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Where are the female composers? Human capital and gender inequality in music history☆

Karol Jan Borowiecki [a,*], Martin Hørlyk Kristensen [a], Marc T. Law [b]

[a] University of Southern Denmark, Denmark
[b] University of Vermont, United States of America

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ABSTRACT

Ludwig van Beethoven, Johann Sebastian Bach, and Frédéric Chopin are household names, but few will recognize Francesca Caccini, Elisabeth Lutyens or Amy M. Beach, who are among the top-10 female composers of all time. Why are female composers overshadowed by their male counterparts? Using novel data on over 17,000 composers who represent the entire history of western classical music, we conduct the first quantitative exploration of the gender gap among composers. We use the length of a composer's biographical entry in *Grove Music Online* to measure composer prominence, and shed light on the determinants of the gender gap with a focus on the development of composers' human capital through families, teachers, and institutionalized music education. The evidence suggests that parental musical background matters for composers' prominence, that the effects of teachers vary by the gender of the composer but the effects of parents do not, and while musician mothers and female teachers are important, they do not narrow the gender gap in composer prominence. We also find that the institutionalization of music education in conservatories increases the relative prominence of female composers.

1. Introduction

> Women are taught music, but not for the purpose of composing, only for executing it: and accordingly, it is only as composers, that men... are superior to women...
>
> *John Stuart Mill, 1869*

Throughout history, important inventions — like the printing press, the light bulb, and artificial intelligence — have largely been attributed to men. Men are credited with major discoveries, whether of new continents or in outer space. The most renowned

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* Correspondence to: Department of Economics, University of Southern Denmark, 5230 Odense, Denmark.
E-mail address: kjb@sam.sdu.dk (K.J. Borowiecki).

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works of art — paintings like the *Mona Lisa* or *Guernica*, or sculptures like *David* or the *Thinker* — were male creations. Science is still male dominated with only five women having won the Nobel Prize in Physics, and even fewer receiving the Nobel Prize in Economics or the Fields Medal in Mathematics. These observations prompt two questions. Are men indeed more prominent than women in significant human accomplishments, as first impressions suggest? And, if so, why?

We address these questions through the lens of classical music. Classical composers have left a legacy of magnificent and timeless masterpieces that continue to shape the cultural landscape. However, the classical cannon was written by men, and the composers with whom the public is most familiar — Bach, Beethoven, and Mozart, for instance — form an exclusively male group.[1] We focus on classical composers for three reasons. First, the gender gap among composers can be measured over an extremely long period — 1800 years — longer than has been documented for any other field of human endeavor. Second, the technology of composition offers no clear advantage to either gender and has remained unchanged until recently.[2] Third, we can measure composers' early exposure to music, as well as access to informal and formal training, which gives us leverage to investigate factors that influence the gender gap.

Using data on composers from *Grove Music Online* (henceforth *Grove*), on teacher–student linkages from Pfitzinger (2017), and on the location and founding dates of conservatories from the International Directory of Music and Music Education Institutions, we conduct the first systematic quantitative exploration of the classical composer gender gap, encompassing over 17,000 composers who span the entire history of western classical music.[3] Following Borowiecki et al. (2023) we measure the prominence of composers using the word counts of their biographical entries in *Grove*. These entries are written by experts who are charged with explaining the musical careers and contributions of their subjects. If experts have more to say about composers who are judged favorably by posterity, the word count of a biographical entry should be a reasonable proxy for a composer's prominence, with longer entries signifying greater importance.

Consistent with first impressions, we find a sizeable gender gap among composers in terms of their prominence and representation. Only six percent of composers in *Grove* are women, and, holding constant a composer's time period and country of birth, the biographical entries of female composers are 25 percent shorter. The magnitude of this gap narrows marginally with time and varies by geographic region.

We then turn to an investigation of the determinants of the gender gap. Music composition has historically been human capital intensive, but access to education has long varied by gender. Our conceptual framework therefore focuses on human capital and gender differences in its acquisition. We explore factors influencing composers' musical training, including their parents' musical background, the quantity and quality of their teachers, and their proximity to institutionalized musical education (e.g., conservatories). This allows us to develop a nuanced understanding of how disparities in access to training may have contributed to the gender gap.

We begin with families, historically a key channel for transmitting human capital (see, for instance De la Croix and Goñi, 2024). We assess whether female composers were more or less likely to have musician-parents, whether male and female composers benefited equally from this, and if musician-mothers were especially helpful for female composers. Our analysis of a matched sample reveals that male and female composers were equally likely to have musician-fathers, but female composers were three times more likely to have musician-mothers. Composers with musician-parents, particularly mothers, enjoy a significant prominence premium, though female composers do not gain an advantage over their male counterparts in this regard.

We then examine how teachers shape composers' human capital (e.g. Hanushek et al., 2019; Chetty et al., 2014; Rivkin et al., 2005). We find that female composers had more teachers than male composers but were not disadvantaged in terms of teacher quality. Composers with access to more and better teachers became more prominent, but the benefits were attenuated for female students. Additionally, female composer–teachers did not help narrow the gender gap.

Over time, musical training moved from households and informal networks to conservatories (Weber et al., 2001). We investigate how the rise of conservatories affected composer prominence and the gender gap, using geographic and temporal proximity to conservatories as a proxy for exposure. We find that the opening of a conservatory is associated with increased prominence among composers born nearby, greater prominence for female composers relative to males, but also a decline in the representation of female composers compared to male composers.

Finally, we turn to downstream consequences of the gender gap, specifically regarding female composers' roles as teachers and their use of pseudonyms. While a composer's gender does not correlate with the number or quality of their students, female composers are more likely to use pseudonyms, particularly those of the opposite-gender.

Before proceeding, it is important to clarify this study's scope and limitations. First, *Grove* is not a flawless source of information about composers. Although entries within it are periodically updated, they are highly persistent, and the predominance of men among music historians and biographers may introduce a "similar-to-me" bias in favor of male composers (Bagues and Perez-

[1] Classic FM's recent ranking of the 30 greatest composers includes only two women (Pentreath, 2023). Likewise, only two women appear in BBC Music Magazine's top 50 composers list (Wright, 2023). According to Bachtrack's 2022 statistics, there were no women among the top 10 most performed classical composers (Bachtrack, 2023).

[2] While musical instruments and consumption technologies have evolved, the art of composition has, until the rise of computing, only required a pen, staff paper, and brain. We have no reason to suspect that men should have a greater aptitude than women in the art of musical composition.

[3] The earliest composer listed in *Grove* is Bardaisan (born in 154 CE), followed by Hilary of Poitiers (310 CE). *Grove* includes only two women composers who were born before 1500: Kassia (810 CE) and Hildegard of Bingen (1098 CE). Therefore, while our regression analysis spans composers from the second century to the twentieth — covering the history of western classical music — our maps and figures comparing male and female composers start around 1500.

Villadoniga, 2012, 2013).[4] Second, historical social norms and prejudices concerning the role of women undoubtedly matter.[5] Relatedly, changes in the diverse market and production systems in which composers worked — for instance, the transition from court patronage to market-based systems (for a fuller discussion, see Barrère and Santagata, 1999; Scherer, 2004) — may also have had consequences for the gender gap among composers. We do not explore these factors explicitly, but we attempt to hold them constant and condition the interpretation of our findings in light of them. Finally, we hesitate to make strong causal claims due to the noisy, non-experimental nature of our data. The value of this study lies in its being the first rigorous quantitative analysis of women composers, shedding light on factors that may have disadvantaged them, contributing to our understanding of how human capital was formed in pre-modern societies, and addressing broader issues concerning the role of families, teachers, and formal educational institutions in shaping an important realm of human achievement.[6]

The remainder of this paper is structured as follows. In Section 2 we review related literature and highlight our contribution to scholarship on gender gaps in history as well as in the cultural sector. We outline our conceptual framework in Section 3. In Sections 4, 5, and 6 we discuss our data sources, present descriptive statistics, and provide estimates of the gender gap. Section 7 follows with our empirical exploration of the factors (families, teachers, and conservatories) that influence the extent of the gender gap. In Section 8, we discuss the downstream consequences of the gender gap, and we conclude in Section 9.

2. Related literature

Labor economists have extensively studied gender gaps, exploring a wide range of its causes (for an overview, see Blau and Kahn, 2017). Scholars have investigated the role of discrimination (e.g. Aigner and Cain, 1977; Becker, 1957), sex segregation (e.g. Bayard et al., 2003), access to birth control (e.g. Goldin and Katz, 2002; Bailey, 2006), labor regulations (e.g. Goldin, 1990, 1988), occupational characteristics (e.g. Goldin, 2021), parental role models (e.g. Adams et al., 2018), and cultural factors (e.g. Jessen, 2022) in explaining gender inequality. Additionally, studies have estimated gender gaps through history and the consequences of gender inequality for long run economic performance (e.g. Perrin, 2022; Perrin et al., 2023). We add to this literature in two ways. First, we introduce a novel approach to measuring the gender gap (the gender gap in prominence). Second, we emphasize the role of human capital acquisition in shaping the gender gap, highlighting how gender differences in access to training varies across different historical modalities such as families, networks of teachers, and conservatories. Our study enhances understanding of how different modes of acquiring human capital influence gender disparities.[7]

Another body of work to which our study relates concerns gender gaps within human capital intensive occupations over time. Iaria et al. (2022), for instance, investigate the gender gap among university faculty over the twentieth century while De la Croix and Vitale (2023) examine women in academia prior to 1800. Card et al. (2023, 2022) analyze gender gaps in peer recognition in science. We add to this vein of scholarship by documenting the gender gap in a different domain (musical composition), using a different approach (the length of composers' biographical entries in *Grove*) and over a much longer time horizon (several centuries) than previous studies which, with the exception of De la Croix and Vitale (2023), do not extend earlier than the mid-nineteenth century. Additionally, we build on these studies by investigating how differences in access to training contribute to historical gender gaps, with specific attention to the various historical modalities (families, networks of teachers, conservatories) in which training occurred. We therefore provides new insights into human capital formation during pre-modern times.

We also add to the literature on the role of teachers in narrowing the gender gap. In the context of K-12 education, several studies examine the effect of being assigned a "teacher like me" (along gender or racial lines) on student learning outcomes. Many of these studies report favorable effects. Dee (2007), for instance, finds that matching students to teachers of the same gender results in improved academic performance (for both male and female students) as well as improved teacher perception of student performance and engagement. Female teachers also narrow the gender gap in K-12 student performance (Winters et al., 2013; Muralidharan and Sheth, 2016). We extend this literature to a new setting, looking at the impact of same-gender matching on composer prominence. Unlike these studies, however, we do not find evidence that same-gender matching improves student outcomes, nor that female teachers are more effective than male ones in reducing the gender gap in composer prominence. However, we caution that our findings are not directly comparable, since the assignment of composition students to teachers is not random, and, for most of history, composition instruction was not conducted in a classroom (as in K-12 schooling), but on a one-to-one, master-pupil basis.

[4] We estimate that women authored 26 percent of the composer entries in *Grove* and nearly 60 percent of entries on female composers were written by women. The share of female composers in *Grove* might be higher if scholarship on composers were less male dominated. However, our estimate of the gender gap in composer prominence is robust to controlling for an author's gender.

[5] For instance, Fanny Hensel's (1805–1847) father, Abraham Mendelssohn, did not support his daughter's desire to compose. In a letter to Fanny, he wrote, "Music will perhaps become his [Felix's] profession, while for you it can and must be only an ornament" (see letter of 16 July 1820 in Hensel (1884, p. 82)). Music historian Richard Taruskin asserts that Hensel's life is "compelling proof that women's failure to 'compete' with men on the compositional playing-field has been the result of social prejudice and patriarchal mores". See Taruskin (2006, p. 186).

[6] Like many studies of human capital, we cannot distinguish the benefits of training from those of being in a network (see De la Croix and Goñi, 2024, for an exception). Composers with better teachers or from musical families receive superior training and benefit from networks that increase their visibility.

[7] While Perrin (2022) and Perrin et al. (2023) also examine historical gender gaps, our approach is quite different. Perrin (2022) and Perrin et al. (2023) are single-country studies (of France and Sweden, respectively) that measure gender gaps along a wide variety of domains (economic opportunities, educational attainment, and health), with the goal of understanding how gender inequality affects economic development. Our study, in contrast, focuses on a single occupation (musical composition), is not limited to a specific country, and has a different objective (to understand how differential access to training may have contributed to the composer gender gap). Although Perrin (2022) and Perrin et al. (2023) offer detailed country-specific insights, which may be obscured by our analysis, we identify overarching trends and patterns that may be applicable across different geographic contexts.

We contribute to a growing body of quantitative scholarship on "famous people" — inventors, academics, artists, and other creative individuals — who represent the far right tail of human talent and accomplishment. Among other things, these studies find that famous people are geographically mobile, tend to cluster geographically, are more likely to be from high income families, benefit from early exposure to their craft (either through their families or their proximity to others), and experienced improvements in longevity in advance of the general population (e.g. Bell et al., 2019; De la Croix et al., 2023; De la Croix and Goñi, 2024; De la Croix and Licandro, 2015; Serafinelli and Tabellini, 2022). In line with these studies, we show that family background and proximity to other creatives — via teachers or conservatories — matter for composer prominence. However, we extend this to investigate whether the importance of these factors varies by gender.

Methodologically, this paper is related to studies that use biographies as a data source. In economic history, scholars have used biographical data from a wide range of sources — for instance, *Deutsche Biographie*, *Wikipedia*, *Wikidata* and *Freebase.com* — to investigate far-right tail human capital individuals of earlier times (e.g. Dittmar and Meisenzahl, 2019; Laouenan et al., 2022; Yu et al., 2016; Serafinelli and Tabellini, 2022). Biographical data have also been used by cultural economists to study the clustering of visual artists and composers (e.g. Kelly and O'Hagan, 2007; O'Hagan and Borowiecki, 2010; Borowiecki, 2013). We extend this literature by adding gender to the analysis to see if the benefits of teacher quality and access were different for female composition students. We also go beyond teachers and gather information on composers' parents to investigate if parental musical background matters, and if the effects differ by gender.

Lastly, we add directly to the literature on the gender gap in artistic professions (e.g. Cowen, 1996). Much of this scholarship focus on visual artists (i.e., painters), using auction prices to measure the magnitude of the gender gap, with studies generally finding that the work of female artists is discounted and less likely to appear at auction (e.g. Vecco et al., 2024; de Beyssat et al., 2023; LeBlanc and Sheppard, 2022; Bocart et al., 2022; Hoffmann and Coate, 2022; Adams et al., 2021).[8] Another set of studies examines gender gaps in classical music performance. Goldin and Rouse (2000) find that the introduction of blind orchestra auditions raises the probability that female musicians advance in the recruitment process. Examining international classical music competitions, Asmat et al. (2024, 2023) present evidence suggesting that competition judges are biased against women. We document the gender gap in a new artistic occupation (composers) using a different measure of the gender gap (the gap in terms of prominence). Additionally, unlike these studies, we examine the role that differential access to training may play in driving gender gaps in artistic professions. Finally, we investigate the downstream consequences of the gender gap in terms of the use of pseudonyms to conceal gender, and whether being a woman affected a composer's ability to attract composition students. More generally, our study highlights the important role of gender differences in human capital acquisition for understanding gender gaps in the cultural sector.

