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Climbing the ladder? The gender gap in art prices across artists' cohorts in the Dutch art market

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ABSTRACT

This study focuses on gender-based price differences across age cohorts in the primary art market, where art is sold for the first time, largely by living artists. This is an area that remains under-explored due to a lack of data on artwork sales. We use an exclusive dataset from the Mondriaan Fund, consisting of 10,922 paintings sold, under the Kunstkoopregeling scheme, by 663 Dutch artists from 2000 to 2010 in the Netherlands. Given the presence of significant unobserved heterogeneity, we use finite mixture models to estimate hedonic painting price equations and to decompose the gender price gap. Additionally, we use the standard Oaxaca–Blinder model to compare our results with a more traditional approach to estimating gender differences. Our findings indicate that the significant gender price imbalance for the oldest cohort is smaller in the second cohort, and is insignificant for the youngest one. The present study provides important implications for understanding gender differentials in labour market outcomes within cultural markets and other creative industries.

"Dearest Art collector,
It has come to our attention that your collection, like most,
does not contain enough art by women.
We know that you feel terrible about this and will rectify
the situation immediately; All our love"
Guerrilla Girls postcard, 1985

1. Introduction

Gender inequality and discrimination are more evident in some labour markets than in others. The art market exemplifies such inequalities and discrimination to a considerable degree (Stern, 2005). As the anonymous, gorilla-masked feminist activist artist collective, The Guerrilla Girls, have shown since 1985, gender inequalities are particularly striking in the arts: "Women in America earn only 2/3 of what men do. Women artists earn only 1/3 of what men do" ((Brenson, April 21, 1984), p. 2). Furthermore, in the art

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labour market, female artists have consistently been underrepresented (Galenson, 2007). What is more, the proportion of female artists progressively diminishes along the career ladder, indicating impaired mobility and a higher attrition for female artists (Bocart et al., 2018; Vecco et al., 2019). Nevertheless, Bocart et al. (2022) identify that the proportion of contemporary female artists has increased and that the price of artworks made by female artists is 4.4 percent higher than artworks by male artists, which demonstrates that the market has been improving for women over the last decade.

This article aims to investigate gender price inequalities in the art market to verify the extent to which it differs among different contemporary artists' age cohorts (hereafter referred to as cohorts). To address this research question, we use a unique dataset derived from the Mondriaan Fund, consisting of information on 10,922 painting sales made by 663 Dutch artists in the period 2000–2010, using the *Kunstkoopregeling*, a specific Dutch incentive scheme in the primary art market, where art is sold for the first time, which is the entry point for living artists. As this dataset is not designed as a longitudinal dataset, we can only analyse current differences in achieved prices by gender, and how they differ in size by age cohort, rather than investigate how they changed over time.

Our findings reveal a significantly narrower gender gap in painting prices in the Dutch primary art market for the youngest generations of artists than for older ones. Moreover, during the period of analysis, the artworks that young females produced are similar in their observable characteristics to those of their male counterparts. However, this is not the case for the oldest cohort, since the oldest female artists in our sample sell paintings that were less attractive in terms of their observable characteristics than those sent to the market by their male peers. The fact that the overall gender gap in the Netherlands is declining[2] invites the possibility that our results may be a consequence of this decline in the gender gap over time. However, with our data, we cannot test whether these changes over time actually took place in the Dutch art market. Moreover, we cannot be entirely sure whether the absence of a gender gap for young artists is the same as what we would have found for older artists had we observed them earlier in their careers, since we do not have data on the performance of older artists at this point in their careers. In addition, given the relatively short time period of the analysis, our database does not capture the slow changes that have taken place over a long period of time that affect the relative demand for all female artists ((Bocart et al., 2022) and (Cameron et al., 2019)). Hence, even if these changes account for the evolution of the art price gender gap in the long term, they cannot be used to clarify why this gap is, at a certain point in time, narrower for the youngest artists.

However, overall, our results are consistent with the long-term trend of reducing gender gaps such as those captured by the *grand gender convergence* (Goldin, 2014). Moreover, there is evidence that the small educational gap by gender in the Netherlands in the late 20th century is partly due to the increase in women's educational levels and, specifically in the art market, to more and better (artistic) training (Brouwer and Meulenbeek, 2000; Joosten-Merx, 2007). This may help to account for why female artists' skills are closer to those of their male counterparts for the youngest cohort in our sample. It may also be a reason behind the absence of a gender gap in art prices for this group.

To analyse the gender gap in art prices, we use finite mixture models (FMM) (Aitkin and Rubin, 1985; McLachlan and Peel, 2000; Quandt and Ramsey, 1978). This technique is a regression method for obtaining precise segmentation results under the presence of multiple, latent subpopulations, each characterised by its own set of parameters (Andrews et al., 2010; Durand et al., 2022). It is especially well-suited for addressing unobserved heterogeneity, even in more complex econometric problems such as duration data (Heckman and Singer, 1984). In order to compare our results with a more traditional approach, we also estimate hedonic price equations independently by gender, using the Oaxaca (1973) and Blinder (1973) model.

In our context, FMM enable us to check whether there are statistically distinct price segments in the art market, and to estimate the likelihood of a painting being sold within either segment using a Bayesian approach that evaluates posterior probabilities that consider both the hedonic price equations and other factors that may determine the prior probability of belonging to any market segments. Meanwhile, the Oaxaca-Blinder model assumes that the market segments are rigidly defined by certain fixed characteristics, such as gender. The allocation of groups by FMM used all the available information, since FMM "provides a data-driven approach to any groupings and/or sample splitting" (Durand et al., 2022). Its potential group assignment is so general that it does not rule out the possibility of a painting allocation consistent with the racial or gender assumption of the Oaxaca-Blinder model, or any other grouping criterion that may be used to estimate the two independent equations of this model. In this sense, the FMM is a more comprehensive and flexible approach than the Oaxaca-Blinder model. The present article advances the current literature mainly by focusing on the primary art market, which is underexplored due to a lack of data mainly in terms of artwork sales. Focusing on this market, we consider gallery prices rather than auction prices.

The structure of the article is as follows: Section 2 reviews the empirical literature on gender inequality in the art labour market; Section 3 introduces the conceptual framework, while Section 4 describes the data, variables and the methodological approach used. Section 5 presents the empirical results, and Section 6 discusses the main findings, as well as providing the conclusions and implications of our research.

2. Empirical literature review

2.1. The contemporary art market: main features and prices

Several authors have provided arguments as to why the art market differs from other markets. Caves (2000) lists various

[2] Using the Dutch Labour Force Survey, the general gender wage gap has been estimated to have dropped from roughly 20 percent in 1986 to 9 percent in 2012 in The Netherlands (Verkroost, 2016).

characteristics of the art world, such as the role of experts, insecurity, group dynamics, speculation and the importance of status and reputation. The art market is not a standard market in which competition is centred mainly on price; rather, it is a status market, one which is dynamic and where the actors are of particular importance (Aspers, 2007).

Artworks are not homogenous products (Prieto-Rodriguez and Vecco, 2021). Campos and Barbosa (2009) describe them as "an extreme case of a heterogeneous commodity" (p. 31) since every work is different. Here, competition is not based on price but on the artworks' unique characteristics, a notion which challenges the economic mechanism of price-setting. Besides the artworks' uniqueness, two additional factors make it difficult to establish a price on the primary market, because at the beginning of an artist's career, there is not much known yet about demand, and there is often no fixed economic pattern established (Savage, 1969). An artwork's price will ultimately depend on aesthetic satisfaction, which is not necessarily linked to the conditions of production (Greffe, 2002). Two of the most objective determinants of an artwork are medium and size. However, other variables such as the sale's environment and location, which are not directly related to the artwork, may play a significant role in determining the price. It is likely that the pricing decisions about artists vary, and that art pricing is influenced by organizational context, social relationships and status concerns (Diamantopoulos and Mathews, 1995; Uzzi and Lancaster, 2004; Zanola et al., 2021). Status has an influence since a price often signals a firm's market niche (Podolny and Hill-Popper, 2005).

The primary art market is characterised by different idiosyncrasies (Hartog and Kackovic, 2019): an oversupply of producers (Alper and Wassall, 2006), strong product heterogeneity (Galenson, 2006),[3] fierce competition (Caves, 2000), elusive buyer tastes, highly uncertain incomes. Self-employment is the norm, often supplemented by other (non) art-related work (Menger, 2006). Since new artists are unknown, galleries have to establish a price without many reference points, especially for young artists (Crane, 1987), trying to match supply and demand. Therefore, instead of using strict calculations, intermediaries often have their "rules of thumb" (O'Neil, 2008), as do gallery owners. Velthuis (2005) labels these rules as "pricing scripts", which differ for new or more established artists. The price for new artists is generally set low with respect to comparable established artists. More established artists are valorised based on past prices and any price increases when the demand is high, the reviews are good or simply on an annual basis. In the contemporary art market, the pricing mechanisms are anything but standard (Di Caro and Mazza, 2020; Velthuis, 2005). This unconventional method of setting prices, combined with the wide range of formats, supports, compositions or textures, leads to a large heterogeneity in prices (Mei et al., 2023).

