The End of a Gender Quota in Elite Higher Education*

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Abstract

We show that a gender quota system in competitive higher education institutions could be an efficient solution to address the issue of women under-representation in math-intensive fields and elite environments. We use original hand-collected historical data from the entrance exam for one of the most competitive graduate schools in France to evaluate the effect of a change in admission policy that removed a hard gender-based quota system. We document that the end of the quota led to a sharp decline in the percentage of admitted female candidates, but only in math-intensive fields. We then focus on the mathematics entrance exam to delve into the mechanisms. We show that half of this fall can be mechanically explained by a gender performance gap. However, we also uncover a behavioral response by female candidates: there are fewer female candidates at the entrance exam once it became mixed-gender, and this *turning-away* mechanism is mostly driven by potentially high-achieving female candidates. This detrimental behavioral response of women in a real-life context is important. As this elite institution leads to high-level academic careers in France, we show that the removal of the gender quota increased the gender gap in academic careers for affected students.

JEL Codes: I23, I24, J16, J24, J78

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Introduction

In many higher education systems, recruitment into elite schools relies on competitive exams, which are the cornerstones of meritocratic admissions policies. By definition, selective education faces capacity constraints due to its limited number of available seats. Competitive exams are often considered as a fair and equitable method for assessing and selecting students based on their abilities.[1] However, recent experimental literature has shown the extent of gender differences in attitudes towards competition. Women's performances and their willingness to compete have been shown to be lower in mixed-gender rather than single-gender settings (Gneezy et al., 2003; Niederle and Vesterlund, 2007), especially while performing stereotypically male-associated tasks (Niederle and Vesterlund, 2010). Gender differences in aptitude during high-stakes exams (Azmat et al., 2016; Ors et al., 2013; Montalbán and Sevilla, 2023) can have detrimental effects on women's outcomes in higher education (Arenas and Calsamiglia, 2022). Gender quotas have been shown in experimental design to be an effective tool to level the playing field between male and female students, especially in STEM (Niederle et al., 2013). However, little is still known about the real-world effect of such a policy, as there have been limited sources of exogenous variations in the implementation or the end of gender quotas in the educational context.

In this paper, we attempt to empirically assess the potential effects of gender quotas in selective higher education. We combine an original hand-collected dataset from diverse archival sources with the unexpected end of a hard gender-based quota at one of France's most prestigious elite graduate schools. This allows us to provide new evidence on the impact of introducing mixed competition on the profiles and trajectories of admitted candidates.

We leverage a natural experiment that occurred in 1986 at the *École Normale Supérieure de Paris* (hereafter ENS Paris), a French public elite graduate school (*Grande École*) whose purpose is to train future high-level teachers and researchers. Its recruitment mainly relies on a highly competitive anonymous written entrance examination, followed by an oral examination for a subset of qualified students in four different tracks: mathematics, physics-

[1] In addition to the French "Grandes Écoles", which are the focus of this study, competitive exams (or multiple examinations) are common practice in several countries (OECD, 2019). Other countries rely on entrance examination (e.g. India or Turkey), or standardized aptitude tests (e.g. SAT in the United States, SweSAT in Sweden).

chemistry, biology, or humanities. ENS Paris is globally renowned for its excellence in research, including in mathematics (Clynes, 2016).

Before 1986, ENS Paris was composed of two single-gender schools: ENS d'Ulm (men-only) and ENS de Sèvres (women-only). These schools were located in separate areas of Paris, each with its own administration and entrance examination. However, starting in the 1970s, male and female students studied together in mixed-gender preparatory programs before taking the entrance exam. While the examination topics were identical for both genders[2], candidates were graded and ranked separately, with a fixed number of seats allocated to men and women. Once admitted, male and female students attended most of their classes in mixed-gender public universities and ultimately pursued similar careers in research and teaching. This system effectively imposed a hard gender-based quota at ENS Paris. ENS d'Ulm and ENS de Sèvres eventually merged in 1986, which led to the removal of the gender quota system and the introduction of mixed competitive exams. Though ENS Paris was one of the last schools to comply with the law on compulsory co-education in 1975 (*loi Haby*), the exact year of the merger of the two schools was not anticipated.[3] We take advantage of the unforeseen timing of this event to study the effects of the end of a gender quota in elite higher education.

We document that the introduction of mixed competition at the entrance exams for ENS Paris led to a dramatic fall in the share of admitted female candidates to the mathematics and the physics-chemistry tracks, while it remained unchanged in the biology and humanities tracks.[4] However, in all four tracks, the end of the gender quota led women to be under-represented among admitted candidates with respect to their enrollment in preparatory programs. For instance, in the mathematics track, the percentage of admitted female candidates fell from an average of 39 % in the ten years before the end of the quota to an average of 9 % in the twenty years that followed, while women represented about 17 % of students in mathematics preparatory programs in France over the same period.

We then focus on the mathematics entrance examination to better understand the underlying mechanisms, as it is the track with the most significant and long-lasting reduction in the share of admitted female candidates. Using relative odds ratios to take

[2]Except in the humanities track, until 1985.

[3]See Section 1 for details about the institutional background.

[4]Before 1986, the quota was set to be around 30-40 % of female students in mathematics, 45-50 % in physics-chemistry, and around 50 % in biology and humanities.

into account the gender composition of candidates and students in preparatory programs, we show that female students were actually more likely to be admitted to ENS before the introduction of the mixed competition. This pattern is then entirely reversed after 1986. Male students then have a substantial advantage in qualification at the written exam and in final admission. Using our detailed information about students' scores at the entrance examination, we show that, on average, male students outperform female students at the written exam over the entire study period, but perform as well as them at the oral exam, with and without controlling for their grades at the written exam. We then perform counterfactual simulations for the years when the gender quota was implemented by ranking both male and female candidates together on their final grade at the exam. We find that about half of the fall in the share of admitted female candidates can be explained by this gender performance gap at the exam. However, a substantial portion remains unexplained by it. We investigate the causes of this unexplained decline in admitted female candidates and show that women tend to opt out of the ENS Paris entrance examination following the implementation of the mixed competition. This behavioral response seems concentrated among candidates who are likely to be high performers, the ones from the best preparatory programs in France, which could represent an absolute loss of talents for the school.

We deepen the analysis of the extensive and intensive margins of this behavioral response using hand-collected data on student grade reports from the best mathematics preparatory program between 1978 and 1988. Although students from this preparatory program represent only a subsample of ENS candidates in the mathematics track (roughly 13 %), they account for a third of admitted students. We find an overall decrease in the probability of applying to ENS for female students after the end of the gender quota, whereas this probability increased for male students. Interestingly, we observe fewer female candidates throughout the grade distribution, suggesting that the decline in female participation cannot be explained solely by lower-achieving female students turning away from the heightened, mixed-gender competition. Finally, we find no evidence that women underperformed at the entrance exam compared to their male counterparts, once we control for their grades at the end of the preparatory program, nor do we observe the emergence or widening of a gender gap in performance after the transition to a mixed-gender exam.

Finally, we investigate the long-term impact of ending gender quotas at ENS Paris

entrance exams on French scientific academia. This aspect is particularly relevant in the case of ENS Paris, as between 1984 and 2010, the school trained more than 30 % of French public university professors across various fields, including mathematics. We define a group of both male and female candidates who are likely to have been impacted by the gender quota system, or by its ending in 1986, and we gather different sources of information about their professional careers. We especially use the administrative data of the human resources of the Ministry of Higher Education about the stock of assistant and full professors in French public universities between 1984 and 2010. Our results suggest that the end of the quota system led to an increase in the gender gap in the probability of pursuing a teaching or a research career in mathematics-related fields. Given the literature on the importance of (same-sex) role models for women representation in STEM, this could have inter-generational consequences on women in STEM studies and careers in France.

Related Literature This paper makes several contributions to the literature on gender segregation in education and the labor market. Women outnumber men in higher education, but they still account for less than 20 % of new entrants in computer science and approximately 18 % in engineering on average among member countries of the Organization for Economic Co-operation and Development (OECD, 2017). This unbalance raises concern for three main reasons. First, the lack of women in Science, Technology, Engineering and Mathematics (STEM) generates a potential loss of talents that could help meet the growing demand for these types of skills (Hoogendoorn et al., 2013; Hunt, 2016; Hsieh et al., 2019). Second, it contributes to gender inequality in the labor market, as STEM occupations lead to higher income on average (Brown and Corcoran, 1997; Black et al., 2008; Blau and Kahn, 2017). Finally, the under-representation of women challenges the production of ethical and fair knowledge (Truffa and Wong, 2024), which has notably been shown to be a concern for the development of artificial intelligence (UNESCO, 2020).[5] Some interventions have been shown to be effective in reducing this gender gap, such as information provision (Li, 2018), (same-gender) mentoring (Lim and Meer, 2017), or (same-gender) role models (Carrell et al., 2010; Kofoed and McGovney, 2019; Porter and Serra, 2020; Riise et al., 2022; Breda et al., 2023; de Gendre et al., 2023). However, these

[5] A similar phenomena has been shown with respect to racial minorities (Dossi, 2024).

interventions must happen early enough in students' lives to affect their school choices. A more short-term solution in higher education could be to implement gender quotas. This tool has been, until now, more extensively used and studied in the context of the workplace (Bertrand et al., 2019), in hiring committees (Deschamps, 2023), or in politics (Bagues et al., 2017; Besley et al., 2017; O'brien and Rickne, 2016), including in France (Lippmann, 2021, 2022). While the use of gender-based affirmative action may seem unusual in an educational context, such policies have already been in place in countries like Finland (Schaede and Mankki, 2024; Silliman and Virtanen, 2022) or Norway. We show that affirmative action in favor of women in STEM could increase their participation in competitive exams, potentially benefiting high-achieving women who would not have applied in the absence of such policies. This finding sheds light on the mechanisms at play in the ongoing debate over the efficiency-equity trade-off of affirmative action policies in education, with results that are consistent with Bleemer (2022) in the context of race-based affirmative action in the United States. Our paper also provides new real-world evidence on the detrimental effects of mixed competition for women performance in stereotypically masculine tasks, notably by showing the existence of a *turning away* effect exhibited in the experimental literature (Niederle and Vesterlund, 2010), driven mostly by potentially high-achieving candidates.

Our study eventually speaks to the social science literature on the effect of the internalization of gender stereotypes on women's performance and school choices (Breda et al., 2020; Charles and Bradley, 2002; Charles and Grusky, 2005; Charles and Bradley, 2009; Huguet and Régner, 2007; Sikora and Pokropek, 2012; Spencer et al., 1999). Recent literature, finding its theoretical basis in evolutionary psychology, posits that in more equal countries, men and women would have more freedom to express their inner preferences (Lippa et al., 2010; Stoet and Geary, 2018; Falk and Hermle, 2018), resulting in more horizontal differentiation. In the schooling context, this would imply that women would outperform men in humanities, and men, women in science, maintaining a status quo in the end. However, we do not observe this phenomenon in our historical experiment; the introduction of the mixed competition eventually led to an absolute decrease in the number of women admitted to ENS Paris, as there were fewer women admitted in the mathematics and physics track, but not more admitted in the biology and humanities tracks. These results are in line with previous studies on the impact of the merger of elite graduate schools

in France (Bataille, 2011), and extend the results of Blanchard et al. (2014) by analyzing the effects of the end of the gender quota at ENS Paris on candidates' profiles, candidates' performances at the exam and on long-run labor market outcomes. More broadly, it contributes to the growing literature on the effect of the development of co-education. It notably speaks to the paper by Calkins et al. (2021), which shows that women's colleges' transitions to co-education in the United States led to a 3.0 percentage-point (30 %) decline in the share of women majoring in STEM.

The rest of the paper is organized as follows. Section 1 describes the institutional background, and Section 2 presents the data used for this study. Section 3 presents the results on admission, and Section 4 delves into the mechanisms, disentangling the mechanical part due to a gender gap in performance and an additional behavioral response from female candidates. Section 5 discusses the long-run consequences of the end of the gender quota on the mathematics academic landscape in France. The last section concludes and discusses our findings.

1 Institutional Background

1.1 Academic Higher Education in France

In the early 1980s, less than 30 % of a birth cohort graduated from high school in France (MENJS, 2023). The vast majority of these graduates (more than 80 %) chose to pursue higher education, which offered vocational and academic tracks (DEPP, 1997). Students willing to follow the academic track had two main options: (i) non-selective public universities, which enrolled about 68 % of higher education students, and (ii) an elite track consisting of preparatory programs (*Classes Préparatoires aux Grandes Écoles*), followed by elite graduate schools (*Grandes Écoles*), which enrolled 3 % of higher education students. The coexistence of these two distinct paths is a defining feature of the French educational system. Figure A1 in the Appendix A displays a simplified version of the different paths available to students in France.

Preparatory programs and elite graduate schools Preparatory programs last two years, although many students extend their studies to three years due to the highly selective nature of the entrance exams for elite graduate schools. These programs consist of intensive

undergraduate studies and are located in high schools, where students are taught by the highest qualified secondary teachers.[6] Tuition fees are very low for public preparatory programs, and more than 80 % of students are enrolled in a public one (MENESR, 2022). There are different tracks of preparatory programs: humanities, social sciences, and science (with various majors in mathematics, physics-chemistry, engineering sciences, and biology).

Access to preparatory programs has always been highly selective. Admission is largely based on academic performance in high school, and these programs consistently attract the highest-achieving students. At the end of their second year, students take competitive entrance examinations for several elite graduate schools, with exam topics depending on their preparatory program track. These elite graduate schools typically last three years, and students graduate from them with an equivalent to a master's degree. There is a strong hierarchy among preparatory programs based on their success rates in entrance examinations to elite graduate schools.

Our paper studies the entrance examination to one of these elite graduate schools, the *École Normale Supérieure de Paris* (ENS Paris), with a particular focus on its mathematics track. In Section 4, we analyze data from the top mathematics preparatory program, located at the *Lycée Louis le Grand*. In the 1980s, this program accounted for about 13 % of ENS Paris mathematics entrance exam candidates but represented a third of the admitted students.

1.2 The École Normale Supérieure: a School for Research and Teaching

The School ENS Paris is an elite graduate school established after the French Revolution. Its initial purpose was to give homogeneous training to high school teachers across France, and now mostly leads to high-level teaching and academic careers. There are three other ENS besides the one in Paris, located in Lyon, Saclay and Rennes. ENS Paris has almost no tuition fees (only a couple hundred euros per year), and students who enter the school through the main entrance examination are paid to study for four years.[7] The school has different tracks (humanities, social sciences, biology, physics-chemistry, mathematics) for

[6] Only teachers who obtained the *agrégation* can teach in preparatory programs.
[7] Students are then formally in contract with the state as civil servant trainees for 10 years.

the entrance examination.[8] However, students are free to study what they want once they enter the school. Though some classes can be taken on site, a large part of ENS students' training takes place at public universities.

This context is particularly relevant for studying inequalities in access to top positions in academia, especially in mathematics, as it is one of the main pathways to an academic career in France. On average, between 1984 and 2010, 28 % of all mathematics professors in French universities were former students of ENS Paris. Recognized as one of the world's leading research institutions, ENS Paris boasts the highest ratio of Nobel Prize winners per capita globally (Clynes, 2016). Moreover, out of 13 French Fields Medal winners, the highest distinction in mathematics, 10 are former students of ENS Paris.

Recruitment Recruitment at ENS Paris mainly relies on a highly competitive entrance examination.[9] Taking the entrance examination is not expensive (roughly 100 euros today). The number of seats offered in each track is defined by law at the beginning of the school year by the Ministry of Higher Education. Exams take place at the end of the school year, between April and June. Since the merger of the two single-gender schools in 1986, more than 800 candidates are registered for the mathematics written exam on average each year, for approximately 40 seats available.

The entrance examination is staged in two steps: a written examination, and then for qualified candidates, an oral examination. All candidates are ranked according to a weighted average of all written test scores, and the highest ranked students are declared qualified for the oral examination. The qualification threshold is track and year specific, and the number of qualified students is around twice the final number of seats available. The mathematics track written examination consists of five written exams over a week: two in mathematics, one in physics, one in French, and one in a foreign language.[10] In particular, the largest weight is given to the first mathematics exam, which lasts 6 hours. It has a reputation for being particularly difficult and hard to complete in time. The written part of the entrance exams is graded anonymously.

[8] In this paper, we exclude the social sciences track as it was only created in 1982.

[9] A small number of students are also recruited based on their academic records. During the past decade, the number of students admitted through this admission procedure has fairly increased; it has been used by the administration has used it to increase diversity in the school, although students at ENS Paris are still largely coming from very high socioeconomic status backgrounds (Bonneau et al., 2021).

[10] Since 1994, the French and foreign language exams are taken at the written stage, but their scores do not count to be qualified at the oral part of the exam. Their scores are only added to the oral exams.

The oral examination takes place in June, two weeks after the results of the written exam have been disclosed to the candidates. Candidates are unaware of their grades and rank at the written exams, so that low and high performers in the first stage prepare for the final examination in the same way. Except for some slight variations over time, subjects at the written and oral exams are essentially the same. Finally, qualified candidates are ranked according to a weighted average of all written and oral test scores and the highest-ranking students are admitted to the school. Oral examination typically accounts for more than 85 % of the final average. Admission to ENS Paris in mathematics is highly selective: the final acceptance rate is only 5 % (compared, for instance, to 7 % for the Massachusetts Institute of Technology). Students have the possibility to do a third year of preparatory program to retake the exam.

With the exception of the 1986 merger, the preparation conditions and the recruitment procedures for the entrance examination to ENS Paris in mathematics have remained stable over time. The other major change took place in 1994 with the creation of a common written exam for all ENS, which made it easier for students to apply to multiple ENS and helped to standardize the admission procedure across the different institutions.[11] It mainly resulted in a change in the weights applied to each subject for ENS Paris.

1.3 Two Single-Gender Schools until 1986: A Gender Quota?

Two single-gender schools The *École normale supérieure de jeunes filles*, later known as ENS de Sèvres due to its location, was created in 1881 as an equivalent to the *École normale supérieure de la rue d'Ulm* (hereafter ENS d'Ulm), which was for men. Except during the interwar period, when some female candidates could take part in the male examination (mainly for tracks that were not available at their school), admission to ENS de Sèvres and ENS d'Ulm was conducted through two separate entrance examinations.

Before 1986, the existence of these two single-gender entrance exams effectively created a gender-based hard quota system. Since at least the mid-1970s, preparatory programs were mixed-gender. When taking the ENS exam, male and female students were given the same topics in each subject for the mathematics, biology, and physics-chemistry tracks. However, their exam papers were graded and ranked separately.

[11] Although not impossible, since the calendar was such that students could take all the different exams if they wanted to.

Once admitted to the schools, ENS students attended most of their classes at public universities (mixed-gender institutions) and conducted internships in the same research laboratories. Both male and female ENS students were strongly encouraged to take the same examination to become a teacher after their studies (the *agrégation*, the national competitive examination for secondary school teachers). Nevertheless, some differences persisted between the two institutions: specific classes—namely the preparation for the *agrégation*—and dormitories remained officially separate for men and women until the merger of the two schools in 1986.

The merger abolished the hard gender-based quota system in the entrance examinations, introduced full co-education, and eliminated the symbolic separation of the two distinct schools. While we cannot disentangle these effects, we believe that this unique natural experiment provides valuable insights into the impact of gender quotas in elite higher education.

Juries and Exam Topics Before 1985, ENS de Sèvres and ENS d'Ulm each had separate entrance exams, but the two schools shared common features in their selection processes. A notable one was that male and female candidates were given the same exam topics in the mathematics, physics-chemistry and biology tracks, since at least the 1970s.[12] However, in the mathematics track, their exam papers were graded by entirely separate juries. The gender composition of the juries also differed markedly for the sciences subject within the track: at the women-only school, there were a few female jury members, while at the men-only school, the juries were composed exclusively of men. As a result, variation in jury gender balance is not a dimension we are able to study.

For the physics-chemistry and biology tracks, the exam topics and juries were the same for both male and female candidates. Nonetheless, their exam papers were graded separately, meaning that jury members knew whether they were grading a woman's or a man's work. In contrast, for the humanities track, both the exam topics and the juries differed for male and female candidates. Additional details on the entrance exam juries and topics, particularly for the mathematics track, can be found in Online Appendix section D. In 1985, in preparation for the merger of the two schools the following year, all entrance exam tracks provided the same topics for both male and female candidates, and a single

[12]The earliest period for which we could retrieve exam topics from the archives is the early 1970s.

jury graded both male and female candidates together. Thus, the 1985 exam year acts as a valuable counterfactual in our study, offering insight into the impact of a hard gender-based quota.

The 1986 Merger ENS d'Ulm and ENS de Sèvres were among the last schools to comply with the 1975 Haby law which sanctioned compulsory co-education in France. Other elite graduate schools had opened their recruitment to female students in the 1970s, and the other ENS single-gender schools —*Ecole Normale Supérieures de Fontenay-aux-Roses* and *Saint-Cloud* —had merged in 1981. Though the conditions of the merger of the two schools were largely discussed, as it is documented in different reports found in the archives of ENS, the exact year of its implementation was not anticipated: it was announced in January 1985 by the Prime Minister.[13] This means that students who enrolled in preparatory program in 1984 were not aware of the merger of the two entrance examinations until the middle of their first year of training. The documentation we found in the archives of the school clearly stresses the inconvenience of the short timing of the merger. It was then decided to proceed in two steps. In 1985, female and male candidates had the same exam topics, the same juries, were graded together but were still ranked separately. The real merger of the two entrance examinations occurred in 1986, when male and female candidates were ranked together for the first time. This last step validated the merger of the two schools.

There is an extensive body of administrative archives which documents the reflections on the roots and the potential consequences of the merger of the two schools. It appears that, beyond social justice considerations, the merger was also motivated by budgetary reasons: having two different schools became too costly in terms of teaching and administrative staffs. The different reports and letters from former students and contemporary professors also report the difficulties that the school was facing, coined by many as "the ENS crisis". The merger of the two schools was seen as a way to solve these issues.

It has to be noted that, rather than a merger, ENS de Sèvres was eventually absorbed by ENS d'Ulm.[14] The merger was challenged both by students and professors of the school (petitions, letters, etc.). It was seen as a way to use gender equality to justify budget

[13]Laurent Fabius was an alumnus of ENS d'Ulm and made this announcement in a funeral oration for a former researcher at the school, Alfred Kastler. The entire speech announcing the merger of the two schools can be found in Online Appendix Section A.

[14]This is particularly salient in the management of juries after the merger, as presented in Online Appendix section D.

cuts, raising concerns about the impact it might have on female recruitment in science departments. A committee for co-education was thus created to oversee the merger. An interesting take in these reports is the view that the merger would result in two main phenomena: fewer women admitted in the science tracks, but more women admitted in the humanities track. This hypothesis, which conveys the idea that mixed competition would lead men and women to outperform the other in their supposed preferred field, was a common view at the time of the merger.[15]

For the rest of the paper, we refer to the two single-gender schools as ENS d'Ulm and ENS de Sèvres. We refer to the merged school as ENS Paris. More details on the institutional background can be found in Online Appendix Section A.