3. Conceptual framework

This study is anchored in the principles of human capital theory, which posits that individuals acquire skills, knowledge, and abilities through education, training, and experience, all of which contribute to their productivity and economic value (Becker, 1964). In the context of music composition, human capital is accumulated through early exposure to music within families, the influence of teachers, and formal educational institutions (e.g., conservatories). The gender gap in classical music composition can be attributed to the differential accumulation of human capital between male and female composers, arising because of social norms, access to resources, and institutional barriers.[9]

Human capital theory suggests that early exposure to an environment rich in relevant knowledge and skills is crucial for development (e.g. Heckman, 2006). For composers, this often begins within the family, with musical talent being nurtured in households by musician-parents.[10] However, given historical gender norms, a parent's willingness to invest in a child's musical education may depend on the gender of the child, or, on the gender of the parent who possesses a musical background.[11] We hypothesize that the presence of musician-parents, particularly mothers, may have helped provide female composers with the necessary support to pursue composition, though this support might not have been sufficient to close the gender gap in prominence.

Teachers are also vital in transmitting knowledge and enhancing skills (e.g. Hanushek et al., 2019; Chetty et al., 2014; Rivkin et al., 2005). However, access to high-quality teachers has historically been gender-biased, with male students often receiving more attention and opportunities.[12] This study explores whether female composers were disadvantaged in their access to influential

[8] The penalty goes beyond auction prices. Marchenko and Sonnabend (2022) find evidence of a gender gap in the earnings of German artists.

[9] We are not the first to suspect that the gender gap among composers is rooted in human capital formation. In his celebrated essay, *The Subjection of Women*, John Stuart Mill speculated that the paucity of notable female composers could be attributed to women receiving inadequate training in composition. According to Mill, "Women are taught music, but not for the purpose of composing, only for executing it: and accordingly, it is only as composers, that men... are superior to women... But even this natural gift [for composition], to be made available for great creations, requires study, and professional devotion to the pursuit.... [T]he men who are acquainted with the principles of musical composition must be counted by hundreds, or more probably by thousands, the women barely by scores: so that here again, on the doctrine of averages, we cannot reasonably expect to see more than one eminent women to fifty eminent men". See Mill (1869), p. 134–136.

[10] Parents are also important for the inter-generational transmission of occupational status and employment opportunities. See Long and Ferrie (2013) and Corak and Piraino (2011).

[11] Anecdotal evidence suggests that parents may have preferred to invest in their musical sons. For example, Mozart's sister, Maria Anna, Mozart (1751–1829), nicknamed "Nannerl", was denied composition lessons afforded to her brother, despite being an extremely gifted musician (Jarvis, 2020). It is worth noting that it was Mozart's father, Leopold, who was the musician-parent.

[12] For instance, Amy Beach (1867–1944), née Cheney, was prohibited by her husband from having a composition tutor. Beach was only 18 years old when she married and was still developing her skills in composition. Accordingly, she was largely self-taught (Block, 2000).

mentors and whether the presence of female teachers narrows the gender gap. The hypothesis here is that while teacher quality and quantity positively influences composer prominence, female composers may have benefited less from such relationships due to societal biases and fewer opportunities.

The rise of conservatories in the nineteenth century marked a shift towards formalized music education (Weber et al., 2001).[13] Conservatories, however, have not always welcomed women; the Paris Conservatory, for instance, did not permit its female students to enroll in composition classes.[14] Additionally, parents were sometimes unwilling to allow their musical daughters to enroll in conservatories.[15] Nevertheless, the presence of a conservatory might still benefit women in the vicinity if it attracts composition professors who also teach privately.[16] Our framework posits that proximity to and access to conservatories played a crucial role in the human capital development of composers. The opening of a conservatory, by attracting talented teachers and lowering the cost of accessing musical instruction, is likely to increase average composer quality in its vicinity. The beneficial effects of a conservatory may even extend beyond its own students, if composition professors also teach privately. However, the effect of a conservatory on the gender gap is unclear. If conservatories are closed to women, as they have sometimes been, then women may not benefit from the consolidation of teaching in a single institution and the gender gap may widen in surrounding area. On the other hand, if the conservatory is open to women, or if composition professors are willing to teach women privately, female compositional talent may be locally nurtured.

The framework also considers the downstream consequences of gender disparities in human capital formation. For example, female composers, due to their lower prominence, may have had fewer opportunities to mentor students or publish their work, creating a feedback loop that perpetuates their under-representation and lower recognition in music history. Additionally, female composers may have been more likely to use pseudonyms to overcome discrimination in the market for musical compositions.[17]

The conceptual framework leads to several testable hypotheses. First, composers with musician-parents, especially mothers, will have greater prominence, but this effect may be less pronounced for female composers. Second, female composers had less access to high-quality mentorship, and those who did have access may still benefit less than their male counterparts. Third, proximity to conservatories positively influences composer prominence, but the effects on the gender gap are ambiguous. Fourth, female composer–teachers are likely to have attracted fewer students. Fifth, female composers are more likely to use pseudonyms to overcome market discrimination, reflecting broader societal barriers to their recognition.

4. Data

4.1. Biographical entries and teacher–student linkages

We obtain our primary source of data on composers by scraping the music encyclopedia *Grove Music Online*, an English-language encyclopedia covering music, musicians, and related topics. This source, which has been continuously updated since its launch in 2009, incorporates and extends the printed volumes of the *New Grove Dictionary of Music and Musicians*, and is widely regarded as a cornerstone for scholarly work in music.[18] *Grove Music Online* is a "critically organized repository of historically significant information" (see the preface) and has been used in previous work in economic history and cultural economics (e.g., Borowiecki, 2022, 2017, 2013). The encyclopedia is edited by an editorial board of six distinguished scholars, including two women, and receives advice from an international panel representing various scholarly music societies. This ensures that its content is relevant to user communities, remains up-to-date, adapts to evolving new fields of music study, and maintains the highest scholarly standards, with all entries within the encyclopedia being subject to peer-review.[19] From *Grove Music Online* we obtain information about

[13] During the early modern period the church played an important role in institutionalized music education (for a fuller discussion, see Borowiecki, 2022). Convents were important centers for musical study for women during the Middle Ages. Prominent nun composers include the German abbess, Hildegard von Bingen (1098–1179) as well as several sixteenth and seventeenth century Italian female composers, including Chiara Margarita Cozzolani (c. 1676–1678), Caterina Assandra (c. 1590–1618), Lucrezia Orsiana Vizzana (1590–1662), Raffaaella Aleotti (c. 1570–1646), Claudia Rusca (1593–1676), Claudia Sessa (c. 1570–1617/19), and Sulpitia Cesis (1577-?). All of these women are included in *Grove* and in our analysis. While data limitations preclude us from separately exploring the role of convents in women's musical education, many student–teacher relationships in our data were formed in ecclesiastical institutions like convents, monasteries, or schools.

[14] For instance, Louise Farrenc (1804–1875) was prohibited from enrolling in composition classes at the Paris Conservatory. In 1842 Farrenc became a professor of piano at the Conservatory, but was not permitted to teach composition in the school (Wehrich, 2024b). Gates (2006) discusses the barriers women faced in German conservatories.

[15] The parents of Cécile Chaminade (1857–1944), for example, forbid her from studying at the Paris Conservatory (Wehrich, 2024a; Citron, 1988).

[16] At age 15, Farrenc began private composition studies with Anton Reicha (1770–1836), a Czech composer who taught at the Paris Conservatory (Wehrich, 2024b; Friedland, 2001).

[17] Fanny Hensel (1805–1847), née Mendelssohn, attributed some of her compositions to her brother Felix. Mélanie Bonis (1858–1937) published under Mel Bonis, and Augusta Holmès (1847–1903) initially used the name Hermann Zenta for her early works. See Todd (2009), Myers (1967) and Géliot (2009).

[18] The *New Grove Dictionary of Music and Musicians* is itself a descendant of the *Dictionary of Music and Musicians*, which was first published in four volumes between 1879 and 1889.

[19] An often levied criticism of *Grove* is its over-emphasis on composers from English speaking countries (O'Hagan and Borowiecki, 2010). An earlier edition of *Grove* acknowledges this (see Grove and Sadie, 1980): "Grove, by long tradition, is the standard multi-volume musical reference work for the English-speaking world. It is a fully international dictionary. But it is proper if in some respects it reflects the tastes and preferences of the English-speaking countries. The dictionary must serve the needs of the public by which it will be primarily used" (xiii). This, of course, is a reflection of the commercial realities of publishing. Reassuringly, our estimates of the gender gap are not affected by the exclusion of composers from Anglophone countries, suggesting that the over-representation of Anglophone composers in *Grove* is unlikely to introduce significant bias.

each composer's birth and death places, birth and death dates, nationality, and other known occupations.[20] We then hand-collect information on parents' musical backgrounds and the use of pseudonyms.

Conceptually, the prominence, importance, or quality of a composer should be assessed according to the composer's overall reputation and impact, which, unfortunately, does not have a natural unit of measurement. However, we believe that a composer's prominence as viewed through the lens of posterity can be approximated by the length (in words) of a composer's biographical entry.[21] Entries in *Grove* are written by musicologists whose primary focus is on the musical careers and contributions of their subjects. The length of a musician's biographical entry in *Grove* therefore reflects expert assessment of the subject's significance within music history, with longer entries indicative of greater importance.[22] Not all biographies have a works, writings, or bibliography section. Accordingly, our primary metric for composer prominence or quality will be the length of the composer's main description, which is available for all composers with a *Grove* entry. For a subset of composers, we can also use the length of their works section to measure output, which is potentially related to a composer's prominence.[23] Our findings are robust to this alternative approach.

We extract data on teacher–student pairings from Pfitzinger (2017), who assembled a musical genealogy of more than 17,000 composers that links each composer with her teachers and her students. The composers included in Pfitzinger (2017) are described as "composers that wrote music in the broader classical tradition" and include academic composers as well as composers writing film music or electronic music. To obtain information about these composers' birthplaces, death places, and other occupations, we merge this data with information from the *Grove* sample of composers. However, not all composers listed in Pfitzinger (2017) have a biographical entry in *Grove*.

4.2. Gender inference

Grove and Pfitzinger (2017) generally do not report a composer's gender. To code gender, we follow a procedure that combines data-driven and manual inference of gender. The process is as follows. We use an *R* package called *gender* (Mullen, 2021) to infer gender based on the first names of each composer in combination with a database of names developed by the World Gender-Name Dictionary (Martínez et al., 2021). This database includes historical data on names from the U.S. Social Security Administration (SSA), U.S. Census (IPUMS), census microdata created by the North Atlantic Population Project (NAPP), and the Kantrowitz name corpus. SSA, IPUMS, and NAPP also report the fraction of females and males with each name. We assign a gender to a name-nationality combination if each of these three sources agree on the classification (male or female) at the 95 percent confidence level. The name-nationality combinations that remain unclassified at this point are then considered case-by-case. In some of these instances, gender classification is obvious.[24] For those cases in which it is not, we infer gender using online sources, including *Grove*, *Wikipedia*, and other resources.

4.3. Pseudonyms

We manually extract information on composers' pseudonyms from *Grove* and find that one percent of composers the *Grove* sample used a pseudonym. In addition to recording the pseudonym(s), we classify each composer's pseudonym as male, female, or gender neutral.[25]

4.4. Music conservatories

Data on music conservatories are taken from the International Directory of Music & Music Education Institutions (Bartle, 2023, henceforth IDMMEI). An offshoot of UNESCO's International Directory of Music Education Institutions, the IDMMEI aims to collect information about all post-secondary music schools, colleges, academies, conservatories, and university music departments offering a degree in music or music education. From IDMMEI, we collect the name, country, state, and city of each conservatory and extract information about the founding date of each conservatory by reading each conservatory's description. The resulting data set consists

[20] *Grove* biographies usually consist of four sections: (1) a section discussing the life and career of the musician (we will refer to this section as the "main description"); (2) a works section listing the subject's musical compositions (a complete listing of known composition for major composers and an outline of their works for lesser-known ones); (3) a writings section listing other works (e.g. books, articles, etc.) written by the subject; and finally, (4) the bibliography which lists the different sources used as references. For a visual overview of the structure of a *Grove* biographical entry, see Fig. A.1. While all four measures are distinct, they are highly correlated.

[21] Other methods to gauge composer prominence include online streaming frequency or expert rankings by musicologists. However, these approaches often overlook women. Notably, Murray's list of the top 500 composers includes no women (Murray, 2003).

[22] Our approach is not unlike a citation study in which a scientist's impact is measured according to how frequently her papers are cited. In law and economics, citation counts are used to measure the quality of judicial decisions. In a similar spirit, Galenson (2002) compares painters based on how often images of their work appear in leading art history textbooks.

[23] The true correlation between prominence and output is likely positive but not perfect. Bach, Schubert, and Mozart were prolific and important. On the other hand, the reputation of other composers often rests entirely on a single work. For instance, Pietro Mascagni (1863–1945) is known almost exclusively for *Cavalliera rusticana*, a one-act opera, while Carl Orff's (1895–1982) acclaim is heavily based on the cantata *Carmina Burana*. These "one-note wonders" weaken the correlation.

[24] For example, Mohammed from Egypt is classified as male, while Georgina from the United Kingdom is classified as female.

[25] When a composer has multiple pseudonyms, we classify gender based on the predominant gender among all of a composer's pseudonyms. Our results are robust to dropping composers who used multiple pseudonyms.

Table 1
Summary statistics.

Variable	Sample					
	Pfitzinger (2017)			Grove		
	Obs.	Mean	SD	Obs.	Mean	SD
Female	17,390	0.08	0.27	15,637	0.06	0.24
Born	17,271	1882.42	99.41	13,737	1815.88	138.86
Died	10,666	1909.97	108.65	10,818	1831.62	148.84
No. students	7,746	4.76	11.33	–	–	–
No. teachers	17,316	2.13	2.03	–	–	–
Teacher qual.	11,752	1707.10	3341.19	–	–	–
Pseudonym	–	–	–	15,707	0.01	0.10
Occupations						
Composer	7,537	1.00	0.05	15,707	0.98	0.15
Conductor	7,537	0.15	0.36	15,707	0.10	0.30
Teacher	7,537	0.13	0.33	15,707	0.08	0.27
Pianist	7,537	0.11	0.31	15,707	0.10	0.30
Organist	7,537	0.09	0.29	15,707	0.10	0.30
Violinist	7,537	0.06	0.23	15,707	0.05	0.22
Singer	7,537	0.02	0.15	15,707	0.05	0.21
Word counts						
Main desc.	7,537	663.67	1752.18	15,707	461.18	1260.76
Works	7,537	388.50	1156.45	15,707	233.58	839.32
Bibliography	7,537	149.25	670.40	15,707	101.81	466.41
Writings	7,537	19.04	66.97	15,707	12.01	52.58

Notes: This table shows the number of observations, the average values, and standard deviation (SD) for variables in the Pfitzinger (2017) and *Grove* samples. 'Teacher qual.' is the average number of words in the main description of the teachers of a given composer.

of 2174 conservatory observations, each of which we geocode. Fig. B.1 in the Appendix shows spread of conservatories over time within Europe, which houses the bulk of conservatories. Before the nineteenth century, there were few conservatories, and the earliest ones were primarily located in southern and central Europe. Consistent with other qualitative accounts (e.g. Weber et al., 2001), the quantitative evidence shows that the number of conservatories grew rapidly in the nineteenth century, with conservatories being established in nearly all parts of Europe during that period.