2.2. The art price gender gap in the art market literature

Research in the art world (Frey and Pommerehne, 1989) shows that female artists receive a lower income than male artists, even when other characteristics, such as education, are the same. Other empirical studies (Adams et al., 2021; Bocart et al., 2018; Bocart et al., 2022; Cameron et al., 2019; Coate and Fry, 2012; Rengers, 2002) have underlined a high degree of under-representation, lower sales revenues and barriers to market entry for female artists compared to male artists, as well as greater competition among female artists.

In their extensive studies, Bocart et al. (2018, 2022) analysed prices paid in the secondary (auctions) art market and in the primary art market (galleries) for artworks created by female and male artists, based on birth-identified sex and the evolution of prices over time. Female artists were found to be significantly under-represented in both the gallery market as well as the auction market. The starting condition for an artistic career, represented by pursuing a MFA degree, is reported to be equal for men and women in art schools. Notwithstanding this, women represent only 13.7 percent of the primary art market sample of contemporary artists. This percentage decreases to 11.6 percent in the secondary market. However, after controlling for artwork characteristics, the researchers observe the existence of an average price premium of 4.4 percent on the artwork level for female artists of older generations, which includes the best female artists and those most determined to attain success and develop their full career in the art market (Bocart et al., 2018,2022). These findings are in line with those of Cameron et al. (2019), who find a premium for female artists' artworks traded at auction, and empirical evidence of a higher bar for women, within a sample of Yale graduates. However, once again, the female premium is largely driven by older artists (pre-1983 graduates) and found to be insignificant for young artists (post-1983 graduates). Hence, there is an extensive body of literature (i.e. (Alper and Wassall, 2006; Bocart et al., 2018; Galenson, 2007; Greenwald, 2021; LeBlanc and Sheppard, 2022) providing evidence supporting the existence of higher quality standards for female artists as they age, due to prevalent self-selection and attrition issues in the art market.

We are aware of only one study dealing with gender inequalities in artists' direct income in Dutch galleries. Rengers and Velthuis (2002) found that, whilst half of all artists in the Netherlands are women, the primary market is nevertheless dominated by men. Specifically, only 25 percent of the artworks sold between 1992 and 1998 were produced by women, and the prices for artworks produced by men were significantly higher. These findings, revealing a clear gender price gap, have been partly explained by the artist's age (there were younger female artists, on average) and by the hedonic characteristics of the artworks traded.

2.3. The gender gap in the Dutch labour market

The gender differences in the cultural sector are comparable to other sectors of the economy, particularly in the analysed period (Rengers, 2002; Tijdens, 2001). In Western societies in recent decades, society has begun to encourage women's role as full-time

[3] Originality and innovation are key elements of modern art (see (Hughes, 1991)), leading to a large amount of heterogeneity that is only attenuated in certain forms of art, such as engravings.

caregivers to a lesser extent (Euwals et al., 2011; Jaumotte, 2003), so young female workers might have had more time, a better education and skills and even larger social networks to create and promote their work (Fraiberger et al., 2018). This process was particularly apparent in the Netherlands where, compared with other European countries, female labour force participation had been remarkably low in the 1950s and 60 s, but was then followed by a rapid increase from the early 1970s onwards (Balleer et al., 2014; Plantenga, 2003). The so-called "Dutch miracle" (Visser and Hemerijck, 1997) represents an interesting case with regard to female employment. This "miracle" was the result of the government's policy, which at that time was strongly focused on increasing women's educational levels (Van den Berge et al., 2014) and their rate of participation in the labour force. This implies that young women who enter the potential labour force have higher participation rates than older women who reach retirement age (CPB (Centraal Planbureau) 2014; Van den Berge et al., 2014). In addition, discrimination was tackled by 'equal pay for equal work' legislation implemented in 1975. As a consequence of these social and legislative changes, all of which fed back on each other, from the mid-1980s onwards, several labour market inequalities between men and women in the Netherlands began to decline. Furthermore, the differences in job levels between men and women diminished, and "more and more can be explained by differences in age, education and part-time work" ((Brynin and Perales, 2016), p. 790). This became increasingly evident from the mid-1990s (Euwals et al., 2007), when the position of women in the labour market significantly improved both in terms of the rate of female employment (female participation had more than doubled, from 31 percent in 1975 to 69 percent in 2006 (OECD 2002) as well as their mean job characteristics (Bevelander and Groeneveld, 2006).

Overall, the decline of the gender earnings gap in the Dutch labour market mirrors the changes characterising other Western countries' labour markets (Albrecht et al., 2009; Blau and Kahn, 2017; Brynin and Perales, 2016; Fouarge et al., 2004; Fransen et al., 2012; Kunze, 2018; O'Neill, 2003; O'Neill and Polachek, 1993; Van der Meer, 2008). The gender earnings gap progressively decreased in the Dutch labour market, where the education level of women has risen sharply and the educational field chosen by women also changed (Brouwer and Meulenbeek, 2000; Joosten-Merx, 2007). These changes were a consequence of state interventions in the form of developing progressive welfare policies regarding both women's employment patterns and gender inequality in occupational attainment (Mandel and Semyonov, 2006).

3. Conceptual framework

Regarding the conceptual origins of the art price gender gap, two distinct, expected features emerge from the previous section. Firstly, the gradual reduction in the gender gap in artwork prices could be associated with the broader societal trend of legally advocating for "equal pay for equal work", especially in more developed countries (Hyland et al., 2020). This factor has been included in different legislation with varying standards of implementation, usually stronger in high-income countries, across industries. This trend may contribute to the overall narrowing of the gender price gap over time, regardless of the artists' cohort; nevertheless, we cannot draw any solid conclusions about this from our data set. Secondly, the gender gap in art prices may gradually decrease throughout artists' careers, primarily due to attrition. Older cohorts are expected to have a smaller number of members, as former painters decide to transition to alternative pursuits due to difficulties in establishing a successful artistic career. However, if attrition disproportionately affects females in the creative industries (Eikhof and Warhurst, 2013; Munro, 2017), it will impact the gender price gap, causing it to narrow throughout artists' careers, with a decreasing difference as artists get older (Bocart et al. 2018, 2020).

These arguments clearly align with the three main factors contributing to the gender earnings gap among artists within the same cohort at a specific point in time. First, there may be differences in the number of artworks that male and female artists sell. This affects earnings through the artwork supply but does not contribute to the gender gap in art prices. Second, there may exist systematic gender-based differences in the artworks' characteristics. For example, if drawings are predominantly produced by women and paintings by men, part of the gender gap in art prices will be associated with the disparity in the media and techniques used by artists of both genders. Regarding this point, there is evidence that differences in access to arts education, training networks and expensive materials, as well as the existence of the motherhood penalty, contribute to female artists' underachievement in the art market producing artworks of a lower quality (Cowen, 1996; LeBlanc and Sheppard, 2022). Third, the market may assign different values and prices to artworks with identical observable traits - such as style, technique and medium - based on the artist's gender and cohort. This can be related to their social networks (Fraiberger et al., 2018) and professional career discontinuities, such as maternal leave, and also to prejudices. The remainder of this section mainly focuses on this last aspect, as it violates the 'equal pay for equal work' principle, and could be labelled as discriminatory.[4]

In general terms, for any labour market, Becker's seminal model (Becker, 1957) launched the formal analysis of discrimination in economics, focusing on racial prejudice and discrimination against racial minorities in a competitive model. However, according to Bertrand (2011), as the taste-based model was developed to analyse discrimination against a minority, it cannot easily be applied to women. In fact, the experiment developed by Bertrand and Mullainathan (2004) finds that, although there is an important racial bias when judging similar resumés by firms, the gender bias is much smaller and statistically insignificant. In any case, one long-term implication of Becker's model is that discriminatory tastes or prejudices, whether based on race or gender, tend to diminish over time in competitive markets. Consequently, while we might anticipate a relative improvement for female artists compared to their

[4] If gender differences in expectations regarding artistic careers or future prices exist, they could, for instance, lead to disparities in artistic training (as in (Charness et al., 2020), and (Lepage et al., 2022)) and, consequently, gender-based differences in the observable characteristics of the artworks. The resulting gender gap in art prices would also be discriminatory in a broader sense, even if, at first glance, gender disparities in the observable characteristics may not suggest it.

male counterparts as time passes, there is no clear implication when comparing across different cohorts.

