

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 roughly half of this fall can be mechanically explained by a gender performance gap. However, we also uncover an endogenous 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 endogenous 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, elective education faces capacity constraints due to a limited number of 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 stake exams, which has already been documented among high-school students ([Azmat et al., 2016](#)), can have detrimental effects on women's outcome 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 known still 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 thus aim to empirically evaluate the potential effects of gender quotas in selective higher education. We combine a large 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 to provide new evidence on the impact of introducing mixed-competition on the profiles and trajectories of admitted candidates.

We leverage a natural experiment which occurred in 1986 at the *École Normale Supérieure de Paris* (ENS Paris), a French elite graduate school (*Grande École*). It was established after the French Revolution and leads to high-level teaching and academic careers. Its recruitment mainly relies on a highly competitive written entrance examination, followed by an oral examination for a subset of qualified students. After high school, students willing to enter ENS Paris first have to go through a two-year

¹In addition to the French “grandes écoles”, 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).

preparatory program where they can prepare for the entrance examinations to several elite graduate schools. These programs are equivalent to intensive undergraduate studies. Depending on their preparatory program track, students take different ENS Paris entrance exams (mathematics, physics-chemistry, biology, or humanities). Known globally for research excellence, ENS Paris has the largest ratio of Nobel prize winners in the world according to [Clynes \(2016\)](#). Before 1986, ENS Paris was composed of two single-gender schools: ENS d’Ulm (men-only) and ENS de Sèvres (women-only). They were located in different places of Paris, and each had their own administration and entrance exams. However, since the 1970s, men and women studied together in mixed-gender preparatory programs. They were both given the same ENS entrance exam topics, but were graded and ranked separately, with a fixed number of seats for male and female students.² Once they were admitted to the schools, male and female students followed the majority of their classes in mixed-gender public universities, and ultimately had the same type of career in research and teaching. However, some aspects, like classes for *agrégation* preparation and dormitories, remained gender-segregated until the two schools merged in 1986. These two single-gender entrance exams at ENS Paris effectively created a hard gender-based quota system.

ENS d’Ulm and ENS de Sèvres merged in 1986, which introduced a mixed competition at the entrance exams to gain admission to ENS Paris and the removal of the gender quota system. 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 the 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

²Except in the humanities track, until 1984.

³See Section 1 for details about the institutional background.

⁴Before 1986, the quota was set to be around 40-35 % of female students in mathematics, 45-50 % in physics-chemistry, and around 50 % in biology and humanities.

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 16.5 % 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 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 female students perform worse than male 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 a counterfactual simulation for the years when the gender quotas were implemented by ranking both male and female candidates together on their final grade to quantify the effect of the gender gap in performance on the under-admission of women at ENS. 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 exams. 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 ENS Paris entrance examination following the implementation of mixed competition. Indeed, the end of the gender quota is followed by a decrease in the number of female candidates. This endogenous response is concentrated among candidates who are likely to be high performers: the ones from best preparatory programs in France. This could represent an absolute loss of talents for ENS Paris.

We study the extensive and intensive margins of this endogenous response thanks to the students' grades report from the best mathematics preparatory program between 1978 and 1988. We hand-collected these grades reports in its archive rooms and digitized them. Although the students of this preparatory program only represent a subsample of ENS candidates in the mathematics track (roughly 13 %), they make up for a third

of all the admitted students. At the extensive margin, we show that after the end of the gender quota, there was an overall decrease in the probability to apply to ENS for female students only, while it increased for male students. Indeed, we observe fewer female candidates throughout the grade distribution, indicating that the decrease in the share of female candidates is not solely explained by the lowest-achieving female students turning away from the heightened, mixed-gender competition, which would be rational given their low admission rate. At the intensive margin, we look at whether, conditional on applying, female candidates performed less well at the exam once it became mixed-sex. We find no evidence of women underperforming at the entrance exam with respect to their male counterparts once we control for their grades at the end of the preparatory program, and no increasing nor appearing gender gap in performance at the exam once it became mixed-gender.

Finally, we investigate the long-term impact of ending gender quotas in ENS Paris entrance exams on French academia. Indeed, ENS Paris is especially relevant to assess the consequences of this reform on the French academic landscape, as between 1984 and 2010, more than 30 % of the French public universities professors in ancient languages, mathematics, philosophy, literature, archaeology, astronomy and astrophysics were former students at the school. 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 to pursue a teaching or a research career in mathematics-related fields. Given the important 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. Firstly, our paper investigates the impact of gender quotas in education on academic achievement and later labor market outcomes. We know that women outnumber men in higher education, but they still account for less than 20 % of new entrants in computer science and approxi-

mately 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, Technologies, 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 on 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 So, if we want to increase women representation in STEM fields, the long-term solution could be to tackle gender stereotypes. 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 interventions must happen early enough in students' life 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 ([Besley et al., 2017](#); [O'brien and Rickne, 2016](#)), including in France ([Lippmann, 2021, 2022](#)). [Schaede and Mankki \(2024\)](#) study the end of a gender quota in favor of men in Finland for primary school teachers on their pupils' long-run outcomes and quantify the efficiency-equity trade-off of such a policy. While the use of gender-based affirmative action may seem unusual in an educational context, such policies are already in place in countries like Finland, where points are awarded to underrepresented genders in a field ([Silliman and Virtanen, 2022](#)). We show that affirmative action in favor of women in STEM could foster their participation in competitive exam, eventually benefiting high-achieving women that would not have applied in the absence of the policy.

We believe that our results can shed light on the symmetric context of an implementation of a gender quota. Our paper can inform us on the mechanisms at play in the

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

long-lasting debate on the efficiency-equity trade-off of affirmative action policies in education. In line with [Bleemer \(2022\)](#), we show that the implementation of quotas counteract some endogenous responses by the targeted candidates: in the absence of quota, they reduce their application behavior. This brings us to our second contribution. Our paper provides new real-world evidence on the detrimental effects of mixed competition for women performance in stereotypically masculine task, 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 also 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. Our paper then contributes to the recent literature on the effect 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.

Finally, our paper also confirms previous results regarding the impact of the merger of ENS de Fontenay-aux-Roses and Saint-Cloud ([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.

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 endogenous 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

French higher education system has always been characterized by a significant degree of academic hierarchy. In the early 1980s, around 30 % of a birth cohort graduated from high school. Students who pursued academic higher education had two main paths choose from: (i) non-selective public universities, which enrolled 68 % of students registered in higher education, and (ii) an elite track composed of preparatory programs (*Classes Préparatoires aux Grandes Écoles*, followed by elite graduate schools (*Grandes Écoles*), which enrolled 3 % of students registered in higher education (DEPP, 1997). The coexistence of these two academic paths is a distinctive feature of the French higher education system. Figure A1 in Appendix displays a simplified version of the different paths available to students in France.

Preparatory programs and elite graduate schools Preparatory programs last two to three years and consists of intensive undergraduate studies. They are located in high schools, and 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 different majors in mathematics, physics-chemistry, engineering sciences and biology). Given their limited number of available seats, access to preparatory programs has always been highly selective. Admission is largely based on academic performance and these programs consistently attract the highest-achieving students. At the end of the preparatory programs, students take competitive entrance examinations for several elite graduate schools. Their exam

⁶Only teachers who obtained the *agrégation* can teach in preparatory programs.

topics depend on their preparatory program track. These elite graduate schools typically last three years, and students graduate from them with a master’s degree. A strong hierarchy exists among preparatory programs based on their success rates in entrance examinations to elite graduate schools.