The Women-Only ENS: A Second Class School? One might be concerned that ENS de Sèvres, being a school for female students only, would not lead to the same type of career opportunities as ENS d'Ulm. Several sources tend to invalidate this hypothesis. A 1966 report by mathematician Pierre Samuel showed that among ENS de Sèvres' mathematics students, 80 % chose research careers, either in universities or at the *Centre National de la Recherche Scientifique* (CNRS).[16] The author deplored that only 20 % of them chose to teach in secondary schooling, as there was a need for highly qualified teachers. The report also highlights that France was among the countries with the largest share of female mathematicians in the world, and that ENS de Sèvres largely contributed to that phenomenon. Both the directors of ENS d'Ulm and ENS de Sèvres shared this opinion.[17]

Table 1 displays statistics drawn from different waves of survey carried out by the administration of the school regarding students' outcomes after their studies. Among male students who entered the school between 1975 and 1977 in mathematics, 14 % had chosen to become teachers in secondary schooling about 10 years after their entry, mostly in preparatory programs; 55 % of them decided to pursue a career in research, while 11 % of them chose to pursue different types of careers, mainly by becoming high officials of the French administration.[18] Figures are comparable for the promotions of female students who entered the school between 1981 and 1982: only 13 % of them chose to become

[15]This hypothesis was documented in *Le Monde*'s 1985 coverage of the merger between the two institutions. The article can be found in Online Appendix section A.

[16]The report can be found in Online Appendix Section A.

[17]The report can be found in Online Appendix Section A.

[18]This include any position as an assistant and full professor in France or abroad, in a public university or a private college, or as a researcher in a public or private institution.

teachers in secondary education, while 40 % pursued careers in higher education and research; a slightly higher share of female students turned to other types of careers.

Table 1: Outcomes of Students Enrolled in ENS Mathematics Track Before the Merger, ENS de Sèvres and ENS d'Ulm, 1975-1982

	ENS d'Ulm (men only)	**ENS de Sèvres (women only)**	
Entrance Class	1975-1977	1960-1962	1981-1982
Number of Students	91	68	39
Measured in	1984	1966	1990
Secondary Education	14%	15%	13%
(Mostly in preparatory programs)			
Higher Education & Research	55%	79%	40%
Other	11%	6%	37%
Unknown	20 %	0 %	0 %

Source: Documentation is sourced from the ENS archives, most of which can be found in the Online Appendix.
Notes: The category "Other" refers to career types different from research or teaching. It primarily includes various positions in the French administration, specifically high-ranking officials in ministries and statistical institutions.
Lecture: Among male students who entered the ENS mathematics track between 1975 and 1977, 14 % chose to become teachers in secondary education, 55 % pursued a career in higher education and research, and 11 % chose other career paths. Additionally, 20 % of the students did not respond to the survey.

Further evidence that ENS de Sèvres did not admit students with lower skills than ENS d'Ulm is demonstrated by their performance on the Mathematics examination to become a secondary teacher, the *agrégation*. Male students from ENS d'Ulm and female students from ENS de Sèvres performed equally well on this exam in the cohorts just before the merger of the two schools (see Table A1 in Appendix A).

2 Data

Our analyses rely on numerous historical data sources, many of which we hand-collected and digitized.

ENS Paris Entrance Examination We collected information about the ENS Paris entrance examination from the archive rooms at ENS Paris and the French National Archives. Documents stem from the archives of the entrance examination administration service. All the data sources were digitized by hand, then transformed from image to text either with an Optical Character Recognition (OCR) software or by a typist for the oldest data sources (mainly entrance examinations from the 1970s and 1980s), as the OCR performances were too poor on these materials.

We brought together an individual-level dataset about the mathematics entrance examination at ENS d'Ulm, ENS de Sèvres and ENS Paris from 1969 to 2009. However, the data from ENS de Sèvres was better preserved than the one from ENS d'Ulm. We only managed to recover individual data about the male mathematics entrance examination for the years 1978, 1979, 1982, 1984 and 1985, which are of crucial importance for the analysis of the effect of the merger.[19] For years with complete archives, we have, for each candidate, information about the grades they obtained in every subject of the written examination, their ranking, and whether they were qualified for the oral examination. We also have grades obtained in each subject at the oral examination (for qualified candidates), their final ranking, and whether they were admitted to ENS or on the waiting list. We also retrieved the list of candidates who actually enrolled in the school at the beginning of the following school year. Finally, we have some socio-demographic information about the candidates (gender, birth date, the preparatory program they attended and where they took the entrance examination). When not available in the administrative sources, the gender of the candidate was guessed based on their first names.[20]

We also collected aggregated data on candidate numbers (total, qualified, and admitted) at ENS d'Ulm, ENS de Sèvres, and ENS Paris for all examination tracks (physics-chemistry, biology, and humanities).[21]

Preparatory Programs We gathered aggregated data about the gender balance of second-year preparatory programs in France between 1976 and 1995. This information was originally available only as images in the digitized archives of the French Ministry of Higher Education, which we converted into a structured dataset. We also collected individual

[19] Details about the collected data can be found in Online Appendix section B.

[20] This concerns 12 years of our sample after the merger.

[21] We began collecting individual-level data for the other tracks in Summer 2024. We are in the process of converting these records to facilitate comparisons with our findings from the mathematics track.

student grade reports from the top mathematics preparatory program in France between 1978 and 1988. This information was hand-collected from the archive rooms of *Louis le Grand* high school and was converted from image to text by a typist.

Long-run Outcomes We were granted access to the administrative data of the human resources of the Ministry of Higher Education about the stock of assistant and full professors in French public universities between 1984 and 2010. We also assembled a large dataset about long-run outcomes of students affected by the (end of) the gender quota. Some information was available in the ENS archives, but we also added information on results obtained at the high secondary teaching examination (*agrégation*), collected in the French National archives, as well as individual information on mathematics doctorate completion in France (1985-2021) from *theses.fr* and worldwide (1930s-2021) from the *Mathematics Genealogy Project*. Other public information about the labor outcomes of former students of the school was retrieved online.[22]

3 Results on Admission

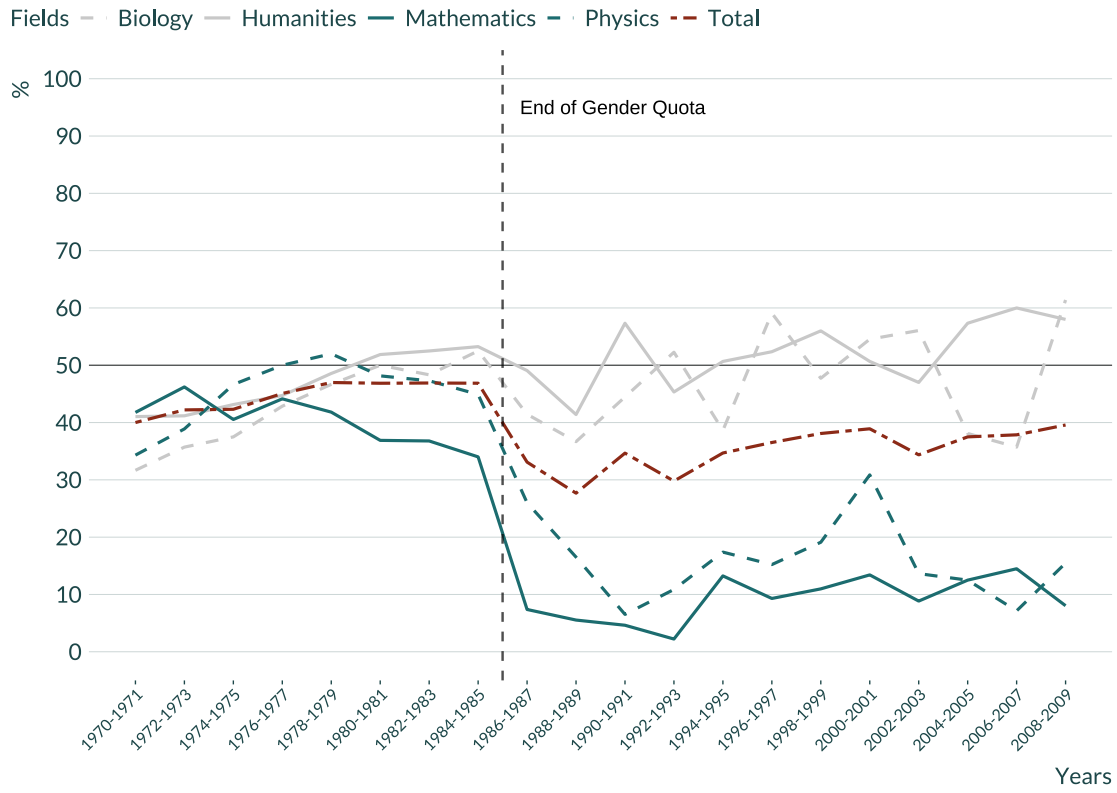
Our first analyses focus on the effect of the end of the gender quota on the overall gender balance of admitted candidates at ENS Paris. To improve readability, we present two-year averages rather than yearly values, as the small number of admitted students to the school makes yearly variations less relevant. Year-by-year results are available in Appendix Section B and show consistent trends.

3.1 Different Effects on Different Tracks

The end of the gender quota had different implications for the gender composition of admitted candidates across entrance examination tracks. Figure 1 displays the percentage of admitted female candidates to ENS Paris from 1970 to 2009 in mathematics, physics-chemistry, biology, and humanities, with the vertical dotted black line marking the quota's end in 1986. Year-by-year results are displayed in Figure B1.

[22] e.g. official records such as the French *Journal Officiel*, the official gazette where all public service appointments are formally published.

Figure 1: Percentage of Female Students Admitted to the ENS Paris (Ulm & Sèvres)
All fields, 1970 - 2009



Source: Documentation from the ENS archives.
Notes: For clarity, we grouped the years two by two. Year-by-year results are presented in the Appendix Section B. The patterns are similar.
Reading: In 1986-1987, there were 7,4 % of female students admitted to the ENS in the mathematics track; 26 % in the physics track; 49.1 % in the humanities track; and 41,4 % in the biology track.

The first notable point is that the proportion of admitted female candidates to the mathematics and the physics-chemistry tracks (green lines) sharply decreased right after the introduction of the mixed-gender competition, while it remained at the level of the gender quota in biology and humanities (light gray lines). This result contradicts the widely held belief at the time of the merger that the introduction of the mixed competition would lead to two phenomena: a decrease in the number of female candidates admitted to the mathematics and physics tracks, and a simultaneous increase in the number of female candidates admitted to the humanities track.[23] This idea conveyed the message that the mixed entrance examination would still be an equitable competition. In this setting, horizontal differentiation would result from a fair game, where men and women would outperform each other in their supposed preferred track. As a result, their representation at ENS Paris should, at a minimum, mirror the gender distribution in their respective

[23] see Section 1 for more details on this.

preparatory program tracks.

Before 1986, the quota was set to ensure that female candidates represented about 40 % of admissions in mathematics, and about 50 % in physics-chemistry, biology, and humanities. As soon as the gender quota came to an end, the share of admitted female candidates dropped to an average of 9 % in mathematics and 15.9 % in physics-chemistry over the next two decades (1986 - 2009).[24] By contrast, in the biology track, except for a sizable drop in 1986 (see Figure B1), the proportion of admitted female candidates remained relatively stable over time, with an average of 47.2 % after the quota was lifted. The humanities track followed the same trend, achieving parity on average after the merger. These results can be interpreted as evidence that mixed competitions can have a detrimental impact on women's performance in stereotypically male-associated tasks, which are represented here by mathematics-intensive tracks (mathematics and physics-chemistry). On the other hand, the introduction of mixed competitions did not foster women's performance in humanities, which are stereotypically female-associated. Rather than keeping a status quo, the introduction of the mixed competition led to an absolute decrease in the number of female students admitted to ENS Paris.

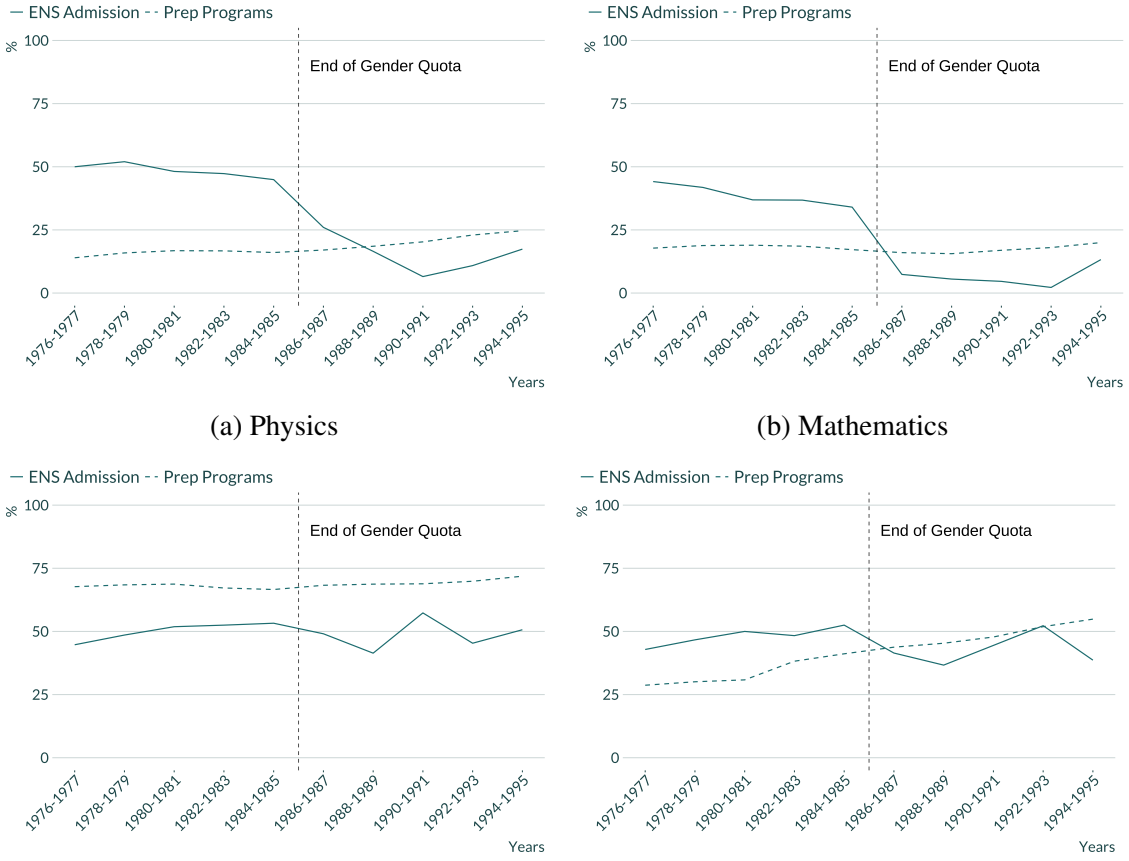
The end of the gender quota had two simultaneous effects: it not only reduced the share and number of female students admitted to ENS Paris, but also led to their under-representation across all four tracks compared to their proportion in corresponding preparatory programs. Figure 2 illustrates this phenomenon by comparing the share of female candidates admitted to ENS Paris (presented in Figure B1, solid lines) with the share of female students enrolled in the second year of preparatory programs during the same period (dashed lines), across different fields of study.

Between 1976 and 1995, the average share of female students in the second year of physics-chemistry preparatory programs in France was 18.3 %, with a slight increase toward the mid-1990s, reaching 25 % (Panel 2(a)). Trends in mathematics (Panel 2(b)) and humanities (Panel 2(c)) remained relatively stable, averaging 17.8 % and 68.6 %, respectively. In contrast, biology saw a significant rise in female enrollment, increasing from 27.6 % to 55.1 % (Panel 2(d)).

Had the share of admitted female candidates at ENS Paris merely reflected their representation in preparatory programs, the end of the gender quota should have resulted in

[24] It is worth noting that the decline in female admissions to the physics-chemistry track was more irregular than in mathematics, at times reaching 40 % in the 2000s, yet never returning to its pre-merger level.

Figure 2: Percentage of Female Students in Preparatory Programs and ENS Admissions, by Track (1976 - 1995)



(a) Physics

(b) Mathematics

(c) Humanities

(d) Biology

Source: Documentation from the ENS and the DEPP archives.
Reading: For each field of study, the solid line represents the share of female candidates admitted to ENS Paris, while the dashed line represents the share of female students enrolled in the second year of preparatory programs. For example, in 1986-1987, the share of admitted female candidates in the mathematics track was 7.4 %, while they accounted for 16 % of students in the second year of mathematics preparatory programs.

a sharp decline in female admissions in mathematics and physics-chemistry, while leading to a slight increase in humanities and biology. However, in mathematics, the share of admitted female candidates dropped from 40 % under the quota system to just 9 % on average post-merger—well below their representation in preparatory programs. A similar pattern emerged in physics-chemistry. In biology, female admissions did not fully keep pace with the increasing feminization of preparatory programs, despite some fluctuations in the early 1990s. Finally, in humanities, the share of admitted female candidates remained well below their proportion in humanities preparatory programs.

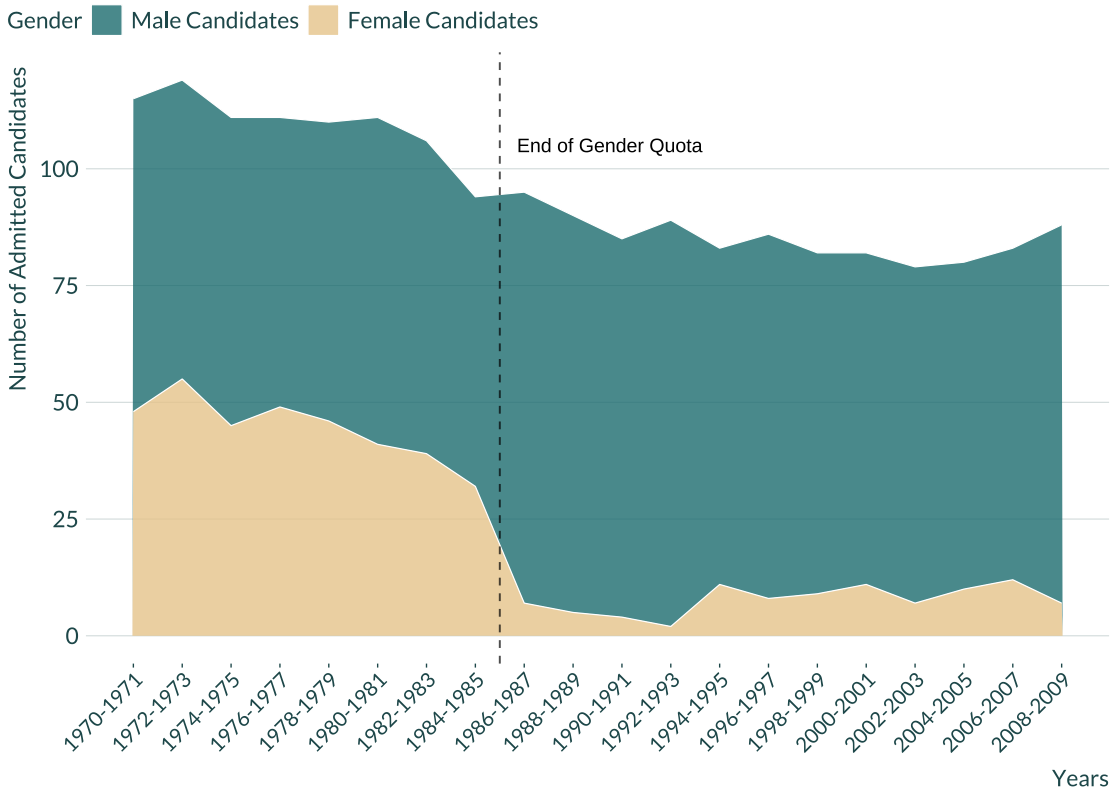
The seemingly neutral impact of the quota's end in biology and humanities masks a

more concerning trend: in both tracks, women ended up underrepresented relative to their numbers in preparatory programs. Overall, these findings suggest that the introduction of mixed competition had a negative impact on female candidates across all tracks in the ENS Paris entrance examinations.

3.2 Focus on the Mathematics Track

We then focus on the mathematics entrance examination, as it is the one with the largest and most persistent effect of the end of the gender quota on female representation among admitted candidates.

Figure 3: Candidates Admitted to the ENS Paris (Ulm & Sèvres) in the Mathematics Track, by Gender (1970 - 2009)



Source: Documentation sourced from the ENS archives.
Reading: In 1986-1987, 95 candidates were admitted to the ENS through the mathematics entrance examination; 7 were female candidates, and 88 male candidates.

Admission Figure 3 displays the number of male candidates (green area) and female candidates (yellow area) admitted to ENS Paris through the mathematics entrance examination. For each couple of years, the sum of the two areas represents the total number of

students admitted to the mathematics track. Figure B2 presents the yearly variation.

There is a decreasing trend in the total number of admitted candidates to the ENS throughout the period: there were on average 55 candidates admitted to the mathematics track before the merger, and only 43 after the merger (Figure B2). This is in line with the information retrieved from administrative documentation announcing the need for budget cuts in the school. Nonetheless, the total number of admitted candidates remained stable around the period of the merger (around 90 between 1984-1985 and 1988-1989). Before the merger, the number of female and male students followed the same trend. Though the cohorts of the ENS d'Ulm were on average larger than the ones of the ENS de Sèvres, female students still represented on average 40 % of admissions, which was fairly larger than the share of female students in second year of mathematics preparatory programs (17.7 % on average between 1976 and 1995). ENS de Sèvres entrance examination could thus be considered as a generous quota system towards female students.

The implementation of the mixed competition led to a dramatic fall in the number of female candidates admitted to the mathematics track. In 1984-1985, there were 32 female candidates admitted to the mathematics track; there were only 7 in 1986-1987 after the end of the quota. The number of admitted female candidates then sharply declined, until reaching its lowest point in 1992-1993 (including zero in 1993). It then slowly rose again from the second half of the 1990s, which coincides with the implementation of the common written examination for the three ENS schools (Paris, Lyon and Saclay).[25] This fall is all the more striking since the number of admitted female candidates never reached its pre-merger level, even 25 years later. On average, there were only 4 female candidates out of 43 admitted students to the ENS Paris in mathematics between 1986 and 2009.