A second class of models is based on statistical discrimination. In such models, the lack of information on an individual's abilities forces employers to use aggregate group characteristics as a predictor for productivity (Arrow, 1973; Cain, 1986; Lundberg and Startz, 1983; Phelps, 1972). This implies that individual minority workers who are more skilled or productive than the group average are discriminated against, even if employers are not prejudiced against them. As regards the art market, statistical discrimination models can be useful to account for differences in prices under, for instance, a high variance in the quality or expected returns of an art investment. Intermediaries such as galleries and potential buyers will then use all the available information, including the artist's gender, to make judgments about the risk of potentially profitable foregone market transactions. This leads to discriminatory outcomes if the statistical information used does not accurately reflect the risk profile of each individual within the group, or if the existence of prejudice regarding gender affects the decisions of risk-averse agents. In the art market, galleries can play a significant role in statistical discrimination by acting as information intermediaries and gatekeepers. If they provide biased and unfair information to buyers about the characteristics of painters and their artworks, galleries can worsen the effects of statistical discrimination (Marchenko and Sonnabend, 2022).

More specifically, in the face of a high information asymmetry and a significant uncertainty about artwork quality and artists' skills, statistical discrimination models help to explain why players such as dealers, auction houses and curators use gender as a proxy for assessing quality (Bocart et al., 2018). Furthermore, even in the absence of a taste against female art (as in Hoffmann and Coates, 2022), because quality is difficult to measure objectively, quality assessment is frequently affected by a gender bias linked to cultural factors (Adams et al., 2021) or to other traits, such as the expected level of the artist's fame (Hoffmann and Coate, 2022). This bias has important implications in hiring and in career development, but seems to have diminished for artistic jobs over recent decades (Goldin and Rouse, 2000).

Bagues and Perez-Villadoniga (2012;2013) empirically and theoretically expanded upon the traditional statistical discrimination model by incorporating a "similar-to-me" effect, rooted in skills. They prove that applicants with skills similar to those of their recruiters enjoy an advantage. One implication of this model is that a narrower gender gap in skills corresponds to smaller disparities in the labour market. In addition, the "similar-to-me" effect predicts an increase in female art prices as females increase their purchasing power, and are thereby more likely to buy art. Consequently, a prediction from these models is a narrower gender gap in art prices among younger artists compared to older ones, since young artists have undergone a educational process comparable to that of their male counterparts, and face a demand from more females of a similar age (McAndrew, 2020).

Finally, there may also be factors unrelated to the observable characteristics of the artworks linked, for instance, to men having lower risk aversion and more competitive behaviours (Niederle and Vesterlund, 2007), as well as being part of better networks that enhance their perceived talent and reputation, or having better negotiating skills (Bertrand, 2011). These factors also have an influence on prices, and are the source of discriminatory differences based on galleries' and art dealers' tastes *à la* Becker. Nevertheless, as in Becker's model, non-discriminatory agents will take advantage and increase their profits. For instance, Sussman and Hart (2017), comparing the art registries of 199 galleries under women's and men's leadership at the sixteenth annual edition of Art Basel in Miami Beach, report that female gallerists tend to represent more female artists than males.

4. Data, variables used and methodological approach

4.1. Data

The dataset used in this study includes information regarding 663 Dutch artists, whose 10,922 artworks were purchased using the *Kunstkoopregeling*[5] by the Mondriaan Fund in the period 2000–2010.[6] In our sample, female painters represent 25.6 percent of the 663 painters and account for 24 percent in terms of the sales volume. The *Kunstkoopregeling* is a subsidy scheme introduced by the Dutch government aimed at supporting the demand side of the primary art market in the Netherlands. It can act as a stimulus for both collectors and incidental buyers.

The government provides private buyers of contemporary art at a large selection of galleries with interest-free loans. The artwork purchase is financed by the government, after which the buyer pays in monthly instalments. Therefore, the government does not intervene in the art market directly. The selection is based on the professionalism of the gallery and the quality of the work of the artists it represents. To be entitled to use the *Kunstkoopregeling* there are various requirements: the artwork was created after 1945 by a living artist; the minimum price is €450; the loan has a maximum of €7000 per artwork and the prepayment is at least 10 % of the price, with a maximum of €450. For any works with a higher price than €7450, higher prepayments are required; the duration of the loan is a maximum of three years. Early redemption is always possible; the minimum redemption per month is €22.50 and the minimum (maximum) age of the buyer is 18 (75) years. The *Kunstkoopregeling*, which is the most significant subsidy scheme to support the demand side of the primary art market in the Netherlands, can act as a stimulus for collectors and incidental buyers. In 2010, 10 percent of the turnover of Dutch galleries was stimulated because of the *Kunstkoopregeling* (Van der Valk, 2010).

[5] Since 1997, the Mondriaan Fund has been in charge of the *Kunstkoopregeling*. The *Kunstkoopregeling* has a predecessor in the *Rentesubsidieregeling*, which was set up in 1984 and was the successor to the *Aankoopsubsidieregeling Kunstwerken* (ASK), created by the Dutch government in 1960 to stimulate individuals to buy contemporary art.

[6] Starting from 2011, the Mondriaan Fund changed the criteria for collecting the data referring to the Kunstkoopregeling, therefore it was not possible to include more recent data.

We selected only those Dutch artists born between 1920 and 1979, excluding foreign artists working in the Netherlands, whose paintings were sold under this scheme. We decided to exclude foreign artists from the final sample due to the possible self-selection sample bias that they could generate, as occurs with migration decisions (Borjas, 1987; 1994; Borjas et al., 2019). The total sample was partitioned into three age cohorts of artists born within distinct time periods: 1920–1939, 1940–1959 and 1960–1979. These cohorts are labelled as the oldest, middle and youngest cohorts, respectively. Moreover, we intentionally decided to focus on paintings in order to have a more homogeneous sample.

The focus in this study is on the lower- and middle-range of the artworks sold in the Netherlands, since there is a lower and upper limit for a *Kunstkoopregeling* loan. This dataset is both extensive and unique, since it is difficult to obtain data about sold artworks, as this is a sensitive topic for art dealers, especially in the primary market. Although we also have information on the gallery, this variable could be similar to the occupation dummies in standard gender gap analysis, as it is an endogenous variable affecting the estimated gender gap. As "discrimination or anticipated discrimination may cause women and men with equal abilities to hold different occupations" ((Niederle and Vesterlund, 2007), p. 1068), similar prejudices can result in equally skilled artists being represented by different galleries, with male painters getting contracts with the larger and more successful ones. Hence, including the gallery as an independent variable helps explain price differences, but probably underestimates the effect of the constraints faced by female artists (see (Altonji and Blank, 1999)). In the following section, we provide an overview of the variables used for this study.

4.2. Variables

Apart from the artist's gender, we have used the traditional variables in hedonic art price equations (artwork selling price, artist's year of birth, the techniques or materials used, the date of creation, the size of the artwork, date of sale) adopted in the existing literature on the art market (Agnello and Pierce, 1996; Beckert and Rössel, 2004; Chanel, 1995; Frey and Pommerehne, 1989; Higgs and Worthington, 2005; O'Neil, 2008; Ursprung and Wiermann, 2011; Zanola et al., 2021), and added the variable *figurative* (as opposed to non-figurative) as per Nahm (2010) and Hodgson (2011).

Some demographic variables have a significant influence on an artwork's price. Because age is often related to experience and reputation, it usually has a positive influence, meaning that older artists sell for a higher price (Velthuis, 2005). Gender also influences price (Rengers and Velthuis, 2002). Table 1 introduces the variables used in our analysis with some descriptive statistics of our sample.

4.3. Methodological approach

In this study we analyse the determinants of prices in the Dutch primary art market, focusing on the price gender gap and how it varies across different cohorts. The data on sales cover a relatively short time span; however, since unobserved heterogeneity could be a problem in the art market, as discussed above, we restricted our sample to paintings by Dutch painters born between 1920 and 1979.

As regards price equations, we assume that art prices depend on the various characteristics that we reviewed in Section 4.2, such as size, technique, medium and genre. Specifically, the dependent variable is the natural logarithm of the sales price in Euros (*lnPrice*), and the independent variables include size, and its square, acrylic, oil, watercolour and mixed technique dummies; canvas, panel, paper and unknown medium as medium-dichotomous variables and figurative dummy, and the number of artworks sold by the artist as a control for the supply. As regards the artist's characteristics, the price equations also include the age of the painter at the date of sale and its square. Moreover, we have included yearly controls to consider the evolution and trends of the Dutch art market. Accordingly, the empirical equation can be written as follows:

$$lnPrice_i = f(X_i, A_i, T_i) \tag{1}$$

Table 1
Descriptive statistics of the sample used.