Our paper study the entrance examination to one of these elite graduate school, the *École Normale Supérieure de Paris* (ENS Paris), with a focus on its mathematics track. We thus mainly present the mathematics track in the rest of this Section. In Section 4, we use data from the top mathematics preparatory program, located in high school *Louis le Grand*. In the 1980s, it accounted for about 13 % of the ENS Paris mathematics entrance exam, but for 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 purpose was initially 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 aside from the one in Paris, located in Lyon, Saclay and Rennes. ENS Paris has barely no tuition fees (only a couple hundreds of 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)⁸ for the entrance examination. 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.

It is a particularly relevant context to study 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 the full professors in mathematics in French Universities are former students of the school. ENS Paris is considered as one of the top schools in research in the world. It has the largest ratio of Nobel Prize winners per capita in the world according to [Clynes \(2016\)](#). Out of 13 French Fields medals, 10 were former students from ENS Paris.

⁷Students are then formally in contract with the state as civil servant trainees for 10 years.

⁸In the paper, we do not study the social sciences track because it was only created in 1982.

Recruitment Recruitment at ENS Paris mainly relies on a highly competitive entrance examination.⁹ Taking the entrance examination is free. 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 at 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 to be particularly difficult and hard to complete in time. The written part of the entrance exams is graded anonymously.

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 the final examination in the same way. Except 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.

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

¹⁰Since 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.

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. Prior to this change, each ENS conducted its own separate entrance exam, which made it difficult for students to apply to multiple schools.¹¹ The creation of a common written exam made it easier for students to apply to multiple ENS and helped to standardize the admission procedure across the different institutions. It mainly resulted in a change in the weights applied to each subject for ENS Paris.

Juries and Exam Topics Before 1985, ENS de Sèvres (women-only school) and ENS d'Ulm (men-only) each had their own entrance exams. The juries and exam topics differed depending on the entrance track. At least since the 1970s, for the mathematics track, the exam topics were the same for male and female students, but their exam papers were graded by different juries. In science subjects, there were hardly any female jury members at the women-only school, and a men-only jury at the men-only school. Variation in the gender balance of the jury is thus not a dimension we are able to study. For the physics-chemistry and the biology tracks, the exam topics and the juries were the same for both male and female students. However, their exam papers were graded separately, meaning that the jury members knew whether they were grading a woman or a man's work. For the humanities track, both the juries and the exam topics were different for male and female students. See [Online Appendix section D](#) for more details about entrance exam juries and exam topics, especially in the mathematics track.

In 1985, in order to anticipate for the merger of the two schools the following year, all the entrance exam tracks provided the same exam topics for both male and female students, and the same jury graded male and female students together.

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 for women as an equivalent

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

of the *École normale supérieure de la rue d’Ulm* (hereafter ENS d’Ulm) which was for men. Except from the interwar period when some female candidates could take part in the male examination (mainly for tracks that were not available in their school), admission to ENS de Sèvres and ENS d’Ulm was done through two separate entrance examinations.

Before 1986, the existence of these two single-gender entrance exams was equivalent to a gender-based hard quota system. Since at least the mid 1970s, preparatory programs were mixed-gender, even though the share of women in mathematics track was fairly small (about 16.5 % in second year of mathematics preparatory classes around the time of the merger). The same exam topics were given to male and female students in each subject in the mathematics, biology and physics-chemistry tracks. Male and female students were graded and ranked separately. Once they entered the school, most ENS students took classes at public universities (mixed-gender institutions) and male and female students interned in the same research laboratories. At the time of the merger of the two schools, almost all classes were taken outside of ENS Paris. They took the same examination to become a teacher after their studies (the *agrégation*), which both female and male ENS students were strongly encouraged to take. Nonetheless, some differences remained between the two institutions: specific classes—namely the preparation to the *agrégation*, the examination to become a secondary school teacher—and the dormitories were still separate for men and women until the merger of the two schools in 1986. So, the merger removed the hard gender-based quota in the entrance examination, introduced full co-education and eliminated the symbolic separation of being in two different schools. We cannot disentangle these effects, but we believe that this particular natural experiment can provide us with useful information about the impact of gender quotas in elite higher education.

The Merger in 1986 ENS d’Ulm and ENS de Sèvres were among the last schools to comply to 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 Laurent Fabius.¹² 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 students 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 students 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 consideration, the merger was also motivated by economic 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.¹³ The merger was challenged both by students and professors of the school (petitions, letters, etc.). "It was seen as a way to instrumentalize gender equality to justify budget cuts, and some concerns were raised regarding the impact it might have on female recruitment in science departments. A comity 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: less 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

¹²Laurent 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. You can find the entire speech announcing the merger of the two schools in [Online Appendix Section A](#).

¹³This is particularly evident in the management of juries after the merger, as presented in [Online Appendix section D](#).

supposed preferred field, was a common view at the time of the merger.¹⁴

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 about 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. In 1966, a report¹⁵ by mathematician Pierre Samuel about the mathematics track at ENS de Sèvres reported that about 80 % of ENS de Sèvres students chose to pursue a research career (either at the university or the *Centre National de la Recherche Scientifique* (CNRS)). 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.¹⁶ Our own computations made with the ENS Alumni database and the administrative data from the human resources of the Ministry of Higher Education in France tell us that 8.8 % of the male students who entered ENS Paris in mathematics between 1969 and 1985 ended up having an assistant and/or a full professor position in a French public University, while the share was 9.6 % for female students.

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 classes; 55 % of them decided to pursue a career in research, while 11 % of them chose to pursue different types of career, mainly by becoming high officials of the French administration.¹⁷ Figures are comparable for the promotions of female

¹⁴In an article published on January 15th 1985 in the newspaper *Le Monde* announcing the merger of the two schools, the journalist states this widespread hypothesis. You can find this article in [Online Appendix section A](#).

¹⁵The report can be found in [Online Appendix Section A](#).

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

¹⁷This 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.

students who entered the school between 1981 and 1982: only 13 % of them chose to become teachers in secondary education, while 40 % pursued career in higher education and research; a slightly higher share of female students turned to other types of careers.

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. More details can be found in [Online Appendix section A](#).

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 <i>(Mostly in preparatory programs)</i>	14%	15% 13%
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.

2 Data

Our analyses draw on numerous historical data sources, many of which we have 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 a individual-level dataset about the mathematics entrance examination at ENS d’Ulm, ENS de Sèvres and ENS Paris from 1969 to 2007. 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 years 1978, 1979, 1982, 1984 and 1985, which are of crucial importance for the analysis of the effect of the merger.¹⁸ 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 the 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.¹⁹

We also collected aggregated information about the number of candidates, qualified candidates, and admitted candidates at ENS d’Ulm, ENS de Sèvres and ENS Paris for tracks other than mathematics in the entrance examination (physics-chemistry, biology, and humanities).²⁰

Preparatory Programs We gathered aggregated data about the gender balance of second-year preparatory programs in France between 1978 and 2000. This information

¹⁸Details about the collected data can be found in [Online Appendix section B](#).

¹⁹This concerns 12 years of our sample after the merger.

²⁰We began collecting individual-level data for the other tracks in Summer 2024. We are in the process of converting them into data to enable comparisons between our current results in the mathematics track and those in the other tracks.

is available on the digitized archives of the French Ministry of Higher Education. We also collected individual students' grades reports from the top mathematics preparatory program in France between 1978 and 1988. We hand collected this information in the archive rooms of *Louis le Grand* high school and was transformed 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 were retrieved online (e.g. the *Journal Officiel*).