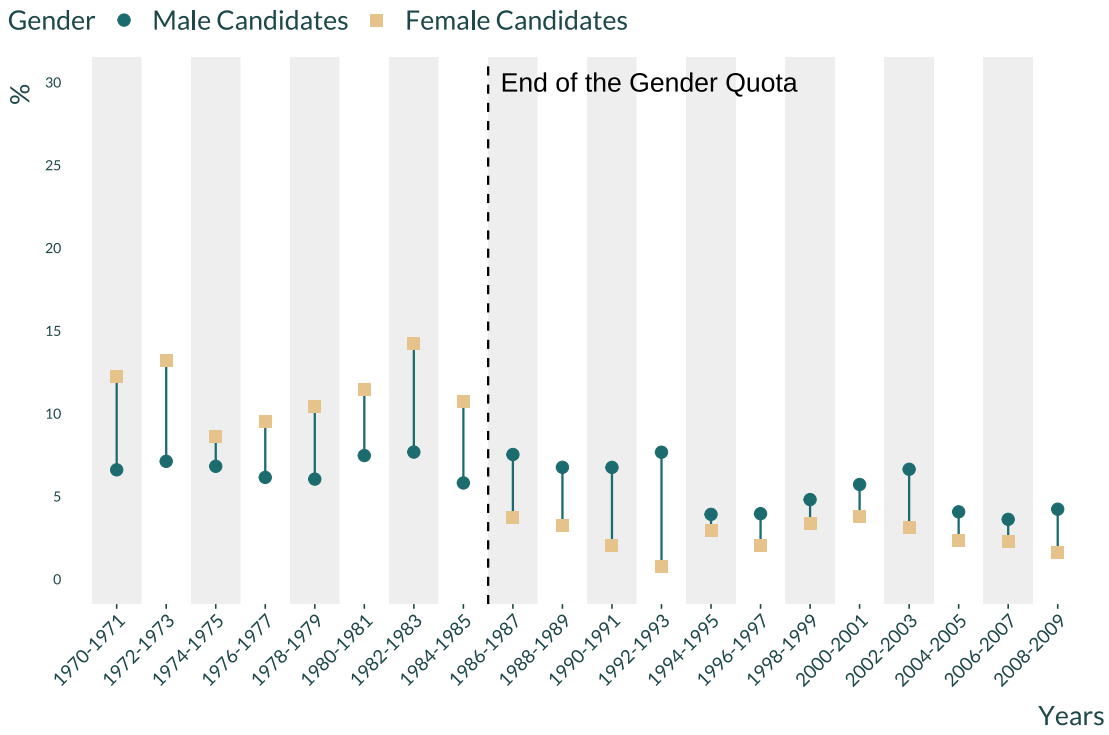
Success Rates by Gender The gender composition of admitted candidates to the mathematics track does not, on its own, provide information on how admission chances evolved for male and female candidates before and after the merger. Figure 4 displays the success rate (i.e., the number of admitted candidates divided by the number of candidates) separately for female and male candidates. Figure B3 presents these rates on a year-by-year basis.

The first key observation is that success rates at ENS Paris tended to decline over time

[25] See the Online Appendix section E for more details about this event and its consequences

for both male and female candidates. This trend resulted from a reduction in the number of seats offered in the mathematics track (Figure 3) combined with an increasing number of candidates over the years. The success rate of female candidates began to decline slightly even before the merger, likely due to a reduction in the number of seats at ENS de Sèvres in its final years. However, the number of female candidates taking the written exam remained fairly stable, fluctuating between 132 and 150 in the four years leading up to the end of the quota. After the introduction of the mixed competition, the success rate of female candidates dropped sharply, from 10.7 % in 1984-1985 to 3.7 % in 1986-1987.

Figure 4: Success Rates in Admission to the ENS Paris (Ulm & Sèvres) Mathematics Track, by Gender (1970 - 2009)



Source: Documentation sourced from the ENS archives.
Reading: In 1986, the success rate (number of admitted students over the number of candidates at the written exam) was 2.6 % for female candidates and 7.6 % for male candidates.

Two main features stand out. First, before the merger, the success rate of female candidates was significantly higher than that of male candidates, largely because a higher number of seats were allocated to female students relative to their representation in preparatory classes (Figure 2). Second, in the twenty years following the merger, the success rate of female candidates remained consistently lower than that of male candidates. This shift represents a complete reversal of the admissions pattern: prior to the merger,

female candidates were more likely to be admitted to the mathematics track (with an average success rate of 11.3 % compared to 6.7 % for male candidates), whereas after the end of the quota, male candidates were nearly twice as likely to succeed as their female counterparts (5.5 % versus 2.6 %).

Odds Ratios To measure the evolution of gender disparities in access to the mathematics track, it is necessary to compare the evolution of the recruitment to the underlying deformation of the gender composition of the pool of candidates. To take potential structural changes into account, we use *odds ratios*, which account for changes in the ratio of the relative chances of admission of female candidates with respect to male candidates.

We first consider the universe of candidates at the ENS entrance examination as the reference group. The value of the odds ratio ranges from 0 to plus infinity. A value of the relative odds ratio greater than 1 denotes an advantage for female candidates, whereas values comprised between 0 and 1 (excluded) denote an advantage for male candidates. Zero denotes perfect inequality and one perfect equality. The methodology for the computation of the odds ratios and their confidence intervals is given in Online Appendix Section C.

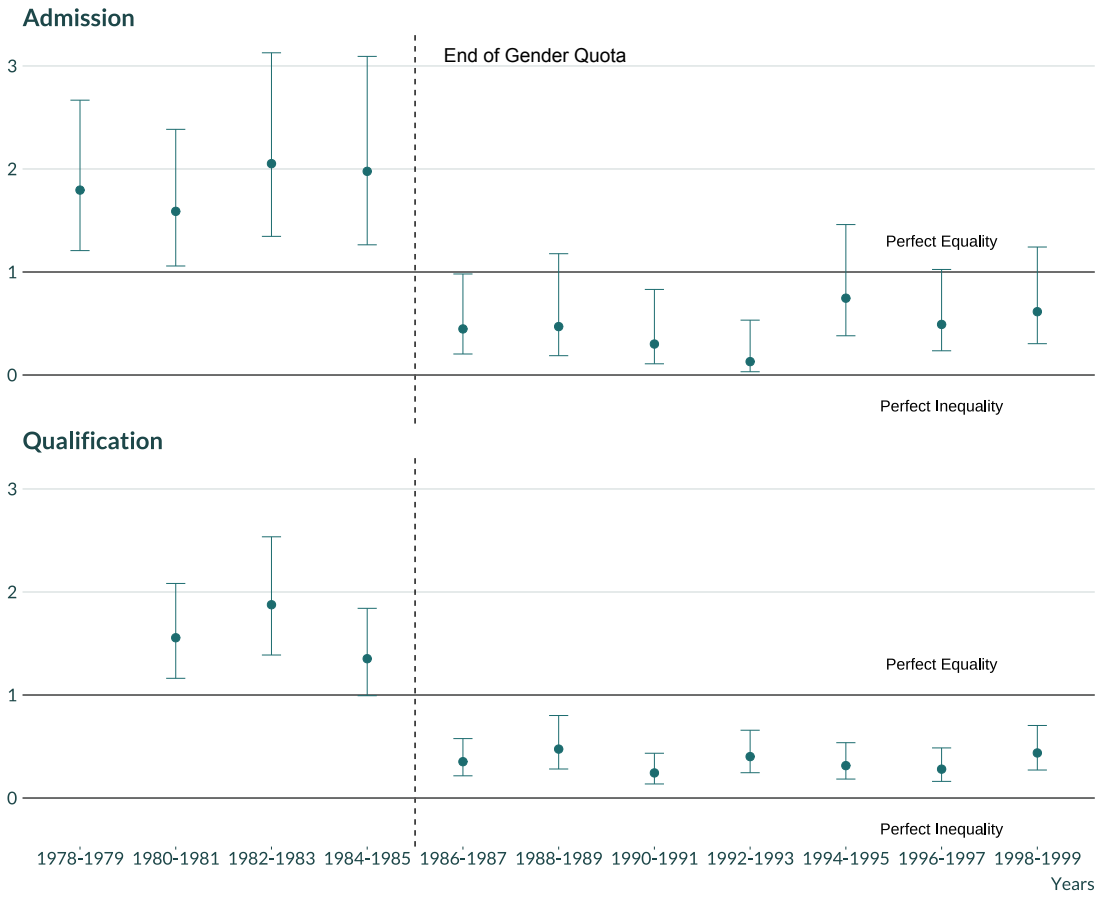
We want to assess whether the odds ratio is significantly different from 1, i.e. whether the situation is different from perfect equality between the two genders.[26] Year-by-year results are presented in the Appendix B. The patterns exhibited in the yearly or grouped graphical representation are similar.

Figure 5 presents the relative odds ratio (later referred to as odds ratio) of female candidates with respect to male candidates at the admission and qualification stages. Error bars denote the 95 % confidence interval. The two horizontal black lines denote the cases of perfect equality and perfect inequality, while the vertical line denotes the quota's ending. We take the pool of candidates at the written exam for each year as the population of reference.

The results can be interpreted as follows: in 1984-1985, a female candidate at the written exam was twice more likely than a male candidate at the written exam to be admitted to the mathematics track rather than not being admitted. This ratio went down to 0.4 for candidates who took the exam the following years. This means that in 1986-1987,

[26] One must note that odds ratios are not distributed symmetrically; confidence intervals are not necessarily centered on the sample value.

Figure 5: Odds Ratios, Admission and Qualification, 1978 - 1999



Source: Documentation sourced from the ENS archives.
Notes: Reference population is the ENS candidates at the written exam.
Reading: In 1984-1985, a female candidate at the written exam was twice more likely than a male candidate at the written exam in this period to be admitted to the ENS mathematics track rather than not being admitted.

a female candidate was less likely than a male candidate to be admitted to the mathematics track rather than not being admitted. The values of the odds ratios between 0 and 1 are not directly understandable; by inverting the ratio (i.e., computing the odds ratio with male candidates as the interest group), we find that in 1986-1987, the years just following the merger, a male candidate at the written exam was 2.2 more likely than a female candidate at the written exam to be admitted to the mathematics track rather than not being admitted. In 1993, as there were no female students admitted to the ENS Paris in mathematics, the odds ratio reaches zero (Figure B5).[27]

There are three main takeaways from these results. First, female candidates had a clear advantage in admission to the mathematics track before the merger. This is a direct result

[27] In this peculiar case, the variance of the logarithm of the odds ratio is not defined. See Online Appendix Section C for more details.

of the hard quota system: there were more available seats for female students at the ENS de Sèvres compared to the initial number of candidates, whereas there were relatively fewer seats available for male students at the ENS d'Ulm. This trend is then entirely reversed after the end of the gender quota: on average, male candidates were 2.1 more likely than female candidates to be admitted to the mathematics track rather than not being admitted. The year of the implementation of the ENS common written exam (1994) also marks a slight shift in the trend; male candidates' advantage is at its peak between 1986 and 1993 (the odds ratio is on average 3.1 over this period), and decreases to some extent afterwards (1.8 on average over the rest of the period). We observe a similar trend in qualification as we did in admission. However, the advantage held by male candidates after the quota was lifted was even greater than the advantage female candidates had before, when it was still in place. On average, male candidates were 3.2 times more likely to qualify for the oral exam than not, whereas before the merger, female candidates had only 1.6 times higher chances of qualification. After 1994, when the ENS common written exam was introduced, we observe no major changes in these relative chances of qualification.

In addition, Figure B6 displays odds ratios computed for the pool of candidates who actually took the exam (i.e., excluding blank copies). The order of magnitude and pattern are similar, suggesting that our results are not driven by a higher share of female candidates who registered for the exam but did not attempt it.

With a clearer understanding of how the end of the gender quota has impacted the proportion of women among qualified and admitted candidates at ENS Paris, we can focus on examining the underlying mechanisms that contributed to this decline.

4 Mechanisms

We document that the introduction of the mixed competition led to a dramatic decrease in the share of women admitted to ENS Paris in the physics-chemistry and mathematics tracks. This could be due to several factors. Women might perform worse than men on average, which would result in fewer admissions once the quota is lifted. Experimental studies have also demonstrated that, conditional on ability, women's performance and their willingness to compete are lower than men's in mixed-gender settings compared to

single-gender settings (Gneezy et al., 2003; Niederle and Vesterlund, 2007, 2010), and especially while performing stereotypically male tasks.

This section tries to disentangle the following mechanisms for the ENS mathematics entrance exam: (i) the presence of a gender performance gap, (ii) the detrimental impact of the mixed-gender competition on performance, (iii) the format of the exam that could favor men's performance, and (iv) a behavioral response from female candidates who could *turn away* from the heightened and mixed-gender competition.

4.1 Gender Gap in Performance

It has been shown in several contexts that, on average, women under-perform in mathematics with respect to men, and this divergence starts as early as in 1st grade in France (Breda et al., 2024). In our case, our studied population consists of a very selected sample of higher education students who decided to pursue competitive mathematics studies. This is thus not obvious that women in this selected sample would under-perform with respect to men. However, if women were to perform worse than men at the ENS mathematics entrance exam, this could explain the sudden fall in the share of female students among admitted candidates. The quota was potentially forcing in lower-achieving female candidates, who would not have made it in the absence of the gender quota.

We investigate this hypothesis by looking at the average difference in performances between male and female candidates, at the written and oral examination.

Percentile Ranks For each subject and each year, we compute percentile ranks of scores obtained by female and male candidates at the written and oral exams. This transformation is done for two main reasons. First, as explained by Breda and Ly (2015), we focus on a competitive exam, where candidates are not expected to achieve a given score, but to be ranked according to the number of predefined available seats for qualification and admission. Second, the distribution of scores for the written and oral examinations are also very different, as the purpose of the oral examination is to differentiate and identify the better candidates. Using percentile ranks makes it possible to keep only the ordinal information we are interested in.

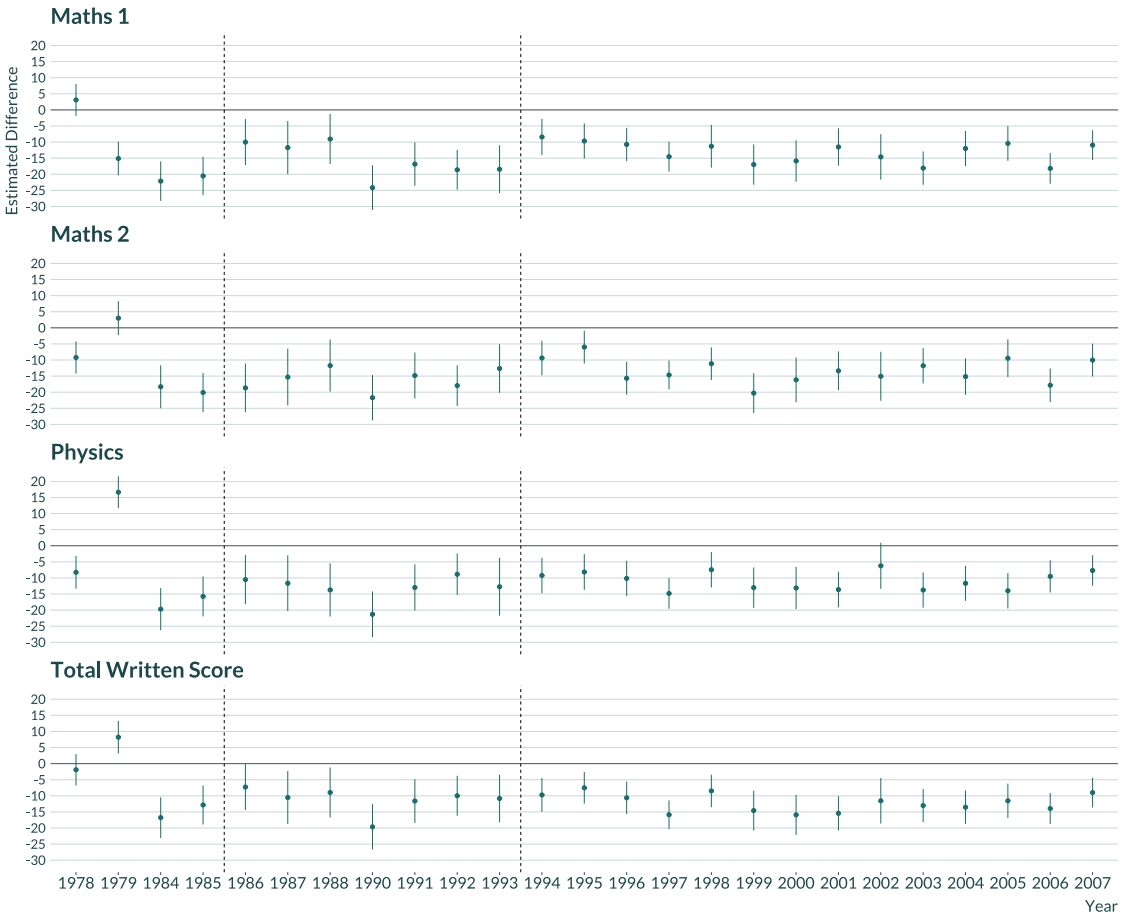
Subject and Evaluation We focus on the set of subjects that were passed every year by candidates at the written exam and at the oral exam. For the written exam, this includes two subjects in mathematics, denoted as Maths 1 and Maths 2, and one subject in physics. The first mathematics exam (Maths 1) is the flagship exam of the ENS mathematics track. It lasts six hours and is widely recognized as the most challenging subject among the entrance examinations for STEM elite graduate schools. Physics and Maths 1 have the same weight in the total written score (6), and the second maths subject has a smaller weight (4). We only consider two subjects in the oral examination: mathematics and physics. The total written and oral scores represent the weighted average obtained in the written and oral examinations, including other subjects which are year-specific (e.g. French, foreign languages, or computer sciences).

Before the end of the gender quota, though the exam topics given to female and male candidates were the same in every subject, the juries were different for the two entrance examinations (see Online Applendix Section D). A common jury was established in 1985 to evaluate female and male candidates together, both in the written and oral stages. Female and male candidates were then ranked separately, and a certain number of seats were still reserved for female candidates. Additionally, in 1984, part of the jury from ENS d'Ulm was assigned to ENS de Sèvres, particularly for the mathematics main examination (Math 1). In subsequent sections, we discuss whether female and male candidates were evaluated in the same way before 1985 in the written exam, and its implications for our results.

Differences in the Written Exam Figure 6 shows the results of a regression of candidates' percentile rank in each subject on a binary variable equal to one if the candidate is a female. Error bars display the 95 % confidence intervals. The figure basically shows the evolution of the gender difference in the average percentile rank in each subject. A positive difference indicates that female candidates performed better than male candidates on average. The total score is a weighted average of scores obtained in Math 1 and 2, Physics, and other year-specific subjects.

Female candidates consistently perform worse than male candidates on the written exam across all subjects and time periods, except for the late 1970s. The difference in performance between male and female candidates was particularly noticeable in mathematics exams, with the largest difference observed in 1984 and 1990, where male candidates

Figure 6: Differences in Mean Percentile Rank, by Gender, Subject and Year
ENS Paris (Ulm & Sèvres) Entrance Written Exam, 1978-2007



Source: Documentation from the ENS archives.
Note: Error bars represent the 95 % confidence interval.
Reading: In 1985, the average percentile rank of female candidates in the total written score was 39, whereas it was 52 for male candidates. The difference between the two is -13, which is reported in the graph.

scored over twenty percentile ranks higher than female candidates in Maths 1. There is, however, no discontinuity in performance between male and female students observed around the time of the end of the gender quota. The gender gap in performance is even at its smallest in 1986, the first year without a gender quota.

We were not able to retrieve individual data for ENS d'Ulm between 1980 and 1983. However, we retrieved information on female candidates' performances in the entrance examination for ENS de Sèvres in the longer run. Figures B10 and B11 show the average score obtained by female candidates on the written exam, and in Math 1 separately. While this measure of performance is imperfect, it reveals a discontinuity in the trend around

1984, where the average grade for both the entire exam and Math 1 declined.[28] One possible explanation for the decline in performance among female candidates after 1984 is that female candidates' examination papers might have been overrated with respect to male candidates before the implementation of the common marking. Alternatively, disclosing the information about common grading might have affected female student performances in itself.

Differences in the Oral Exam Differences between male and female candidates are not as strongly pronounced in the oral examination. Figure 7 displays the differences in performance for qualified candidates, controlling for their initial performance in the written exam. Figure C1 displays the raw difference in performance in the written exam, without controlling for their initial performance in the written exam, and the results are fairly similar.[29] The total oral score is once again an average of Maths 1 and Physics 1, plus other subjects that were year specific (e.g. computer science, chemistry, or languages).

For most years, we do not observe significant differences in performances between male and female qualified candidates. If anything, it seems that female students slightly outperform men. Once again, we do not observe a clear discontinuity in the gender gap in performances around the time of the end of the gender quota.

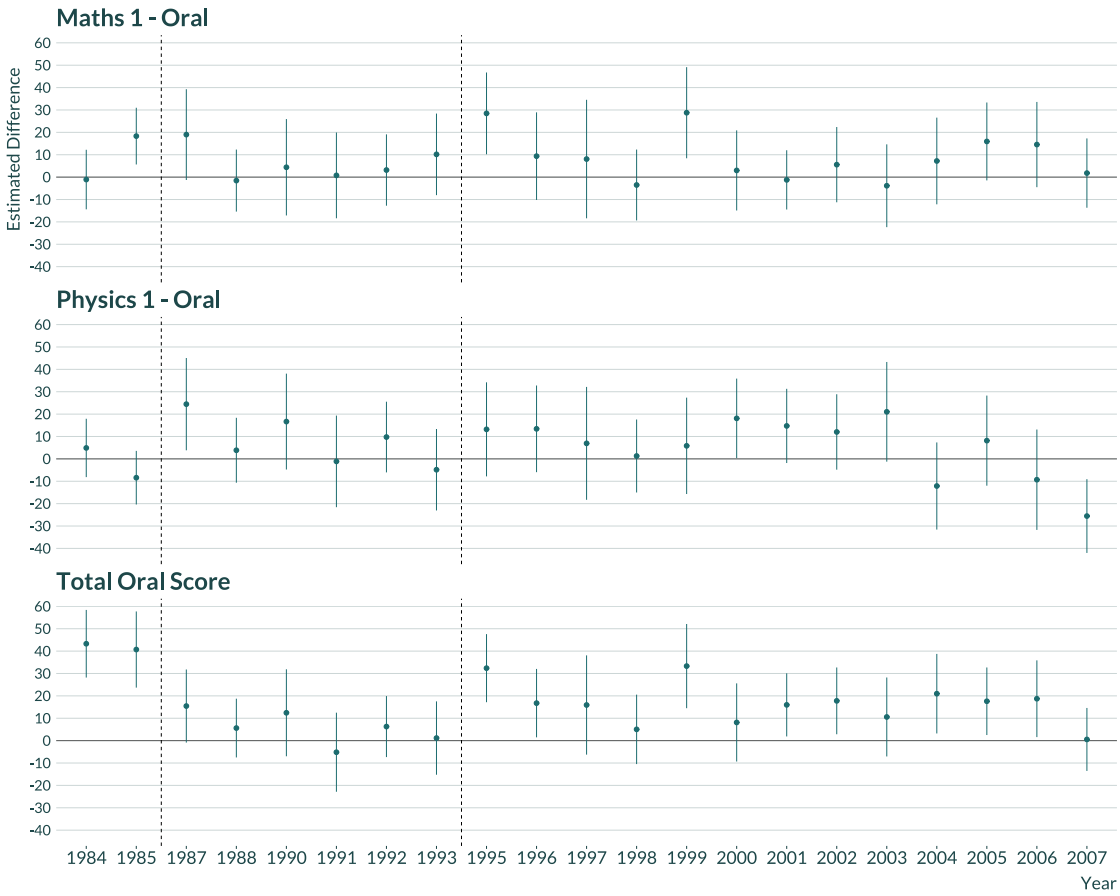
Test Scores Transformation As previously mentioned, the distribution of scores is quite different for the years 1978-1979 and the years 1984-1985. Since the distribution of scores for men is almost stationary over these years, we mean-shift the distribution of scores in the written exams for female candidates in 1978, 1979, and 1984 to match the mean difference between the male and female distribution of scores in 1985, when there was a unique jury for the two schools. These transformed mean-shifted scores are used in the subsequent sections of the paper, as a way to rank male and female candidates together.