Variable	Mean	St. Dev.	Definition
Ln(Price)	7.95108	0.7459	Log of inflation-adjusted final price in euro
Size	10,271.5	54,187	Size in square centimetres
Acrylic	0.17808	0.3826	Dummy: 1 if painting uses acrylic paint and 0 otherwise
Oil	0.66344	0.4726	Dummy: 1 if painting uses oils and 0 otherwise
Watercolour	0.02893	0.1676	Dummy: 1 if painting uses watercolour and 0 otherwise
Canvas	0.57938	0.4937	Dummy: 1 if painting on canvas and 0 otherwise
Panel	0.16288	0.3693	Dummy: 1 if painting on panel and 0 otherwise
Paper	0.03571	0.1856	Dummy: 1 if painting on paper and 0 otherwise
Mixed	0.07508	0.2635	Dummy: 1 if painting on mixed medium and 0 otherwise
Unknown medium	0.20930	0.4068	Dummy: 1 if painting on unknown medium and 0 otherwise
Figurative	0.71809	0.4500	Dummy: 1 if painting has a figurative style and 0 otherwise
# artworks	7.74922	7.4495	Number of artworks by artist
Female	0.24345	0.4273	Dummy: 1 if artist is a female and 0 otherwise
Year of birth	2.05182	11.969	Year of birth mean deviation (actual year of birth -1950)
Age at sale	52.3282	11.902	Artist age at the time of sale
Year of sale dummies	–	–	Set of dummy variables denoting the year of the sale

where the dependent variable is the logarithm of the price in Euros, and the vector of independent variables includes the characteristics of the painting (X_i), the author's characteristics (A_i), and year dummies as controls for when the painting was sold (T_i).

To identify different price formation processes in the art market and, therefore, different segments in the Dutch primary art market, apart from using the traditional approach to analyse discrimination by Oaxaca (1973) and Blinder (1973), we also propose the use of finite mixture models (FMM) (Aitkin and Rubin, 1985; McLachlan and Peel, 2000; Quandt and Ramsey, 1978). These models are particularly well-suited to accounting for unobserved heterogeneity (Arcidiacono and Jones, 2003; Kasahara and Shimotsu, 2009), and are characterised by comprising two parts that are estimated simultaneously. In our case, the first part consists of modelling the hedonic price equation for art prices for different unobserved segments of the market. The second part classifies observations into groups, using all the information available in the hedonic price equations plus other variables not necessarily included in these equations, such as the artist's gender and age, in our case.

By using a Gaussian mixture model, we assume that the density for each segment of the art market is normally distributed. In the FMM approach, the likelihood of a particular artwork i being sold in segment j is assumed to be as follows:

$$L_{ij}(\theta_j) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{\left(ln(Price_i) - X_i\theta_j\right)^2}{2\sigma^2}} \tag{2}$$

where θ_j is a vector of parameters to be estimated, $lnPrice_i$ is the dependent variable and x_i is a vector of explanatory variables that could determine the price of the artwork, such as size, technique, etc. It is worth noting that a different vector of parameters is estimated for each segment.

Simultaneously, an FMM will exploit data to identify the probability of one observation belonging to a particular market segment. Thus, artworks are probabilistically separated into market segments (or classes), and a hedonic price function is estimated for each segment. In an FMM, the segment probabilities are often parameterised as a multinomial logit model. Following this specification, the probability of artwork i being sold at the art market segment j, $P_{ij}(\delta_j)$, can be written as:

$$P_{ij}(\delta_i) = \frac{\exp(\delta_i^{'} q_i)}{\sum_{j=1}^{J} \exp(\delta_i^{'} q_i)}, j = 1, ..., J, \delta_J = 0 \tag{3}$$

where δ_j is a vector of parameters to be estimated, q_i is the vector of variables included in the segmentation equation and J is the total number of segments in the art market. In our case, we set the number of classes to two segments to examine the presence of a discriminatory and a privileged group, as postulated by the Oaxaca-Blinder model. Hence, since the gender gap in art prices could be related to a systematic allocation of female artists to the segment where prices are lower, we include a gender dummy variable (*Female*) in Eq. (3). Furthermore, as we are interested in how the gender price gap may vary across cohorts, we also included, in this equation, the year of birth mean deviation (actual year of birth -1950) and its square and the corresponding iteration terms with the *Female* dummy. If these variables were statistically significant, it would imply that the different segments of the art market - each with its own price determinants - have a different composition in terms of the gender and age of the artist. By including gender and age in the segmentation equation, Eq. (3), we assume that the gender price gap may be more subtle, rather than simply assuming that all female or young artists could be discriminated against.

The unconditional likelihood for observation i is obtained as the weighted sum of their j-class likelihood functions, L_{ij}, where the weights are the probabilities of segment or class membership, P_{ij}. That is,

$$L_i(\theta, \delta) = \sum_{j=1}^{J} L_{ij}(\theta_j) \cdot P_{ij}(\delta_j), 0 \le P_{ij}, \sum_j P_{ij} = 1 \tag{4}$$

where $\theta = (\theta_{1,}..., \theta_J)$, $\delta = (\delta_{1,}..., \delta_J)$.

The overall likelihood function resulting from (3) and (4) is a continous function of the vectors of parameters θ and δ that can be written as:

$$In\, L(\theta, \delta) = \sum_{i=1}^{N} In\, L_i(\theta, \delta) = \sum_{i=1}^{N} In\left\{ \sum_{j=1}^{J} L_{ij}(\theta_j) \cdot P_{ij}(\delta_j) \right\} \tag{5}$$

Under the mantained assumptions, maximum likelihood techniques will give asymptotically efficient estimates of all the parameters. A *necessary* condition for identifying the parameters of this model is that the sample must be generated differently for each segment or class.

Once the parameters of the model are estimated, they can be used to compute the conditional posterior art market segment probabilities as:

$$P(j / i) = \frac{L_{ij}(\widehat{\theta}_j) \cdot P_{ij}(\widehat{\delta}_j)}{\sum_{j=1}^{J} L_{ij}(\widehat{\theta}_j) \cdot P_{ij}(\widehat{\delta}_j)} \tag{6}$$

Hence, posterior class probabilities depend on the estimated parameters, as well as the estimated for each group without imposing

any a priori assumption as to how the resulting groups are formed. Furthermore, to control more robustly for the cohort effect, we estimated alternative FMM using different subsamples, representing three different age cohorts. Models 1 to 3 feature 20-year cohorts, consisting of paintings by artists born between 1920 and 1939 (oldest cohort), 1940–1959 (middle cohort) and 1960–1979 (youngest cohort) respectively. Model 4 includes all the paintings in our sample, i.e. paintings by artists born between 1920 and 1979.

5. Empirical results

5.1. Testing equality in price distributions by gender

Before using regression methods to analyse differences in the artworks' prices produced by male and female artists in the Dutch primary art market, we analyse whether price distributions differ by gender, conditional on the three age cohorts we have defined in Section 4.1. This constitutes a first insight regarding the existence of a gender price gap, although discrimination in prices cannot be ruled out if, for instance, in order to achieve a similar price, female artists should sell paintings with better marketable characteristics.

In Fig. 1, the *ln (Prices)* kernel density plots are displayed for each gender, conditioned on their cohort. As we move to the younger cohorts, there is a clear convergence between male and female paintings' prices, the disparity between the genders for the oldest cohort being the greatest. For the middle cohort, the density plot of males is still shifted to the right compared to that for females, indicating that, within this age range, male artists receive higher prices on average than their female counterparts. However, no difference is easily identifiable for the youngest cohort, although very high prices are more likely to be paid for females' paintings.

To complement this figure, we ran two statistical tests to check for equality of the males' and females' price distributions, as presented in Table 2.

First, the Wilcoxon rank-sum test comparing prices between male and female artists suggests that there is no statistically significant difference in prices between genders for the youngest cohort. However, for the other two cohorts, the distributions of the male and female artwork prices do not appear to follow the same pattern. The same conclusion can be drawn from the independent samples' Kolmogorov-Smirnov test, which shows evidence that the artwork prices by male and female artists do not share the same distribution for the two oldest cohorts. These findings are consistent with the Kernel densities featured in Fig. 1,[7] suggesting that there is an underlying gender gap in prices among older artists, whereas for the youngest artists there is no significant difference in the male and female artist artwork price distributions. However, it is important to note that, since no controls are used either in the Kernel

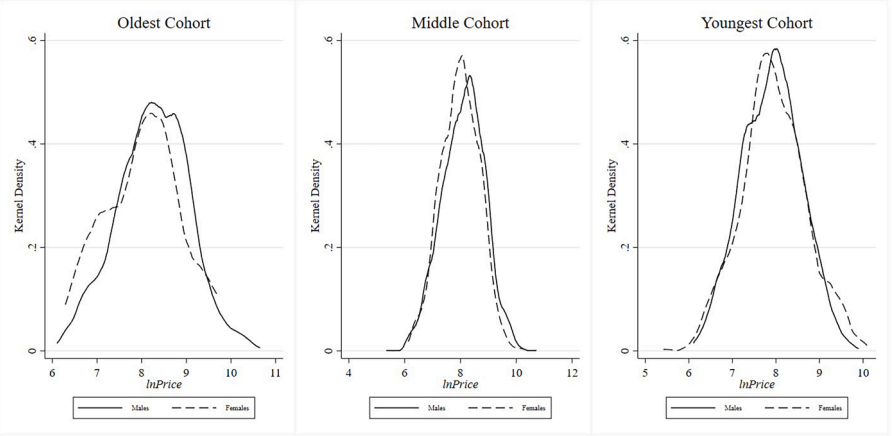

Fig. 1. Painting prices in the Dutch primary art market by gender and cohorts.