5. Descriptive statistics

Table 1 presents an overview of the key variables we collect from the *Grove* and Pfitzinger (2017) samples. The Pfitzinger (2017) sample is slightly larger than the *Grove* sample (17,390 composers versus 15,637 composers), reflecting the fact that there are composers listed in the first source that do not have entries in the second. However, the female fraction of composers is similar in both samples of composers (eight percent in Pfitzinger (2017) versus six percent in *Grove*). Additionally, there are some differences in the average birth and death years across the two samples, with the Pfitzinger (2017) sample representing a somewhat more recent group of composers than the *Grove* sample.

Full information on composers' other reported occupations and biographical entries is available for 15,707 composers in *Grove* and 7537 composers in Pfitzinger (2017). The composers in the Pfitzinger (2017) sample for which we have full information are more distinguished; the average length of a main description entry in the Pfitzinger (2017) sample is 664 words, versus 461 words in *Grove*. Additionally the composers in the Pfitzinger (2017) sample have longer entries discussing their output and other writings. However, in terms of the frequency of composers' other reported occupations, the two samples are roughly similar.

How do male and female composers compare? A preliminary glimpse is provided by Table 2, which lists the ten most prominent male and female composers, using the word count of composers' main descriptions in *Grove* to measure prominence. While the ten most prominent male composers will likely be familiar to most laypersons, we suspect relatively few will recognize the ten most prominent women, with perhaps the exceptions of Clara Schumann (1819–1896), née Wieck, who was married to Robert Schumann and is primarily known as a concert pianist, and possibly Dame Ethel Smyth (1858–1944), who was a key member of the UK women's suffrage movement. It is also worth noting that the biographical entries of the top-10 male composers are approximately 20 times longer than those of the top-10 female composers, implying an enormous (95 percent) gender gap in prominence in the extreme far right tail of composers.

More complete evidence of the differences between male and female composers is provided by Table C.1, which displays summary statistics by gender for the Pfitzinger (2017) and *Grove* samples. As established by the *t*-tests, for all four components of composers' biographical entries, the entries of male composers are significantly longer than the entries of female composers. Focusing on the *Grove* sample, the gap in the word counts of the main description section of male and female composer's entries is 47 percent; the magnitude of the raw gender gap remains substantial when looking at a broader sample of composers.

Male and female composers are also different from each other in terms their other occupations as reported in *Grove*. Male composers are more likely to have been conductors, violinists, and organists, while female composers are more likely to have been pianists and singers. These differences are shared by both samples. In the Pfitzinger (2017) sample we can also compare male and

Table 2
Top 10 most prominent composers by gender.

Male composers		Female composers	
Name	Word count	Name	Word count
Ludwig van Beethoven	42,011	Clara Schumann	2358
Johann Sebastian Bach	39,533	Hildegard of Bingen	1998
Joseph Haydn	32,325	Dame Ethel Smyth	1852
Robert Schumann	29,997	Elisabeth Lutyens	1594
George Frederic Handel	29,560	Amy Marcy Beach	1589
Wolfgang Amadeus Mozart	27,670	Francesca Caccini	1406
Antonio Vivaldi	25,699	Thea Musgrave	1318
Hugo Wolf	25,699	Pauline Viardot	1315
Igor Stravinsky	24,703	Rebecca Clarke	1126
Franz Liszt	24,370	Ruth Crawford	1058

Notes: Prominence is measured by the number of words in the main description section of a composers' biographical entry in *Grove*.

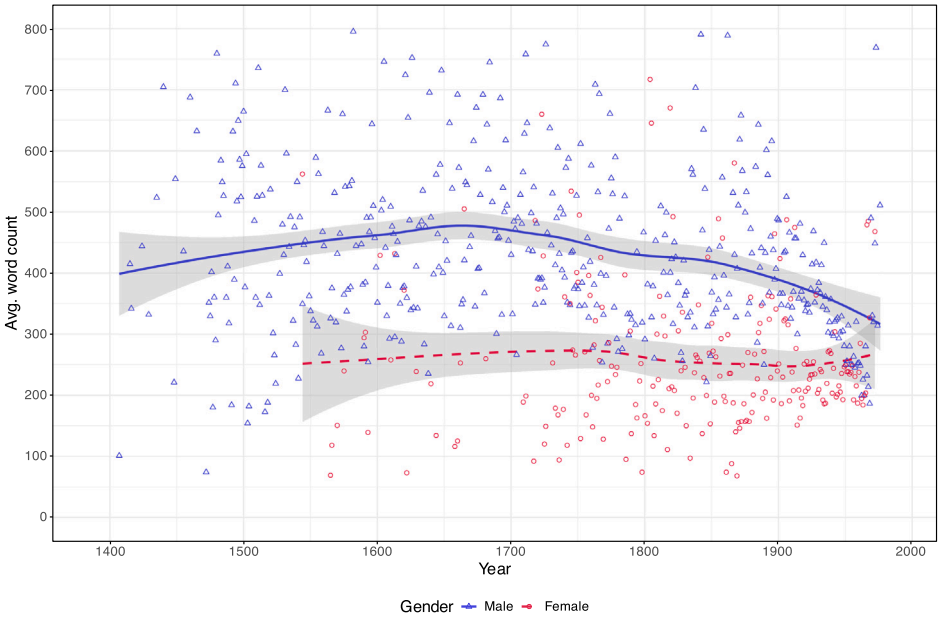

Fig. 1. Avg. word count over time. *Notes*: This figure depicts the average word count of composers' main description on *Grove* by gender and birth year. The average word count of male composers in a given year is shown as a triangle, while that of female composers is depicted as a circle. Years prior to 1400 are excluded as there are too few composers. The best fit lines are estimated using local polynomial regression.

female composers in terms of the number of teachers that they had, the quality of their teachers, and the number of students they taught. As students, female composers had more teachers than their male counterparts, but male composers had higher quality teachers on average. As teachers, male and female composers had a similar number of students.

Having established a raw gender gap between male and female composers in terms of their prominence, it is worth asking if the size of the gender gap in prominence has changed over time. Fig. 1 plots the average word count of composers' main descriptions in *Grove* by gender and birth year from the fifteenth century until the end of the twentieth. We do not extend the figure to earlier centuries because, as noted earlier, there are only two female composers in *Grove* who were born prior to 1500. Across all periods, male composers, on average, have longer biographical entries in *Grove* than female composers. However, the average prominence of male composers has declined since 1700, while the average prominence of female composers has remained relatively flat. The magnitude of the raw gender gap in composer prominence therefore appears to narrow with time.

We also use our data to trace the representation of female composers over time. To do this, we bin composer birth years into 50 year intervals and compute the share of composers born within each 50 year interval who are female. Fig. 2 plots these series for the *Grove* and Pfitzinger (2017) samples from 1250 to 2000. There are some divergences in the two series, but the overall trend is similar regardless of the sample. While female composers are underrepresented in all periods, the female share of composers increased dramatically beginning in the eighteenth century, reaching approximately 15 percent by the 1950 for the *Grove* sample and almost 20 percent by 2000 for the Pfitzinger (2017) sample.

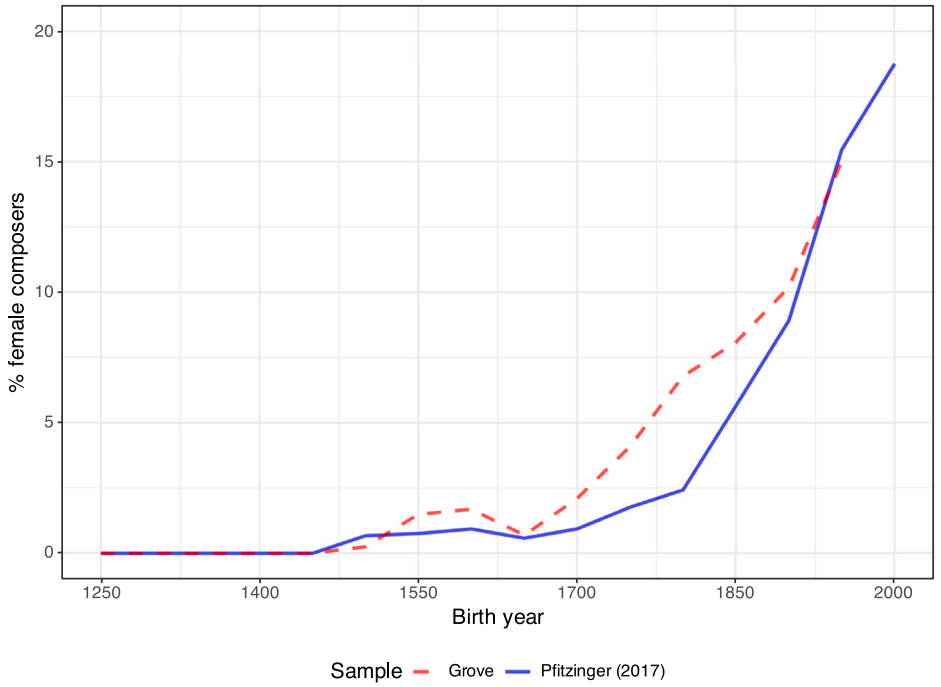

Fig. 2. Fraction of female composers over time. *Notes*: This figure depicts the share of female composers in the sample. Birth years are binned in 50-year intervals. Years before 1250 are excluded as the number of observations is too small. There are only 23 composers who were born between 154 — the birth year of Bardaisan, the oldest composer in *Grove* — and 1250.

We next use our data to track where composers were born, whether there are differences by gender, and how this may have changed over time. Fig. 3 displays the spatial distribution of male and female composers within Europe (where the lion's share — approximately 80 percent — of the composers in our sample were born), categorized according to their birth location and century of birth from the sixteenth to the twentieth centuries.[26] Once again, we do not extend the figure to earlier centuries due to the paucity of female composers in our data prior to 1500. As shown in Panel (a), in the sixteenth century, male composers were primarily from central and southern Europe. In subsequent centuries, the birth locations of male composers spread outward, gravitating to northern and eastern European countries. Panel (b) shows that the birth locations of female composers follow the same pattern as male composers, beginning in the southern and central Europe and spreading east and north with time.[27] However, the process was delayed for female composers. Going beyond composers from Europe, Fig. D.2 presents the spatial distribution of male and female composer births in the United States from the eighteenth to the twentieth centuries (composers from the U.S. comprise 14 percent of the sample). For both male and female composers, birth locations are primarily in the northeast in the eighteenth century and gradually spread south and west in subsequent centuries.

Finally, Fig. E.1 depicts the correlation between teacher and student prominence divided into male–female panels using the Pfitzinger (2017) sample of composers. In all plots there is a positive relationship between teacher and student prominence. However, because there are few female teachers in the sample, the relationships, while steeper, are not statistically significant in the bottom two panels.

6. Estimating the gender gap

Comparing means, the data show a raw gender gap in composer prominence of 47 percent. However, as discussed earlier, there are important differences between male and female composers in terms of when and where they were born. If the time period or location of a composer's birth is correlated with composer prominence, our estimate of the magnitude of the gender gap will be biased. This could easily be the case. Posterity does not judge the work of composers who lived in different eras equally; romantic era

[26] To facilitate navigation we use today's country borders. For maps that use historical borders, see Fig. H.1.

[27] De la Croix and Vitale (2023) show that during the Protestant Reformation, female academics were more likely to be found in Catholic southern Europe than Protestant northern Europe, perhaps because Catholicism was more willing to tolerate exceptional women at the top of the human capital distribution. The spatial distribution of composers over time is consistent with this conjecture. During the sixteenth century, the barycenter of the birthplaces of female composers (i.e., the center of mass of the distribution of birthplaces) is in northern Italy, while the barycenter of the birthplaces of male composers is in Switzerland. In subsequent centuries, the birthplace barycenters for male and female composers moved northward. See Fig. D.1.

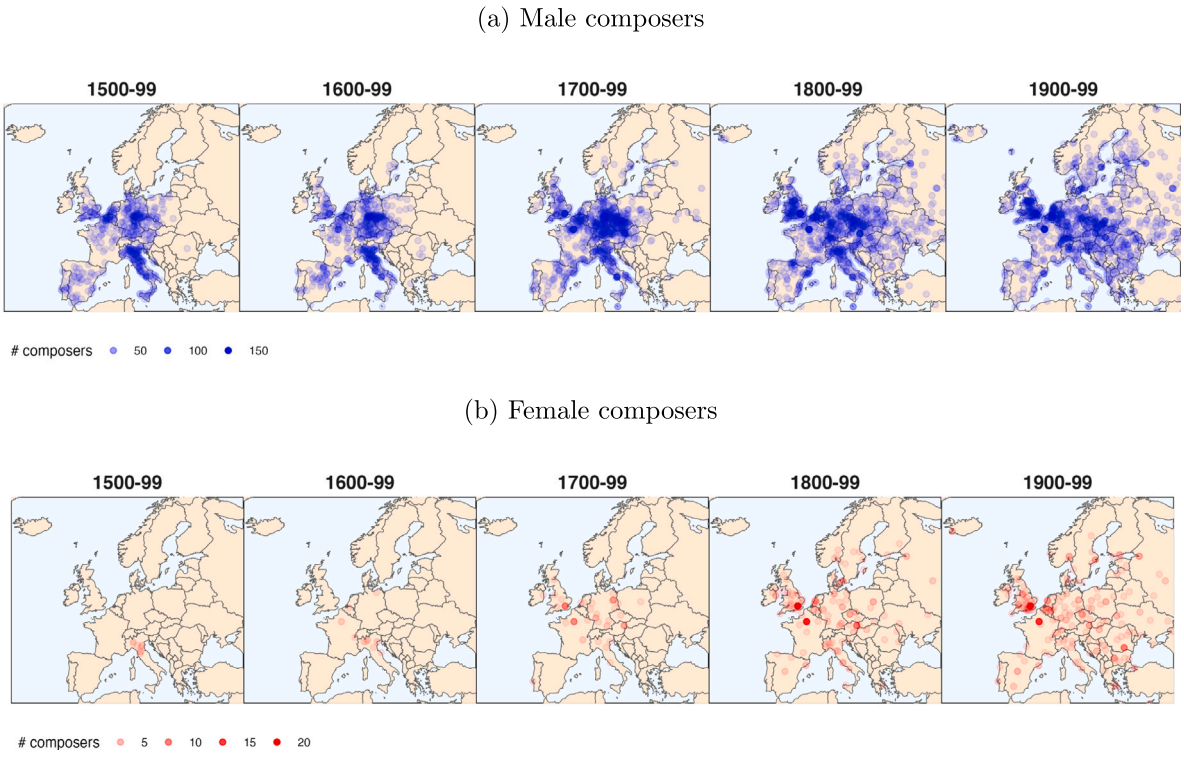

Fig. 3. Number of composers by gender, Europe. *Notes*: This figure shows the spatial distribution of birth locations of composers in the Pfitzinger (2017) sample by gender in Europe. Each dot represents a city. Darker dots indicate a higher concentration of composers. We include today's country borders to facilitate the reader's navigation. For maps using historical country borders see Fig. H.1. Earlier centuries are not displayed as there are only two female composers in *Grove* born prior to 1500.

music from the nineteenth century receives more attention than the works of mid-twentieth century atonal composers or Rococo composers of the mid-eighteenth century. Additionally, there is geographic variation in what is known and admired; in general, composers from the German-speaking world are more acclaimed than their Spanish-speaking counterparts. Finally, the gender gap in prominence may also be related to gender norms, or the institutional setting in which music is composed and distributed (for instance, court-based patronage versus market-based production), which may vary by time and place. It is therefore important to control for these factors when estimating the gender gap.