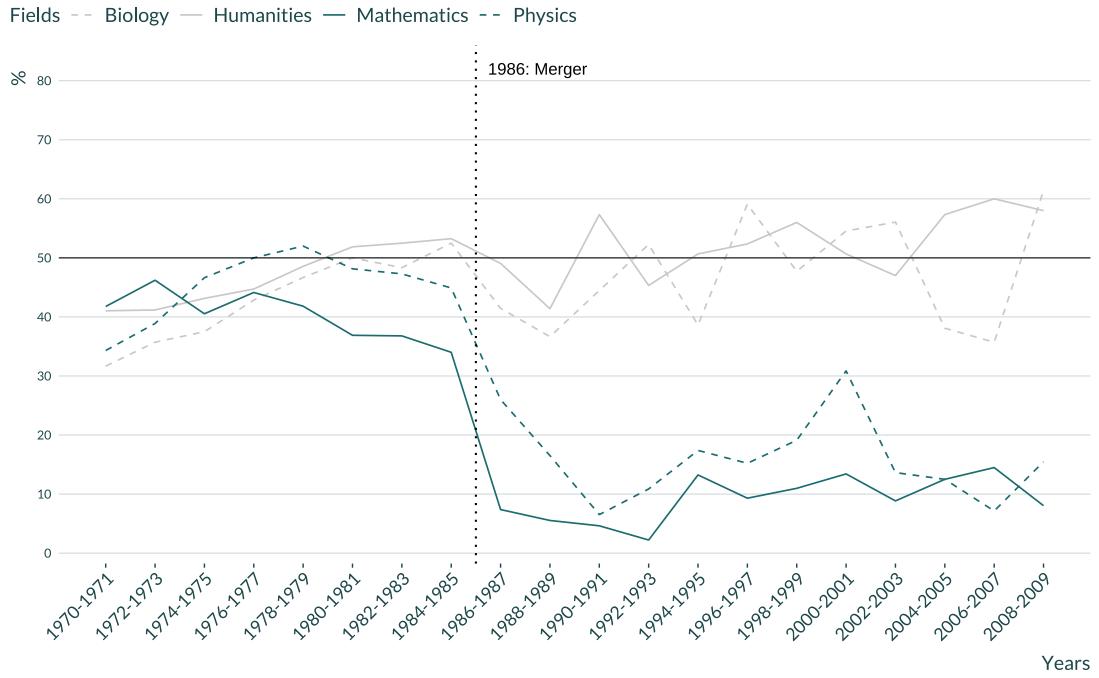
3 Results on Admission

Our first analyses focus on the effect of the end of the gender quota on the share of admitted female candidates at ENS Paris.

3.1 Different Effects on Different Tracks

The end of the gender quota had different effects on the gender balance of admitted candidates, depending on the track of the entrance examination. Figure 1 displays the actual percentage of admitted female candidates to ENS Paris for each track between 1970 and 2009, namely mathematics, physics-chemistry, biology, and humanities. The dotted black line denotes the year of the merger of the two schools, 1986. To gain a clearer understanding of the evolution, we grouped the years two by two. Year-by-year results are presented in the Appendix Section B. The patterns exhibited in are similar.

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.

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.

The first notable point is that the proportion of admitted female candidates to the mathematics and the physics-chemistry tracks 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. 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. (see Section 1 for more details on this). 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 and end up represented at ENS Paris in proportions similar to those in their respective preparatory program tracks.

Before 1986, the quota was set to be around 40 % of women 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 % over our studied the period (1986 - 2009) in mathematics and to 15.9 % in physics-chemistry. It is interesting to note that the decline in the number of female candidates admitted to the physics-chemistry track was more volatile than in mathematics, with the proportion of admitted female candidates even reaching 40 % in 2000, though it has never returned to its pre-merger level since then. In biology, there was a significant drop in 1986 but the proportion of admitted female candidates remained around 47.2 % on average after the merger. The humanities track followed the same trend, achieving parity on average after the merger.²¹ These results can be interpreted as evidence that mixed competition 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 the mixed competition did not foster women's performance in humanities, which are stereotypically female-associated. Rather than keeping a status quo through increased horizontal differentiation, the introduction of the mixed competition led to an absolute decrease in the number of female students to ENS Paris.

Figure 2 illustrates that the end of the gender quota not only led to an absolute decrease in the share and number of women at ENS Paris but also resulted in women being underrepresented in all four tracks at ENS with respect to their representation in the related preparatory program tracks. Between 1980 and 1994, the share of female students enrolled in the second year of a physics-chemistry preparatory program in France remained fairly constant and was 17 %. The trend also remained fairly constant in mathematics at 16.5 % and at 63.9 % in humanities. However, in biology, the share of female students increased over this period from 31.9 % to 47.9 %.

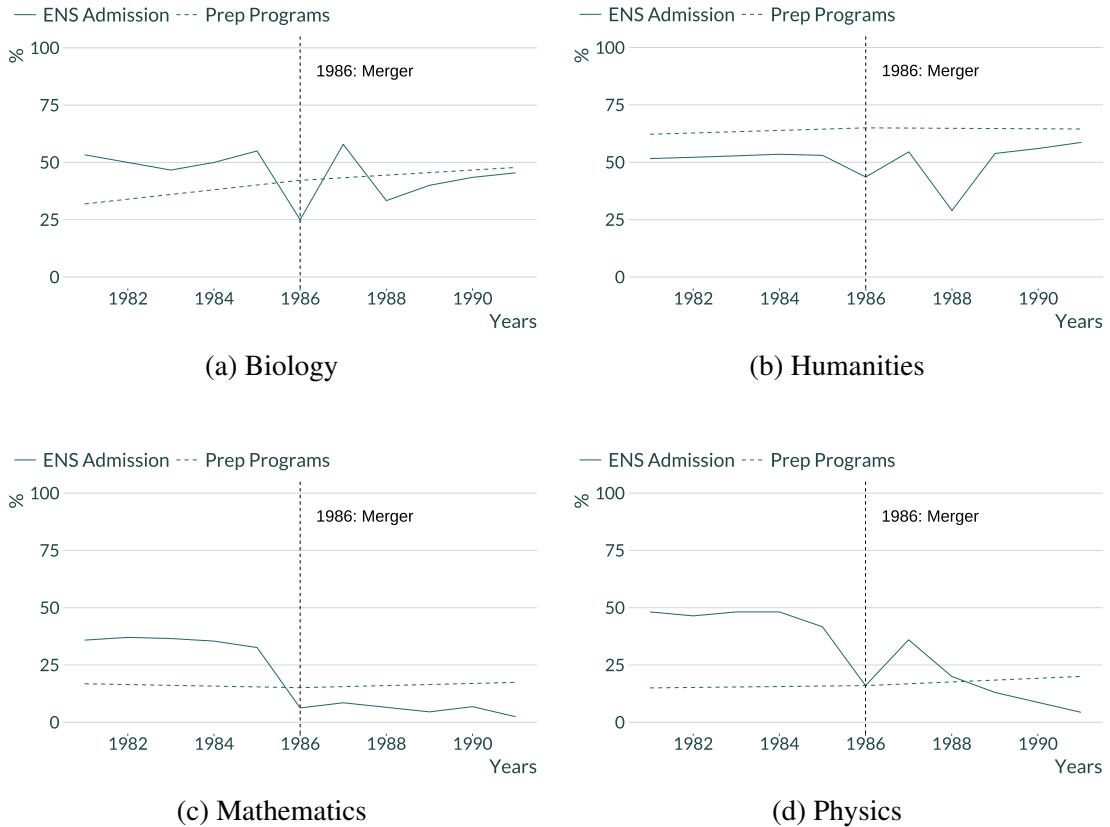
If one expected the share of admitted female candidates at ENS Paris to mirror their share in preparatory programs, one would have expected the end of the gender quota to decrease the share of female students from 47.5 % (enforced by the gender quota) to 17 % in the physics-chemistry track and from 40 % to 16.5 % in the mathematics one. On the other hand, it should have increased the share of admitted female candidates in

²¹It has to be noted that the share of admitted female candidates is rather volatile; in humanities for instance, the share of admitted female candidates ranges from 30 % to 70 %. This volatility is partly due to the small size of the ENS cohort (75 admitted candidates per year on average in humanities, which is the largest track in ENS Paris).

humanities from 52% to 63.9 %.