Table 2
Wilcoxon rank-sum and Kolmogorov–Smirnov tests for equality of the price distributions functions.

	Total sample		Oldest Cohort		Middle Cohort		Youngest Cohort	
	W. rank sum test	K-S test	W. rank sum test	K-S test	W. rank sum test	K-S test	W. rank sum test	K-S test
Test Value	6.559	0.078	2.104	0.154	6.150	0.093	-1.182	0.049
P-value	0.000	0.000	0.035	0.063	0.000	0.000	0.237	0.168

[7] Even though Fig. 1 may imply that the more unequal distributions correspond to the older cohort, the disparity in the number of observations among the groups (the older cohort having many fewer observations than the other cohorts), and their respective degrees of freedom, lead to a higher p-value for the statistical rejection of the null hypothesis of distributional equivalence for the older cohort.

Table 3
Values of the *t*-test statistic of females' paintings at the upper end of the Dutch primary art market.

	Oldest cohort	Middl cohort	Youngest cohort
# paintings in top 1 percentile	8.9221***	4.6423***	-3.0587***
# paintings in top 5 percentiles	-0.4753	5.5830***	-3.3661***
# paintings in top 10 percentiles	-0.3159	6.2111***	-1.8317*
# paintings in top 25 percentiles	1.7358*	4.7547***	-1.4016

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

distributions or in the Wilcoxon rank-sum and Kolmogorov-Smirnov tests, the present results do not necessarily imply the absence of discrimination in prices.

Finally, to examine the upper end of the price distributions, within each cohort, we divided the price distribution into two distinct categories: paintings that fall within the top 1 percent of the price distribution, and those that do not. We then performed an unpaired *t*-test to compare the probability that a painting in the top group is created by a female artist, compared to this probability for the rest of the price distribution. Under the null hypothesis, which assumes equality of means in both market segments, the male-female ratio in the most exclusive one would be equal to this ratio for the whole art market. We repeated this procedure for the top 5, 10 and 25 percent.

Table 3 displays the values of the *t*-test statistic, comparing the average number of paintings by female artists in each cohort with the top-priced paintings of that age group, assuming that there is unequal variance within each subgroup identified. In this table, large positive values indicate that the respective cohort as a whole has an overrepresentation of male paintings among the top 1, 5, 10 or 25 percent most expensive paintings of that cohort. On the other hand, large negative values indicate just the opposite, an over-representation of female-made artworks in the most expensive paintings of the cohort.

The results reveal that, in the oldest and middle cohorts, if differences in the proportion of female artists in the most expensive paintings versus the rest of the market are significant, then female artists are comparatively underrepresented in the most expensive segment. However, among younger painters, being a female artist does not negatively affect the likelihood of being successful in the Dutch primary art market. In fact, female artists are significantly overrepresented at the upper end of this art market. Thus, the Oaxaca-Blinder's assumption that paintings by male and female artists constitute two independent and distinct segments of the art market may be overly rigid. This is particularly pertinent for the younger cohort as, for this group, being a female artist does not, *a priori*, seem to be an obstacle to obtaining very high prices for their artworks. Although obtained without considering the characteristics of the artworks, the results of this section provide an initial understanding of how the gender price gap varies among the different artists by cohorts in the Dutch art market. More importantly, they are consistent with our hypothesis that, in this market, the gender gap in prices is narrower as we look at younger artists. In the next section, we use regression models to include the paintings' characteristics to explain the price gap between Dutch female and male artists, and to assess the extent to which this gap, if significant, can be attributable to differences in the artworks' characteristics, or whether it is due to discrimination.[8]

5.2. *Decomposing the gender price gap using regression methods*

With the price distributions having been analysed, in this section we present the results of the decomposition of the gender price gap of prices by cohort. Two possible and traditional methods can be used to do this. First, we estimated a simple model including cohort and gender dummies and their cross effects, with and without controls. The results are presented in Table A1 in the Appendix. Second, the Oaxaca (1973) and Blinder (1973) model was estimated independently by gender and cohort.

Nevertheless, this approach presented two caveats in our case. First, considering the results of the previous section, the implicit grouping assumption of the Oaxaca-Blinder model may be inaccurate. Second, the female sample of the oldest cohort does not have enough variation in the independent variables to allow the estimation of the full set of coefficients for this group. This also made it difficult to decompose the observed gender gap in art prices into the part explained by differences in the observed paintings' traits, as well as the part due to differences in how the market rewards the observable characteristics, which is usually labelled as discriminatory. Nevertheless, in order to show that our results are robust, the Oaxaca-Blinder equations and the corresponding gender price gap decomposition are presented in the Appendix (Tables A2 and A3). In addition, to partially address the limitations in the sample variability of the oldest cohort, we included paintings by artists born before 1920 in the Oaxaca-Blinder estimations.

As previously mentioned, four alternative models in terms of the age cohorts were estimated. From the segmentation equation of the four estimated models, Table 4 displays the average *ln(Price)* at both segments and the average probability of artworks having been sold in segment 1 and segment 2. Moreover, since we are interested in any potential systematic allocation of female artists to these segments, these probabilities were also computed conditional on the artist's gender.

Prices are always higher in segment 1. However, the estimated average prices in both segments can differ by as much as 60 percent (model 2, i.e. the 1940–59 cohort) or as little as 6 percent (model 3, i.e. the 1960–79 cohort). If the price differences between segments

[8] It is worth noting that even the price gap attributed to differences in characteristics may be influenced, at least in part, by the presence of discrimination. Women's choices to engage in different forms of artistic expression compared to those of men could be linked to the anticipation of the discrimination they will face when selling their artworks.

Table 4
Marginal predicted probabilities and average ln(Price) by segments.

	Oldest Cohort	Middle Cohort	Youngest Cohort	Total sample
ln(Price)	8.1437	7.9675	7.7939	7.9511
If male	8.1545	7.9999	7.7812	7.9763
If female	7.9177	7.8871	7.8299	7.8728
ln(Price) segment 1	8.1790	8.1507	7.9514	8.1601
ln(Price) segment 2	8.0192	7.4552	7.8978	8.0015
Probability segment 1	0.6860	0.4406	0.3099	0.2617
If male	0.7099	0.5190	0.3002	0.2988
If female	0.1634	0.2423	0.3376	0.1446
Probability segment 2	0.3140	0.5594	0.6901	0.7383
If male	0.2901	0.4810	0.6998	0.7012
If female	0.8366	0.7577	0.6624	0.8554

have their origin in a gender gap, a non-random allocation of female and male artists between segments is required. This would imply that the respective probabilities of male and female artists being in a particular segment must be dissimilar. From Table 4, it is clear that the convergence of the membership probabilities is conditional on the artist's gender as we approach the youngest cohort, which

Table 5
Estimated FMM of hedonic prices for the Dutch primary art market.