Quantifying the Effect of the Gender Performance Gap While we do not observe any discontinuity in scores around the time of the end of the gender quota, it remains unclear whether the sharp fall in the number of female candidates admitted to the mathematics

[28] For instance, it does not take into account differences in the difficulty of the exam each year or the different jury from one year to the other.

[29] As we did not retrieve complete archives for the oral examination in 1986 and 1994, these data points are missing from the figures.

Figure 7: Differences in Mean Percentile Rank Controlling for Written Exam Performances, by Gender, Subject and Year
ENS Paris (Ulm & Sèvres) Entrance Oral Exam, 1978-2007



Source: Documentation from the ENS archives.
Note: Error bars represent the 95 % confidence interval.

track is solely due to the gender gap in exam performance, or whether there is an additional detrimental effect of the mixed-gender setting. To quantify the extent of the effect of the gender performance gap, we simulated the share of female candidates who would have been admitted to the mathematics track if there were no gender quota prior to the merger. To do so, we ranked female and male candidates together based on their written and oral exam scores. In this counterfactual simulation, it is as if male and female candidates competed in a single-gender setting, but ultimately, would have been ranked together. Figure B12 in the appendix presents a visualization of the intuition behind this exercise.

Table 2 presents the results of our simulations. For each year prior to the end of the gender quota for which we have all candidates' exam scores (1978, 1979, 1984, and 1985), we defined n_{year} as the number of open seats (Panel A). We then ranked male and female

candidates together based on either their raw score (for 1985) or their transformed score (for 1978, 1979, 1984). For years 1978 and 1979, for which we do not have oral exam scores, candidates were ranked based on their total written score. The share displayed in Panel B was computed by considering the first n_{year} candidates and looking at the gender composition. If the decline in the number of admitted female candidates after the end of the quota were solely due to the gender gap in performance, we would expect the simulated share of admitted candidates prior to the introduction of the mixed competition to be equivalent to the one observed after it (between 6 and 9 %).

Table 2: Share of Female Admitted Students

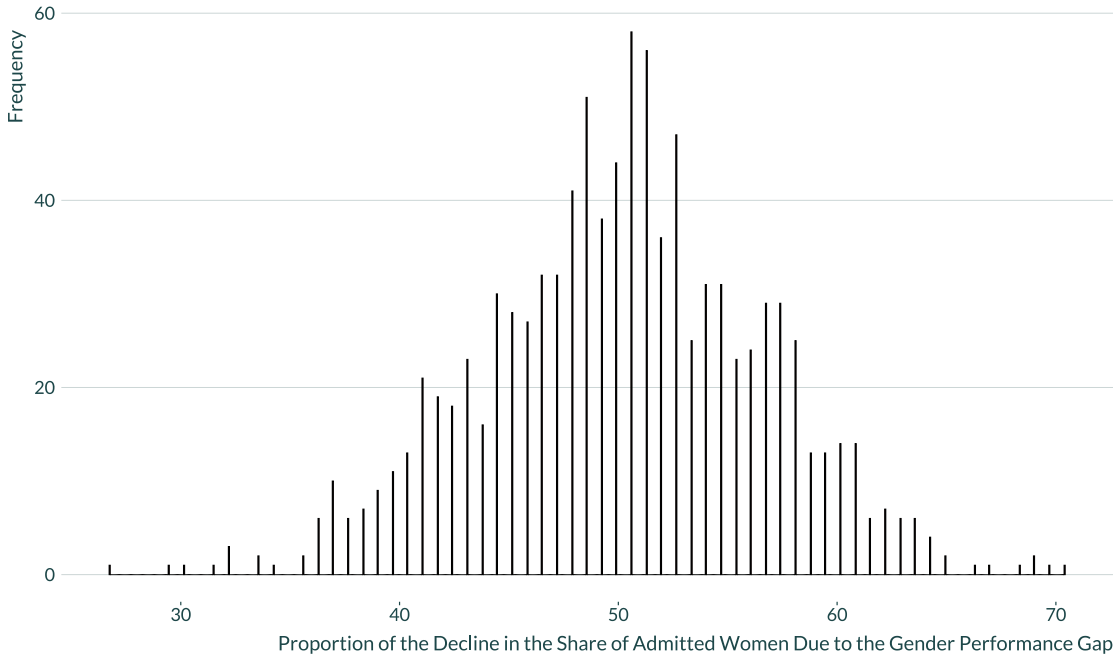
	1978	**1979**	**1984**	**1985**
Panel A. Number of Seats Opened				
ENS d'Ulm	32	32	31	31
ENS de Sèvres	23	23	17	15
Total (n_{year})	55	55	48	46
Panel B. Share of Female Candidates				
Actual Share		*with gender quota*		
	42%	42%	35%	33%
Simulated Share		*without gender quota*		
Raw Scores	35%	36%	8%	20%
Transformed Scores	22%	15%	21%	20%

Source: Documentation sourced from the ENS and French National Archives.
Notes: Candidates are ranked according to their total final score, except for years 1978 and 1979 for which oral score are not available, and candidates are ranked on their total written score. Transformed scores are average scores modified so that the gender difference in average score at the oral and written exams remains at the level of 1985 in 1978, 1979 and 1984.
Lecture: In 1985, there was 46 offered seats in the mathematics track. The actual share of female among admitted students was 33 %, which was determined by the quota system. If we would have ranked male and female together based on their average total score, this share would have reached 20 %.

Our results do not support this hypothesis. In 1985, there were 46 offered seats in the mathematics track. The actual share of female students among admitted candidates was 33 %, which was determined by the quota system. If we had ranked male and female together based on their total final score, this share would have reached 20 %. There are

however substantial differences between raw and transformed scores depending on the year considered; in 1984 for instance, the share of female students among admitted candidates would have been 8 % based on their raw score, but 21 % with transformed score.

Figure 8: Distribution of the Statistic S_i Across 1,000 Bootstrap Iterations



Source: Documentation from the ENS archives.
Note: The mean is 50.1 % with a 95 % confidence interval of [37.5; 62.8]. The standard error is 6.5.

Between 1985 and 1986, there was a 27 percentage point fall in the share of admitted female candidates (from 33 % to 6 %), but this fall would have been only 33 - 20 = 13 percentage points if we only take into account the gender gap in performance. We can thus extrapolate that $\frac{13}{27}$ = 48 % of the fall can be explained by the average difference in performance between male and female candidates in the exam. To test the robustness and precision of this result, we ran 1,000 bootstrap iterations of this statistic. We randomly draw (with replacement) 1,000 samples from the real 1985 pool of 543 candidates and we estimate who would have been admitted to ENS Paris in the absence of a gender quota. We then compute the gender balance of this simulated pool of admitted students, $share_i$, and the share of the decline "explained" by the gender gap in performance, i.e $S_i = \frac{33-share_i}{33-6} \times 100$. Figure 8 plots the 1,000 bootstrap values of S_i. We can conclude that, on average, 50 % of the observed decline in the share of women admitted to ENS Paris, before and after the end of the gender quota, can be explained by a gender performance

gap in the mathematics track entrance examination. The 95 % confidence interval for this estimate is [37.5; 62.8].

Table B1 in the appendix displays the results of a similar simulation that takes not only the number of admitted candidates but also the number of candidates on the waiting list, which draws similar conclusions.

Taken together, our findings indicate that female candidates perform less well on the exam compared to male candidates. However, our simulation exercise shows that this disparity alone cannot fully account for the change in the proportion of admitted female candidates following the implementation of the mixed competition.

4.2 High-Stake Exams and Mixed-Gender Competition

We have shown that the average gender gap in performance can only partially explain the sudden drop in the share of admitted female candidates. Building on the experimental literature, we posit the hypothesis that, even conditional on ability, the introduction of mixed competition could have exacerbated these discrepancies.

To test this hypothesis, we use the students' grade reports from the top mathematics preparatory program to study potential gender differences in performance in the ENS entrance exam, controlling for students' performance before the exam. Table 3 displays our results. Column (1) shows a naive double difference on the performance in the written exam between male and female students, before and after the end of the gender quota, without controlling for any academic ability measure. If we do not take into account students' grades in the end of their mathematics preparatory program, we observe a significant gender gap in performance in the ENS written exam, and this gap actually reduces after the end of the gender quota. However, column (2) shows that once we control for students' academic achievement just prior to the ENS entrance exam, the gender gap is no longer significant, neither before nor after the end of the gender quota.

Therefore, we cannot validate the hypothesis that the introduction of mixed-gender competition in the ENS entrance exam exacerbated the gender performance gap, based on our data from the top preparatory program. However, it is important to note that this hypothesis may hold for other subsamples of students or time periods, even in similar settings. For instance, Bonneau and Dousset (2025) examines a broader range of STEM preparatory programs in France in the late 2010s and finds a gender performance gap in

competitive entrance exams, even after controlling for academic achievement just before the exams.

Table 3: Performance of Candidates from Louis le Grand Preparatory Program at the ENS Entrance Exam (1978-1988)

	Percentile Rank at the Written Exam	
Female	$-.216^{***}$	$-.059$
	(.045)	(.045)
After the End of Gender Quota	$-.063^{*}$	$-.048$
	(.034)	(.034)
Female × After	.135	.015
	(.084)	(.084)
Decile of Math GPA		✓
N	654	654

Source: Document sourced from the Louis le Grand *archives*
Note: Standard errors in parentheses. Significance levels: *** p < 0.01, ** p < 0.05, * p < 0.1. Standard errors are clustered at the class level.
Lecture: On average, once we control for students' decile of math GPA at the end of their preparatory program at *Louis le Grand*, there is no gender gap in percentile rank in the written exam for ENS Paris, either before or after the end of the gender quota.

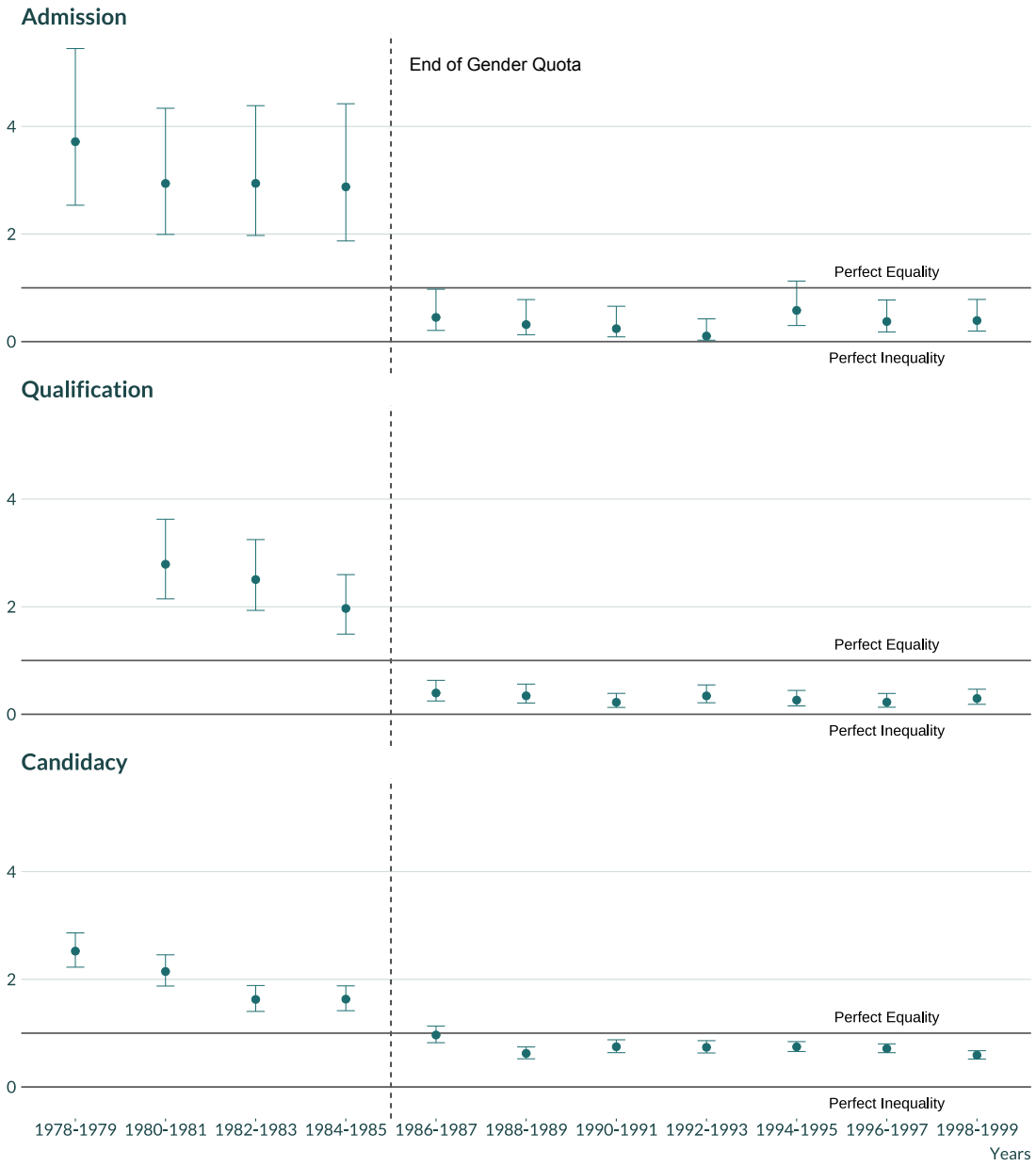
4.3 Behavioral Response: Female Students Turning Away from the Heightened and Mixed-Gender Competition

The end of the gender quota and the introduction of the mixed-gender competition not only impacted the gender composition of admitted candidates, but also led to changes in the gender balance of the candidate pools at earlier stages of the admission process.

Odds Ratios Computed on the Pool of Students in Preparatory Programs Figure 9 shows the odds ratios computed on the pool of students enrolled in the second year of mathematics preparatory programs between 1978 and 1999. This comparison makes it possible to assess the effect of the merger on students' probability of applying for the written exam in the first place.

We observe a discontinuity regarding candidacy at the time of the merger, although

Figure 9: Odds Ratios, Admission, Qualification and Candidacy, 1978 - 1999



Source: Documentation from the ENS archives and the archives of French Statistical Services (DEPP).
Notes: Qualification information is missing for the ENS d'Ulm in 1978.
Sample: Students in second year of mathematics preparatory programs.
Reading: In 1984-1985, a female student in preparatory programs was 1.6 more likely than a male student to be candidate to the written exam rather than not to be.

the value of the odds ratio gradually decreases over the pre-merger period. Prior to the merger, female students were more likely to apply for the written exam, with a value of the odds ratio of 2.5. After the merger, the value of the odds ratio is close to one on average, suggesting that female and male students are then almost equal in terms of their probability of being a candidate for the entrance examination. This effect is not driven by

the number of female students in preparatory programs, which remains stable over that period (Figure 2). These findings also confirm our previous results about admission and qualification, which were computed on the pool of candidates at the written exam.

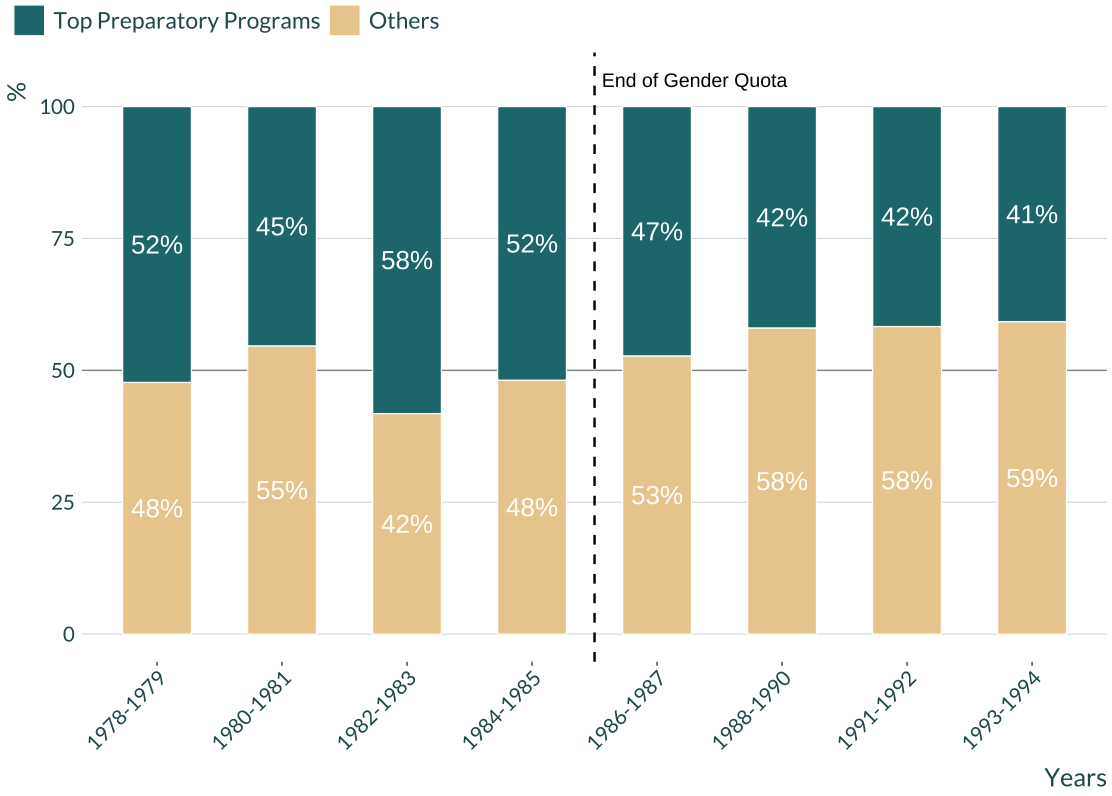
Characterizing Missing Candidates Figure 9 provides evidence that female students were less likely to take the written exam after the implementation of the mixed competition. It is possible that a specific group of female candidates chose to opt-out of the competition. However, without detailed information on students' prior academic achievement, it is difficult to determine the direction of this selection effect. Nevertheless, the data comprises information on the preparatory program students attended, which is highly informative about their academic level. In France, preparatory programs are highly vertically differentiated. Thus, the preparatory program attended is highly predictive of students' chances of success on competitive entrance exams.

Preparatory Program Typology We divide preparatory programs into two groups based on the number of female candidates admitted to ENS de Sèvres before the merger. The top 10 preparatory programs each provided more than 5 admitted students to ENS de Sèvres between 1978 and 1985. Taken together, these programs account for two thirds of total admissions before the end of the gender quota.[30] The remaining 57 preparatory programs are grouped together in the second category.

Evolution of the Composition of Candidates Figure 10 shows the proportion of female candidates who took the written exam (i.e., completed at least one test) by type of preparatory program, in two-year intervals from 1978 to 1994. Before the end of the gender quota, female candidates from the top 10 preparatory programs accounted for an average of 51.6 % of all female candidates. After the quota was lifted, this share dropped to 42.6 % on average. A two-sided t-test confirms that this 9 percentage point decline is statistically significant at the 1 percent level. This decline was not solely driven by an increase in candidates from other preparatory programs but also by an absolute decrease in the number of female candidates from the top 10 programs, despite overall female enrollment in these

[30]The top 10 preparatory programs are: Louis le Grand (Paris), Saint-Louis (Paris), Thiers (Marseille), Montaigne (Bordeaux), Hoche (Versailles), Fénelon (Paris), lycée du Parc (Lyon), Condorcet (Paris), Sainte Geneviève (Versailles), Pierre de Fermat (Toulouse)

Figure 10: Percentage of Female Candidates, by Preparatory Programs Type



Source: Documentation sourced from the ENS archives.
Reading: In 1984-1985, 52 % of female candidates who took the ENS Paris written exam came from the top 10 preparatory programs, and 48 % from the remaining ones.

programs remaining relatively stable over the period. Notably, we do not observe a similar trend among male candidates around the time of the merger (see Figure B13)

Although several explanations could be put forward to explain this phenomenon, these results are consistent with the framework of the stereotype threat (Spencer et al., 1999), which suggests that candidates who identify the most with the performed task (e.g. high-achieving candidates) are more likely to be the most affected by the activation of stereotype threats. Indeed, as explained by Huguet and Régner (2007) in their experiment about the effect of the internalization of gender stereotypes on mathematics performances in French middle schools, "susceptibility to stereotype threat derives not from internal doubts about one's ability based on one's history of failure [...] but from one's identification with the critical domain and the resulting concern about being stereotyped in that domain." Provided that high performing candidates identify strongly with mathematics, the stereotype threat is expected to be especially prominent among candidates in the top 10 preparatory programs.