However, this is not what happened. In the mathematics track, the share admitted female candidates dropped from 40 % before the merger to 9 % after on average, which is far below their representation in mathematics preparatory programs (16.5% over our studied period). We observe a similar phenomenon in the physics-chemistry track.

Figure 2: Share of Women in Admissions and Preparatory Programs, by Track



Source: Documentation from the ENS and the DEPP archives.

Lecture: The full line represents the share of women among the admitted students to the ENS. The dashed line represents the share of women among preparatory programs students in the given track. After 1986, women remained underrepresented at the ENS (50%) with respect to their share in preparatory programs (64%) in humanities.

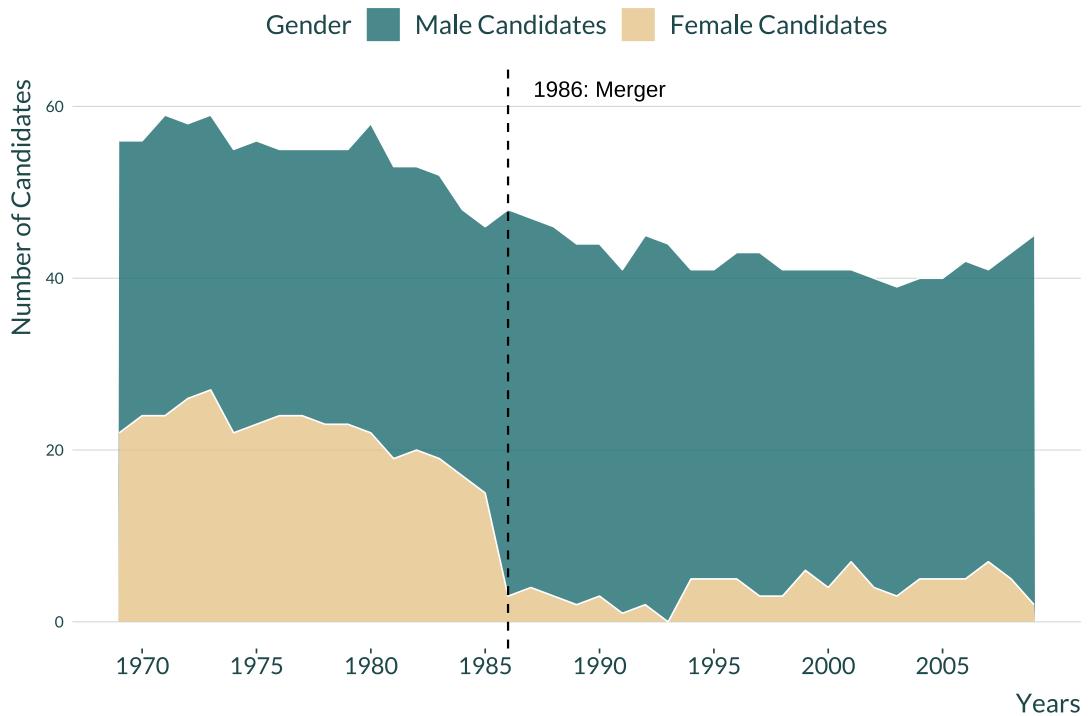
In the biology track, the share of admitted female candidates has not followed in increasing feminization of biology preparatory programs in France. In the humanities tracks, the share of admitted female candidates to ENS Paris remained far below the share of female students in humanities preparatory programs in France over the same period. The apparently *null* effect of the end of the gender quota on the share of admitted female candidates in the biology and the humanities tracks actually hide a negative effect for women, since they ended up under-represented with regard to their representation in the corresponding preparatory programs. Overall, the introduction of the mixed competition

had a negative impact on women across all tracks in the entrance examinations to ENS Paris.

3.2 Focus on the Mathematics Track

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

Figure 3: Candidates Admitted to 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 women and 45 men.

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 year, the sum of the two areas represents the total number of students admitted to the mathematics track.

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. 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 (ranging from 46 to 48 candidates between 1984 and 1988). Before the merger, the number of female and male students followed the same trend; there were, on average, 22 female students admitted to the ENS de Sèvres over the period, and 33 male students. 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 classes (16.5 % on average between 1980 and 1991). The entrance examination of the ENS de Sèvres could thus be considered as a generous quota system towards female students.

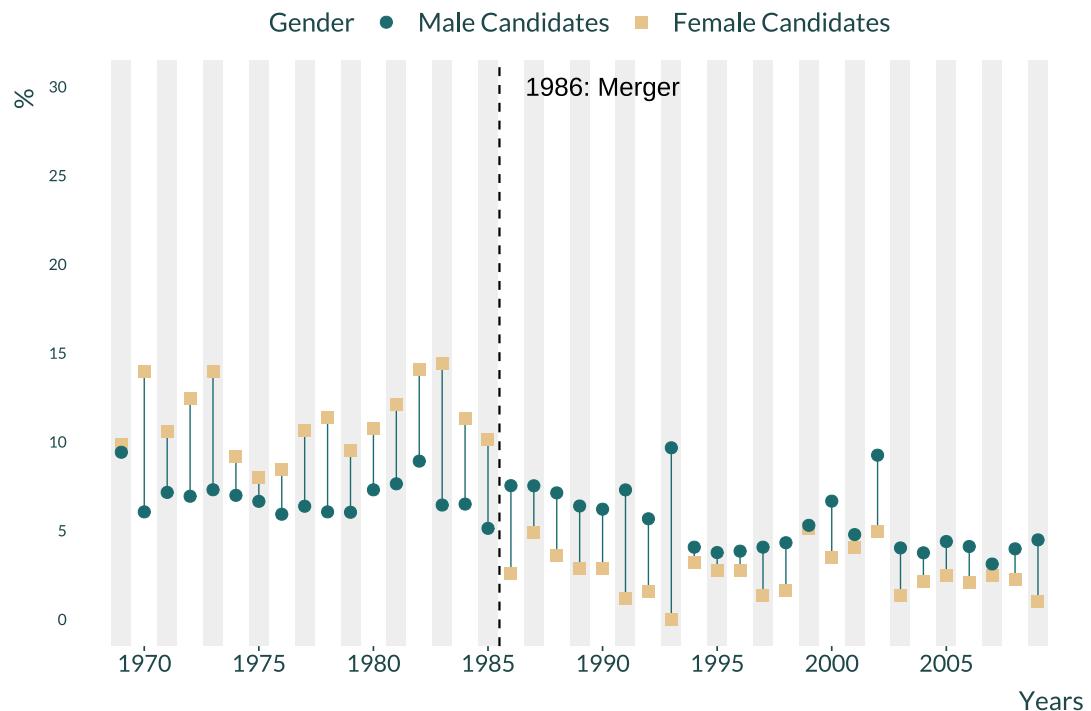
The implementation of the mixed competition led to a dramatic fall in the number of female candidates admitted to the mathematics track. In 1985, there were 15 female candidates admitted to the mathematics track; there were only three the year of the merger in 1986. The number of admitted female candidates then sharply declined, until reaching its lowest point in 1993 (zero). 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).²² This fall is all the more striking since the number of admitted female candidates has 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 provide information on how chances of being admitted have evolved over time for both male and female candidates, before and after the merger. Figure 4 displays the success rate (i.e., the number of admitted candidates on the initial number of candidates) for female and male candidates separately. The first thing to note is that success rates at the ENS tend to decline over time for both male and female candidates. This is due to a decrease in the number of seats offered in the mathematics track (Figure 3) and an increase in the number of candidates throughout the years. The success rates of female candidates began to slightly decrease prior to the merger, which

²²See the [Online Appendix section E](#) for more details about this event and its consequences.

can be explained by a reduction in the number of seats offered at ENS de Sèvres from 20 to 15. However, the number of candidates taking the written exam remained roughly the same, between 131 and 150 candidates. After the introduction of the mixed competition, we observe a sharp decline in the success rate of female candidates, dropping from 10.1 % in 1985 to 2.6 % in 1986. Two main features are worth highlighting. First, before the merger, the success rate of female candidates was substantially higher than that of male candidates, mostly due to a relative larger number of seats offered to female students compared to male students. Second, over the twenty years following the merger, the success rate of female candidates remained consistently lower than that of male candidates. This represents a complete reversal of the admissions pattern: prior to the merger, female candidates were more likely to be admitted to the mathematics track (11.2 % versus 6.9 %), while after the merger, male candidates were twice as likely to succeed as their female counterparts (5.6 % versus 2.7 %).