Our approach therefore involves estimating the following equation using ordinary least squares using the *Grove* sample of composers:

$$ln(word\ count)_i = \beta_0 + \beta_1(female_i) + \gamma_i + \delta_t + \epsilon_i \tag{1}$$

In this regression, the dependent variable, $ln(word\ count)_i$ is the natural logarithm of the number of words in the main description section of the *Grove* entry of composer i; $female_i$ is a binary indicator equal to one if composer i is female and zero otherwise; γ_i and δ_t are country of birth, and half-century of birth fixed effects; and ϵ_i is an error term. These fixed effects allow us to hold constant factors such as musical styles, gender norms, or the institutional environment in which musical compositions were produced and distributed that may affect the relative prominence of female composers. The coefficient of interest in this regression is β_1, which is our estimate of the gender gap in prominence between male and female composers. In addition to estimating Eq. (1), on the full sample of composers in *Grove*, we also run regressions using sub-samples based on region, using the UN M49 standard to classify regions. This allows us to see if there are differences in the magnitude of the gender gap among composers from different parts of the world (e.g., Europe versus North America).

Table 3 displays coefficient estimates from Eq. (1). Column (1) uses the full sample of composers. The estimate of β_1 in the full sample indicates that, holding constant time and country of birth, the main description of female composers is $(e^{(-0.296)}-1)\times 100 \approx 25.6$ percent shorter than the main description of male composers. Recall that the raw (unadjusted) gender gap in the *Grove* sample is 47 percent. While the magnitude of the gap in prominence remains large, it narrows substantially (by almost half) when we account for the fact that female composers are represented differently across different eras and countries.

Columns (2)–(7) display coefficient estimates of Eq. (1) using sub-samples of composers born in different regions. There is a statistically significant gender gap in all regions except Africa. However, the magnitude of the gap varies by region. The gender gap in prominence is largest among European and Latin American composers (over 29 percent in each case), smaller for North American and Asian composers (16.6 percent in both cases), and slightly smaller for composers born in Oceania (15.8 percent).

Table 3
Gender gap in prominence by region.

	Dependent variable: ln word count (main desc.)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Female	−0.296***	−0.354***	−0.182***	−0.345***	−0.182***	−0.172***	−0.003
	(0.036)	(0.033)	(0.003)	(0.068)	(0.055)	(0.013)	(0.181)
Country FE	✓	✓	✓	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓	✓	✓	✓
Sample	All	Europe	N. America	L. America	Asia	Oceania	Africa
Observations	13 162	10 140	1781	544	473	122	101
Adjusted R^2	0.064	0.065	0.030	0.069	0.104	0.080	0.091

Notes: Standard errors are clustered at the country level. N. America denotes Northern America (US, Canada and Bermuda), while L. America denotes Latin America and the Caribbean.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

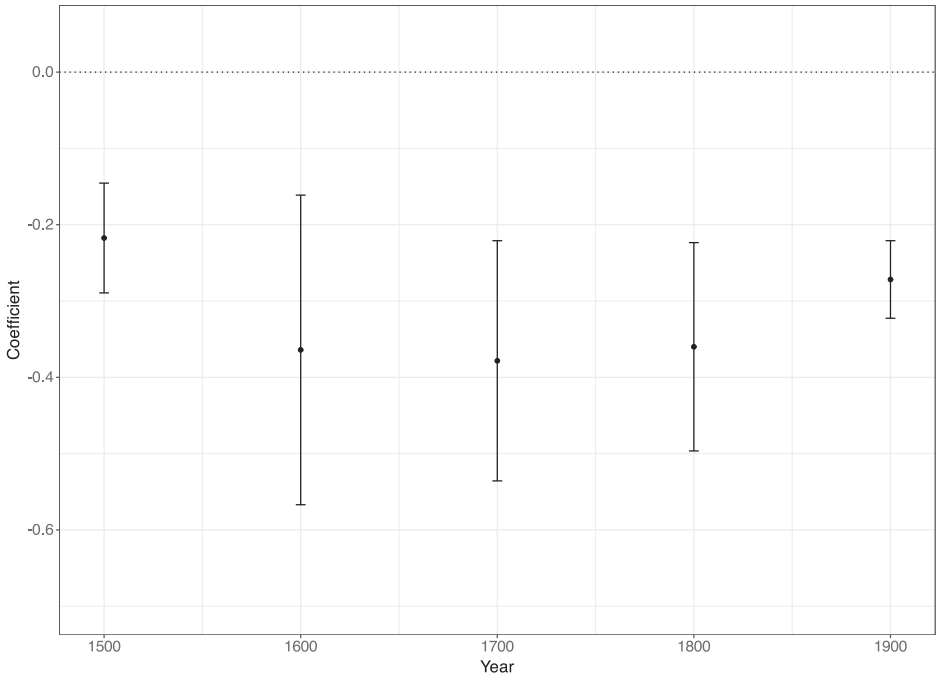

Fig. 4. Estimated gender gap over time. *Notes*: This figure depicts the evolution of the gender gap in prominence. The estimates along with 95 percent confidence intervals are derived from regressing our measure of prominence on the interaction between gender (female) and century of birth. Interactions with earlier centuries were excluded as there are only two female composers in *Grove* born before 1500.

Fig. 1 indicated that the gender gap in composer prominence has narrowed with time. We can also examine this possibility by including gender and century-of-birth interaction terms in our baseline regression model. Fig. 4 displays these interaction terms. Consistent with Fig. 1, we do find that the gender gap is largest in the 1700s and narrows marginally in subsequent centuries. However, in the 1500s, the gender gap was smaller than in subsequent centuries, a finding that should be interpreted cautiously since only 12 female composers in *Grove* were born in that century.

To ensure the robustness of our results we re-estimate Eq. (1) using additional controls, different sub-samples, and alternative measures of composer prominence, as presented in Table 4. Composers' standing within *Grove* may also depend on what other occupations they are known to have had. Since male and female composers are not equally distributed across other occupations — male composers, for instance, were more likely to be conductors than female composers — this may affect our estimate of the gender gap. Accordingly, we include occupation fixed effects for the five most frequently reported other occupations (i.e., conductor, pianist, organist, violinist, and singer). As shown in column (2) of Table 4, including occupation fixed effects does not appreciably change the magnitude of our estimate of the gender gap.

The length of a composer's entry in *Grove* may also depend on a composer's lifespan, perhaps because there is more source material on composers who lived longer. As shown in column (3) of Table 4, if we exclude composers who are still alive and include a control for lifespan (in years), our estimate of the gender gap increases slightly.

Table 4
Robustness checks.

	Dependent variable							
	ln word count(main desc.)						ln word count (works)	Output
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	−0.296***	−0.303***	−0.334***	−0.318***	−0.341***	−0.307***	−0.166**	−0.452***
	(0.036)	(0.035)	(0.043)	(0.030)	(0.060)	(0.042)	(0.074)	(0.066)
Age at death			0.004***					
			(0.001)					
Female author						−0.072***		
						(0.027)		
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓	✓	✓	✓	✓
Occupation FE		✓						
Sample	Full	Full	Full	No Anglo.	Pre-1900	Full	Full	RISM
Observations	13 162	13 162	9637	10 132	7845	11 113	9359	19 612
Adjusted R^2	0.064	0.067	0.049	0.069	0.043	0.067	0.053	0.172

Notes: Standard errors are clustered at the country level. Columns (1) and (2) use all composers in *Grove* who have a main description. Column (3) drops composers who are still alive. Column (4) drops composers from Anglophone countries (i.e., UK, USA, Canada, Australia, and New Zealand). Column (5) drops composers born in the twentieth century. Column (6) controls for the gender of the *Grove* author. Column (7) includes all composers who have a works section as part of their entry in *Grove*, with the dependent variable being the logged word count of the works section. Column (8) includes all composers in RISM, with the dependent variable being the number of known manuscripts and printed editions by a composer.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

As discussed earlier, a potential concern about *Grove* is that it overemphasizes composers from English-speaking countries. As shown in column (4), if we re-estimate the baseline model excluding composers from the English-speaking world, our estimate of the gender gap remains stable.

Social norms concerning gender, the dynamics of human capital acquisition, as well as the nature of classical music and its impact on society were likely very different in the twentieth century than in earlier periods. While our baseline model does include half century of birth fixed effects, it may be informative to re-estimate our baseline model excluding composers born in the twentieth century. As shown in column (5), our estimate of the gender gap increases if we exclude twentieth century composers. However, the 95 percent confidence interval around this estimate encompass the baseline gender gap estimate that uses all composers (column (1)).

Scholarship on composers has traditionally been male dominated. If male authors in *Grove* are less favorable towards female composers, this bias could affect the estimated gender gap in composer prominence. To explore this, we include an indicator variable equal to one if the author is female in our baseline regression model. As shown in column (7), entries written by female authors tend to be shorter. However, the magnitude and statistical significance of our estimate of the gender gap is essentially unaffected. The evidence therefore indicates that the gender of the author does not influence the gender gap in composer prominence.[28]

Finally, we re-estimate Eq. (1) using two alternative measures of composer prominence that proxy for the total output of a composer, specifically the word count of the works section of a composer's entry within *Grove* (if available), and the number of known manuscripts and printed editions by a composer taken from the Répertoire International des Sources Musicales (RISM) Catalog, an online database of musical scores.[29] As shown in columns (7) and (8), we continue to find a sizeable and statistically significant gender gap using these measures of composer's output. Specifically, we find a larger gender gap if we use the RISM data, but a smaller one if we use the word count of a composer's works section in *Grove*. We hesitate to put too much emphasis on these differences, however, since these measures of output are noisy, and are based on different samples of composers.

7. Explaining the gender gap

7.1. Family musical background

We now turn to an exploration of the factors driving the gender gap among composers. Because exposure to music generally starts at home, we first focus on the family, with specific attention to the role of musician-parents. As discussed earlier, parents' willingness to invest in their child's musical training may depend on the gender of the child, the gender of the parent with the

[28] The sample size for this regression is smaller as we were unable classify the gender of some authors, and some entries are co-authored by authors of both genders.

[29] As mentioned earlier, the works section of *Grove* entries lists all known works for important composers and summarizes works for less important ones. Additionally, some composers do not have a works section and are dropped from the analysis. The works section word count is therefore a noisy measure of output. The RISM database features a broader range of composers compared to *Grove*, resulting in a larger sample size for this regression analysis. In the RISM catalog, the average number of sources per composer is 32.9, with a standard deviation of 247.9. Wolfgang Amadeus Mozart is the most prolific composer (18,306 sources), followed by Joseph Haydn (17,998 sources).

Table 5
Gender differences in composers' family background and teacher access.

	Dependent variable							
	Mother musician		Father musician		Num. teachers		ln mean teacher prom.	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	0.056***	0.060***	−0.002	−0.002	0.724***	0.225*	−0.024***	0.061
	(0.016)	(0.014)	(0.020)	(0.022)	(0.075)	(0.123)	(0.054)	(0.064)
Country FE		✓		✓		✓		✓
Half-century FE		✓		✓		✓		✓
Observations	888	888	888	888	7539	7505	5548	5542
Adjusted R^2	0.014	0.005	−0.001	0.121	0.012	0.192	−0.000	0.066

Notes: Standard errors are clustered at the country level.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

musical-background, or some interaction of the two.[30] The goal is to determine how these factors are related to the gender gap between male and female composers.

Our source of information on whether a composer has musician parents is a composer's biographical entry in *Grove*. This creates a selection problem because whether or not any information on parents is provided in *Grove* is positively related to the length of a composer's biographical entry (i.e., longer biographical entries are more likely to disclose information about musicians-parents than shorter entries). Because male composers have longer biographies than female composers, the presence of musician-parents is likely to be over-estimated for male composers relative to female composers. This may, in turn, bias estimates of any gender differences in the consequences of having musician-parents.

To address this selection problem, we create a matched sample of comparable male and female composers by extracting the propensity scores from the following selection equation estimated using the Pfitzinger (2017) sample of composers:

$$P(female_i = 1|X) = \beta_0 + \beta_1 main\ description_i + \beta_2 works_i + \beta_3 birth\ year_i + \epsilon_i \tag{2}$$

In this equation, $main\ description_i$ is the number of words in the main description of the *Grove* entry of composer i, and $works_i$ is the number of words in the works section of composer i. We then extract the propensity scores for male and female composers and match based on the respective length of their *main description* and *works* section in *Grove*, as well as their birth year. The resulting sample consists of 888 composers (444 male and 444 female).

We then read the *Grove* entries of each of the 888 composers to obtain information on whether they come from a family of musicians (i.e., if a composer's *Grove* entry mentions a musician-mother or musician-father). Table F.1 presents summary statistics for the matched sample. As indicated by the t-statistics reported in the table, male and female composers in the matched sample are similar in terms of birth and death years and the length of their biographies, which is as intended. However, male and female composers still differ along other margins. In common with the full (un-matched) sample, male composers in the matched sample are more likely to have also been conductors, organists and violinists, while female composers are more likely also have been pianists, and singers.

Using this matched sample, we first investigate whether male and female composers differ in their likelihood of having musician-parents. To do this, we estimate a linear probability regression model where the dependent variable is an indicator equal to one if composer i has musician parents (either musician-mother or musician-father) and the explanatory variable is an indicator equal to one if composer i is female. We estimate this equation with and without fixed effects for a composer's half-century and country of birth. The coefficient on the female indicator tells us if female composers were more or less likely to have musician-mothers or musician-fathers than their male counterparts.

The results from this regression are shown in columns (1) through (4) of Table 5. In the first two columns, the dependent variable is an indicator for whether a composer has a musician-mother; in the next two columns, the dependent variable is an indicator for a musician-father. The coefficient estimates indicate that while male and female composers were equally likely to have musician-fathers, female composers were a statistically significant 6 percentage points more likely to have musician-mothers than male composers. Given that only 3 percent of male composers had composer-mother (see Table F.1), female composers were three times more likely to have a musician-mother than male composers. Musician-mothers may therefore have been especially important in nurturing female musical talent.