	Model 1 (Oldest Cohort)		Model 2 (Middle Cohort)		Model 3 (Youngest Cohort)		Model 4 (Total sample)	
Logit eq. (prob of belong to segment 2)								
Female	97.615* (1.69)		0.929*** (2.76)		21.842*** (4.17)		2.036*** (7.11)	
Year_b	0.262 (1.40)		0.082*** (3.47)		0.658** (2.34)		0.015 (0.88)	
Year_b_Sq	0.002 (0.40)		0.006 (0.99)		-0.014* (-1.93)		0.006*** (5.42)	
Female*Year_b	10.704 (1.53)		-0.067 (-1.54)		-2.229*** (-3.69)		0.120*** (3.61)	
Female*Year_b_Sq	0.293 (1.39)		0.017* (1.82)		0.050***(3.20)		-0.014*** (-7.36)	
Constant	2.895* (1.83)		-0.358 (-1.49)		-7.511*** (-2.86)		0.161 (0.74)	
Ln(Price) equations for each segment of the art market								
	Segment 1	Segment 2	Segment 1	Segment 2	Segment 1	Segment 2	Segment 1	Segment 2
Age at sale	0.511***	-0.269	-0.091	-0.046	0.201**	0.055	0.043***	-0.009**
	(6.34)	(-1.44)	(-1.58)	(-1.11)	(2.39)	(1.44)	(3.50)	(-2.10)
Age at sale sq.	-0.003***	0.002	0.001*	0.000	-0.003**	-0.000	-0. 000***	0.000***
	(-5.94)	(1.27)	(1.78)	(1.27)	(-2.27)	(-0.89)	(-3.85)	(5.43)
Size	4.3e-05***	8.4e-06***	6.3e 06**	1.1e-04***	4.0e-05***	4.4e-05***	7.8e-06***	4.5e-05***
	(15.04)	(5.02)	(2.56)	(7.31)	(8.92)	(23.99)	(4.15)	(24.53)
Size sq.	-8e-12***	-2e-12***	-5e-12***	-2e-9***	-1e-10***	-1e-10***	-6e-12***	-8e-12***
	(-14.97)	(-4.81)	(-2.72)	(-5.43)	(-10.06)	(-22.73)	(-3.76)	(-24.39)
Acrylic	-0.211**	-0.195	0.054	0.182**	-0.537**	0.012	0.681***	-0.231***
	(-2.21)	(-0.98)	(0.38)	(2.15)	(-2.23)	(0.10)	(3.32)	(-3.98)
Oil	-0.092	0.419**	0.069	0.400***	-0.909***	0.339***	0.835***	-0.101
	(-1.35)	(2.30)	(0.44)	(4.65)	(-5.87)	(3.95)	(3.83)	(-1.62)
Watercolour	-0.203	0.036	-0.211	0.060	-0.602***	-0.645***	0.506*	-0.511***
	(-1.25)	(0.20)	(-1.16)	(0.41)	(-3.58)	(-4.56)	(1.66)	(-6.43)
Mixed	-0.059	0.192	-0.069	0.192**	-0.094	0.005	0.620***	-0.136**
	(-0.58)	(0.83)	(-0.46)	(2.01)	(-0.54)	(0.07)	(2.99)	(-2.34)
Canvas	0.408	0.605***	-0.176	0.290*	0.195	0.136	-0.193**	0.360***
	(1.13)	(2.75)	(-1.14)	(1.85)	(1.40)	(0.75)	(-2.12)	(4.44)
Panel	-0.204	0.558**	-0.314**	0.470**	1.190***	-0.222	-0.317***	0.253***
	(-0.55)	(2.31)	(-1.98)	(2.39)	(8.75)	(-1.12)	(-3.13)	(3.00)
Paper	0.063	-0.201	-0.318*	-0.083	-0.101	0.058	-0.313**	-0.057
	(0.17)	(-0.81)	(-1.87)	(-0.48)	(-0.24)	(0.15)	(-2.17)	(-0.62)
Unknown med	0.202	-0.078	-0.347**	0.200	0.109	0.054	-0.454***	0.213**
	(0.57)	(-0.33)	(-2.24)	(1.19)	(0.75)	(0.29)	(-3.99)	(2.57)
Figurative	-0.316***	0.111	0.283***	0.070*	-0.275***	0.264***	0.717***	-0.131***
	(-6.78)	(0.88)	(2.91)	(1.68)	(-3.85)	(6.73)	(5.77)	(-4.79)
# artworks	0.013***	0.005	-0.007*	0.002	0.002	-0.009***	-0.014***	0.005***
	(5.95)	(1.04)	(-1.93)	(0.98)	(0.63)	(-4.34)	(-4.20)	(5.05)
Constant	-12.351***	18.488***	10.798***	8.100***	4.854***	6.101***	6.579***	7.897***
	(-4.05)	(2.82)	(6.87)	(6.86)	(2.83)	(8.12)	(14.72)	(53.74)
var(e.Ln(Price))	0.215***	0.267***	0.431***	0.194***	0.186***	0.227***	0.293***	0.299***
	(12.65)	(9.37)	(21.28)	(5.42)	(7.36)	(12.65)	(6.77)	(31.54)
N	1674		6518		2730		10922	
AIC	2879.9		11644.5		4312.4		19816.1	
BIC	3183.6		12024.3		4643.5		20224.8	

Robust t statistics in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

also features a smaller price difference. These two results reveal that the gender price gap, if it does exist at all, is narrower among the youngest artists. However, there is another potential component of the gender price gap. Paintings produced by female and male artists may systematically differ in their characteristics, implying a price difference that cannot be considered as discriminatory, since this difference would be caused by applying the same market reward to paintings' features that are unevenly distributed when comparing male and female artists. Table 5 presents the estimated parameters for all models with two market segments, including how the segments value the characteristics of the paintings.

With regards to the independent variables of the price equations, in the most expensive segment, age at the time of sale has no significant effect for the intermediate cohort (1940–1959), but it has a significant inverted u-shaped effect in the other three models, with a declining return at the end of the artist's life. In the less expensive segment, age has only a significant effect on the overall sample, showing a decreasing effect, which probably captures the between-cohorts' differences in prices, which are not relevant when estimating just a one-cohort model.

Artwork size presents the expected effect in all segments, as prices increase with size, but at a decreasing marginal rate, as in Farrell et al. (2021). Moreover, the curvature of the quadratic effect is small, and we only estimate a decrease in price for the largest one percent in Model 3. In terms of the medium, paintings on canvas tend to be more expensive in the cheap segment, which could be a signal of the importance of medium (canvas, panel, paper, etc.) in the contemporary art market. Paper, as expected, either has a non-significant or a negative effect on the price, whereas panel presents mixed effects that change along the cohorts. For instance, among the youngest artists (Model 3), price differences between segments are relatively small. However, paintings on panel have a significant positive impact on prices in the more expensive segment. Conversely, for the other three models, paintings on panel exhibit a negative sign in the most expensive segment, although the effect is not significant for the oldest cohort. With reference to the technique, the considered dummies (oil, acrylics, etc.) present mixed results.

Moreover, no systematic differences are estimated associated with the artwork's style. According to the corresponding *t*-test on mean differences, the average price is similar for abstract and figurative paintings for model 3 (the youngest cohort) and model 4 (the whole sample), respectively. This is consistent with the simultaneous effects estimated in these two cases, with a positive impact on prices in one segment, and the opposite effect in the other, associated with figurative paintings. Conversely, for the oldest cohort (model 1), abstract paintings are, on average, more expensive due to the higher price of abstract artworks in segment 1, while for those painters born between 1940 and 1959 (the middle cohort), the figurative style commanded a higher price in both segments. For the youngest cohort, the two segments seem to be closely related to the style, since abstract paintings command higher prices in the most expensive segment of this art market, while figurative artworks command higher prices in the less expensive segment.

To conduct the decompositions of the gender price gap using both the FMM and the Oaxaca-Blinder regression results, first, an assessment of the price of any painting if it were painted by an artist of the opposite gender is needed. Hence, the gender price gap decomposition, regardless of the regression approach, is based on a type of out-of-sample predicted values. Therefore, the prediction power of the estimates becomes particularly important. We have computed the Root Mean Squared Error (RMSE) of all the estimated regressions to assess the predictive accuracy, always obtaining a smaller value for the FFM (Table 6). Consequently, using all available information to segment the art market leads to a better forecasting accuracy by the FMM estimations, compared to using the two independent equations, as in the Oaxaca-Blinder model.

Using forecasts from models 1 to 4, Table 7 displays the gender price gap decomposition in two parts: the component associated with differences in the paintings' average characteristics produced by male and female artists, and the component due to a different allocation of males' and females' artworks to the two art segments, and a different reward by gender of the same artwork features.

From Table 7 it is possible to observe that, for the whole sample, differences in prices were around 9 percent, and they were due not only to both differences in the average characteristics of the males' and females' artworks, but also to how the market valued them differently. Regarding price differences by cohorts, they are only significant at the one percent level for the oldest cohort, i.e. those

Table 6
Root mean squared error.

	FMM	Oaxaca–Blinder
Oldest cohort	0.484	0.606
Middle cohort	0.520	0.614
Youngest cohort	0.441	0.534
Total sample	0.543	0.637

Table 7
Gender price gap estimated decomposition.

	Total Gender Price Gap	Differences in features	Differences in rewards
Oldest cohort	0.242216*** (0.07291)	0.223703*** (0.07272)	0.018513 (0.08361)
Middle cohort	0.029733** (0.01240)	-0.004378 (0.01208)	0.034111** (0.01497)
Youngest cohort	-0.024538 (0.02112)	-0.018334 (0.02051)	-0.006204 (0.02655)
Total sample	0.093589*** (0.01033)	0.039162*** (0.01029)	0.054427*** (0.01202)

Note: Standard error in parentheses. *$p < 0.10$, **$p < 0.05$, ***$p < 0.01$.

Table 8
Age cohorts' comparison.

Cohort	Gender	Size	Canvas	Panel	Figurative
Oldest cohort	Male	12,171.4	0.538	0.094	0.497
	Female	5748.0	0.288	0.526	0.684
Middle cohort	Male	9731.4	0.545	0.205	0.744
	Female	9362.0	0.685	0.115	0.727
Youngest cohort	Male	10,782.2	0.580	0.172	0.810
	Female	10,960.0	0.653	0.100	0.762

Table 9
Average number of paintings sold between 2000 and 2010 by gender and age cohort in the Dutch primary art market.

	Male	Female	*t*-test
Oldest cohort	21.13	10.10	2.6967
Middle cohort	16.46	16.63	-0.070
Youngest cohort	15.44	13.04	0.974

Dutch artists born between 1920 and 1939. However, although the differences are quite large, we cannot consider them as discriminatory for this cohort, but rather as being based on the observable characteristics of the artworks. On average, if paintings by female artists were rewarded as if they had been painted by a male artist, they would have been only 1.8 percent more expensive, which is not significantly different, statistically, from zero. Hence, price differences are mainly related to the dissimilarities between the artworks produced by male and female artists. The forecasted females' paintings' prices, if we were to assume that they had been produced by their male counterparts, are 24 percent lower than the forecasted prices for male artists' creations.