Figure 4: Success Rates in Admission to the ENS Paris (Ulm & Sèvres) Mathematics Track, by Gender
(1969 - 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.

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.²³ It appears that the odds ratio value, computed year by year, is rarely statistically significant at conventional levels in the case of admission. This can be explained by the fact that female admission to the ENS is a relatively rare event after the merger; there are less than 10 admitted female candidates per year, and the initial pool of candidates is not large to begin with. As a result, this increases the variance of the logarithm of the odds ratio used to compute confidence intervals. However, this issue does not apply to the qualification stage, as there are more female candidates at this stage.

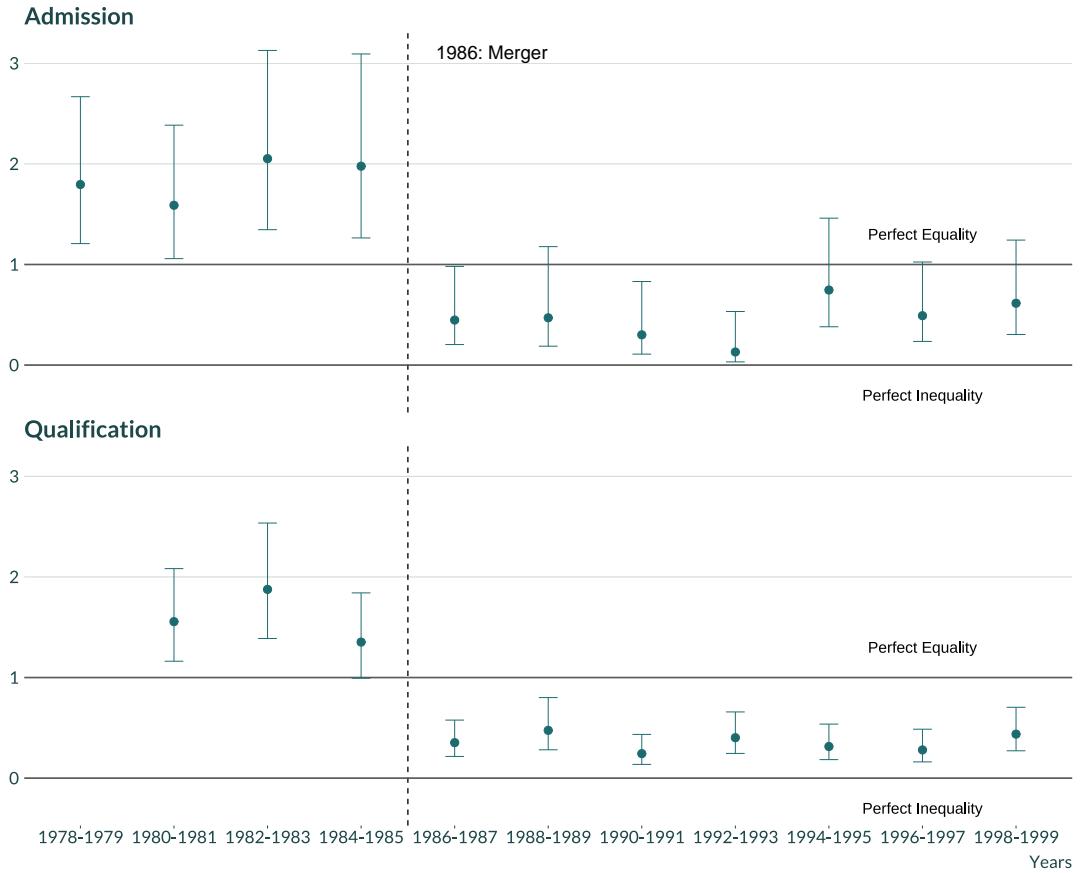
To gain a clearer understanding of the evolution in admission chances, we have grouped the years two by two in the rest of the analysis. Year-by-year results are presented in the [Appendix B](#). The pattern exhibited in the yearly or grouped graphical representation are similar.

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 dashed line denotes the time of the merger. We take the pool of candidates at the written exam for each year

²³Odds ratios are not distributed symmetrically; confidence intervals are not necessarily centered on the sample value.

as the population of reference.

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.

Lecture: 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.

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 in this period 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, 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 interpretable; 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 admitted to the

ENS Paris in mathematics, the odds ratio reaches zero (Figure B3).²⁴

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 of the hard quota system: there were more available seats for female students at ENS de Sèvres compared to the initial number of candidates, whereas there were fewer seats available for male students at ENS d’Ulm. This trend is then entirely reversed after the merger: 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, at this stage, male candidates’ advantage is greater after the merger compared to the advantage female candidates had prior to the merger. On average, male candidates were 3.2 times more likely to be qualified for the oral exam than not be qualified, while female candidates before the merger had only 1.6 times higher chances of qualification. We observe no major changes in relative chances of qualification after 1994 and the implementation of the ENS common written exam.

In addition to this analysis, Figure B4 displays odds ratios computed on the pool of candidates who actually took the exam (no blank copies). The order of magnitude and the pattern are similar, suggesting that our results are not driven by a larger share of female candidates registered at the exam without trying to take it.

We have a clear understanding of how the end of the gender quota has impacted the proportion of women among ENS qualified and admitted students. We now turn to the study of the underlying mechanisms behind this fall.

4 Mechanisms

We documented that the introduction of the mixed competition led to a dramatic decrease in the share of women admitted to the ENS Paris in the physics-chemistry and mathematics tracks. This could be due to several factors. Women might perform worse

²⁴In this peculiar case, the variance of the logarithm of the odds ratio is not defined. See [Online Appendix Section C](#) for more details.

than men on average, which would result in fewer admissions once the quota system is removed. 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) an endogenous response from female candidates who would *turn away* from the heightened and mixed-gender competition.

4.1 Gender Gap in Performance

It has been shown in several context that, on average, women underperform 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 underperform 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 in admitted candidates. The quota was 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 exam 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.