Table 4: Top Mathematics Preparatory Program Students' Candidacy and Success Rate at ENS Paris (1984-1987)

	Number of Students...		Share of Candidates ...	
	in CPGE	**Candidates at ENS**	**at ENS exam**	**Admitted**
Men				
With Gender Quota	480	195	41 %	12 %
W/o Gender Quota	485	238	49 %	14 %
Women				
With Gender Quota	57	26	46 %	27 %
W/o Gender Quota	59	19	32 %	5 %

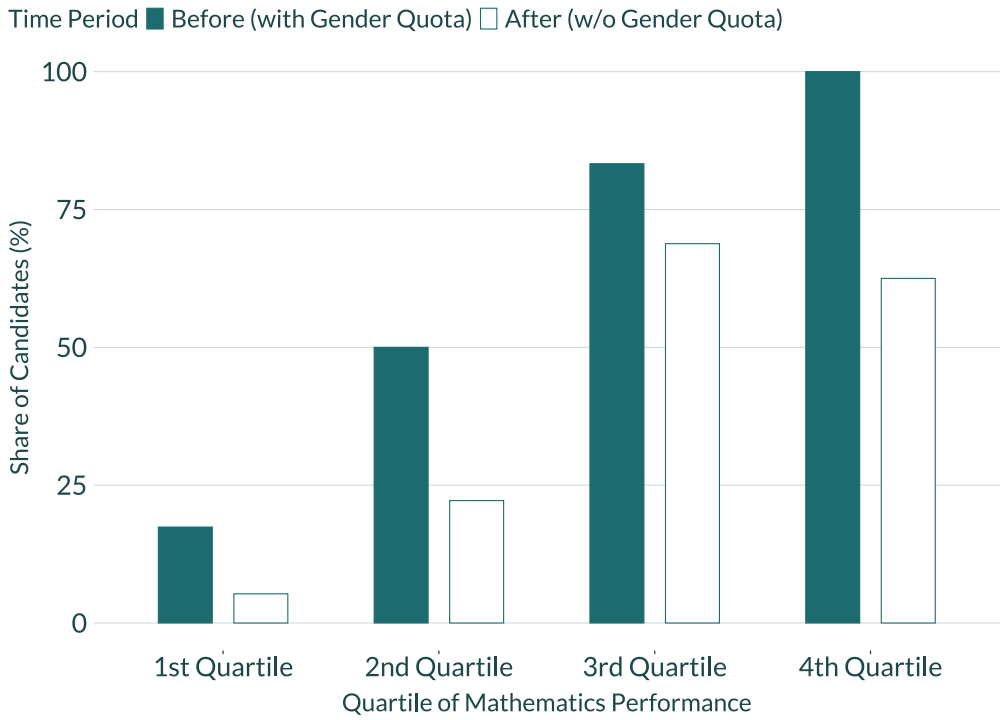
Source: Document sourced from the *Louis le Grand* archives.
Note: The lines "With Gender Quota" represent the exam years 1984 and 1985, while the lines "W/o Gender Quota" represent the exam years 1986 and 1987.
Reading: After the end of the gender quota, 49 % male students enrolled in the mathematics preparatory program in *Louis le Grand* applied to the ENS entrance exams, which means that they were 238 male students from *Louis le Grand* in the exam years 1986 and 1987 combined. Among them, 14 % got admitted to ENS Paris.

Focus on the top mathematics preparatory program We leverage our detailed data on students enrolled in the top mathematics preparatory program (*Louis-le-Grand*) to better understand who these missing female candidates are—those who might have applied to the ENS entrance examination had the gender quota remained in place. One possible explanation is that they are primarily lower-achieving students who made a strategic decision to focus their efforts on other competitive exams, knowing that their chances of admission to ENS were low. Given the highly selective nature of the exam, this choice could be deemed rational. However, another possibility is that some of these female students underestimated their own chances of success. Being surrounded by some of the highest-achieving students in France, their perception of their own performance might have been skewed, leading them to opt out of the ENS entrance examination despite having a reasonable chance of admission.

Since the number of female students remained stable after the end of the gender quota (Table 4), we explore this question by analyzing application patterns to the ENS entrance exam based on students' academic performance. Figure 11 presents the share of ENS candidates among female students, broken down by quartiles of mathematics performance, from the lowest-achieving (first quartile) to the highest-achieving students (fourth quartile).

Across all performance quartiles, we observe a decline in the share of female candidates after the introduction of mixed-gender competition. In contrast, Figure D2 shows the opposite trend for male students, who became more likely to apply across all quartiles after the quota was lifted. While our sample size is relatively small, these findings suggest that some high-achieving female students, who likely had reasonable chances of success, opted out of the ENS entrance exam after the end of the gender quota.

Figure 11: Female Students Application Behavior, by Math Performance at the End of Preparatory Program



Source: Documentation sourced from the *Louis le Grand* and ENS archives.
Notes: The sample consists of students who are enrolled in second year in the top mathematics preparatory program in France, *Louis le Grand* in 1978, 1978, 1982, 1984-1988. The 4th quartile is the top quartile of performance. These are suggestive evidence, as the sample size is fairly small ($n = 122$).
Reading: Before the end of the gender quota, among the female students in the 4th quartile of mathematics performance at the end of their second year of preparatory program, 100 % of them took the ENS Paris entrance examination. After the end of the gender quota, this share fell to 62 %.

Alternative Paths Students enrolled in preparatory programs do not prepare exclusively for the ENS Paris examination. If female students turned away from the ENS examination after the end of the quota, it might have been in favor of other STEM graduate schools. Figure B14 shows the evolution of the share of admitted female candidates in three major STEM graduate schools, which represent key alternatives for students around the time of the ENS merger. We do not observe a sudden increase in female admissions to any

of these schools after 1986, particularly not at *École Polytechnique*, the most relevant alternative for top students in preparatory programs. This suggests that the high-achieving female candidates who opted out of the ENS entrance exam were dispersed across different schools rather than concentrated in a single institution.

4.4 Format of the Exam

One potential explanation for the gender gap in performance at the entrance examination is the format of the exam. Recent literature in economics has raised significant concern on whether differences in performance by socioeconomic status or gender reflect inequities in the testing process itself, rather than differences in underlying skills (Miller and Stassun, 2014; Dobrescu et al., 2021; Duquennois, 2022). It has been notably shown that gender gaps in mathematics performance can be strongly influenced by the format of exams that students take (Griselda, 2022). Combined with the weighting scheme applied to each subject, these factors could potentially affect the gender composition of qualified and admitted students. To explore this question, we simulate different weighting schemes and focus on one main aspect: the weights assigned to each mathematics subject (Maths 1 and Maths 2). [31]

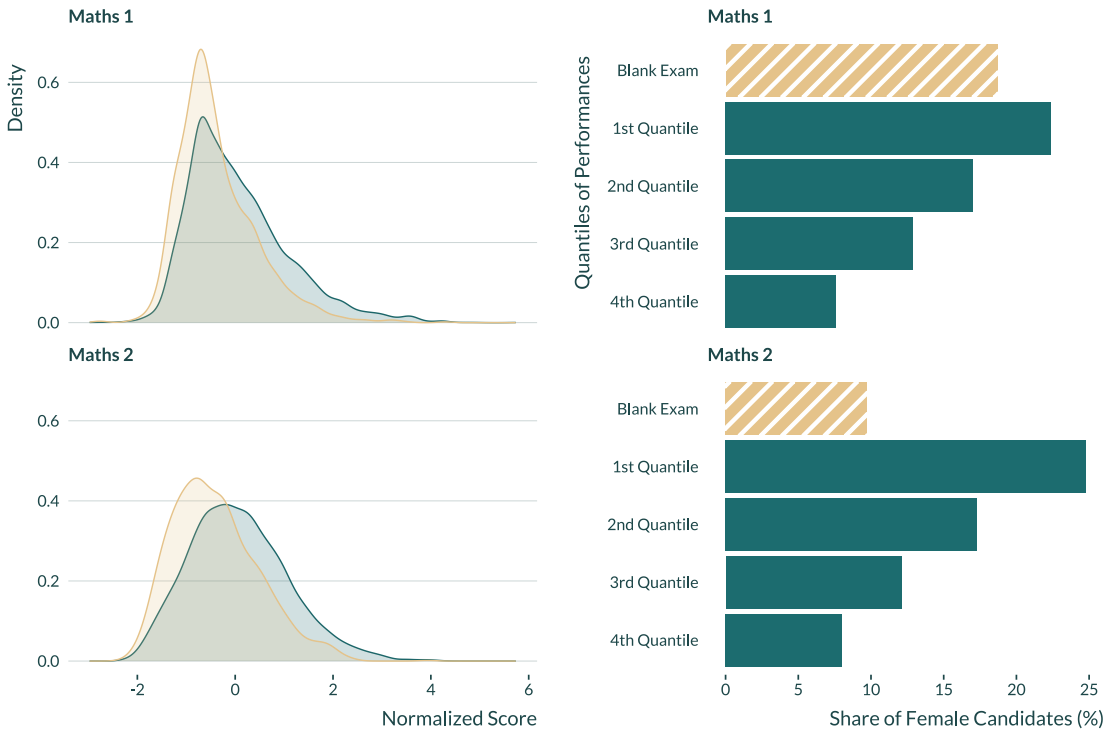
The Two Mathematics Subjects As presented in Section 4.1, the ENS mathematics entrance examination consists of two written mathematics exams, which have an unusual format compared to those of other STEM graduate schools. Maths 1 is considered one of the most challenging mathematics exams across all elite graduate school entrance exams. It lasts six hours, an uncommon feature for this type of examination. In contrast, most written mathematics exams for entrance into elite STEM graduate schools last four hours, meaning that students in preparatory programs are less trained for this extended format. On the other hand, Maths 2 follows a more conventional structure: it lasts four hours and is closer in difficulty and format to other STEM graduate school entrance exams.

Figure 12 presents a comparison of the performances of male and female students at the two mathematics written exams. The left panel shows the density of normalized scores obtained in Math 1 and Math 2 by gender, while the right panel presents the share

[31] An additional analysis, based on the introduction of a common written examination for all ENS in 1994 can be found in Online Appendix Section E.

of female candidates by quartile of performance (including the share of female candidates who hand in a blank exam), in years 1986-2000. The first quartile represents the worst performers, while the fourth quartile represents the top performers.

Figure 12: Performance in Mathematics at the Written Exam, by Gender
1986-2000

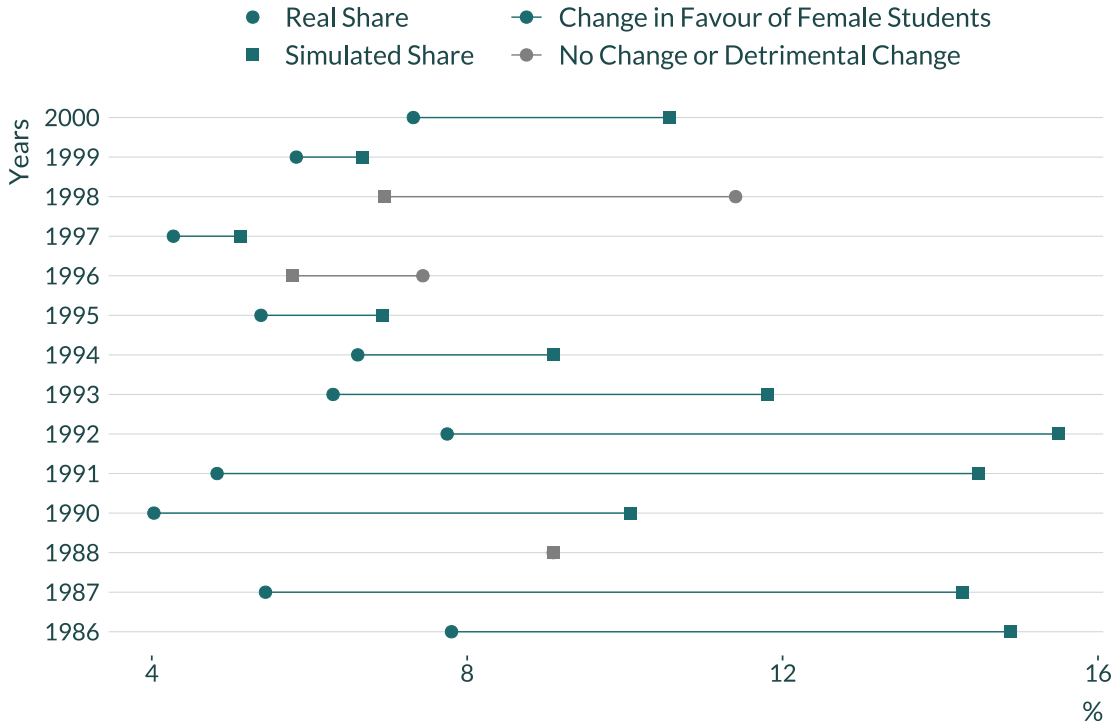


Source: Documentation sourced from the ENS archives.
Note: The yellow density represents women's score, while the green one represents men's scores.
Reading: In Maths 1, female students represent 19% of handed blank copies, while they represents only 10% of them in the Maths 2 written exam.

First, it does not seem that the two mathematics exams assess the same skills, as the distributions of scores are very different between Maths 1 and Maths 2. Both male and female candidates perform worse on average in Maths 1 than in Maths 2, with a higher kurtosis for the distribution of scores for female candidates. The two subjects are however very similar in the representation of female candidates in each quantile of performances, including at the highest level of performance (4th quantile). Interestingly, the proportion of female candidates who hand in a blank exam is almost twice as high in Maths 1 compared to Maths 2, which automatically prevents these candidates from being qualified for the oral stage. It seems that women get discouraged at a higher rate than male candidates by this specific exam.

To see how much Math 1 matters in female candidates' chances to be qualified at the oral exam, we simulate what would have been the total written score of every student without Math 1, from 1986 to 2000. We have to assume that the elimination of Math 1 would not have changed the pool of candidates. Using this simulated total written score, we define a new pool of qualified students at the oral exam.

Figure 13: Real and Simulated Share of Female Candidates, Qualification Stage, 1986-2000



Source: Documentation sourced from the ENS archives.
Reading: In 1986, the share of female qualified candidates was 7.8 %. It would have been 14.9 % if students would have been ranked without taken the Math 1 examination into account.

Figure 13 displays the real share (circle) and simulated share (square) of female candidates at the qualification stage. Years for which the simulated share of female candidates is higher than the real share are highlighted in green. On average, the simulated share is 3.4 percentage points higher than the real share of female candidates qualified for the oral exam (10.1 % against 6.7 %). There are 11 years out of 14 where the simulated share is actually higher than the real share. Eliminating Maths 1 could have a substantial impact on the share of women qualified to the exam; for 6 out of 14 years, it roughly doubles - even triples - the share of qualified female candidates.

We cannot argue that this specific subject in mathematics is irrelevant to select potential

good researchers, which is one of the core missions of ENS Paris. However, recent studies have shown in other contexts that female students' written average scores tend to be dragged down by specific subjects, where male students clearly outperform them, without these subjects being strongly correlated with on-the-job performances. For instance, in the case of competitive exams for admission to administrative civil servant school, Meurs and Puhani (2019) show that women are disadvantaged by the "essay on general knowledge" in the written exam, though they are outperforming men on both "on the job" anonymous written and non-anonymous oral evaluations.

The format of the entrance examination to ENS Paris can have significant consequences on the gender balance of admitted candidates. Improving the representation of female students at ENS Paris requires rethinking the organization of its admission process and considering whether gender quotas could help mitigate unintended consequences. The next section explores the long-term effects of ending the gender-based quota at ENS Paris on research and teaching careers.

5 Long-Run Consequences

The sharp decline in the number of female candidates admitted to ENS Paris following the merger of the two schools likely impacted the French academic landscape. ENS Paris is dedicated to training higher-level teachers and researchers, and the introduction of the mixed competition might have resulted in fewer women pursuing academic careers in scientific fields.

To investigate this question, we study gender differences in labor market outcomes of candidates potentially affected by the quota, before and after its ending in 1986. We identify this group by simulating counterfactual lists of admitted candidates. Figure B12 presents a visual representation of our simulations.[32]

Identifying Candidates Affected by the Merger We identify two groups of candidates potentially affected by the introduction or the end of the gender quota:

[32]This section is still preliminary, as we are currently processing and collecting new information on candidates' labor market outcomes.

Before 1986, when the gender quota was still in place: For the years for which we have information on both scores in the written and the oral exams, we rank male and female candidates together to simulate the pool of admitted candidates in the absence of the gender quota.[33] We identify our group of female and male always-takers as the male and female candidates who would have been accepted with or without the gender quota, given the fixed number of seats for a given year. We identify our group of male switchers as the male candidates who were not accepted because of the gender quota but who would have been admitted without the gender quota. Reversely, we identify our group of female switchers as the female candidates who were admitted thanks to the gender quota but who would not have been accepted without the gender quota. Due to data constraints, we are only able to use the years 1978, 1979, 1984, and 1985.

After 1986, and the end of the gender quota: We fix the quota at the gender ratio of 1985 - roughly one third of female candidates and two thirds of male candidates - and simulate its implementation, given the capacity fixed for each year. We identify our group of female and male always-takers as the male and female candidates who would have been admitted with or without the quota. We identify our group of male switchers as male candidates who were admitted without the gender quota, but who would not have been admitted otherwise. Conversely, we identify our group of female switchers as the female candidates who were not admitted because of the end of the gender quota but who would have been admitted if it were still in place. Due to data constraints, we are only able to use the years 1986, 1987, 1988, and 1990.

Around the time of the merger, there was roughly 40 % of the male candidates and 15 % of female candidates listed on the main admission list and the waiting list who rejected their admission to the ENS, mostly because they preferred to go to another graduate school (mostly to the *École Polytechnique*). It was thus not unusual to be among the last candidates on the waiting list but still be offered a seat at ENS Paris in the end. To account for this, we use the number of available seats from the main admission list and the waiting list to define our sample of analysis. Our calibration for the simulations is presented in Table B2. Table B3 presents our sample size by years.

[33] When score in the oral exam are not available, students are ranked based solely on their score in the written exam.

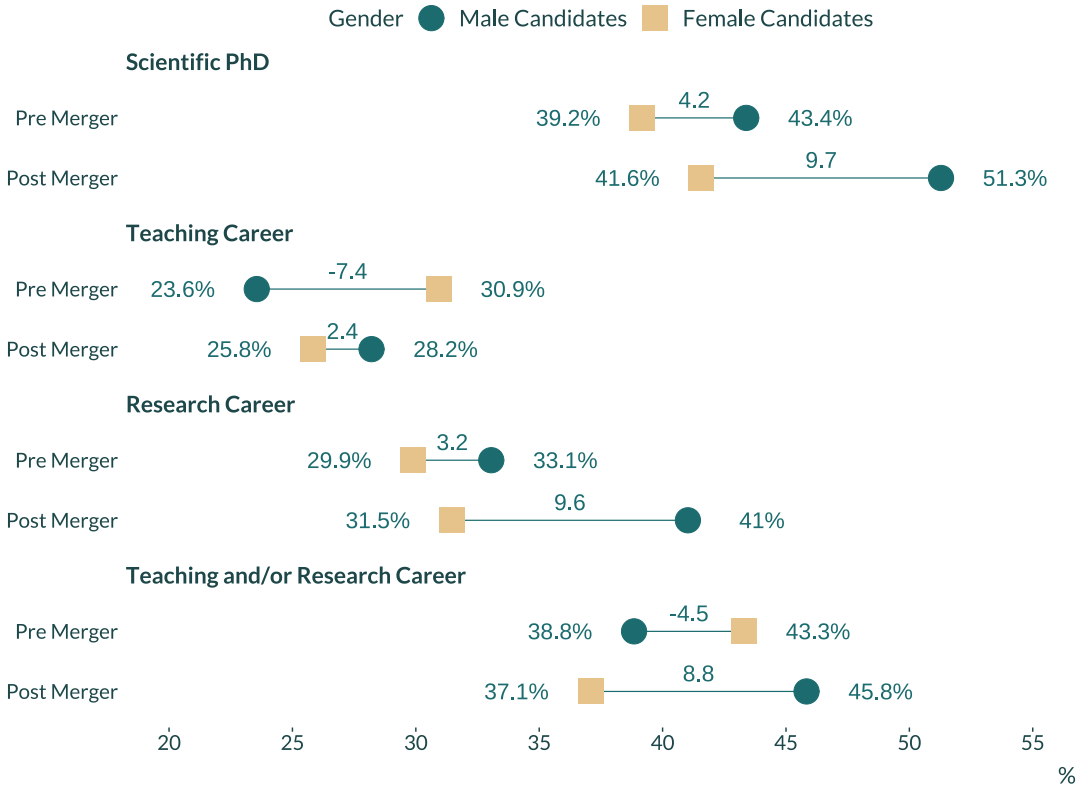
Challenges in the Identification As shown in Section 4, the end of the gender quota led to a shift in the composition of female candidates for the mathematics entrance examination. This suggests that the group of "always-takers" may also have been impacted by the end of the gender quota system. In particular, these individuals might not have been admitted prior to 1986, as the pool of candidates was different. After 1986, female students also were likely to have been treated differently once admitted to ENS Paris. For these reasons, we cannot treat female and male 'always-takers' as comparable over time. Consequently, we are unable to directly compare the outcomes of "always-takers" and "compliers". However, we can investigate potential gender differences in labor market outcomes for the combined group of both "always-takers" and "compliers". This group represents a broader sample of students who were "affected" by the gender quota. Finally, as students listed on the admission and waiting list can resign, we only identify an intent-to-treat, i.e., having a non-null probability of enrolling in the ENS Paris. Candidates in our group of interest have a positive probability of actually entering ENS Paris while candidates whose rank is below the last candidate on the waiting list have zero chances of entering the school (see Figures B15 and B16 in appendix).

Outcomes of Interest We construct four outcomes to qualify candidates' labor market outcomes, distinguishing teaching and research careers. First, we define a dummy variable equal to one if the candidate obtained a PhD in a scientific field. While we restrict our sample to mathematics-intensive fields, our definition of scientific fields is rather broad. It includes domains such as Mathematics, Physics, Computer Sciences, (Applied, Earth) Sciences, Astronomy, Biology, Chemistry, Engineering Sciences, and Economics.

We define having a teaching career as a dummy variable equal to one if the candidate obtained a position as a teacher in a high school, a preparatory program or as an assistant and/or full professor at a university. We define having a research career as a dummy variable equal to one if the candidate holds or held a position as an assistant and/or full professor at a university, as a researcher in a public institute, or as a researcher in the private sector. Finally, we define having a teaching and/or a research career as the union of the two latter categories.[34]

[34]This includes the CNRS, the CEA, and the INRIA, which are French public research institutions

Figure 14: Effect of the End of the Gender Quota on Affected Male and Female Candidates



Source: Documentation sourced from the ENS archives, *theses.fr*, *The Mathematics Genealogy Project*, *LinkedIn* and the French *Journal Officiel*.
Notes: The numbers display the mean difference of the share of male candidates minus the share of female students in different outcomes. Scientific PhD is composed of the following subjects: Mathematics, Physics, Computer Sciences, (Applied, Earth) Sciences, Astronomy, Biology, Chemistry, Engineering Sciences, Economics. A teaching career is defined as holding a position as a teacher in a high school, a preparatory class or as an assistant and/or full professor at a university. A research career is defined as holding a position as an assistant and/or full professor at a university, as a researcher in a public institute (e.g. CNRS, CEA, INRIA), or as a researcher in the private sector.
Reading: Before the merger, 30.9 % of affected female candidates and 23.5 % of affected male candidates had a teaching career. The mean difference between male and female candidates was -7.4 percentage points. After the merger, 25.8 % of affected female candidates and 28.2 % of affected male candidates had a teaching career. The mean difference between male and female candidates was 2.4 percentage points.