We next turn to the consequences of musician-parents for composer prominence. To do this, we estimate the following regression:

$$\begin{aligned} ln(word\ count)_i = {} & \beta_0 + \beta_1(female_i) + \beta_2(mother\ musician) + \\ & \beta_3(father\ musician_i) + \beta_4(female_i) \times (mother\ musician_i) + \\ & \beta_5(female_i) \times (father\ musician_i) + \gamma_i + \delta_t + \epsilon_i \end{aligned} \tag{3}$$

[30] Gates (1997) notes that, prior to the acceptance of women within conservatories, only three groups of women had adequate musical instruction to become composers: nuns, those born into wealth or the aristocracy, and those who had musician parents who were equally willing to invest in the training of their sons and daughters.

Table 6
Family background and composer prominence.

	Dependent variable: ln(word count)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female	−0.057	−0.079**	−0.075*	−0.080**	−0.044	−0.058	−0.071*	−0.078**
	(0.041)	(0.039)	(0.038)	(0.037)	(0.042)	(0.041)	(0.039)	(0.039)
Parent musician	0.364***	0.266**						
	(0.081)	(0.102)						
Mother musician			0.519***	0.434***			0.447***	0.343***
			(0.065)	(0.109)			(0.061)	(0.129)
Father musician					0.305***	0.233**	0.185**	0.179
					(0.085)	(0.114)	(0.073)	(0.119)
Female × Parent musician		0.176						
		(0.108)						
Female × Mother musician				0.115				0.137
				(0.139)				(0.177)
Female × Father musician						0.145		0.021
						(0.159)		(0.183)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓	✓	✓	✓	✓
Observations	888	888	888	888	888	888	888	888
Adjusted R^2	0.144	0.145	0.148	0.147	0.125	0.126	0.155	0.153

Notes: Standard errors are clustered at the country level. All regressions include fixed effects for half-century and country of birth.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

The outcome variable in this equation is the natural logarithm of the word count of composer i's main description; $female_i$ is a binary indicator equal to one if composer i is female; $mother\ musician_i$ and $father\ musician_i$ are binary indicators equal to one if composer i has a musician-mother or musician-father, and the remaining variables are defined as before. If musician-parents are beneficial for a composer's future prominence, β_2 or β_3 should be positive and statistically significant. The coefficients on the interaction terms (β_4 and β_5) tell us if there are differences by gender. For instance, $\beta_5 > 0$ would suggest that musician-mothers are especially beneficial to composer-daughters. On the other hand, $\beta_4 < 0$ would suggest that musician-fathers are less beneficial for their composer-daughters than their composer-sons.

Coefficient estimates of Eq. (3) are shown in Table 6. In all regressions, the dependent variable is our measure of composer prominence. In columns (1) and (2) we estimate the effect of having either parent (mother or father) a musician. Columns (3) and (4) control for only musician-mothers; columns (5) and (6) control for only musician-fathers; and columns (7) and (8) control for musician-mothers and musician-fathers separately. The odd numbered columns exclude interactions with gender while the even numbered columns include them.

The coefficients on *parent musician*, *mother musician* and *father musician* in the even-numbered columns are all positive and statistically significant; having a musician-parent is positively related to future prominence, regardless of the gender of composer or parent. In terms of magnitudes, having either musician-parent raises a composer's prominence by 44 percent, having a musician-mother raises prominence by 68 percent, and having a musician father raises prominence by 36 percent. Accordingly, the benefits of coming from a musical family are economically large.[31] Interestingly, the magnitude of the relationship is larger for musician-mothers than musician-fathers, and when we control for them independently in the same regression, the coefficient on musician mother is more than twice as large as the coefficient on musician-father (column 7); mothers may therefore be more important than fathers for the transmission of musical human capital. Finally, the interaction terms reported in the even-numbered columns are positive but imprecisely estimated. Daughters may have benefited disproportionately from having musician-parents, regardless of the gender of the parent with the musical background, but the data are too noisy for us to detect these effects at conventional levels of statistical significance.[32]

7.2. The role of teachers

Our exploration next turns to teachers. We first investigate whether access to teachers — in terms of quantity and quality — varies by the gender of the composer. Using the Pfitzinger (2017) sample, we estimate regressions where the dependent variable is either the number of teachers who taught composer i or the average quality of those teachers (measured by the log average word count of those teachers) and the key independent variable is an indicator equal to one if composer i is female. We estimate these regressions with and without fixed effects for the composer's half century and country of birth.

[31] We are agnostic about whether this reflects the role of environment or genetics. Having a musician-parent increases musical exposure and also increases the likelihood of inheriting musical genes.

[32] We find a similar pattern of results if we use the word count of the works section of a composer's *Grove* entry as the dependent variable. If we drop composers born in the twentieth century, to account for the fact that gender norms as well as the dynamics of human capital acquisition were different in the twentieth century than in earlier periods, the results are similar, except the interaction term between mother musician and female composer becomes marginally significant (at the 10 percent level), suggesting that mother's may have been especially important for female composers in earlier times.

Table 7
How teachers matter.

	Dependent variable: ln(student word count)							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Female student (S)	−0.267***	−0.089*	−0.264***	0.252	−0.283***	0.433*	−0.282***	−0.282***
	(0.047)	(0.049)	(0.037)	(0.195)	(0.047)	(0.239)	(0.031)	(0.032)
Number of teachers (T)	0.107***	0.112***			0.099***	0.104***		
	(0.028)	(0.029)			(0.025)	(0.026)		
Mean T prom.			0.070***	0.074***	0.064***	0.068***		
			(0.011)	(0.012)	(0.010)	(0.011)		
Female S × Num. teachers		−0.063***				−0.052**		
		(0.021)				(0.025)		
Female S × Mean T prom.				−0.077**		−0.082**		
				(0.030)		(0.033)		
Female teacher							0.028	−0.002
							(0.029)	(0.036)
Female S × Female T							0.001	0.019
							(0.086)	(0.088)
Country FE	✓	✓	✓	✓	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓	✓	✓	✓	✓
Commonality controls								✓
Observations	7505	7505	5542	5542	5542	5542	12 026	12 012
Adjusted R^2	0.157	0.158	0.132	0.133	0.161	0.162	0.139	0.140

Notes: Standard errors are clustered at the country level. Commonality controls includes age distance between student and teacher, same-nationality indicator, and a shared country of birth-indicator.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

Coefficient estimates are shown in columns (5)–(8) of Table 5, which was displayed in the previous section. In columns (5) and (6) of Table 5 the dependent variable is the number of teachers who taught composer i while in columns (7) and (8) the dependent variable is the average quality of composer i's teachers. The coefficient estimates suggest that female composers had more teachers than male composers. The average male composer in the Pfitzinger (2017) sample had 2.06 teachers. Based on the coefficient estimate shown in column (6), this implies that female students had approximately 11 percent more teachers than male composers. The evidence on teacher quality, however, is mixed. Without the fixed effects, the estimate indicates that female composers had weaker teachers. On the other hand, when we include them, the sign flips and the estimate loses statistical significance. Accounting for when and where composers were born, the evidence does not suggest that female composers had lower quality teachers.

We now turn to the relationship between the number and quality of a composer's teachers and a composer's future prominence. To do this, we estimate regressions of the following form:

$$\begin{aligned} ln(word\ count)_i = {} & \beta_0 + \beta_1(female_i) + \beta_2(number\ teachers_i) + \\ & \beta_3(avg\ teacher\ prominence_i) + \beta_4(female_i) \times (number\ teachers_i) + \\ & \beta_5(female_i) \times (avg\ teacher\ prominence_i) + \gamma_i + \delta_t + \epsilon_i \end{aligned} \tag{4}$$

In this equation the dependent variable, $ln(word\ count)_i$, is the natural log of composer i's biographical entry; $female_i$ is an indicator equal to one if composer i is female; $number\ teachers_i$ is a count of the number of teachers who taught composer i; $avg\ teacher\ prominence_i$ is the log of the average word count of composer i's teachers, which is computed using the word counts of i's teachers' biographical entries; and the remaining variables are defined as before. If having more or better teachers improves a composer's prominence, then β_2 and β_3 should be positive and statistically significant. The coefficients on β_4 and β_5 tell us if teacher quantity or quality have different effects depending on the gender of the student-composer. For instance, if having more or better teachers affects female composition students differently from their male counterparts, then the coefficients on these interactions should be different from zero. Once again, we use the Pfitzinger (2017) sample of composers. Additionally, we estimate the model with and without interaction terms, and using different configurations of teacher quality and quantity.

Coefficient estimates of Eq. (4) are displayed in the first six columns of Table 7. In all regressions, the dependent variable is our measure of a composer's prominence. Columns (1) and (2) control for teacher quantity; columns (3) and (4) control for average teacher quality; and columns (5) and (6) control for both. Interaction terms are excluded in the odd-numbered columns and included in the even-numbered columns.

Across all specifications, the coefficients on the number of teachers and average teacher quality (i.e., β_2 and β_3) are positive and statistically significant at conventional levels and the implied effects are economically large. Having one additional teacher increases a composer's prominence by approximately 10 percent and a doubling of average teacher quality raises a composer's prominence by 68 percent.[33] Since there was likely positive selection at work, with the best pupils studying with the best teachers, this is probably an overestimate of the impact of teachers. Interestingly, however, the interaction terms are negative and statistically significant in

[33] The average teacher in the Pfitzinger sample has a word count of 1707.1, which is 7.44 log points. Multiplying this by 0.07, the coefficient on the log of mean teacher prominence, gives us 0.52. $(e^{(-0.52)} - 1) \times 100 \approx 68$.

all specifications. For female composers, the gains from having an additional teacher are cut in half, and the benefits of an increase in average teacher prominence are fully attenuated.

Taking this finding at face value, why might female composers' have benefited less from having more and better teachers? While our data do not allow us to answer this definitively, we speculate that it can be attributed to the fact that composition teachers, at least historically, were reluctant to make serious investments in their female students, since even female students of great promise were unlikely to raise a teacher's reputation. Given prevailing gender norms, a female composer might, upon marriage, be compelled to stop composing.[34] Additionally, the market for music by female composers was itself discounted.[35] Female composition-students may therefore have had more teachers than optimal, and the most distinguished composition-teachers — who had access to the best male and female students — may have been reluctant to commit much attention to their female pupils. As a consequence, increases in the quantity and quality of teachers may have widened the gender gap among composition-students.[36]

In the context of modern K-12 education, several studies have found that female teachers, when paired with female students, improve the relative performance of female students and narrow gender achievement gaps (see, for example, Winters et al., 2013). While our setting is different — instruction in composition, at least historically, was more likely to be one-on-one than classroom based — it seems natural to ask whether same-sex matching of teachers and students improves outcomes for composers. Following Muralidharan and Sheth (2016) and Holmlund and Sund (2008), we estimate regressions of the following form:

$$\begin{aligned} ln(word\ count)_i = \beta_0 &+ \beta_1 female\ student_i + \\ &\beta_2 female\ teacher_j + \\ &\beta_3 female\ student_i \times female\ teacher_j + \\ &\alpha_i + \delta_t + \epsilon_i \end{aligned} \tag{5}$$

The dependent variable, $word\ count_i$, is the word count of student i's entry in *Grove*; $female\ student_i$ is a binary variable equal to one student i is female; $female\ teacher_j$ is a binary variable equal to one if teacher j is female; and the remaining variables are defined as before. The coefficient on the interaction term, β_3, captures the relative effectiveness of female teachers in reducing the gender gap. If $\beta_3 = 0$, male and female composition teachers are equally effective in reducing the gender gap among composition-students; if $\beta_3 > 0$ female teachers are more effective; and if $\beta_3 < 0$ male teachers are more effective.

Columns (7) and (8) of Table 7 display the coefficient estimates from estimating Eq. (5). The dependent variable is the log of the word count of student i's main description in *Grove*. Column (8) also includes commonality controls, which hold constant other factors that a teacher and student may share in common (e.g. nationality, age). The coefficients on the interaction term are positive but imprecisely estimated. Neither male nor female composition teachers appear better at reducing the gender gap in composer prominence.[37]

7.3. The founding of conservatories

During the nineteenth century, music education shifted away from families and informal networks of teachers and students towards conservatories. How did the rise of conservatories affect composer quality? And were the effects different for female composers relative to their male counterparts?

From IDMMEI we know the addresses and founding dates of over 2000 conservatories. Our strategy for exploring the impact of conservatories involves geo-locating conservatories and composers (using their places of birth), and dividing composers into two groups — those who were born "near" the conservatory (the treatment group) and those who were born "far" away (the control group) — and, in turn, sub-dividing these two groups into two cohorts: a "before" cohort that were born in the 20-year interval before the founding of the conservatory (i.e., composers who are unlikely to have been able to benefit from the conservatory), and an "after" cohort that was born in the 20 years after its founding (i.e., composers who could potentially benefit from it). We then estimate the impact of the conservatory by comparing the change in average outcomes between composers born after and before the founding of the conservatory in the treatment group with the change in average outcomes of composers born after and before the founding of the conservatory in the control group. We focus on three outcomes: the average prominence of composers in a group-cohort, the relative prominence of female composers in a group-cohort, and the fraction of female composers in a group-cohort.

Our basic empirical framework can be summarized by the following equation:

$$\begin{aligned} Y_{sgk} = \beta_0 &+ \beta_1 (near_{sgk}) + \beta_2 (after_{sgk}) \\ &\beta_3 (near_{sgk}) \times (after_{sgk}) + \\ &\alpha_c + \delta_t + \theta_{sgk} + \epsilon_{sgk} \end{aligned} \tag{6}$$

[34] Gustav Mahler, for instance, discouraged his wife, Alma (1879–1964), née Schindler, from composing during the early years of their marriage (Monson, 1983).

[35] In a discussion of the critical response to Ethel Smyth's (1858–1944) music, Gates (1997, p. 68) writes that "Smyth's music was seldom evaluated as a work of a composer among composers but as that of a 'woman composer'. This worked to keep her on the margins of the profession".

[36] Even women composition teachers discount their female pupils. Nadia Boulanger (1887–1979), possibly the most important female composition teacher of all time, is reported to have ostracized female students who contemplated marriage and to have preferred her male students. A graduate of the Paris Conservatory, Boulanger taught at the Conservatoire Femina-Musica, the L'ecole Normale de la Musique, and the American Conservatory at Fontainebleau (which she established), and was named a full professor at the Paris Conservatory in 1948. See Rorem (1982), who also notes that Boulanger held the view that there was no room for women composers aside from her sister, Lili Boulanger (1893–1918), whom Nadia idolized and who died at the young age of 24.

[37] The overall pattern of results concerning teachers is similar if we use the word count of a composer's works section as the dependent variable. If we drop composers born in the twentieth century, the results are also very similar.

Table 8
Conservatories (20 & 50 km thresholds).