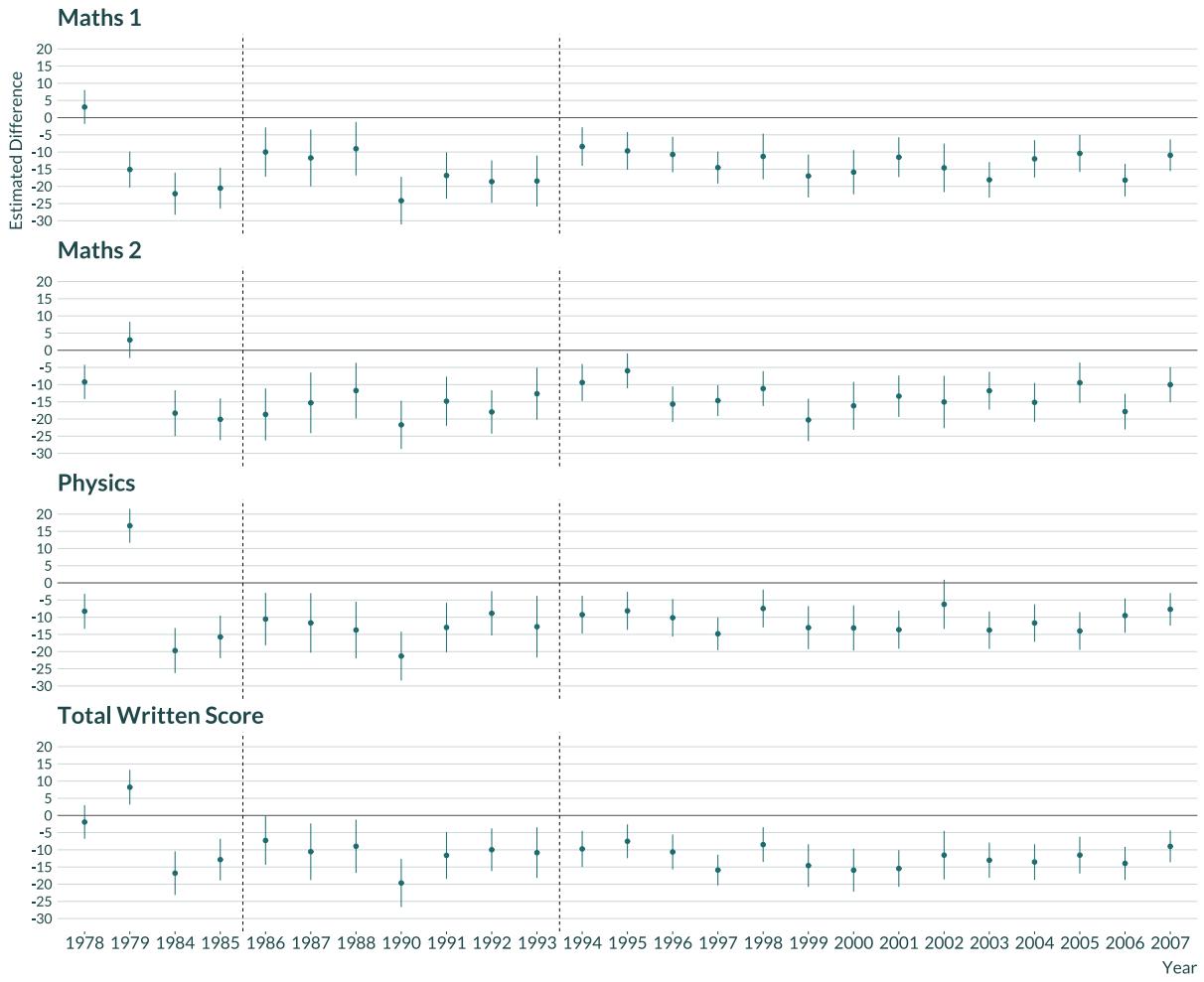
Subject and Evaluation We focus on the set of subjects that were passed every year by candidates at the written exam and at the oral exam. For the written exam, this includes two subjects in mathematics, denoted as Maths 1 and Maths 2, and one subject in physics. The first mathematics exam (Maths 1) 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 a smaller weight (4). We only consider two subjects at the oral examination: mathematics and physics. The total written and oral scores represent the weighted average obtained at the written and oral examinations, including other subjects which are year specific (e.g. French, foreign languages, or computer sciences).

Before the merger of the two schools, 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 Appendix Section D](#)). A common jury was established in 1985 to evaluate female and male candidates together, both at 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 the ENS d’Ulm was assigned to the 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 at the written exam, and its implications for our results.

Differences at 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 displays the 95 % confidence intervals. The figure basically shows the evolution of the difference in the average percentile rank between female candidates and male candidates 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

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.

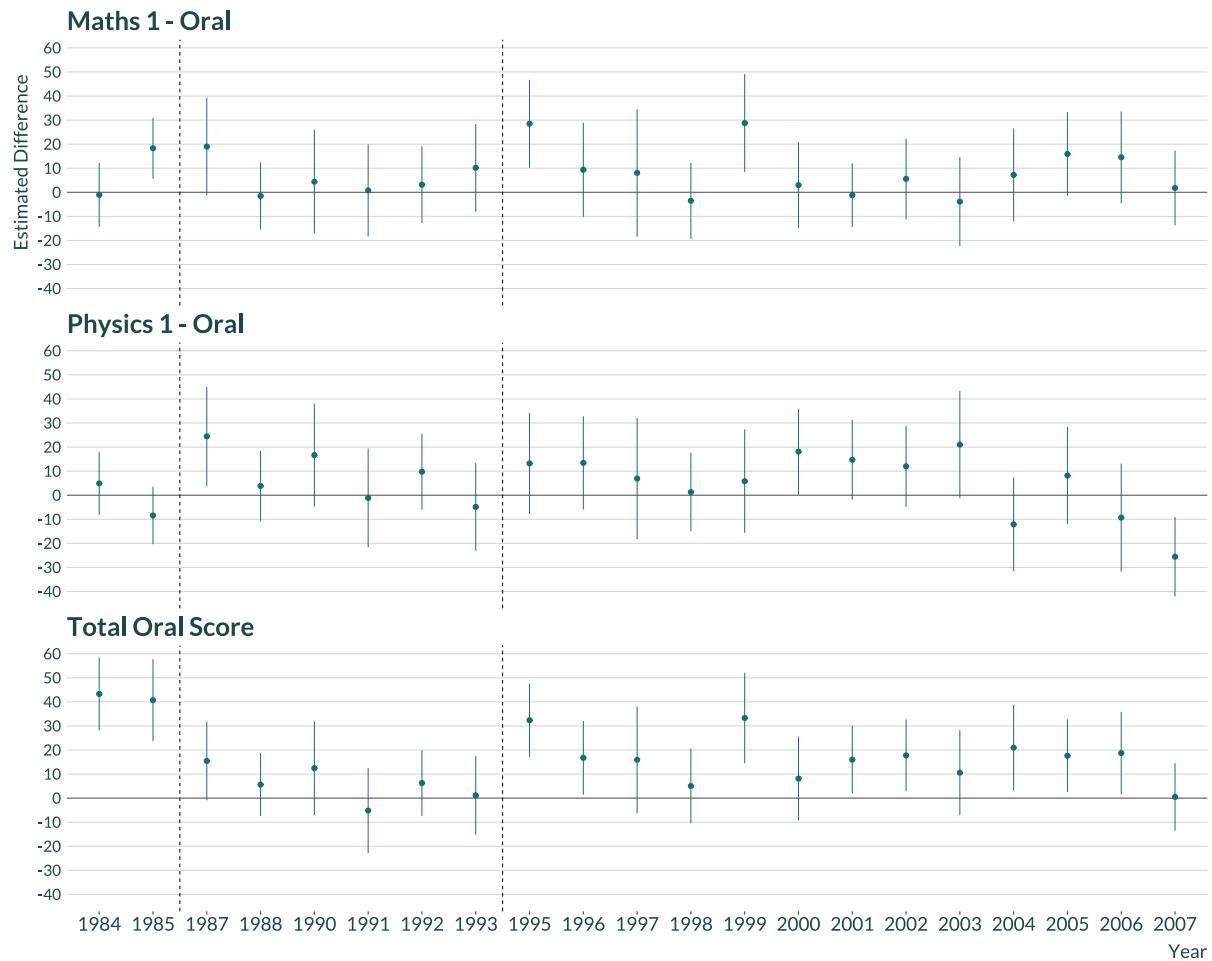
Lecture: In 1985, the average percentile rank of female candidates at the total written score was 39, whereas it was 52 for male candidates. The difference between the two is -13, which is reported in the graph.

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 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 merger. The gender gap in performance is even at its smallest in 1986, the year of the merger.