Among artists born between 1960 and 1979, the observed price differences were negative, i.e. women's paintings were sold at a 2.5 percent higher price than those by male artists. Moreover, the differences associated with artwork characteristics are also negative, meaning that young female artists produce artworks with slightly more marketable characteristics than young male painters. Additionally, the market rewards women slightly better than men. These three differences are not significant, and we conclude that such price differences are absent among the youngest artists. If the gender price gap is linked to discriminatory social attitudes (Janssen et al., 2015), this result is a signal of the improvement in the social status of young female artists relative to their male counterparts.

By contrasting the cohorts, the younger the cohort, the lower the price and, hence, the younger artists of both genders perform worse than older painters. However, differences between genders are smaller for the youngest cohort. These results are in line with the cohort effects found by Addison et al. (2019) regarding occupational mismatch, as females of younger cohorts suffer from a lesser mismatch than older female workers, with the reverse being the case for males. Therefore, our findings, as is the case with Addison et al. (2019), can provide some support for the concept of *grand gender convergence* (Goldin, 2014), that is, the narrowing of the current gender earnings gap in the workplace.

Furthermore, it could be claimed that women have been adapting their artistic production decisions in such a way that the younger generations of female artists produce paintings whose observable characteristics are, on average, similar to those of their male counterpart artists. This convergence can be observed in Table 8. For example, paintings by women from the older cohort are, on average, less than one half the size of those produced by men; meanwhile, young female artists produce paintings that are even larger than those of their male counterparts. A similar argument can be applied with regard to the medium or the style.

Finally, if we look at the average number of paintings sold by male and female artists by cohorts (Table 9), there are no significant differences, with the exception of the oldest cohort. For the oldest cohort, on average, the number of paintings sold by female artists (10.10) represents less than half that of their male counterparts (21.13). Hence, female artists in the oldest cohort not only received a lower price for each painting, but they were also only able to sell a significantly smaller number of paintings compared to their male counterparts.

We can conclude that, when we consider middle and youngest cohorts, the gender disparity in quantity (measured by the number of paintings sold) diminishes, and the disparity in quality, measured by the observable characteristics of their paintings, also decreases. In a nutshell, we have observed that the null hypothesis of the equal prices of artworks painted by male and female artists in the younger cohort cannot be rejected. Additionally, their observable characteristics by gender are more similar compared to those observed for the paintings by artists belonging to the middle and oldest cohorts. Furthermore, we have found no significant differences in the number of

artworks sold by male and female artists from the youngest cohort. Hence, this supports the notion that young female artists who decide to enter the Dutch art market face similar access conditions to male artists of the same cohort.

6. Conclusions

With the present study, we document how the art price gender gap significantly varies across cohorts in the Dutch primary labour art market in the first decade of this century. Our findings also reveal that the gender gap in prices is narrower among younger artists compared to older artists, and it is statistically insignificant within the youngest cohort. This is an area that is underexplored due to a lack of data, mainly as regards artwork sales. Nevertheless, it represents the only entry point to the art market for new artists and the first step toward a successful artistic career. However, measuring the artistic quality of artworks objectively is challenging and, as a result, biases based on gender may play a significant role (Adams et al., 2021) in the entry/hiring decisions made by galleries, similar to the effects of sex-biased prejudices' influence on hiring decisions in other artistic domains (Goldin and Rouse, 2000). If access to the primary art market is equally difficult for female and male artists, we would anticipate a narrower gender price gap among artworks being sold, more equitable career opportunities and no differential gender attrition (as in Bohren et al., 2019). On the contrary, framing the problem using the exit-voice trade-off (Freeman, 1980; Hirschman, 1970; Hirschman, 1976; Williamson, 1976), unequal entry conditions in a context with low bargaining power and, hence, no voice mechanism to express concerns and seek for improvements, gives the artist only the option of the exit mechanism. This has been the most likely case in the primary market of contemporary art until recent times, giving rise to a strong process of attrition, i.e. the implementation of the exit mechanism, which is more accentuated in the case of less successful artists, traditionally women.

We used finite mixture models (FMM) to divide the Dutch primary art market into two segments: one that could be considered the "privileged" one, with higher prices, and the other one characterised by lower prices. This allowed us to estimate the probability of a specific artwork being sold in a particular segment, even when this probability is unobserved. Conditional on the observable characteristics, we computed the posterior probabilities of an artwork being sold in the privileged segment. Interestingly, for the two oldest cohorts, this probability is much higher for paintings by males than by females. However, the youngest females access the favoured segment with a similar probability to their male counterparts. Using the posterior probabilities, we estimated the art price gender gap at the beginning of this century for three different artist cohorts. Since price differences can be accounted for by both differences in the average characteristics of the male and female artists' artworks, as well as how the market values them differently, we decomposed the total gender price gap in these two components. Put simply, the overall difference in price is significant for the two oldest cohorts; this is mainly due to differences in the observable characteristics of the male and female artists' artworks for the oldest cohort, and to discriminatory characteristics for the middle cohort. However, for artists born between 1960 and 1979 (the youngest cohort), the observed price difference and its two components are not statistically significant. This can be explained by the fact that young female artists produce artworks with similar observable characteristics as young male artists, and the artworks' characteristics were valued similarly, regardless of the gender of the artist in this cohort. Therefore, we can conclude that average price differences by gender are irrelevant among the youngest artists. In summary, although entry into, and consolidation in, the art market may still be difficult, we found no evidence of gender-based price differences for the artists entering the Dutch primary art market at the beginning of the 21st century (the youngest cohort). Given the nature of our data, we cannot be completely certain that there is no alternative explanation, but we can say that these findings are consistent with the temporal pattern indicated by Goldin and Rouse (2000) for American orchestras, and the link between the creative sectors and the rest of the economy.[9] Moreover, because of the fact that artists' earnings are dependent on paintings', prices can be considered a flexible payment mechanism that exhibits linearity with respect to time worked, our findings are also compatible with the *grand gender convergence* (Goldin, 2014).

Moreover, young female artists have adapted their artistic production to be similar to that of their male counterparts. When comparing the three cohorts, it seems that female artists, as the human capital gap in their artistic formation narrowed in the Netherlands (Brouwer and Meulenbeek, 2000; Joosten-Merx, 2007), were able and wanted to adapt their artistic production to trigger a convergence process between female and male artists, thereby closing the gender price gap in the Dutch primary art market.

In fact, the younger generation produces paintings whose observable characteristics are - on average – identical, irrespective of the gender of the artist. Gender equality policies, which have resulted in the elimination of the gender gap in artistic skills and education for this cohort (Brouwer and Meulenbeek, 2000; Rommes, 2018; Verloo, 2018), have enabled young artists to enter the art market under similar conditions and to produce similar paintings. This can be assumed to be the result of education and policy actions undertaken by the Dutch government since the 1970s (Visser and Hemerijck, 1997). Furthermore, looking at the available figures for art education, specifically for the Netherlands, the percentages of female and male graduates are equal[10] (Brouwer and Meulenbeek, 2000; Mondriaanfonds 2018), or even higher for women,[11] and the volume of art grants awarded to female high education students in the

[9] "Even though the fraction of new hires who are female rises at somewhat different times across the orchestras, there is a discernible increase for the group as a whole in the late 1970's to early 1980's, a time when the labour force participation of women increased generally and when their participation in various professions greatly expanded" ((Goldin and Rouse, 2000), p. 718).

[10] The same balance has been observed by Cameron et al. (Cameron et al., 2019) in their study on Yale art graduates. More generally, with respect to educational attainment, the glass ceiling has been broken in different countries (Bar-Haim et al., 2018).

[11] In his study on the cohorts of arts graduates who entered the labour market in the years 1993, 1994 and 1995, Rengers (Rengers, 2000, Rengers, 2001) observed that the increase in the number of arts graduates over the past decades can largely be attributed to a growing influx of women, and they found that nearly 60 percent of arts graduates in their study were women.

Netherlands is also equal (Mondriaanfonds 2018).

This is in line with Noback et al. (2016), who observed significant changes in terms of gender equality in the Dutch labour market. However, we cannot reject the possibility that, as they grow older, a gender gap in artwork prices will appear among Dutch artists who were in the early stages of their careers at the beginning of this century.

Thanks to this analysis, first, we have gained a deeper understanding of how the gender gap in art prices varies across different age cohorts in the Dutch primary art market. Previous literature was only able to identify - for the same Dutch market - a difference in selling price for female artists of 20 percent lower than for their male counterparts (Rengers and Velthuis, 2002). Second, we reveal that, in the Dutch primary art market, artists' age is a relevant factor in understanding artists' careers, but gender is less important, as in Baldin and Bille (2021) for Denmark. Third, we find that young female artists have found ways in which to make their production to be attractive in this market, without observing any significant difference in the average price or the number of paintings sold by each artist.

