0.225*** (0.026)	0.061*** (0.019)	0.118*** (0.017)	0.352*** (0.014)	0.354*** (0.011)	0.400*** (0.008)	0.452*** (0.008)	0.314*** (0.007)	0.483*** (0.012)	0.103** (0.042)
Works on paper	-0.601*** (0.013)	-0.467*** (0.009)	-0.402*** (0.010)	-0.475*** (0.013)	-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	0.392* (0.201)	0.119** (0.049)	0.567*** (0.031)	0.513*** (0.020)	0.427*** (0.012)	0.134*** (0.009)	-0.182*** (0.010)	-0.499*** (0.012)	-0.431*** (0.019)	-0.399*** (0.046)
Northern Europe	0.060 (0.189)	-0.537*** (0.020)	-0.659*** (0.018)	-0.209*** (0.013)	-0.224*** (0.010)	-0.145*** (0.008)	-0.221*** (0.007)	-0.476*** (0.007)	0.058*** (0.010)	-0.197*** (0.039)
Southern Europe	0.491*** (0.188)	-0.085*** (0.021)	-0.183*** (0.027)	0.174*** (0.018)	0.089*** (0.013)	0.607*** (0.007)	0.027*** (0.007)	-0.294*** (0.008)	-0.168*** (0.014)	-0.300*** (0.059)
Western Europe	0.500*** (0.188)	-0.299*** (0.020)	-0.327*** (0.017)	0.055*** (0.011)	-0.008 (0.008)	0.081*** (0.006)	-0.022*** (0.006)	-0.335*** (0.006)	-0.212*** (0.010)	-0.322*** (0.038)
Alive							-0.079*** (0.005)	-0.322*** (0.004)	-0.659*** (0.013)	
Log of size	0.133*** (0.003)	0.224*** (0.002)	0.229*** (0.003)	0.206*** (0.003)	0.182*** (0.002)	0.147*** (0.001)	0.182*** (0.001)	0.222*** (0.001)	0.287*** (0.002)	0.220*** (0.008)
Observations	125,023	103,448	103,135	171,749	343,970	612,586	521,910	437,473	159,572	11,237
R-squared	0.455	0.440	0.415	0.445	0.413	0.419	0.412	0.481	0.533	0.589
Year Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

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 A4: Artwork level regression results – child-rearing

Variables	Log of real price	
	OLS	WLS
Female	-0.140*** (0.025)	-0.103*** (0.037)
Above 40	0.153*** (0.009)	-0.041** (0.016)
Female x Above 40	0.067** (0.026)	0.073* (0.041)
Design	-0.172*** (0.009)	0.319*** (0.023)
Photographs	-0.497*** (0.007)	-0.203*** (0.015)
Prints & multiples	-0.808*** (0.006)	-0.503*** (0.020)
Sculpture	0.391*** (0.007)	0.513*** (0.016)
Works on paper	-0.327*** (0.006)	-0.195*** (0.013)
Eastern Europe	-0.347*** (0.012)	-0.014 (0.022)
Northern Europe	-0.053*** (0.007)	0.001 (0.019)
Southern Europe	-0.086*** (0.008)	0.085*** (0.021)
Western Europe	-0.099*** (0.006)	-0.037** (0.017)
Log of size	0.241*** (0.001)	0.175*** (0.003)
	(0.118)	(0.140)
Observations	418,504	418,504
R-squared	0.483	0.357
Year Effects	Yes	Yes
Season Effects	Yes	Yes
Auction house Effects	Yes	Yes

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

This sample includes contemporary artists only.

The above-40 is a dummy variable that equals one if the artist is above 40 years old at the time of the transaction.

The base category for the object type is paintings.

The base category for the region is North America.

Table A5: Summary statistics- Auction house estimation error

	mean	median	sd	no. undervalued artworks	no. overvalued artworks
Male artworks	2.43	1.03	328.7	1,229,644 (47.8%)	1,068,275 (41.5%)
Female artworks	1.78	1.05	126.7	52,931 (50.5%)	42,444 (40.5%)

The estimation error is defined as the artwork sales price divided by the mid-point of the auction house pre-sale price estimate.

Table A6: Artwork level OLS regression results - price scaled by estimate

Variables	Ratio nominal price to action house pre-sale estimate				
	Pooled	Old Masters	Modern	Post War	Contemporary
Female	-0.667 (1.070)	-0.085 (2.116)	0.458 (1.932)	-1.777 (2.453)	-2.268 (2.764)
Design	2.915*** (0.907)	-0.353 (1.670)	4.617*** (1.597)	5.109*** (1.956)	-4.058 (3.531)
Photographs	0.043 (1.036)	-0.151 (2.573)	0.794 (2.081)	-0.783 (2.373)	-0.505 (2.538)
Prints & multiples	0.905 (0.654)	-0.348 (1.278)	2.055* (1.203)	0.157 (1.572)	-0.278 (2.262)
Sculpture Sculpture	0.952 (0.935)	0.229 (1.610)	1.787 (1.963)	-1.092 (2.051)	1.279 (2.755)
Works on paper	0.212 (0.609)	-0.160 (0.917)	0.616 (1.111)	-0.473 (1.601)	-0.600 (2.285)
Eastern Europe	1.383 (1.235)	-0.131 (1.891)	2.823 (2.037)	-0.712 (3.311)	-0.697 (4.501)
Northern Europe	0.084 (0.841)	0.448 (1.408)	-4.825*** (1.753)	1.680 (1.919)	3.668 (2.641)
Southern Europe	0.055 (0.880)	0.040 (1.939)	-0.875 (1.637)	-1.158 (2.068)	-0.712 (3.093)
Western Europe	0.439 (0.686)	0.011 (1.185)	0.887 (1.329)	-0.724 (1.613)	-1.083 (2.345)
Alive	1.060** (0.529)			-1.356 (1.162)	
Log of size	-0.232 (0.148)	0.086 (0.265)	0.035 (0.289)	-1.200*** (0.350)	-0.335 (0.507)
Observations	2,434,732	479,566	772,853	515,204	392,850
R-squared	0.001	0.000	0.003	0.001	0.004
Year Effects	Yes	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes	Yes