We were not able to retrieve individual data for the ENS d’Ulm between 1980 and 1983. However, we retrieved information on female candidates’ performances on the

entrance examination for the 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 does reveal a discontinuity in the trend around 1984, where the average grade for both the entire exam and Math 1 declined.²⁵ 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.

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.

²⁵For 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

Differences at the Oral Exam Differences between male and female candidates are not as strongly pronounced at the oral examination. Figure 7 displays the differences in performance for qualified candidates, controlling for their initial performance at the written exam. Figure C1 displays the raw difference in performance at the written exam, without controlling for their initial performance at the written exam, and the results are fairly similar.²⁶ 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 slight outperform men. Once again, we do no observe a clear discontinuity in the gender gap in performances around the time of the merger.

Controlling for Previous Academic Performance We have documented a gender gap in performance on the written exam for ENS Paris, which remained fairly constant over our studied period. However, without further information, we cannot determine whether this gender gap in performance came from an underlying gender gap in academic abilities or whether women underperformed on the day of the exam, as has been shown to occur in the experimental literature and in high-stakes contexts. ([Azmat et al., 2016](#); [Montalbán and Sevilla, 2023](#)).

We take advantage of students' grade reports from the top mathematics preparatory program to study potential gender difference in performance on the ENS entrance exam, to control for students' academic performance just before the exam. Although our analyses conducted on only a subsample of candidates, they can still inform us about a potential gender gap in academic ability prior to the entrance exam that could explain the gap observed in exam performance, as well as whether a gender gap appeared or increased once the mixed-competition was introduced.

Table 2 displays our results. Column (1) show a naive double difference on the performance at 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 at the end of their mathematics preparatory

²⁶As we do not retrieve complete archives for the oral examination in 1986 and 1994, these data points are missing from the figures.

program, we observe significant gender gap in performance on the ENS written exam, and this gap actually reduces after the end of the gender quota. However, columns (2) and (3) show that once we control for students' academic achievement just prior the ENS entrance exam, there is no significant gender gap, neither before nor after the end of the gender quota.

Table 2: Performance of Candidates from Louis le Grand Preparatory Program at the ENS Entrance Exam (1978-1988)

	Percentile Rank at the Written Exam		
Female	-.216*** (.046)	-.053 (.041)	-.059 (.041)
After the End of Gender Quota	-.063*** (.024)	-.050** (.021)	-.048** (.021)
Female \times After	.135* (.079)	.004 (.069)	.015 (.069)
Star Class		✓	✓
Quintile of Math GPA		✓	✓
Star Class \times Quintile Math GPA			✓
N	654	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

In the second year of mathematics preparatory program, students are placed either in star or standard class, depending on their achievement at the end of their first year. Star classes concentrate the best students. Therefore, one can consider that students in a star class has higher academic ability than a student in a standard class.

Lecture: On average, once we control for students' quintile 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.

Therefore, the hypothesis that the introduction of mixed-gender competition at the ENS entrance exam exacerbated the gender performance gap is invalidated by our data from the top preparatory programs. The gender gap in performance on the written exam for ENS Paris is fully explained by a gender gap in academic achievement by the end of preparatory program. A word of cautious: this result might only apply to this subsample of students, since they are very particular. They are among the highest-achieving students

in mathematics from their birth cohort.²⁷

Test Scores Transformation As previously mentioned, the distribution of scores is quite different for years 1978-1979 and years 1984-1985. Since the distribution of scores for men is almost stationary over these years, we mean-shift the distribution of scores at the written exams for female candidates in 1978, 1979, and 1984 to match mean difference between 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 did not observe any discontinuity in scores around the time of the merger, it remains unclear whether the sharp fall in the number of female candidates admitted to the mathematics 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, they would have been ranked together. Figure B8 in appendix presents a visualisation of the intuition behind this exercise. Table 3 presents the results of our simulation. For each year prior to the merger 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 or their transformed score, matching the score distribution of the one of 1985. 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 merger was solely due to the gender gap in performance, we would

²⁷Bonneau and Dousset (2024) study all contemporaneous STEM preparatory programs in France and do find a gender gap in performance for competitive entrance exams, even after controlling for academic achievement just before the exams.

expect the simulated share of admitted candidates prior to the merger to be equivalent to the one observed after the merger (between 6 to 9 %).

Table 3: 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	<i>with gender quota</i>			
	42%	42%	35%	33%
Simulated Share	<i>without gender quota</i>			
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 was 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 would have ranked male and female together based on their total final score, this share would have reached 20 %. There are substantial difference 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. 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 point if we only took into account the gender performance gap. We

can extrapolate that $\frac{13}{27} = 48\%$ of the fall can be explained by the average difference in performance between male and female candidates at the exam. Table B1 in 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 draw to the similar conclusion.

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 female students among admitted candidates following the implementation of the mixed competition.

4.2 Endogenous Response: Female Students Turning Away from the Heightened 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 distribution of the candidate pools at earlier stages of the admission process. Figure 8 displays the share of female students among mathematics preparatory classes, candidates at the written exam, qualified candidates and admitted candidates, from 1978 to 2000. The introduction of the mixed competition led to a similar substantial fall in the share of female students among the qualified candidates, from 32 % on average before the merger to 6 % after. After 1993, the share of admitted female candidates becomes larger than the share of female students among qualified candidates. This can be identified as a catch-up effect of female candidates at the oral examination. This jump coincides with institutional changes in the entrance examination (notably common examination for all ENS, and changes in weighting of the oral examination, see Section 1.)

Figure 8: Percentage of Female Candidates in Admission, Qualification, Candidacy and Preparatory Classes, 1978 - 2000



Source: Documentation sourced from the ENS archives.

Lecture: First panel: In 1986, there were 6.2 % of female students admitted to the ENS in the mathematics track; the share of female candidates among the qualified candidates (passed the written exam) was 7.8 %. Second panel: In 1986, the share of female students among the candidates at the written exam was 16.3 % and the share of female students in mathematics preparatory classes was 15.1 %.

We also observe that the proportion of female candidates taking the written examination gradually decreased around the time of the merger of the two schools, and reached its lowest point in 1989. This means that the share of female candidates for the mathematics track used to be higher than the share of female students in preparatory classes, indicating that the ENS de Sèvres was a particularly attractive school for female students. The proportion of female candidates then stabilized at roughly 15 % on average during the post-merger period, matching the level of the share of female students in mathematics preparatory classes in 1986 (16 %). However, due to yearly variations and the small