	Avg. prom.	F/M prom.	F/M share	Avg. prom.	F/M prom.	F/M share
	(1)	(2)	(3)	(4)	(5)	(6)
Born after	0.019***	0.000***	0.002***	0.019***	−0.000***	0.002***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Born within threshold	0.009***	0.001***	0.044***	0.035***	−0.001***	0.041***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Born after × Born within	0.017***	0.002***	−0.005***	0.007***	0.006***	−0.008***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Threshold (km)	20	20	20	50	50	50
Conservatory FE	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓	✓	✓
Observations	9788	9788	9788	10 580	10 580	10 580
Num. conservatories	2174	2174	2174	2174	2174	2174
Adjusted R^2	0.547	−0.128	0.940	0.868	−0.002	0.927

Notes: "Avg. prom" is the natural log of the average word count. "F/M prom" is the ratio of the natural log of the average female word count to natural log of the average male word count. "F/M share" is the fraction of composers who are female. Standard errors are clustered at the country level.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

In this equation, s denotes conservatory, g denotes group ("near" or "far" from conservatory s), and k denotes cohort (born "before" or "after" the founding of conservatory s). The dependent variable, Y_{sgk}, is an average outcome among composers in a given conservatory-group-cohort; $near_{sgk}$ is an indicator equal to one for conservatory-group-cohorts born near (i.e., within a distance threshold) of conservatory s; $after_{sgk}$ is an indicator equal one for conservatory-group-cohorts born after conservatory s is founded; α_c is a fixed effect for the country in which a conservatory is located; δ_t is fixed effect for the half-century in which a conservatory was founded; θ_{sgk} is a fixed effect for conservatory s; and ϵ_{sgk} is an error term. The coefficient on the interaction term, β_3 can be interpreted as a difference-in-differences estimate of the effect of conservatories on average outcomes among composers born nearby.

We face several challenges when implementing this framework, most of which do not have obvious solutions. We first need to decide on a distance threshold for "near" and an outer limit to "far". For "near" we simply experimented with different thresholds (20 km, 50 km, 100 km, and 200 km). Given that most of our composers were born and lived in Europe, and musical styles tended to be similar among composers within Europe in a given period, we choose 500 km as the outer limit for "far". A downside with using such a generous outer-distance threshold, however, is that it is possible that composers born in the "far" category could themselves have been exposed to other conservatories, which would contaminate our estimates. Second, we need to decide on the time frame (relative to the founding of a conservatory) in which to focus our analysis. Because musical styles evolve over time, we restrict attention to a 40-year period. Third, it is an open question as to when treatment (i.e., "after") begins. For simplicity and ease of exposition, we use the founding date of the conservatory as the time of treatment and place composers born in the 20-year interval post-founding within the "after" cohort and composers born in the 20-year interval prior within the "before" cohort. To the extent that it takes a few years for a conservatory to establish itself and develop a reputation, this seems reasonable; composers generally attended conservatories in their late teens or early 20 s, which means that composers born in the 20 years prior to a conservatory's founding are unlikely to have been affected by it. On the other hand, if the effects of a conservatory are felt more immediately, then we should not exclude from the treated group those who were born within a few years prior to its founding (e.g., if, for instance, a conservatory is founded in 1870, someone born in 1860 could well have attended it). Accordingly, we also experimented by classifying composers born in the [−30, −10] interval prior to founding as "before" and any composer born in the [−10, +10] interval as being "after". Finally, within each group-cohort, we have a choice about how to aggregate our data. The simplest approach is to aggregate across an entire group-cohort (which is consistent with the set up outlined in Eq. (6)). This gives us four observations per conservatory (two groups, "near" and "far", multiplied by two cohorts, "before" and "after"). However, since we know composers' birth years, we can also aggregate by group-cohort-year, which yields up to 80 observations per conservatory (two groups, "near" and "far", multiplied by two cohorts, "before" and "after", each of which has 20 annual observations).[38] An intermediate approach is to aggregate by 10-year intervals for each group-cohort, which generates 8 observations per conservatory (two groups multiplied by two cohorts, each of which has two 10-year interval bins).

We cannot discuss nor display the results from all these permutations. The overall pattern that emerges, however, is roughly similar regardless of when we decided to turn on treatment, and how we aggregate the data (annually, in 10-year bins, or across an entire cohort-group). Accordingly, we present the results using the 10-year bins and in which we classify composers born after the establishment of a conservatory as "after".

Table 8 displays coefficient estimates using closeness thresholds of 20 km and 50 km. In columns (1) and (4) the dependent variable is average composer prominence; in columns (2) and (5) the dependent variable is the relative prominence of female composers (i.e., average prominence of women less average prominence of men), while in columns (3) and (6) it is the fraction of

[38] Some annual observations may be missing if no composers were born in those years.

Table 9
Women as teachers.

	Dependent variable			
	Num. students		Avg. student qual.	
	(1)	(2)	(3)	(4)
Female teacher (T)	−0.977	−34.301	0.010	0.220
	(3.672)	(34.537)	(0.071)	(0.609)
ln(T word count)	4.733***	4.624***	0.053***	0.053***
	(0.793)	(0.762)	(0.011)	(0.011)
Female T×ln(T word count)		5.861		−0.036
		(6.621)		(0.101)
Country FE	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓
Observations	3780	3780	2790	2790
Adjusted R^2	0.126	0.128	0.231	0.230

Notes: Standard errors are clustered at the country level.
Significance levels: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

composers who are women. The coefficient of interest is the interaction term, which is the average treatment effect of a conservatory. Across the two distance thresholds, the overall pattern is the same: the opening of a conservatory is positively correlated with the average prominence of composers in the area as well as the relative prominence of female composers, and negatively related to the female fraction of composers. As shown in Table G.1, we obtain a similar pattern of results using distance thresholds of 100 km and 200 km.

These findings provide suggestive evidence of the importance of conservatories for composer-prominence and their mixed effects on women (positive effects for their relative prominence but negative for relative representation). While we are heartened by the fact that they are reasonably robust across specifications, we note that this is a very noisy experiment for the reasons discussed earlier.[39] To these reservations, we add that, while we include conservatory-level fixed effects, conservatories are heterogeneous and their quality may change with time. Moreover, the founding of a conservatory is itself endogenous and we have no way to instrument for that. Accordingly, we view these as a "first-cut" effort to untangle the effects of conservatories on composers and the gender gap.

8. The consequences of the gender gap

We have documented a gender gap among female composers, which, along with our historical understanding of the barriers that women composers faced, suggests that women composers were indeed disadvantaged.[40] We now turn to the downstream consequences of this gender gap.

We first examine women as composition teachers, specifically whether they attracted fewer or weaker students than male composition teachers. This involves estimating regressions of the following form:

$$\begin{aligned} Y_j = \beta_0 &+ \beta_1 female\ teacher_j + \\ &\beta_2 ln(word\ count\ (main\ desc.))_j + \\ &\beta_3 female\ teacher_j \times ln(word\ count\ (main\ desc.))_j + \\ &\alpha_j + \delta_t + \epsilon_j \end{aligned} \tag{7}$$

In this equation, j denotes teacher. The dependent variable, Y_j, is either the number of students or the average prominence of the students of teacher j, where the average prominence of students is measured using the average word count of the students' main description in *Grove*; $female\ teacher_j$ is an indicator equal to one if teacher j is female; $ln(word\ count\ (main\ desc.))_j$ is the prominence of teacher j; α_j and δ_t are indicators for teacher j's country and half century of birth; and ϵ_j is an error term.

Regression results are shown in Table 9. In columns (1) and (2), the dependent variable is the number of students taught by teacher j, while in columns (3) and (4) it is the average prominence of teacher j's students. We note that the results in columns (3) and (4) should be interpreted cautiously; ideally, we would like to measure, on average, how promising j's students are, not how prominent they became (which is a function of j's efforts after they became j's students). Unfortunately, a student's promise is unobservable. Taking the results at face value, the coefficients indicate that, holding constant a teacher's era and country, female teachers appear to have attracted fewer students, but the coefficient is imprecisely estimated. The data are therefore too noisy for us to make any clear inferences on the quantity dimension. Our findings do indicate, however, that more prominent teachers attracted more students, and that any penalty female teachers may have suffered in terms of student numbers was partially attenuated by female teacher quality (although, again, the coefficient is statistically significant). In terms of average student quality, the coefficient

[39] Reassuringly, our findings are similar but somewhat noisier across distance specifications if we replace the dependent variable with the word count of a composer's works section to measure prominence, or if we drop composers born in the twentieth century.

[40] For a discussion of these barriers see Gates (2006).

Table 10
Likelihood of adopting a pseudonym.

	Dependent variable: Adopted pseudonym			
	Any pseudonym		Opp. gender pseudonym	
	(1)	(2)	(3)	(4)
Female	0.022***	0.021**	0.186***	0.154***
	(0.003)	(0.009)	(0.037)	(0.046)
Country FE		✓		✓
Half-century FE		✓		✓
Observations	15 637	13 162	169	161
Adjusted R^2	0.003	0.010	0.126	0.044

Notes: Standard errors are clustered at the country level.
Significance levels: ***$p < 0.01$; **$p < 0.05$; *$p < 0.1$.

on the female indicator is positive but statistically indistinguishable from zero. This could imply that female teachers were not disadvantaged in their ability to attract promising students, but as pointed out earlier, the dependent variable is a measure of average student prominence, not average student promise. Perhaps a more correct interpretation is that female composer–teachers added at least as much value to their students as their male counterparts, assuming that their students were, on average, no more promising than the students of male composer–teachers (which seems a reasonable assumption). This, in turn, suggests that, as composition teachers, women were at least as effective as men, despite the significant disadvantages they may have faced.[41]

Finally, we turn to how female composers adapted to the barriers they faced. Our investigation focuses on the likelihood of adopting a pseudonym, and, conditional on having done so, the likelihood of adopting a pseudonym of the opposite gender. We estimate linear probability regressions where the dependent variable is either an indicator equal to one if a composer is reported in *Grove* to have used a pseudonym or an indicator equal to one if that pseudonym is of the opposite gender, and the key right hand side variable is an indicator equal to one if the composer is female.

Columns (1) and (2) of Table 10 indicate that female composers are two percentage points more likely to adopt a pseudonym compared to male composers. Only one percent of composers in *Grove* used a pseudonym; this implies that women composers were three times more likely to adopt a pseudonym, an economically significant difference. Columns (3) and (4) show that, among composers who used a pseudonym, female composers are approximately 16 percentage points more likely to use an opposite gender pseudonym. Given that 4 percent of pseudonym-using composers adopted an alias of the opposite gender, this represents a four-fold increase. Concealing their gender was therefore one way female composers adapted to a market where their music was dismissed and disregarded.

9. Conclusion

Using unique data on several thousand composers who represent the history of western classical music, we document an economically significant gender gap among composers in terms of their prominence. Consistent with popular perceptions, we find women composers are indeed less acclaimed than their male counterparts, although the gap in their relative prominence has narrowed slightly with time and varies by region. We then conduct the first systematic quantitative exploration of the factors behind this gap, focusing on family musical background, composition teachers, and conservatories, factors that shape the acquisition of musical human capital and that may have had different effects by gender. Our analysis highlights the role of differential access to training in contributing to gender gaps within the cultural sector specifically and among highly skilled occupations more generally.

Our data do not allow for definitive causal claims. Additionally, because biographers, music historians, and musicologists have historically been men, the selection of composers into *Grove*, our primary data source, is potentially biased in favor of men. Despite these limitations, our findings highlight the multifaceted ways in which families, teachers, and conservatories — the primary modalities through which composer human capital was acquired — affected female composers. Composers with musician parents, particularly musician-mothers, are more prominent than those without musician parents; however, the effects are not different for composer-sons than for composer-daughters. Female composers were three times more likely to have a musician mother than male composers, suggesting an important role for mothers in encouraging their daughters to compose. Composers who had more and better teachers became prominent, but the effects are substantially attenuated for female composers, which is consistent with a well documented reluctance on the part of composition teachers of the past to make significant investments in their female pupils. Finally, the establishment of conservatories raised the prominence of composers in the vicinity of the conservatory, as well as the relative standing of women composers, but at the expense of female representation. Conservatories may have benefited those women who were determined enough to gain entry (or who could study privately with conservatory professors), but these barriers could easily

[41] The case of Nadia Boulanger is worth mentioning again. Boulanger can possibly claim credit for having had more students (not only composition students, but also pianists, conductors, singers, etc.,) than any other musician of any period. According to Pfitzinger (2017) she had 413 composition students, which is 100 times more students than the average female teacher in our sample (a difference of almost 20 standard deviations) and more than twice as many students as the most prolific male teacher. Many of Boulanger's students became highly influential, including Aaron Copeland, Elliott Carter, Jean Françaix, Virgil Thomson, Darius Milhaud, Astor Piazzola, George Walker and Philip Glass (Rosenstiel, 1998).

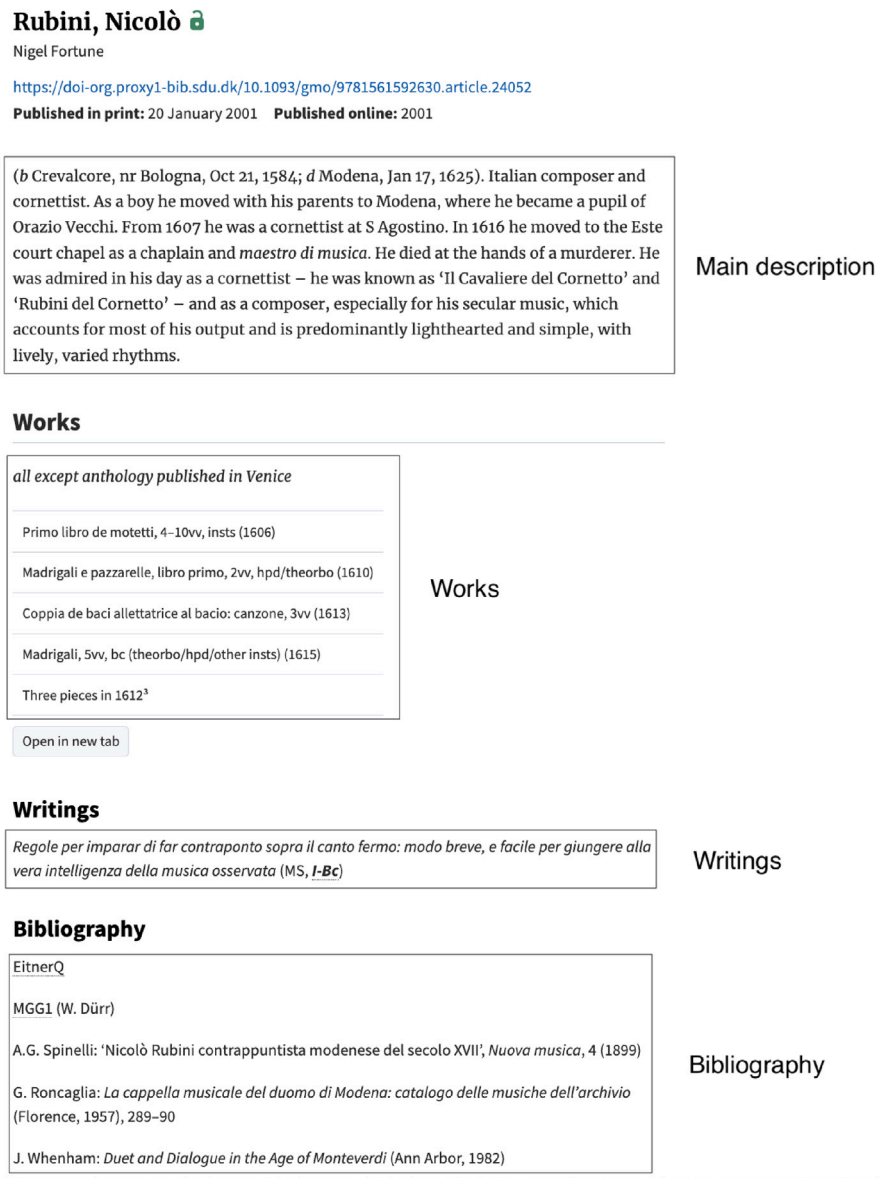

Fig. A.1. Anatomy of a *Grove* entry.

have deterred others. An understanding of the composer gender gap must therefore be conditioned on an appreciation of history and the significant obstacles that women confronted in the past.