Results Our results suggest that the end of the gender quota has increased the gender gap in teaching and research careers. Figure 14 presents the gender gap (male - female) for our four outcomes of interest. When the quota was still in place, 43.4 % of male candidates in our group obtained a scientific PhD, compared to 39.2 % for female candidates, representing a gap of 4.2 percentage points. After the end of the quota, the share of candidates who obtained scientific PhD increased for both male and female students. However, the gap increased as well; 51.3 % of male candidates obtained a scientific PhD, compared to 41.6 % for female candidates, representing a gap of 9.7 percentage points. We observe a

similar pattern for the probability to pursue a research career. While male candidates were already more likely pursue this type of profession before the merger (33.1 % compared to 29.9 % for female candidates), the gender gap increased after the end of the quota system, from 3.2 to 9.6 percentage points.

The findings related to teaching are particularly noteworthy. Prior to the end of the quota, female candidates were more inclined than male candidates to pursue a career in teaching, with 30.9 % of them opting for this profession, compared to 23.6 % for male candidates. However, after 1986, this trend was entirely reversed, resulting in a gap of 2.4 percentage points in favor of male candidates. While this result is still exploratory, it may be worth exploring its potential link to the impact of role models on students' enrollment in scientific fields. Recent research has emphasized the importance of female role models, including both professors and researchers, for female students' engagement in STEM subjects (Porter and Serra, 2020; Breda et al., 2023). A decrease in the proportion of female teachers coming from ENS Paris may have had an adverse effect on female students' aspirations toward the school and STEM studies.

6 Discussion and Conclusion

In this paper, we investigate the effect of the end of a gender quota for admission to one of France's most prestigious elite graduate schools, the *Ecole Normale Supérieure de Paris*, in 1986. This school is of particular interest since its purpose is to prepare students for high-level teaching and academic careers. Between 1984 and 2010, it provided more than 20% of all the French public university professors in various fields such as literature, philosophy, history, mathematics, astronomy, and astrophysics. This historical event provides us with a unique opportunity to evaluate the potential effects of gender quota in academic careers.

We document that the end of this hard gender-based quota had a detrimental long-lasting effect on the share of admitted female candidates in the mathematics and physics tracks, but did not foster the number of women admitted in humanities or in biology. It eventually led to an absolute decline in the number of women admitted to the school.

Further analyses on the mathematics entrance exam show that women had a significant advantage in qualification and admission before the merger of the two schools, which was later entirely reversed in favor of men. Moreover, our counterfactual simulations show that

the gender gap in performance only explains half of the fall in the share of admitted female candidates. The remaining half is partly explained by women opting-out from the newly mixed competition, especially in the top preparatory programs.

In line with the stereotype threats framework (Spencer et al., 1999), high performing students, and students who identify the most to the task, are more likely to be affected by activated stereotype threats, in this case mixed competition in mathematics. This could also be explained by the fact that female students in top preparatory programs have more information about competitive exams and act more strategically. The mathematics subject with the largest weight at the ENS written examination is particularly demanding; it requires specific training, and skills that are not directly transferable to the preparation of other competitive exams for elite graduate schools. Hence, women studying in top preparatory programs could have chosen to focus on the other entrance examinations rather than losing time on this particular subject. We cannot argue that this mathematic examination is irrelevant to select potential good researchers, but it is worth noting that we find no correlation between Math 1 test score and the probability to obtain a scientific PhD or the probability to have a research career in our sample of affected candidates by the gender quota. Nonetheless, we show that the gender differences in scores obtained in this subject are especially pronounced, and that suppressing it could lead to substantial increase in the share of women qualified at the oral examination. Evidence on the good performances of women candidates at the oral examination—including in 1985, when the pool of female qualified candidates was less self-selected—suggests that this could be an efficient policy to increase the share of women among admitted candidates. Lastly, we document that the long-run consequences of the implementation of the mixed competition have increased gender differences in the probability to obtain a doctorate degree in a scientific field and to pursue a teaching and research career for the affected students. This new empirical evidence highlights that gender quotas can serve as a tool to reduce gender inequality in access to competitive institutions, without incurring high efficiency costs. Not only do quotas affect admissions, but their presence (or absence) also influences the application behavior of targeted students. Introducing quotas in admissions to STEM programs could, therefore, encourage applications from high-achieving female students with reasonable chances of being admitted to these programs.

Finally, in terms of public policy, the potential consequences of this decline in female

representation at ENS Paris can be examined from both the students' and the broader societal perspectives. From the students' standpoint, it is not entirely clear whether women are worse off, at least in terms of income, as they may have alternative opportunities at other elite graduate schools. However, from the perspective of a "social planner", this decline suggests a shift in the gender composition of ENS admissions, raising questions about potential losses or gains in research output. Assessing these outcomes is complex, as measuring researchers' productivity can be influenced by gender biases in evaluation methods. Moreover, diversity in recruitment may hold intrinsic value, contributing to a broader range of research topics and perspectives. Eventually, the under-representation of women at ENS could also have long-term, inter-generational consequences, as the institution's unique emphasis on both teaching and research plays a critical role in shaping future academic and scientific leadership, potentially limiting the diversity of those leading and shaping tomorrow's intellectual and scientific advances.

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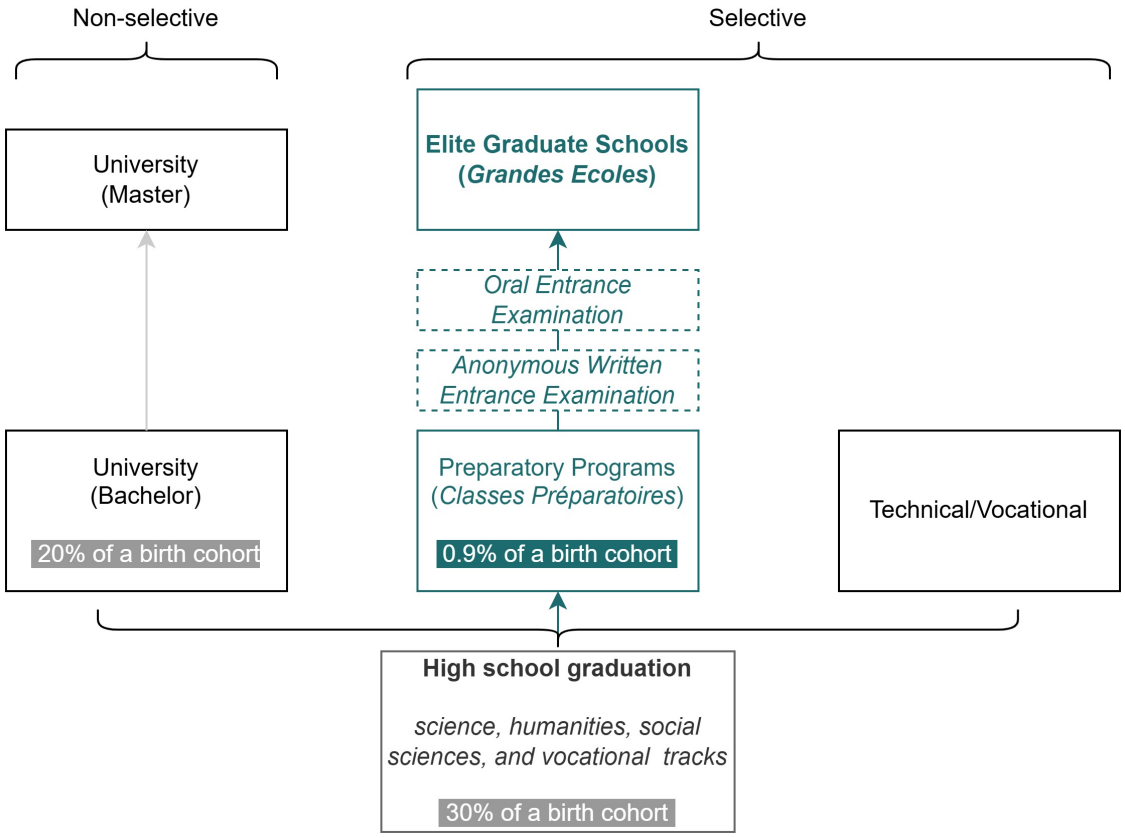
Appendix

A Institutional Background

Figure A1: Tracks in Secondary and Post-Secondary Education in France



Note: Trackhighlighted in green show the main educational pathway considered in this article.

The Mathematics Agrégation Further evidence that the ENS de Sèvres did not admit students with lower skills than the ENS d'Ulm is demonstrated by their performance on the Mathematics examination to become a secondary teacher, the *agrégation*. In France, most prospective high secondary education teachers and researchers take the *agrégation* exam. It is a competitive exam, which grants passing students a higher wage, fewer teaching hours, the possibility to teach in higher grades (high schools and preparatory programs), and can be a pre-requisite to pursue a PhD in some fields.[1] Since the ENS d'Ulm and the ENS de Sèvres were both intended to train future researchers and teachers, it was strongly

[1]This is mostly the case in humanities.

encouraged for students to take the *agrégation* exam after their second or third year of schooling.

Table A1: Success Rate at the Mathematics *Agrégation* in 1984, 1985 and 1986

	ENS de Sèvres (women only)			**ENS d'Ulm (men only)**		
	1984	1985	1986	1984	1985	1986
Number of candidates	14	10	7	13	10	20
Share of qualified candidates	93%	80%	100%	85%	90%	85%
Share of admitted candidates	93%	80%	100%	85%	90%	77%
Average final rank	43.1	45.6	33.4	45.5	32.7	32.4

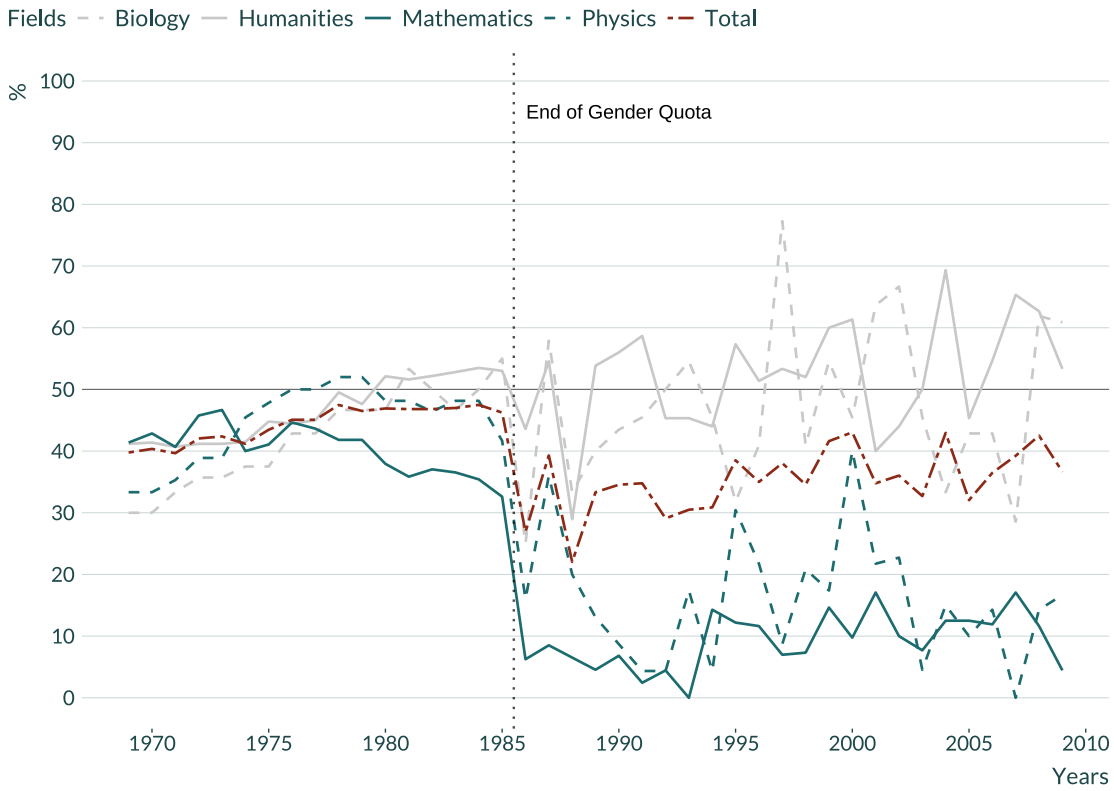
Source: Documentation sourced from the ENS and French National Archives.
Notes: The first part of the Mathematics agrégation is composed of three written exams: one of Algebra, one of Analysis, and one option (Probability and Statistics, Numerical Analysis, Mechanics). If the candidate is qualified for the second part of the *agrégation*, they take the two oral exams: one of Algebra and one of Analysis. There were 128 seats available in the 1984 Mathematics *agrégation*, 180 in 1985 and 180 in 1986. The lower the rank, the better. The final rank is only available for qualified candidates.
Lecture: In 1985, 80% of the 10 ENS de Sèvres female students who registered at the Mathematics *agrégation* were qualified for the oral part of the exam and all of them passed the *agrégation.* Their average final rank was 45.6.

Table A1, which displays the success rates of ENS students at the Mathematics *agrégation* in years 1984-1986, shows that male students from the ENS d'Ulm and female students from the ENS de Sèvres performed equally well on the test.[2]

[2]There is some selection bias, because students can choose in which subject they take the *agrégation*. About a third of the admitted students through the Mathematics entrance exam to the ENS in the 1980s decided to take the Physics *agrégation*, and a handful took it in another subject (e.g. Economics). Some other do not take any *agrégation* exam at all.

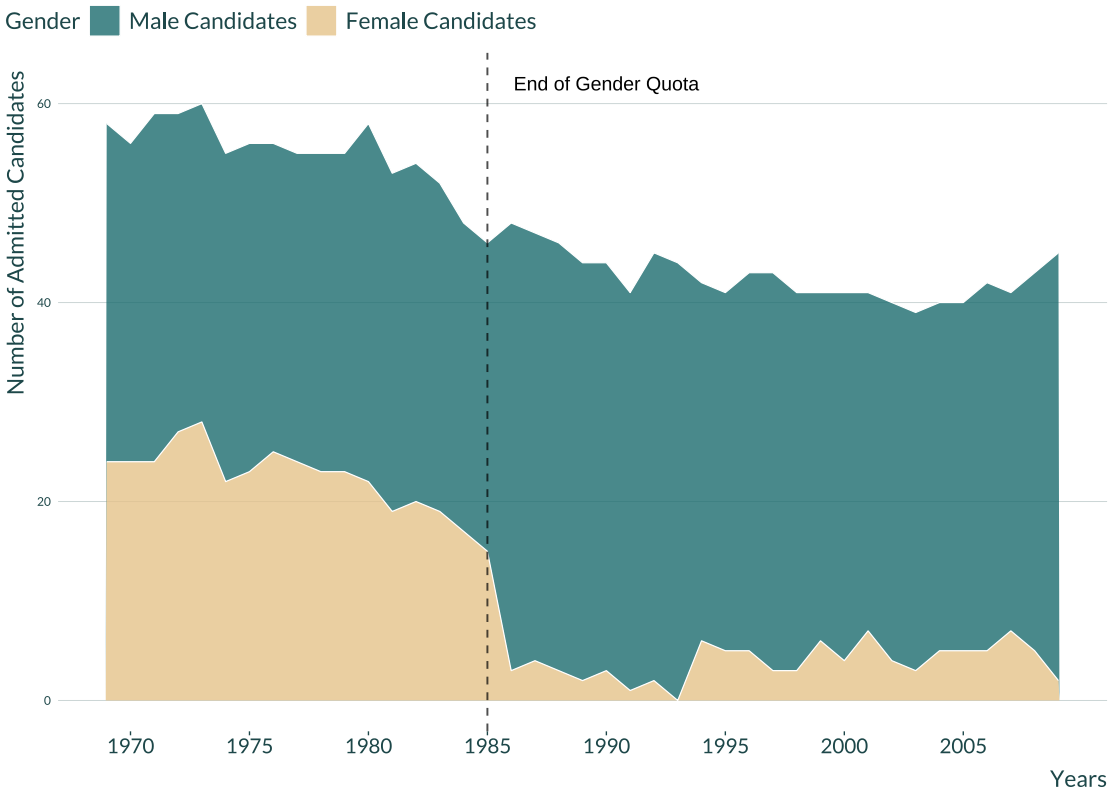
B Additional Figures and Tables

Figure B1: Percentage of Female Students Admitted to the ENS Paris (Ulm & Sèvres) All fields, 1969 - 2009



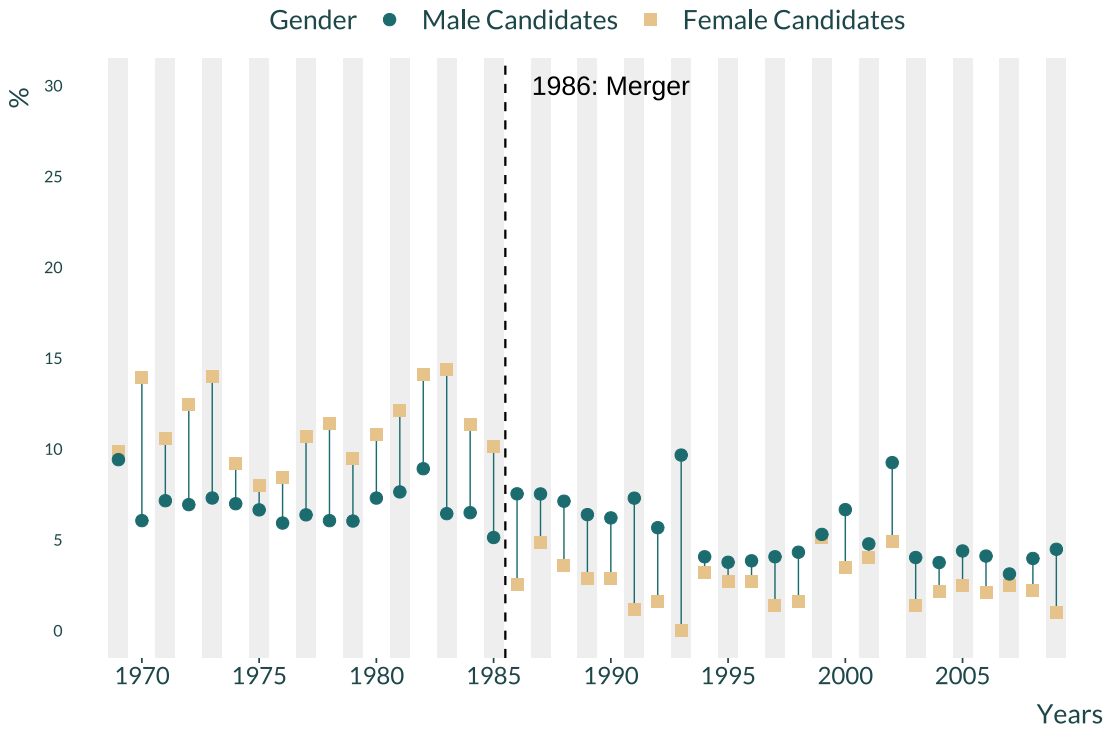
Source: Documentation from the ENS archives.
Lecture: In 1987, there were 8,7 % of female students admitted to the ENS in the mathematics track; 36,0 % in the physics track; 54,5 % in the humanities track; and 57,9 % in the biology track.

Figure B2: Candidates Admitted to the ENS Paris (Ulm & Sèvres) in the Mathematics Track, by Gender
(1969 - 2009)



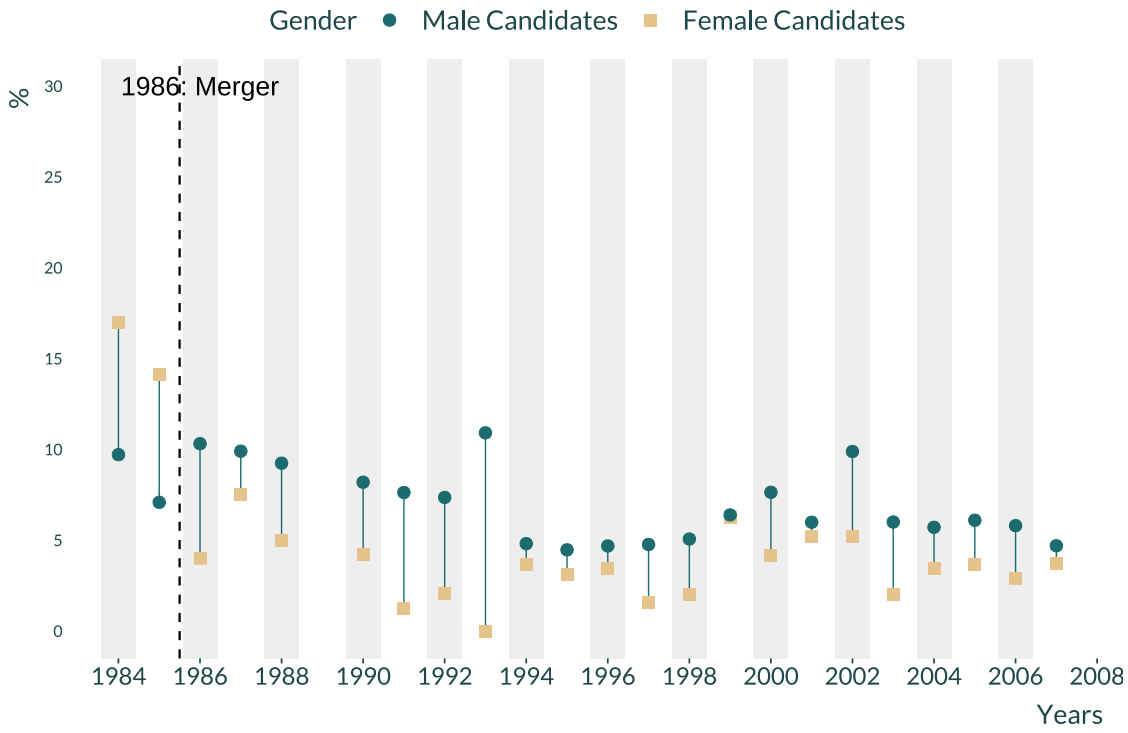
Source: Documentation sourced from the ENS archives.
Lecture: In 1986, 48 candidates were admitted to the ENS through the mathematics entrance examination; 3 were female candidates, and 45 male candidates.