The lower presence and mobility of female artists at the top of the art market has traditionally been attributed to the problem of attrition (Bocart et al., 2018). This mechanism, based on the anticipation of lower revenues by less successful artists, may particularly discourage female artists from pursuing a professional artistic career. However, as a cumulative mechanism, it does appear to be more significant in the primary art market for the older cohorts. Our results can be extended to other creative sectors such as high-end gastronomy, academia or journalism and other sectors where freelance jobs are prevalent and gatekeepers and experts are essential to assess quality.

This study has limitations that may be viewed as useful opportunities for future research. First, the dataset does not allow us to analyse dynamic changes; we can only compare differences among age cohorts at a certain point in time, but we cannot derive any conclusions about the relative situation of male and female artists that may evolve within an artists' cohort. Second, the dataset gathered refers only to the Dutch art market. It could be useful to apply the same methodological approach to other contemporary primary art markets in different geographical contexts, to verify if the present results hold for these countries and their labour markets too. Third, it could be even more interesting to extend the analysis to other sectors characterised by professionals of both genders competing to gain a better reward when quality is difficult to assess, particularly *a priori*, such as with engineers, lawyers, doctors or academics. Expanding the reach beyond the primary art market would provide a comprehensive understanding of the true significance of education and equality policies developed in the Netherlands and in many Western countries. These policies have created opportunities for females to pursue professional challenges that were previously less accessible. By examining the impact of these policies in various contexts and sectors, we can better appreciate the broader implications and benefits they bring to gender equality and women's empowerment.

Declaration of competing interest

The authors declare that they have no known competing interests or personal relationships that could have appeared to influence the work reported in this paper.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.euroecorev.2023.104657.

Appendix

Table A1
Simple female artist-cohort price equations.

	Cohort 1		Cohort 2		Cohort 3		Total sample	
	No controls	Controls	No controls	Controls	No controls	Controls	No controls	Controls
Female	-0.2368**	0.1754	-0.1128***	-0.1300***	0.0487	0.0214	–	–
	(0.1021)	(0.1219)	(0.0197)	(0.0191)	(0.0325)	(0.0297)	–	–
Middle Cohort	–	–	–	–	–	–	-0.155***	-0.047
	–	–	–	–	–	–	(0.023)	(0.038)
Youngest Cohort	–	–	–	–	–	–	-0.373***	-0.372***
	–	–	–	–	–	–	(0.025)	(0.049)
Female*Oldest Cohort	–	–	–	–	–	–	-0.237**	-0.132
	–	–	–	–	–	–	(0.102)	(0.105)
Female*Middle Cohort	–	–	–	–	–	–	-0.113***	-0.143***
	–	–	–	–	–	–	(0.020)	(0.019)
Female*Youngest Cohort	–	–	–	–	–	–	0.049	0.024
	–	–	–	–	–	–	(0.033)	(0.032)
N	1674	1674	6518	6518	2730	2730	10922	10922
R-sq	0.004	0.235	0.005	0.123	0.001	0.238	0.024	0.098
adj. R-sq	0.003	0.228	0.004	0.121	0.001	0.234	0.024	0.097
AIC	4065.7	3650.5	14754.3	13952.5	5879.4	5165.8	24739.2	23903.3
BIC	4076.6	3731.8	14767.8	14054.2	5891.2	5254.5	24783.0	24042.0

Note: Standard errors in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table A2
Oaxaca-Blinder estimated price equations.

	Total sample		Oldest cohort		Middle cohort		Youngest cohort	
	Male	Female	Male	Female	Male	Female	Male	Female
Age at sale	0.0185***	0.0214***	0.0354***	-0.4847***	-0.1958***	-0.0659	0.1705***	0.1210**
	(0.003)	(0.005)	(0.011)	(0.086)	(0.025)	(0.049)	(0.034)	(0.057)
Age at sale sq	-8.9e-05***	-1.9e-04***	-1.9e-04***	2.7e-03***	1.7e-03***	5.2e-04	-2.2e-03***	-1.5e-03**
	(2.2e-05)	(4.3e-05)	(6.2e-05)	(5.0e-04)	(2.3e-04)	(4.7e-04)	(4.3e-04)	(7.5e-04)
Size	7.6e-06**	5.7e-05***	1.3e-05***	1.9e-05	1.9e-05***	5.8e-05***	3.9e-05***	6.2e-05***
	(3.3e-06)	(2.9e-06)	(2.9e-06)	(2.2e-05)	(4.1e-06)	(3.5e-06)	(2.1e-06)	(6.4e-06)
Size sq.	-1.4e-12**	-5.6e-10***	-2.4e-12***	5.5e-10	-1.5e-11***	-6.0e-10***	-9.8e-11***	-5.7e-10***
	(6.0e-13)	(6.1e-11)	(5.4e-13)	(6.7e-10)	(3.0e-12)	(7.8e-11)	(5.1e-12)	(1.7e-10)
Acrylic	0.0435	-0.0733	-0.0789	0.4011*	0.3636***	0.0270	-0.2408***	-0.4261**
	(0.044)	(0.079)	(0.082)	(0.205)	(0.068)	(0.087)	(0.073)	(0.185)
Oil	0.0718*	-0.0170	0.1571***	0.7488***	0.3256***	0.0675	-0.0651	-0.2486
	(0.039)	(0.077)	(0.060)	(0.254)	(0.066)	(0.084)	(0.065)	(0.176)
Watercolor	-0.3364***	-0.2199*	-0.3692***	-0.3310	0.0770	-0.1589	-0.7693***	-0.6779**
	(0.063)	(0.133)	(0.102)	(0.296)	(0.098)	(0.140)	(0.125)	(0.263)
Mixed	-0.0921*	0.0590	0.1068	–	0.2124***	0.0845	-0.2064***	-0.2748
	(0.047)	(0.083)	(0.113)	–	(0.073)	(0.093)	(0.077)	(0.186)
Canvas	0.3568***	0.2669*	0.5174	0.5460	0.3026**	0.4174**	0.3300***	-0.2872***
	(0.098)	(0.159)	(0.382)	(0.586)	(0.141)	(0.168)	(0.121)	(0.057)
Panel	0.1864*	0.3895**	0.0329	-0.1351	0.1915	0.5389***	0.3253**	-0.2916***
	(0.105)	(0.166)	(0.388)	(0.570)	(0.147)	(0.178)	(0.127)	(0.100)
Paper	-0.0397	0.1893	0.1153	–	-0.1316	0.2537	0.2228	-0.4184**
	(0.109)	(0.172)	(0.391)	–	(0.155)	(0.180)	(0.158)	(0.207)
Unknown med	0.2296**	0.1740	0.3800	0.0407	0.1940	0.3123*	0.2586**	-0.3551***
	(0.101)	(0.162)	(0.381)	(0.604)	(0.145)	(0.171)	(0.124)	(0.066)
Figurative	-0.0384**	0.1608***	-0.3676***	0.5925***	0.2420***	0.0676**	-0.0828**	0.4105***
	(0.019)	(0.026)	(0.037)	(0.175)	(0.026)	(0.032)	(0.035)	(0.050)
# artworks	0.0051***	0.0199***	0.0153***	0.0148	-0.0062***	0.0114***	-0.0098***	0.0439***
	(0.001)	(0.002)	(0.001)	(0.021)	(0.002)	(0.002)	(0.001)	(0.004)
Constant	6.8503***	6.3250***	5.9936***	26.9994***	12.5802***	8.8290***	4.1147***	4.9043***
	(0.146)	(0.222)	(0.613)	(3.524)	(0.696)	(1.311)	(0.683)	(1.081)
N	8524	2684	1859	101	4643	1875	2022	708
R-sq	0.088	0.217	0.252	0.607	0.129	0.191	0.260	0.391
adj. R-sq	0.086	0.213	0.247	0.554	0.126	0.185	0.255	0.378
AIC	19027.9	5254.3	3991.0	177.8	10124.8	3618.9	3656.2	1303.5
BIC	19126.7	5336.8	4068.4	206.5	10215.0	3696.4	3734.8	1367.4

Note: Standard error in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table A3
Oaxaca-Blinder estimated price gaps.

	Male ln(Price)	Female ln(Price)	Total Gender Price Gap	Differences in features	Differences in rewards
Oldest cohort	8.165*** (0.019)	7.821*** (0.083)	0.344*** (0.085)	0.336*** (0.039)	0.008 (0.093)
Middle cohort	8.000*** (0.011)	7.887*** (0.016)	0.113*** (0.020)	-0.012 (0.008)	0.125*** (0.018)
Youngest cohort	7.781*** (0.015)	7.830*** (0.029)	-0.049 (0.033)	-0.029* (0.016)	-0.020 (0.028)
Total sample	7.984*** (0.008)	7.870*** (0.014)	0.114*** (0.016)	0.019*** (0.006)	0.095*** (0.015)

Note: Standard error in parentheses. *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

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