What were the downstream consequences of the gender gap for women composers? In spite of the barriers that women faced as composers, they do not appear to have been disadvantaged as composition teachers and may have been at least as effective as men in that role. In addition, female composers were more likely to adopt a pseudonym than their male counterparts, especially one of the opposite gender. This need to conceal the feminine gender underscores the extent to which women were simply not taken seriously as composers in the past, which may well be the most important reason for classical composer gender gap.

Declaration of competing interest

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

Appendix A. Anatomy of a *Grove* entry

See Fig. A.1.

Appendix B. Location of conservatories, Europe

See Fig. B.1.

Appendix C. Summary statistics by gender

See Table C.1.

Appendix D. Additional maps

See Figs. D.1 and D.2.

Appendix E. Teacher-student correlations

See Fig. E.1.

Appendix F. Matched sample summary statistics

See Table F.1.

Appendix G. Effects of establishment of conservatories

See Table G.1.

Appendix H. Maps using historical borders

See Figs. H.1–H.4.

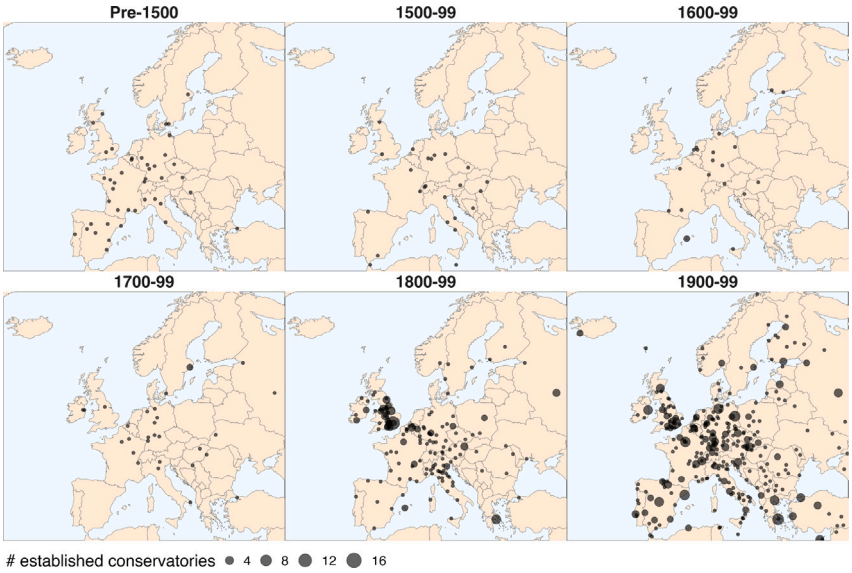

Fig. B.1. Location of conservatories, Europe. *Notes*: This figure depicts the spatial distribution of conservatories by their century of establishment. The data comes from the International Directory of Music and Music Education Institutions, which collects information on post-secondary music schools, academies, colleges, conservatories, and university music departments worldwide. To facilitate navigation we use today's country borders. For maps with historical country borders see Fig. H.2.

Table C.1
Summary statistics by gender.

(a) Pfitzinger (2017) sample

Variable	Male composers					Female composers					*t*-test	
	Obs.	Mean	SD	Min	Max	Obs.	Mean	SD	Min	Max	*t*-statistic	*p*-value
Born	15,887	1878.20	101.38	505.00	2,001.00	1384	1930.80	53.02	1098.00	2,001.00	−32.14	0.00
Died	10,171	1907.45	109.65	571.00	2,016.00	495	1961.78	67.16	1179.00	2,016.00	−16.93	0.00
No. students	7,370	4.79	10.55	1.00	206.00	376	4.15	21.60	1.00	412.00	0.57	0.57
No. teachers	15,930	2.06	2.00	0.00	22.00	1386	2.87	2.26	0.00	13.00	−12.88	0.00
Teacher qual.	10,740	1743.16	3410.10	21.00	42,011.00	1012	1324.41	2464.29	97.00	39,533.00	4.98	0.00
Occupations												
Composer	7,093	1.00	0.05	0.00	1.00	444	1.00	0.00	1.00	1.00	−4.13	0.00
Conductor	7,093	0.16	0.36	0.00	1.00	444	0.06	0.24	0.00	1.00	8.00	0.00
Teacher	7,093	0.13	0.34	0.00	1.00	444	0.10	0.30	0.00	1.00	1.93	0.05
Pianist	7,093	0.10	0.30	0.00	1.00	444	0.22	0.42	0.00	1.00	−6.03	0.00
Organist	7,093	0.10	0.30	0.00	1.00	444	0.02	0.15	0.00	1.00	9.49	0.00
Violinist	7,093	0.06	0.23	0.00	1.00	444	0.01	0.12	0.00	1.00	7.25	0.00
Singer	7,093	0.02	0.14	0.00	1.00	444	0.05	0.22	0.00	1.00	−2.85	0.00
Word counts												
Main desc.	7,093	685.84	1802.68	15.00	42,011.00	440	309.51	263.70	58.00	2,358.00	15.18	0.00
Works	7,093	397.03	1189.38	0.00	46,397.00	444	252.13	289.60	0.00	2,898.00	7.35	0.00
Bibliography	7,093	154.72	689.93	0.00	16,402.00	444	61.96	130.02	0.00	2,263.00	9.04	0.00
Writings	7,093	19.88	68.67	0.00	1,616.00	444	5.60	25.04	0.00	264.00	9.91	0.00

(b) Grove sample

Variable	Male composers					Female composers					*t*-test	
	Obs.	Mean	SD	Min	Max	Obs	Mean	SD	Min	Max	*t*-statistic	*p*-value
Born	12,781	1810.29	140.44	154.00	1,976.00	954	1890.87	85.83	810.00	1,972.00	−26.47	0.00
Died	10,314	1827.50	149.60	163.00	2,010.00	502	1916.12	100.29	867.00	2,009.00	−18.80	0.00
Pseudonym	14,645	0.01	0.10	0.00	1.00	992	0.03	0.17	0.00	1.00	−3.91	0.00
Occupations												
Composer	14,645	0.98	0.15	0.00	1.00	992	0.97	0.16	0.00	1.00	0.65	0.52
Conductor	14,645	0.11	0.31	0.00	1.00	992	0.04	0.20	0.00	1.00	9.21	0.00
Teacher	14,645	0.08	0.28	0.00	1.00	992	0.08	0.27	0.00	1.00	0.22	0.83
Pianist	14,645	0.09	0.29	0.00	1.00	992	0.23	0.42	0.00	1.00	−10.54	0.00
Organist	14,645	0.11	0.31	0.00	1.00	992	0.03	0.16	0.00	1.00	14.33	0.00
Violinist	14,645	0.05	0.23	0.00	1.00	992	0.01	0.11	0.00	1.00	10.24	0.00
Singer	14,645	0.04	0.21	0.00	1.00	992	0.10	0.30	0.00	1.00	−5.51	0.00
Word counts												
Main desc.	14,645	476.60	1300.94	7.00	42,011.00	992	251.71	195.52	17.00	2,358.00	18.12	0.00
Works	14,645	238.18	851.28	0.00	46,397.00	992	161.78	225.53	0.00	2,898.00	7.61	0.00
Bibliography	14,645	105.69	481.26	0.00	16,402.00	992	47.89	95.35	0.00	2,263.00	11.56	0.00
Writings	14,645	12.65	54.17	0.00	1,616.00	992	3.36	18.76	0.00	264.00	12.47	0.00

Notes: This table shows the number of observations, the average values, standard deviation, minimum and maximum values for variables in the Pfitzinger (2017) and *Grove* samples.

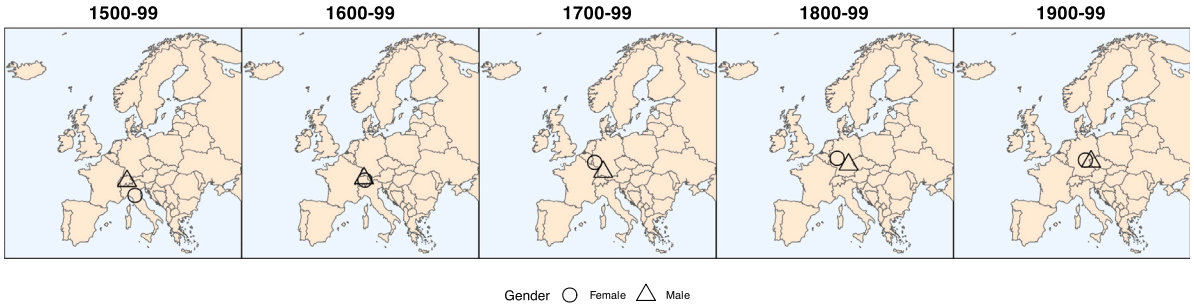

Fig. D.1. Spatial distribution of composers by gender, Europe. *Notes*: This figure shows the center of mass of the distribution of birthplaces of female and male composers in Europe. Earlier centuries are not displayed as there are only two female composers in *Grove* born prior to 1500. To facilitate navigation we use today's country borders. For maps that use historical country borders see Fig. H.3.

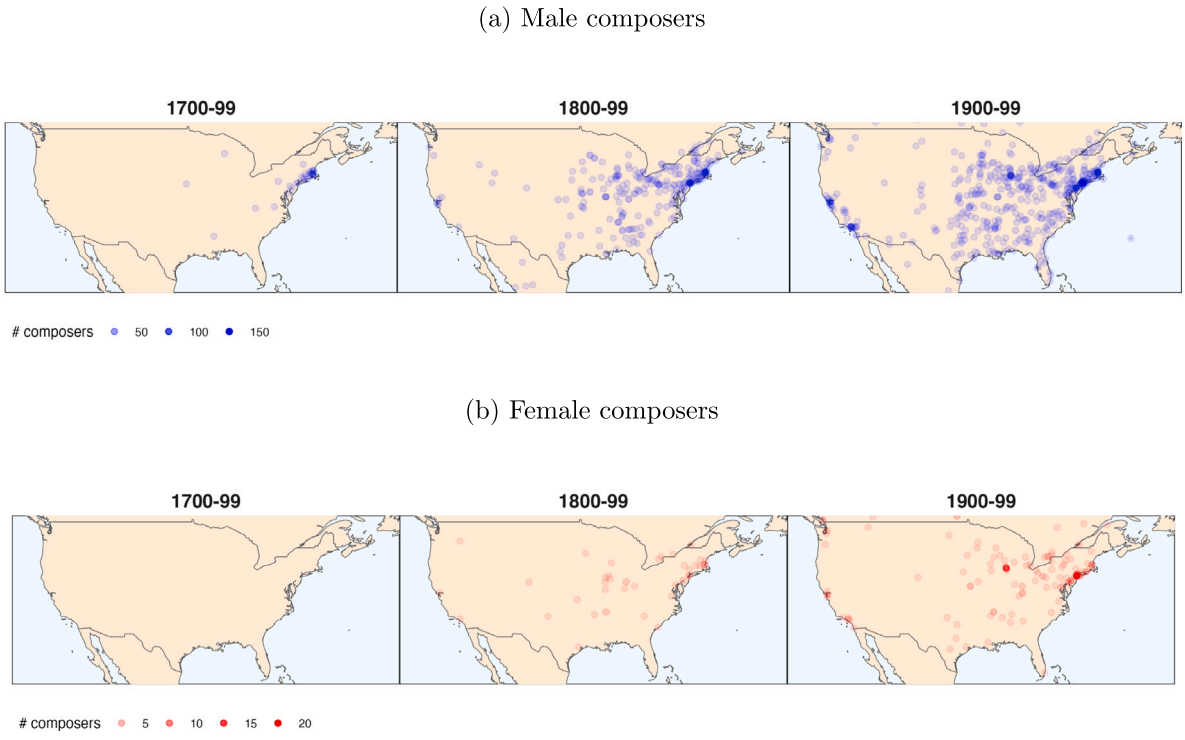

Fig. D.2. Number of composers by gender, US. *Notes*: This figure shows the spatial distribution of birth locations of composers by gender in the US using today's borders to facilitate navigation. Each dot represents a city and dots that are less transparent indicates a higher concentration of composers. For maps using historical borders see Fig. H.4.

Table F.1
Summary statistics by gender (matched sample).

Variable	Male composers					Female composers					*t*-test	
	Obs	Mean	SD	Min	Max	Obs	Mean	SD	Min	Max	*t*-statistic	*p*-value
Born	444	1904.50	62.90	1510.00	1970.00	444	1903.12	70.62	1098.00	1972.00	0.31	0.76
Died	261	1947.29	73.21	1559.00	2015.00	249	1944.57	84.36	1179.00	2016.00	0.39	0.70
No. students	238	6.11	10.47	1.00	62.00	154	7.08	33.48	1.00	412.00	−0.35	0.73
No. teachers	444	2.40	1.91	0.00	12.00	444	2.78	1.87	0.00	11.00	−2.99	0.00
Occupation												
Composer	444	1.00	0.00	1.00	1.00	444	1.00	0.00	1.00	1.00	–	–
Conductor	444	0.13	0.34	0.00	1.00	444	0.06	0.24	0.00	1.00	3.65	0.00
Teacher	444	0.11	0.31	0.00	1.00	444	0.10	0.30	0.00	1.00	0.44	0.66
Pianist	444	0.13	0.33	0.00	1.00	444	0.22	0.42	0.00	1.00	−3.83	0.00
Organist	444	0.05	0.21	0.00	1.00	444	0.02	0.15	0.00	1.00	2.01	0.04
Violinist	444	0.03	0.17	0.00	1.00	444	0.01	0.12	0.00	1.00	1.62	0.10
Singer	444	0.01	0.12	0.00	1.00	444	0.05	0.22	0.00	1.00	−3.22	0.00
Word counts												
Main description	444	320.82	380.43	42.00	7073.00	444	309.51	263.70	58.00	2358.00	0.51	0.61
Works	444	247.72	272.79	0.00	4177.00	444	252.13	289.60	0.00	2898.00	−0.23	0.82
Bibliography	444	53.41	78.97	0.00	1133.00	444	61.96	130.02	0.00	2263.00	−1.18	0.24
Writings	444	16.67	43.35	0.00	345.00	444	5.60	25.04	0.00	264.00	4.66	0.00
Mother musician	444	0.03	0.17	0.00	1.00	444	0.09	0.28	0.00	1.00	−3.63	0.00
Father musician	444	0.10	0.30	0.00	1.00	444	0.10	0.30	0.00	1.00	0.11	0.91
Relative musician	444	0.06	0.23	0.00	1.00	444	0.07	0.25	0.00	1.00	−0.70	0.49
Spouse musician	444	0.04	0.20	0.00	1.00	444	0.13	0.34	0.00	1.00	−4.86	0.00

Notes: This table summarizes the variables of the matched sample constructed via propensity score matching.