Figure B3: Success Rates in Admission to the ENS Paris (Ulm & Sèvres) Mathematics Track, by Gender (1970 - 2009)



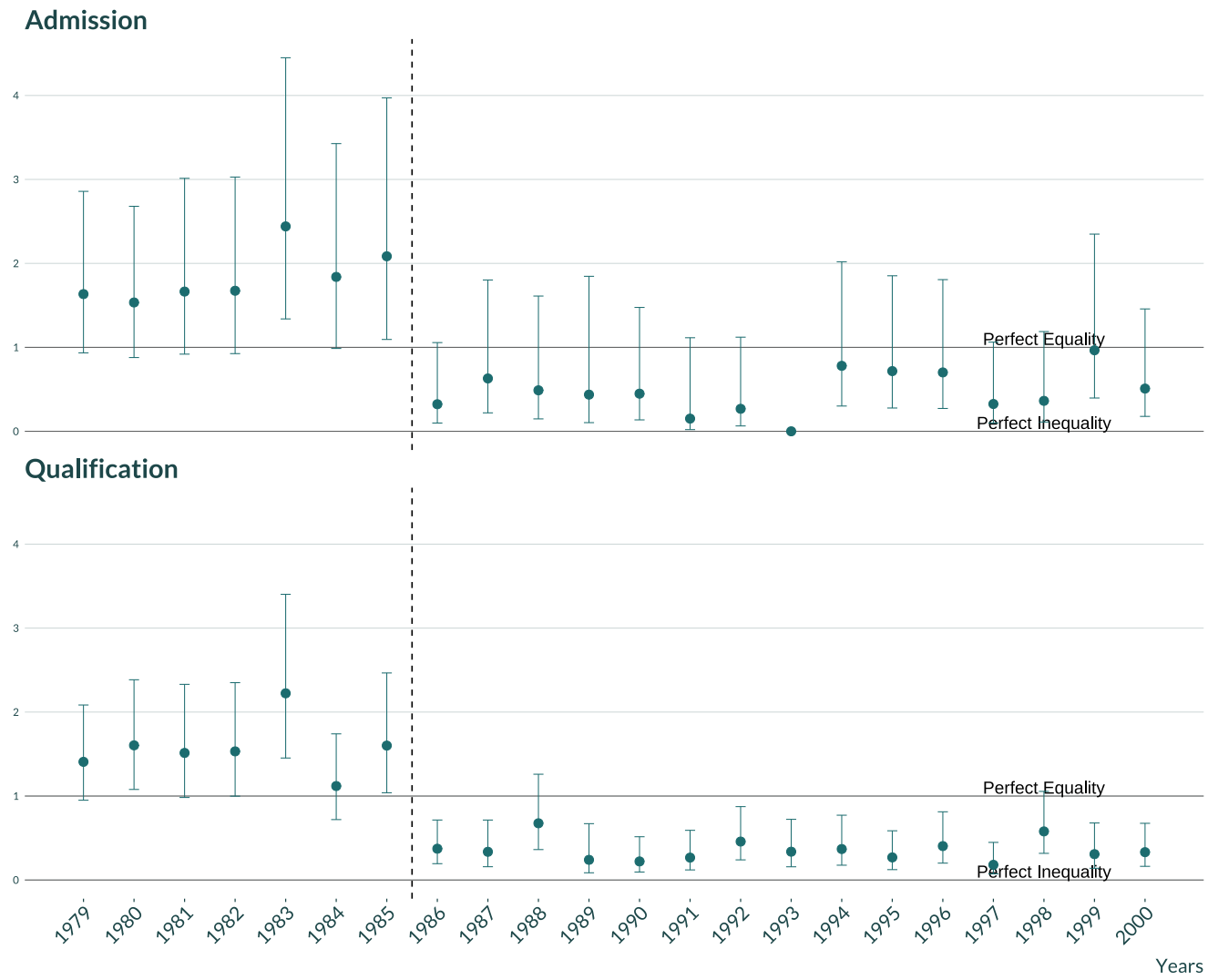
Source: Documentation sourced from the ENS archives.
Lecture: In 1986, the success rate (number of admitted students over the number of candidates at the written exam) was 2.6 % for female candidates and 7.6 % for male candidates.

Figure B4: Success Rates in Admission to the ENS Mathematics Track, by Gender, Pool of Candidates which Took the exam, 1984 - 2007



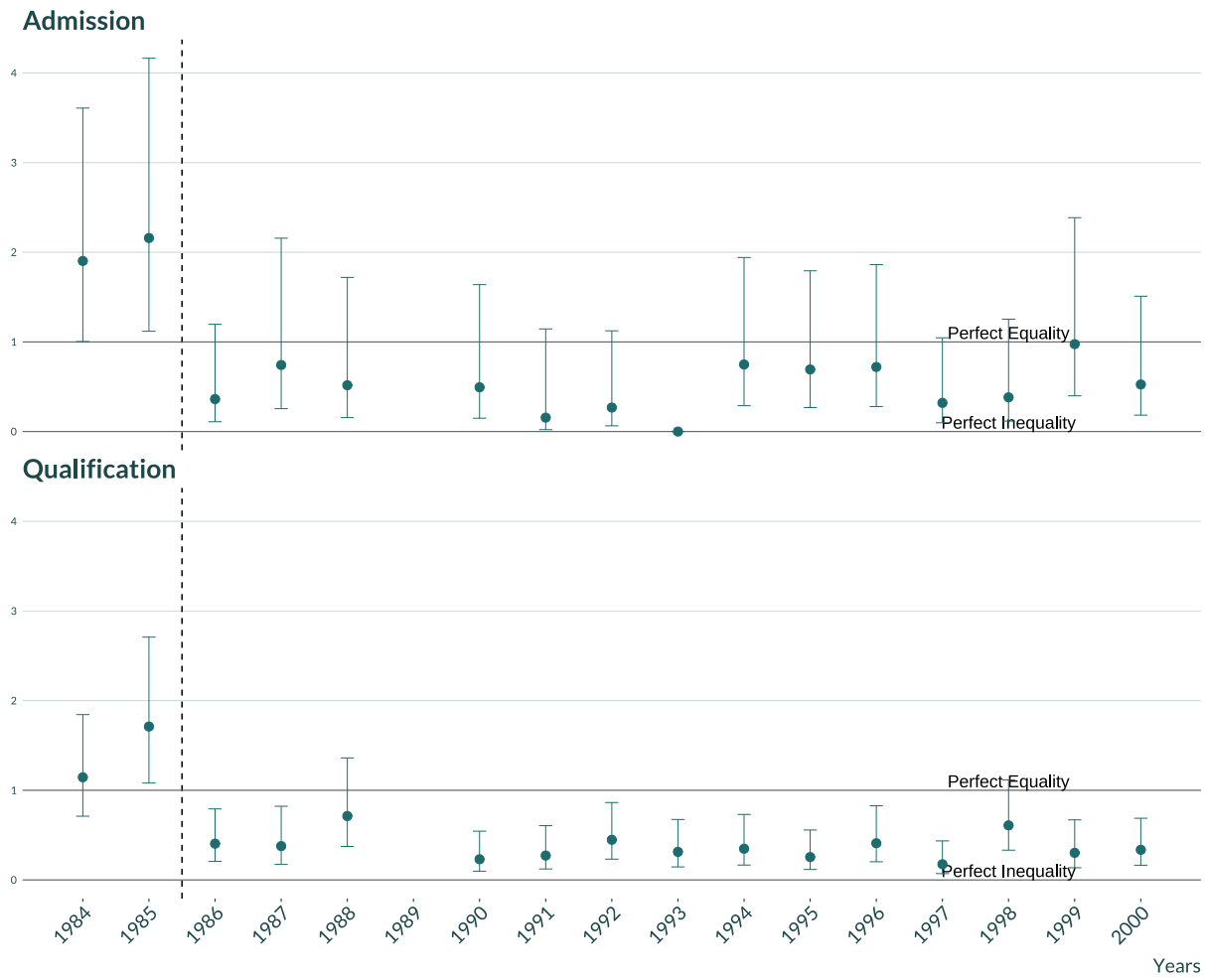
Source: Documentation sourced from the ENS archives.

Figure B5: Odds Ratios, Admission and Qualification, 1978 - 2000



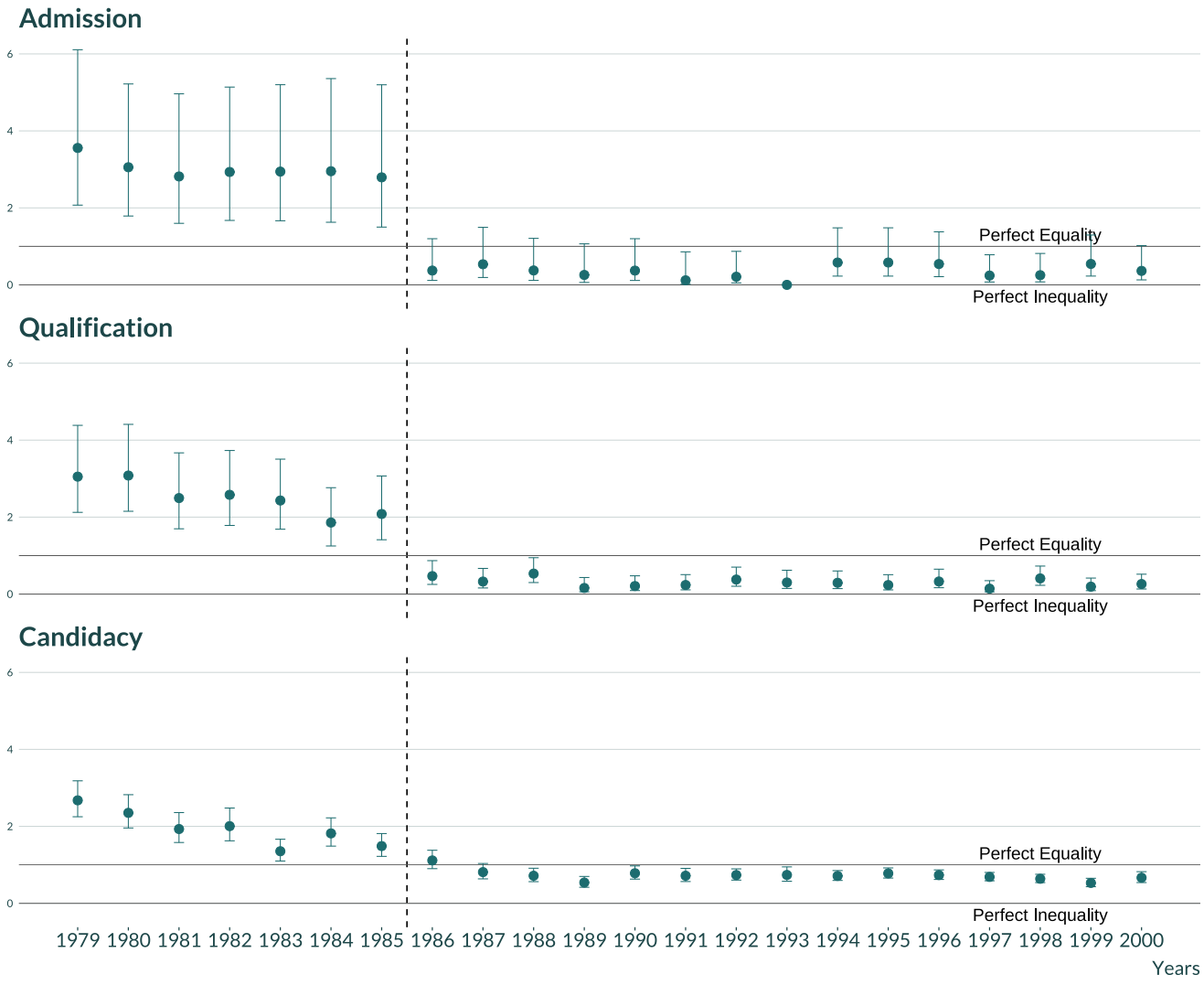
Source: Documentation sourced from the ENS archives.

Figure B6: Odds Ratios, Admission and Qualification, 1978 - 2000, Pool of Candidates which Took the Exam



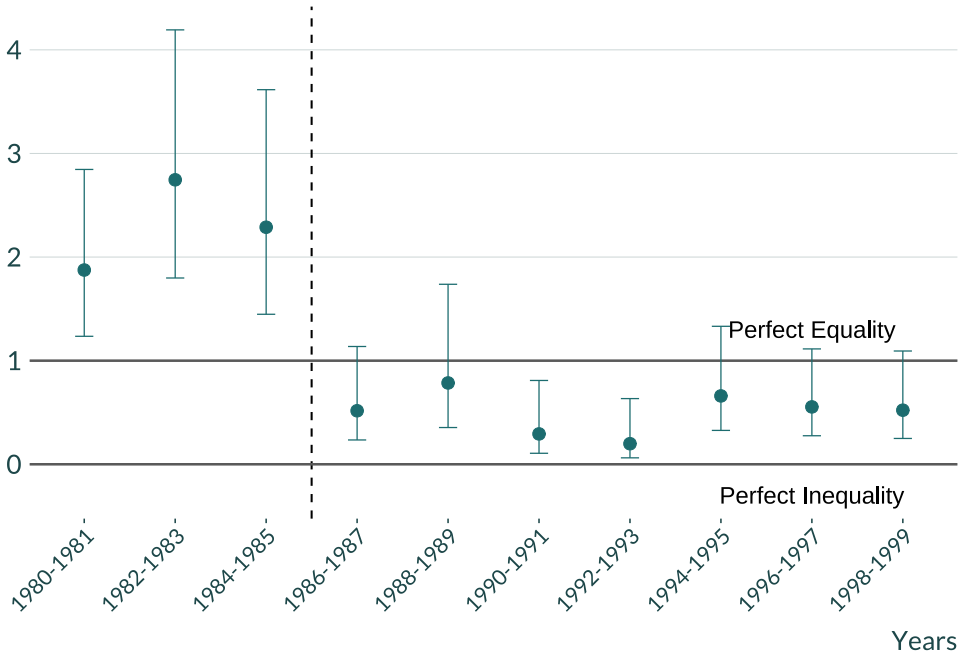
Source: Documentation sourced from the ENS archives.

Figure B7: Odds Ratios, Admission, Qualification and Candidacy, 1978 - 2000



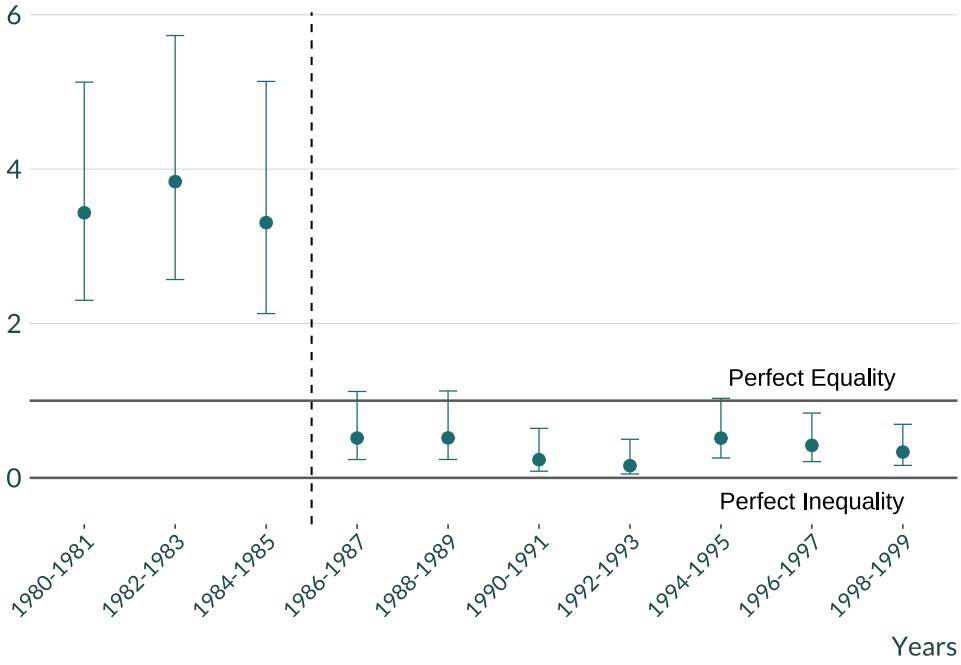
Source: Documentation sourced from the ENS archives.

Figure B8: Odds Ratios, Admission, Final Entrance to the ENS and Pool of Candidates Registered at the Written Exam, 1980-1999



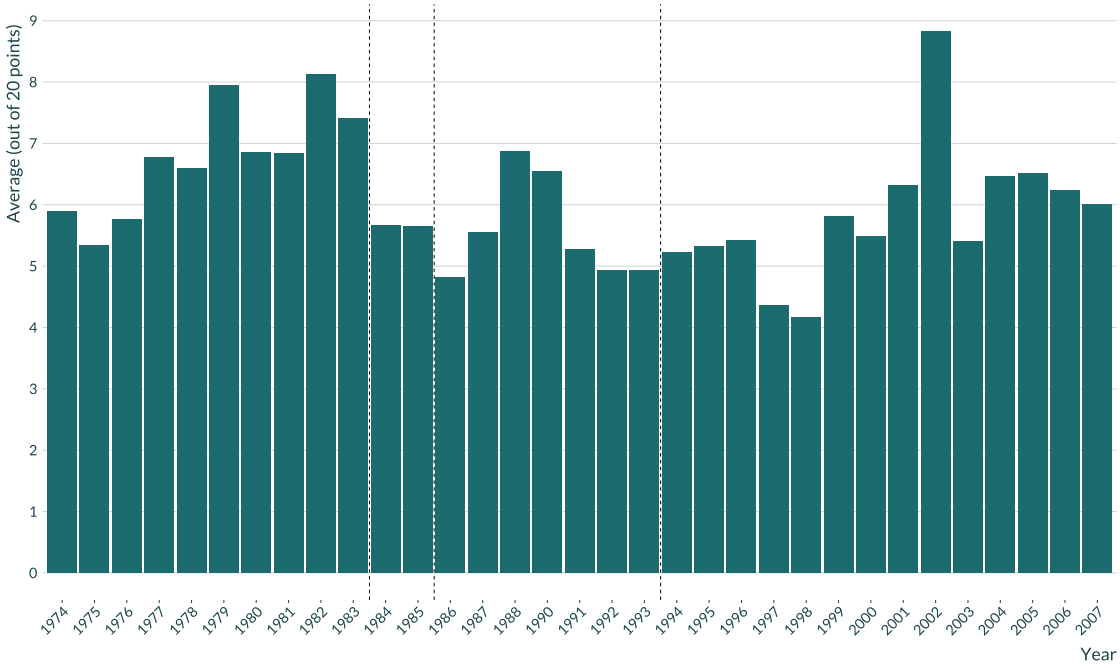
Source: Documentation sourced from the ENS archives.

Figure B9: Odds Ratios, Admission, Final Entrance to the ENS and Pool of Students in Preparatory Classes, 1980-1999



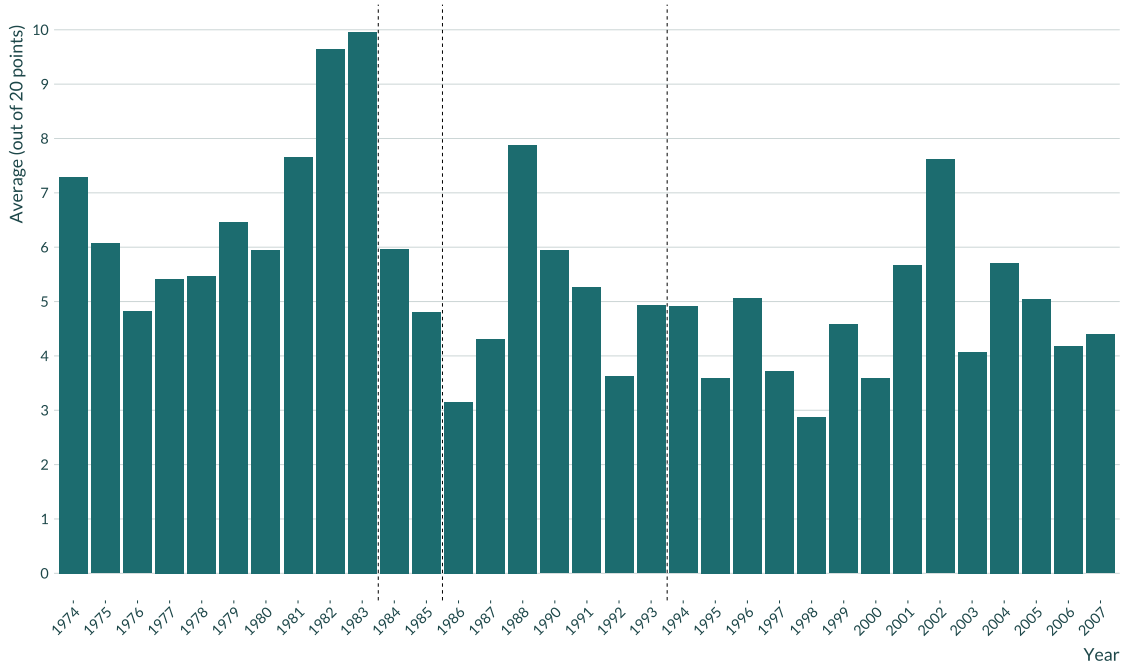
Source: Documentation sourced from the ENS archives.

Figure B10: Average grade at the Written Exam, Female Candidates at the ENS, 1974-2007



Source: Documentation sourced from the ENS archives.

Figure B11: Average grade at the First Mathematics Written Exam, Female Candidates at the ENS, 1974-2007



Source: Documentation sourced from the ENS archives.