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 A7: Artwork level OLS regression results – mega transactions

Variables	Log of real price			
	All	All	Contemporary	Contemporary
	Only mega transactions	Excl. mega transactions	Only mega transactions	Excl. mega transactions
Female	-0.184*** (0.033)	0.046*** (0.004)	-0.179** (0.073)	-0.053*** (0.007)
Design	-0.317*** (0.068)	-0.192*** (0.003)	-0.316 (0.250)	-0.146*** (0.009)
Photographs	-0.333*** (0.074)	-0.627*** (0.004)	-0.361*** (0.075)	-0.445*** (0.006)
Prints & multiples	-0.265*** (0.060)	-0.869*** (0.002)	-0.350*** (0.131)	-0.759*** (0.006)
Sculpture	-0.028 (0.022)	0.318*** (0.003)	0.050 (0.041)	0.385*** (0.007)
Works on paper	-0.229*** (0.025)	-0.381*** (0.002)	-0.315*** (0.081)	-0.300*** (0.006)
Eastern Europe	0.004 (0.034)	0.021*** (0.004)	0.058 (0.146)	-0.337*** (0.011)
Northern Europe	0.076*** (0.025)	-0.256*** (0.003)	-0.101** (0.045)	-0.052*** (0.007)
Southern Europe	0.136*** (0.022)	0.142*** (0.003)	-0.268*** (0.064)	-0.078*** (0.008)
Western Europe	-0.281*** (0.019)	-0.368*** (0.002)	0.197*** (0.041)	-0.104*** (0.006)
Alive	-0.487*** (0.005)	-0.397*** (0.004)		
Log of size	0.084*** (0.005)	0.169*** (0.001)	0.096*** (0.012)	0.228*** (0.001)
Observations	15,881	2,661,309	2,270	416,234
R-squared	0.095	0.410	0.138	0.472
Year Effects	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes

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

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

The base category for the object type is paintings.

The base category for the region is North America.

Table A8: Artwork level WLS regression results – mega transactions

Variables	Log of real price			
	All	All	Contemporary	Contemporary
	Only mega transactions	Excl. mega transactions	Only mega transactions	Excl. mega transactions
Female	-0.049 (0.074)	-0.100*** (0.010)	-0.103 (0.080)	-0.041*** (0.016)
Design	0.022 (0.163)	0.232*** (0.011)	-0.107 (0.164)	0.319*** (0.023)
Photographs	-0.170** (0.068)	-0.369*** (0.011)	-0.119 (0.074)	-0.199*** (0.015)
Prints & multiples	0.032 (0.238)	-0.666*** (0.009)	0.231 (0.310)	-0.502*** (0.020)
Sculpture	0.016 (0.069)	0.438*** (0.010)	0.016 (0.060)	0.511*** (0.016)
Works on paper	-0.059 (0.059)	-0.337*** (0.006)	-0.308*** (0.076)	-0.194*** (0.013)
Eastern Europe	-0.150** (0.066)	0.248*** (0.012)	0.083 (0.121)	-0.011 (0.022)
Northern Europe	-0.237*** (0.072)	0.001 (0.009)	-0.062 (0.069)	0.002 (0.019)
Southern Europe	-0.133** (0.066)	0.488*** (0.011)	-0.068 (0.090)	0.085*** (0.021)
Western Europe	-0.029 (0.055)	0.153*** (0.008)	-0.085 (0.059)	-0.037** (0.017)
Alive	-0.306*** (0.049)	-0.356*** (0.005)		
Log of size	0.053*** (0.013) (0.137)	0.137*** (0.002) (0.040)	0.089*** (0.019) (0.342)	0.174*** (0.003) (0.138)
Observations	15,881	2,661,309	2,270	416,234
R-squared	0.153	0.360	0.137	0.356
Year Effects	Yes	Yes	Yes	Yes
Season Effects	Yes	Yes	Yes	Yes
Auction house Effects	Yes	Yes	Yes	Yes

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

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

The base category for the object type is paintings.

The base category for the region is North America.

Table A9: Quantile regression on OLS residual

Variables	OLS residual					
	q25	q50	q75	q95	q99	q99.9
Female	0.033*** (0.000)	0.055*** (0.000)	0.096*** (0.000)	0.079*** (0.000)	-0.068*** (0.000)	0.031 (0.689)
Observations	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 .