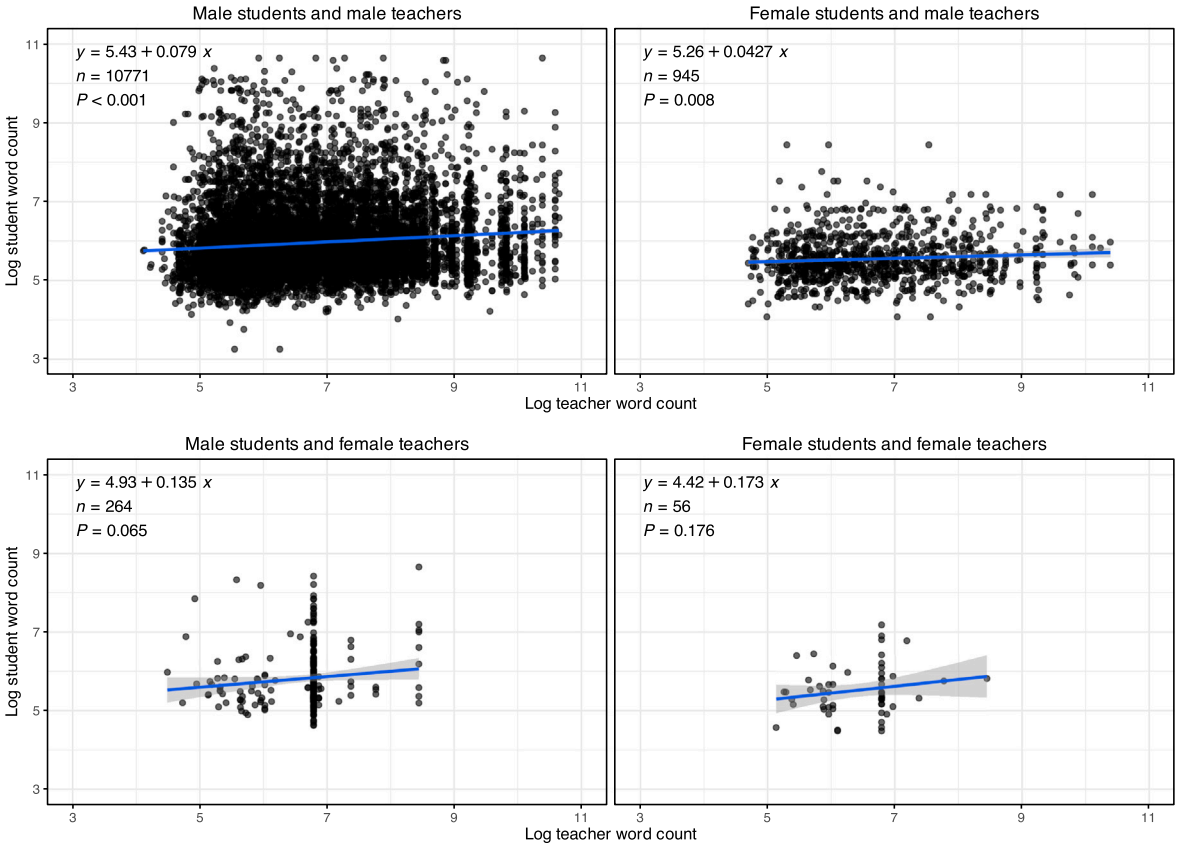

Fig. E.1. Correlation between student and teacher quality by gender. *Notes*: This figure depicts the correlation between the length of student's word count and the word count of their respective teachers' *Grove* biographies.

Table G.1
Conservatories (100 & 200 km thresholds).

	Avg. prom.	F/M prom.	F/M share	Avg. prom.	F/M prom.	F/M share
	(1)	(2)	(3)	(4)	(5)	(6)
Born after	0.018***	0.000***	0.002***	0.019***	−0.001***	−0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Born within threshold	0.034***	0.002***	0.031***	0.030***	0.002***	0.017***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Born after × Born within	0.014***	0.001***	−0.010***	0.002***	0.006***	−0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Threshold (km)	100	100	100	200	200	200
Conservatory FE	✓	✓	✓	✓	✓	✓
Country FE	✓	✓	✓	✓	✓	✓
Half-century FE	✓	✓	✓	✓	✓	✓
Observations	11 648	11 648	11 648	13 035	13 035	13 035
Num. conservatories	2174	2174	2174	2174	2174	2174
Adjusted R^2	0.900	−0.074	0.916	0.800	0.268	0.840

Notes: Standard errors are clustered at the country level.
Significance levels: $^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

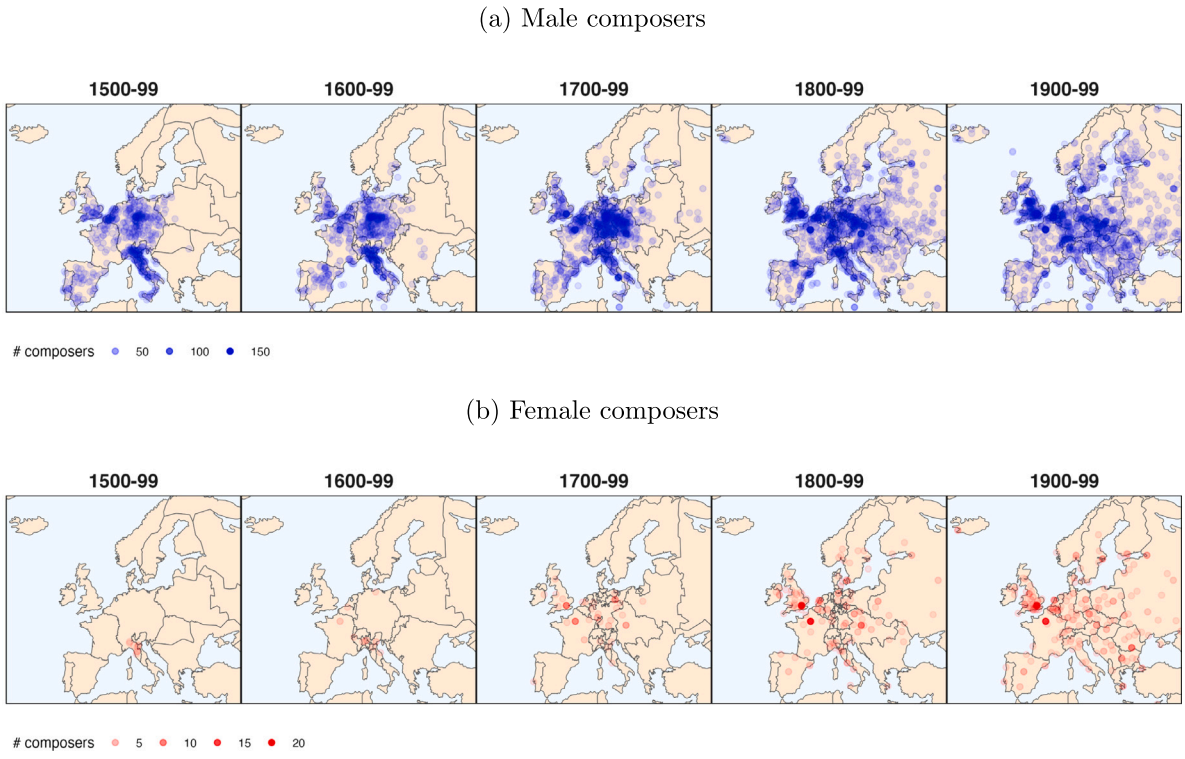

Fig. H.1. Number of composers by gender, Europe. *Notes*: This figure shows the spatial distribution of birth locations of composers in the Pfitzinger (2017) sample by gender in Europe. Each dot represents a city. Darker dots indicate a higher concentration of composers. We use historical borders at 1530, 1650, 1715, 1815, and 1945, respectively. Earlier centuries are not displayed as there are only two female composers in *Grove* born prior to 1500.

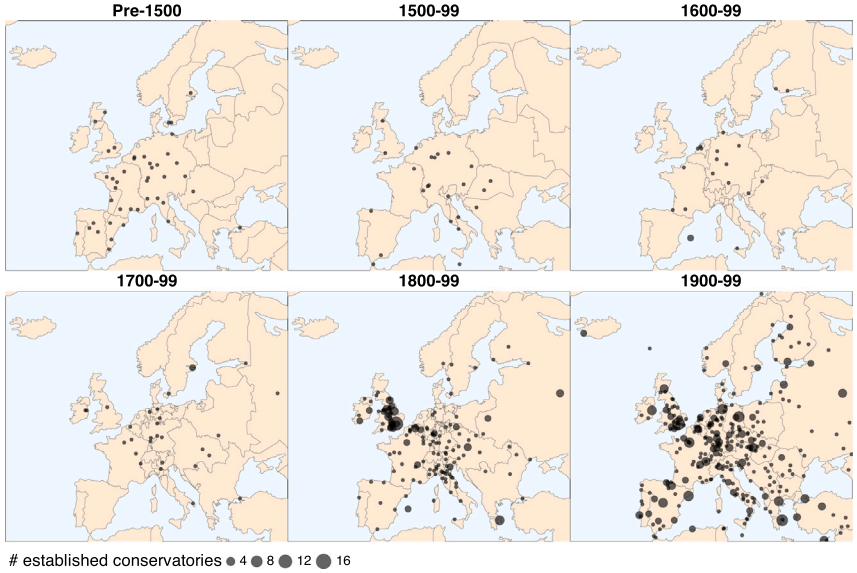

Fig. H.2. Location of conservatories, Europe. *Notes*: This figure depicts the spatial distribution of conservatories by their century of establishment. The data comes from the International Directory of Music and Music Education Institutions, which collects information on post-secondary music schools, academies, colleges, conservatories, and university music departments worldwide. We use historical borders at 1279, 1530, 1650, 1715, 1815, and 1945, respectively.

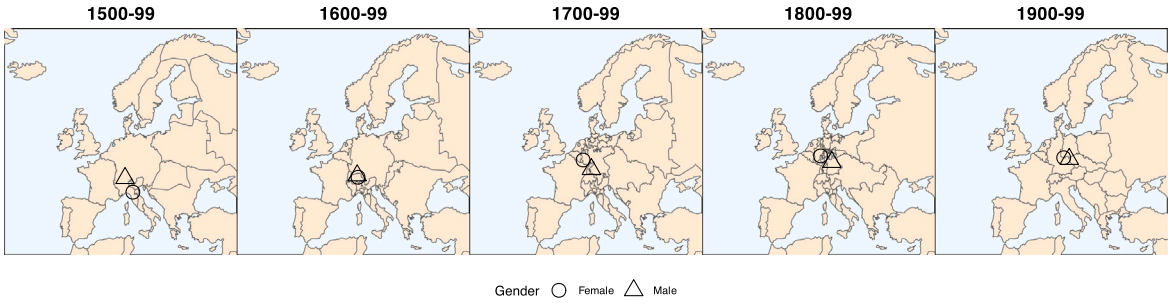

Fig. H.3. Spatial distribution of composers by gender, Europe. *Notes*: This figure shows the center of mass of the distribution of birthplaces of female and male composers in Europe. We use historical borders at 1530, 1650, 1715, 1815, and 1945, respectively. Earlier centuries are not displayed as there is are only two female composer in *Grove* born prior to 1500.

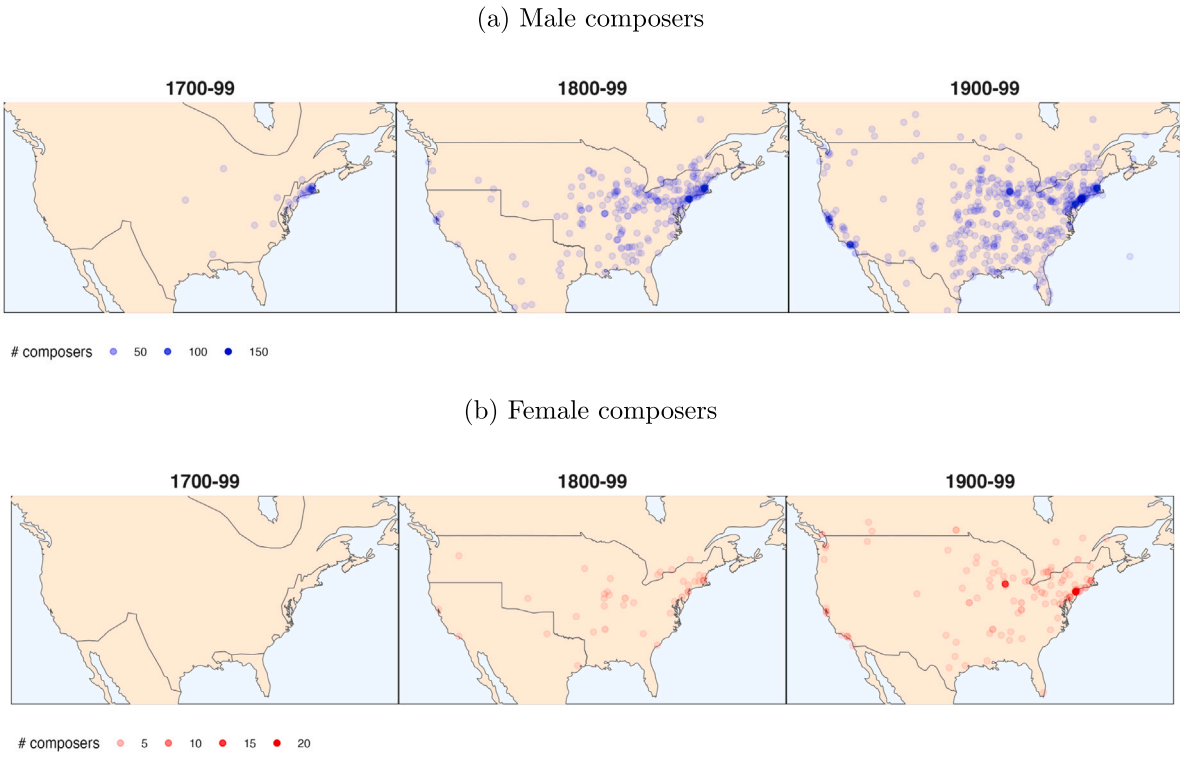

Fig. H.4. Number of composers by gender, US. *Notes*: This figure shows the spatial distribution of birth locations of composers by gender in the US. Each dot represents a city and dots that are less transparent indicates a higher concentration of composers. We use historical borders at 1715, 1815, and 1945, respectively.

Appendix I. Supplementary data

Supplementary material related to this article can be found online at https://doi.org/10.1016/j.euroecorev.2024.104893.

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