Figure B12: Simulation of Counterfactuals

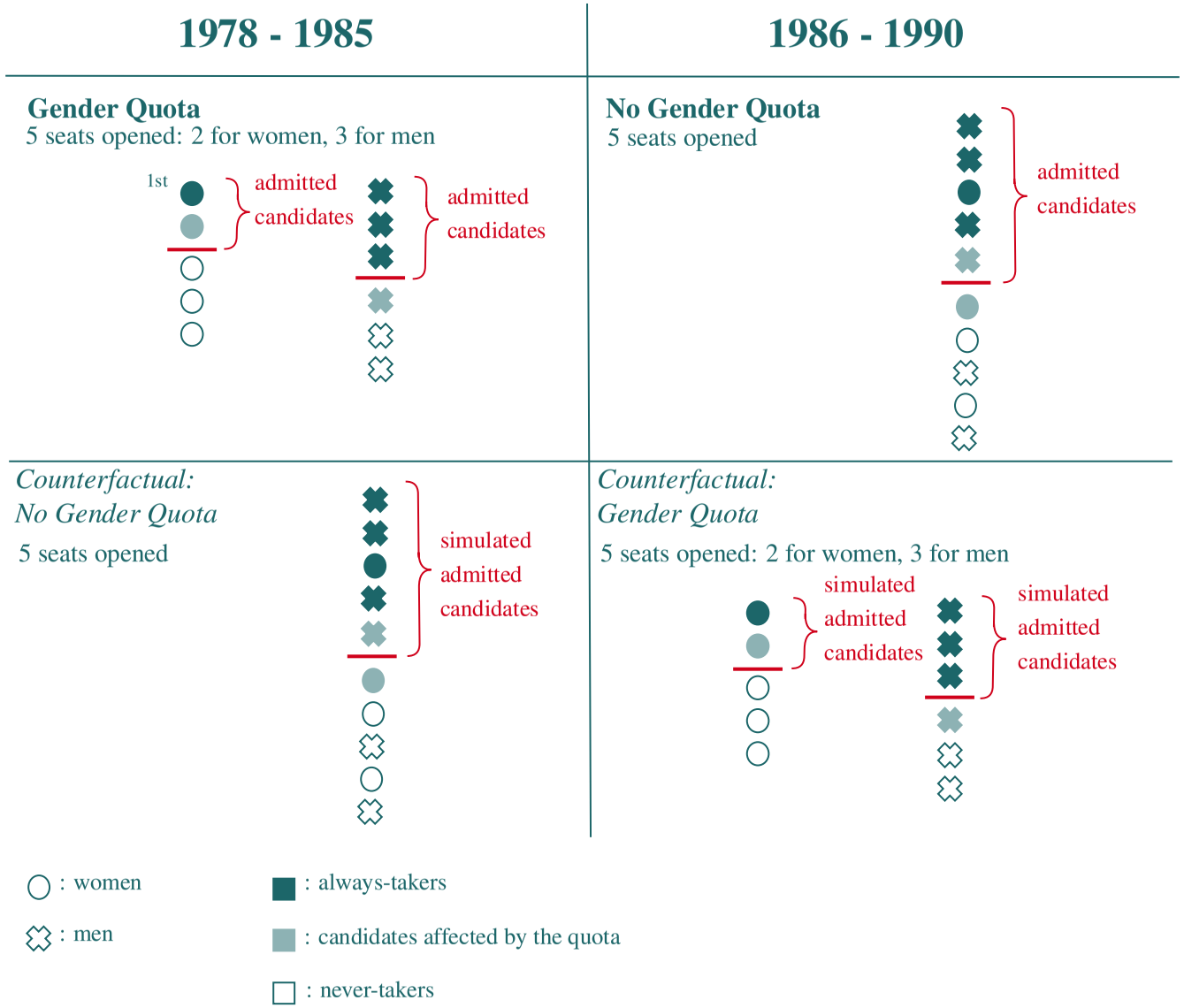
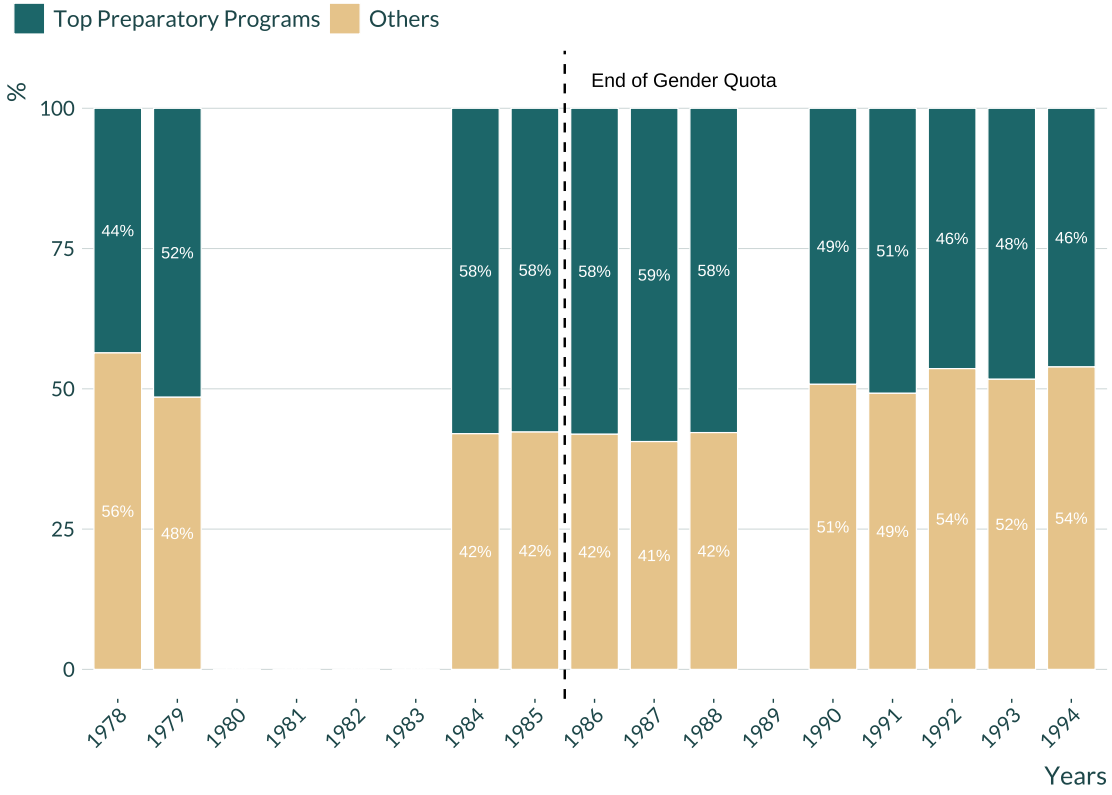


Table B1: Share of Female Among Admitted and Waiting-List Candidates

	1978	1979	1984	1985
Panel A. Number of Candidates				
ENS d'Ulm	46	46	61	61
ENS de Sèvres	26	26	22	23
Total (n_{year})	72	72	83	84
Panel B. Share of Female Candidates				
Actual Share		*with gender quota*		
	36%	36%	27%	27%
Simulated Share		*without gender quota*		
Raw Scores	33%	38%	20%	25%
Transformed Scores	22%	14%	27%	25%

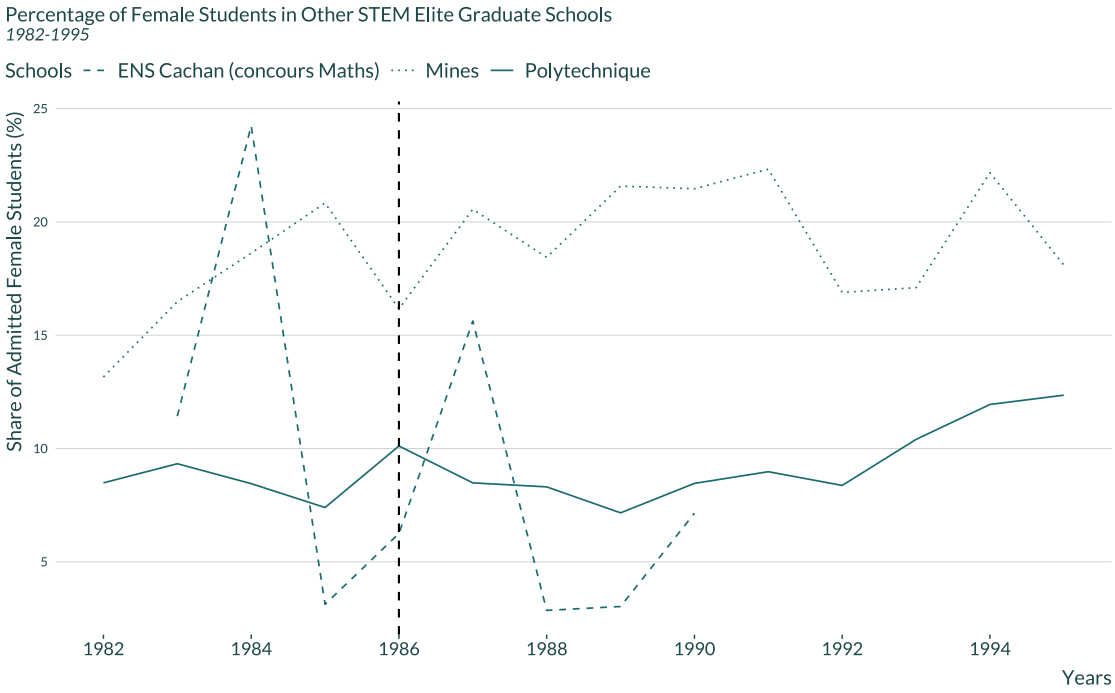
Source: Documentation sourced from the ENS and French National Archives. We use the transformed test scores for the year 1978, 1979 and 1984 to simulated the admitted students.

Figure B13: Share of Male Candidates Coming From Top Parisian High Schools, Top High Schools Outside of Paris and Other High Schools



Source: Documentation sourced from the ENS archives.

Figure B14: Percentage of Female Students in Other Sciences Schools, 1975-1995



Source: Bataille (2011) and Benveniste (2023) databases on elite graduate schools in France.

Table B2: Actual and Simulated Number of Seats Opened for Female and Male Candidates (Admission and Waiting-List)

	1978	**1979**	**1984**	**1985**	**1986**	**1987**	**1988**	**1990**
Panel A. Actual Number of Seats Opened for...								
	Gender Quota				*No Gender Quota*			
Male Candidates	46	46	61	61	0	0	0	0
Female Candidates	26	26	22	23	0	0	0	0
Any Candidates	0	0	0	0	83	83	82	85
Panel B. Simulated Number of Seats Opened for...								
	No Gender Quota				*Gender Quota*			
Male Candidates	0	0	0	0	22	22	22	23
Female Candidates	0	0	0	0	61	61	60	62
Any Candidates	72	72	83	84	0	0	0	0
Total (n_{year})	72	72	83	84	83	83	82	85

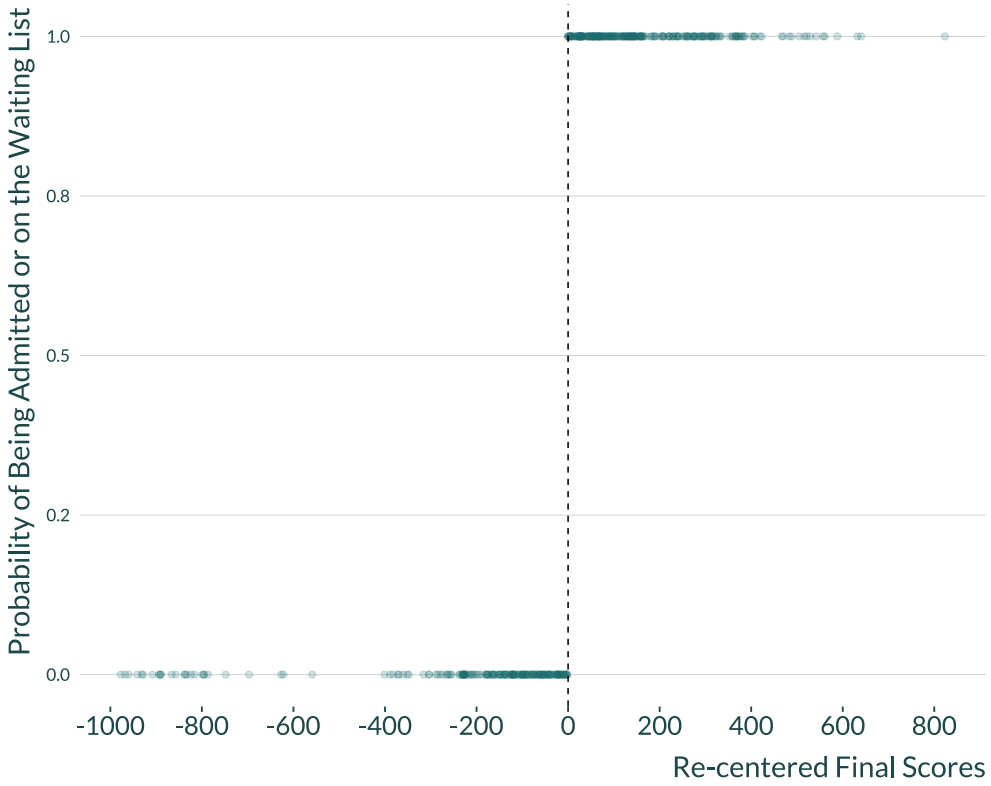
Source: Documentation sourced from the ENS and French National Archives.
Notes: To simulate the gender quota after 1985, we used the gender implemented in 1985 (27% of female students and 73% of male students.). We take n_{year} as given.

Table B3: Number of Candidates Affected by the Gender Quota, by Years

	1978	1979	1984	1985	1986	1987	1988	1990
Male Always Takers	38	41	61	61	55	61	60	62
Female Always Takers	15	8	22	21	4	6	7	4
Male Compliers	18	21	0	2	24	16	15	19
Female Compliers	11	18	0	2	18	16	15	19
Total	82	88	83	86	101	99	97	104

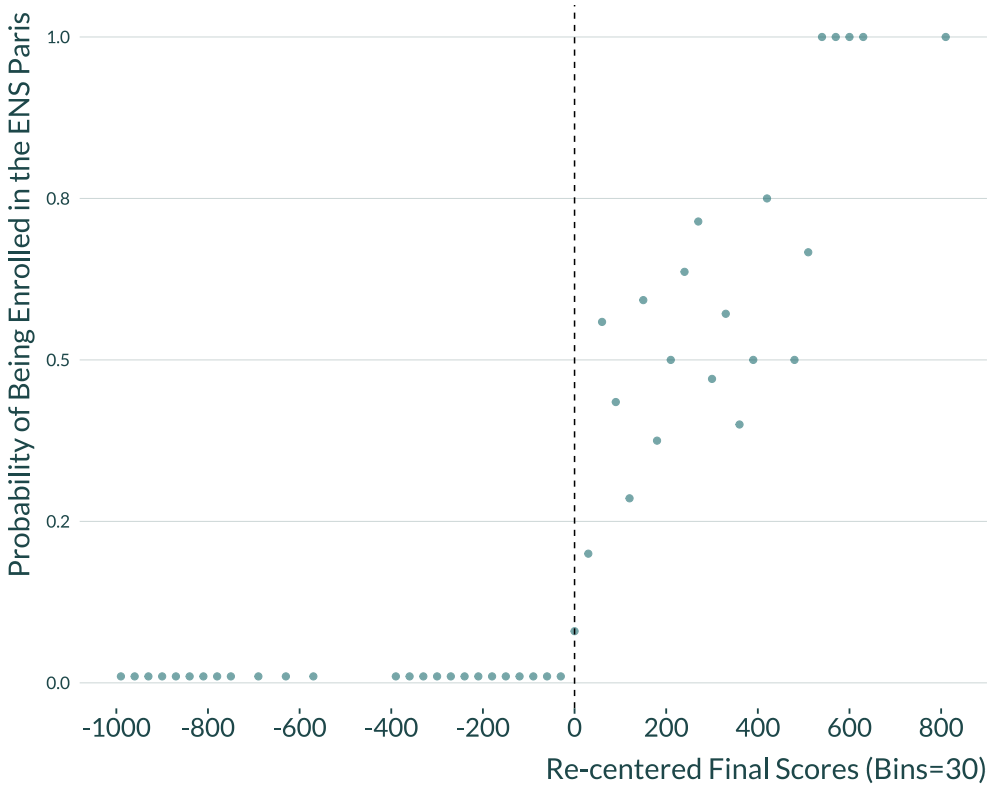
Source: Documentation sourced from the ENS and French National Archives.

Figure B15: Probability of Being Admitted or on the Waiting list for the Mathematics Track as a Function of Re-Centered Total Scores, 1987-1990



Source: Documentation sourced from the ENS archives.
Notes: The 0 is set at the total score of the last student on the waiting list.

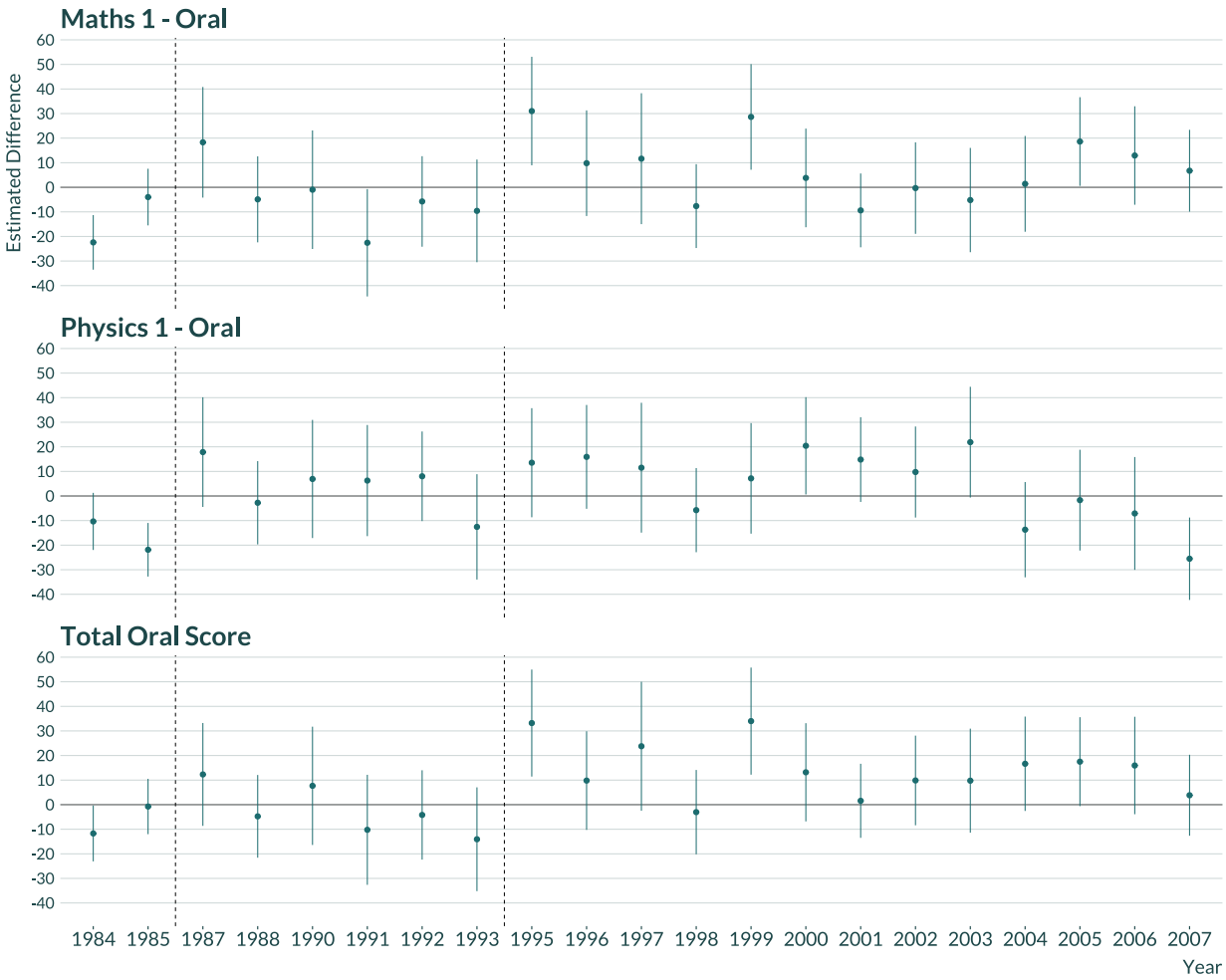
Figure B16: Probability of Enrolling in the ENS Paris in the Mathematics Track as a Function of Re-Centered Total Scores, 1987-1990



Source: Documentation sourced from the ENS archives.
Notes: The 0 is set at the total score of the last student on the waiting list.

C Gender Performance Gap

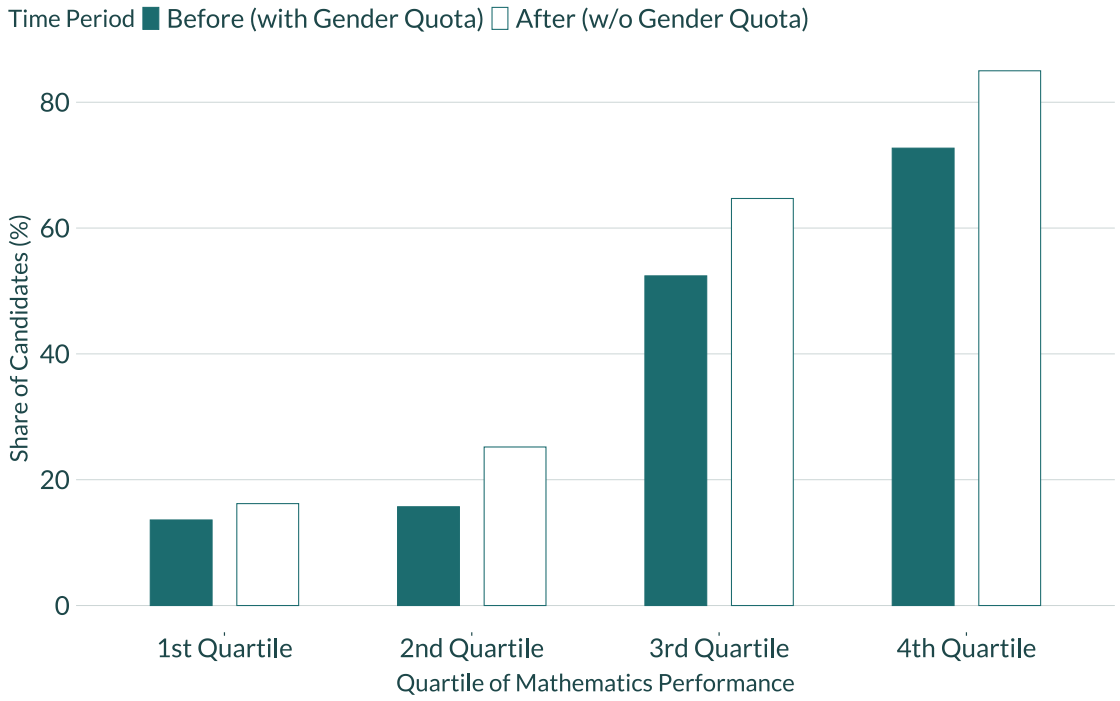
Figure C1: Raw Differences in Mean Percentile Rank, by Gender, Subject and Year
ENS Paris (Ulm & Sèvres) Entrance Oral Exam, 1978-2007



Source: Documentation from the ENS archives.
Note: Error bars represent the 95 % confidence interval.
Lecture: In 1985, the average percentile rank of female candidates at the total oral score was 50, whereas it was 49 for female candidates. The difference between the two is -1, which is reported in the graph.

D Louis le Grand Students Analyses

Figure D2: Male Students Application Behavior, by Math Performance at the End of Preparatory Program



Source: Documentation sourced from the *Louis le Grand* and ENS archives.
Notes: The sample consists of students who are enrolled in second year in the top mathematics preparatory program in France, *Louis le Grand* in 1978, 1978, 1982, 1984-1988. The 4th quartile is the top quartile of performance.
Reading: Before the end of the gender quota, among the male students in the 4th quartile of mathematics performance at the end of their second year of preparatory program, 72 % of them took the ENS Paris entrance examination. After the end of the gender quota, this share increased to 85 %.