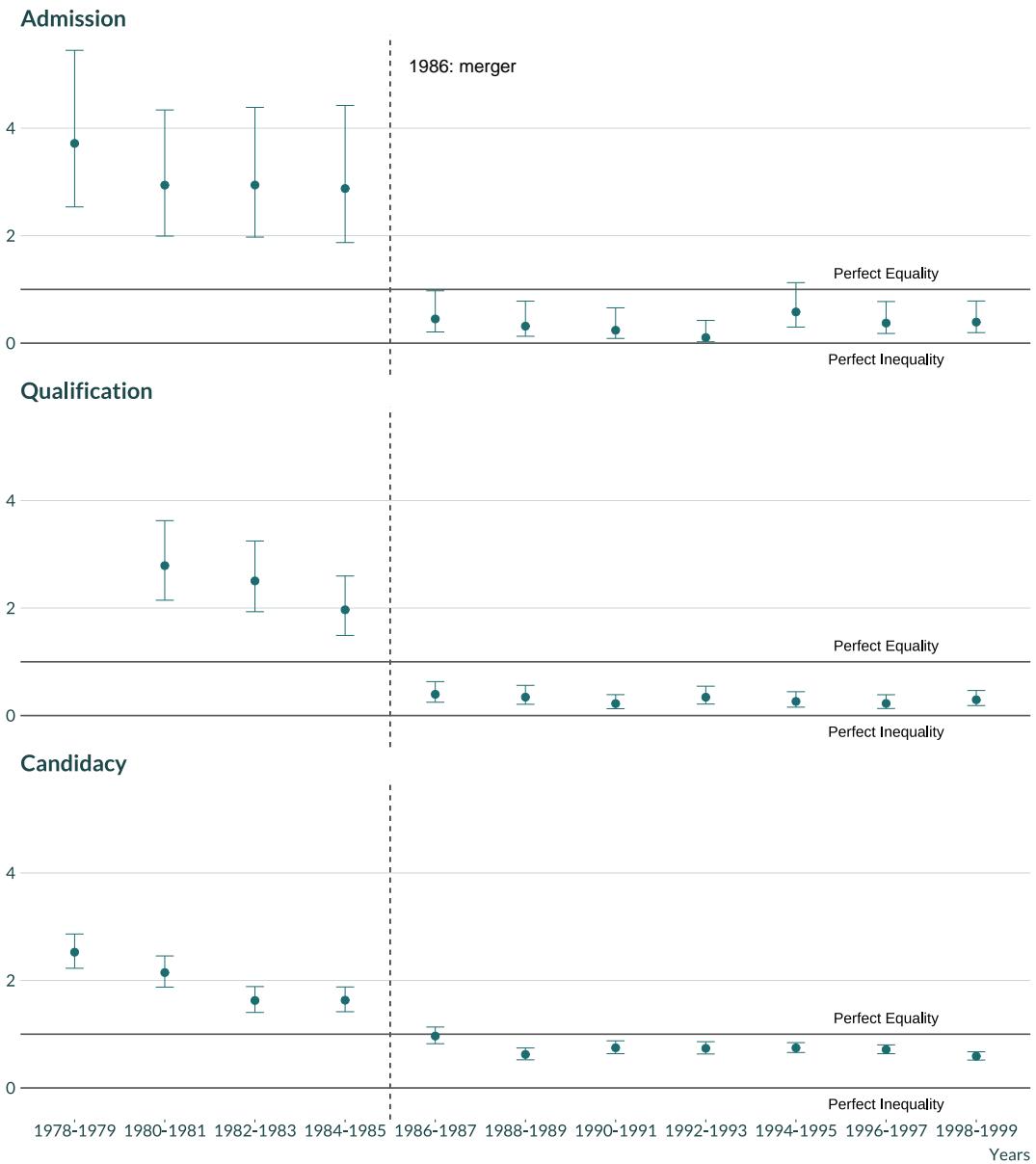
number of observations, the timing of this decline is hard to interpret.²⁸ Finally, although the shares of female candidates and female students in preparatory classes followed a similar pattern of slight increase since the 1990s, the proportion of female candidates never again reached the level of female students in mathematics preparatory classes after the merger. This result can be considered as the first indication that women tended to avoid the mixed competition after the merger.

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

We observe a discontinuity regarding candidacy at the time of the merger, although 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 classes, which remains stable over that period (Figure 8). These findings also confirm our previous results about admission and qualification, which were computed on the pool of candidates at the written exam.

²⁸For instance, the proportion of female students among admitted candidates are equal in 1983 and 1985.

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 classes.

Lecture: In 1984-1985, a female student in preparatory classes was 1.6 more likely than a male student to be candidate to the written exam rather than not to be.

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. Therefore, the preparatory program attended is highly predictive of students' chances of success on competitive entrance exams.

Preparatory Program Typology We divide preparatory programs into three groups according to the number of female candidates which were admitted to the ENS de Sèvres before the merger. Top high schools gather high schools with more than 5 students admitted to the ENS de Sèvres from 1978 to 1985. Top Parisian ones are mainly composed of Louis le Grand and Saint-Louis, which account for roughly 50 % of admissions before the merger, and other high schools from the Paris region.²⁹ Top high schools outside of Paris are mainly located in large urban centers and account for 26 % of admission at the ENS de Sèvres.³⁰ The remaining high schools (both located in and outside the Paris region) are grouped together.

Evolution of the Composition of Candidates Figure 10 displays the proportion of female candidates who took the written exam (i.e., at least one exam completed) by type of preparatory class and two-year intervals from 1978 to 1999. Prior to the merger of the two schools, the composition of the candidate pool remained stable with the majority of candidates coming from top Parisian high schools, comprising between 41 to 53 % of the pool depending on the time period. However, after the merger, there was a noticeable shift in the candidates' composition with a decline in the share of candidates from top Parisian high schools and an increase in candidates from high schools outside of Paris. This change was not solely due to an increase in the number of candidates from high schools outside of Paris, but also to a significant decrease in the number of candidates from top Parisian high schools, despite the total number of students at these schools remaining relatively stable over the same period.

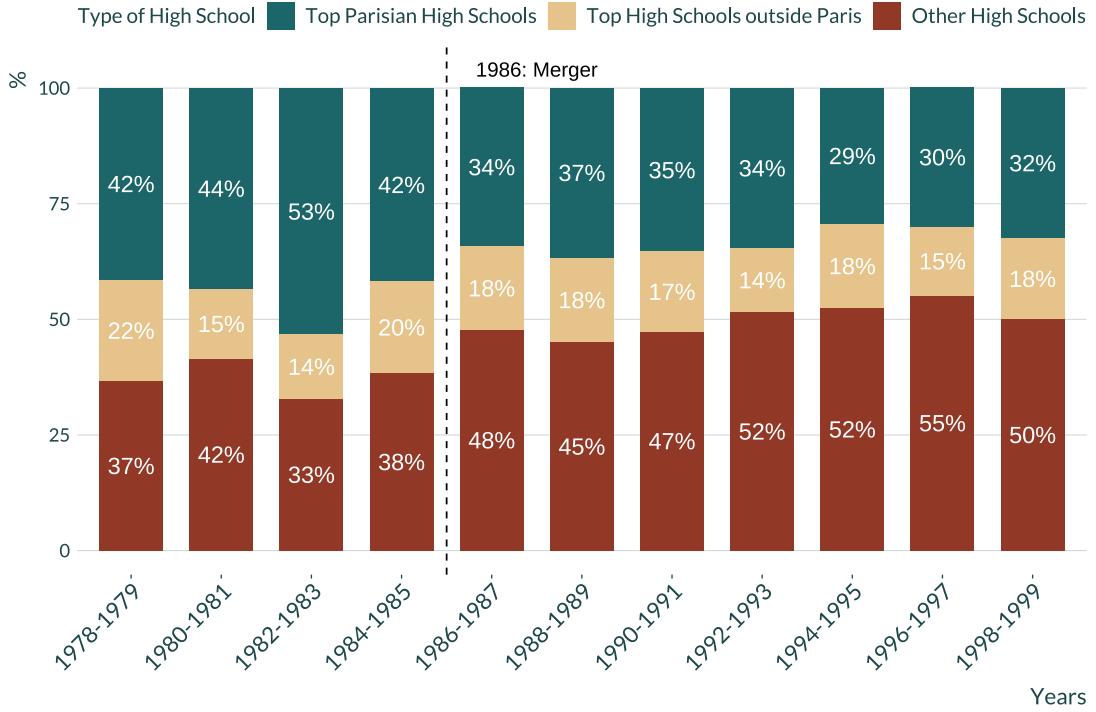
Notably, we did not observe the same trend among male candidates around the time of the merger (see Figure B9).

Although several explanations could be put forward to explain this phenomenon,

²⁹Top Parisian high schools include Louis le Grand, Saint-Louis, Hoche, Condorcet, Fénelon, Janson de Sailly, Sainte Geneviève, and Henri IV

³⁰This group includes Thiers (Marseille), lycée du Parc (Lyon), Pierre de Fermat (Toulouse), Montaigne (Bordeaux), and Clemenceau (Nantes).

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



Source: Documentation sourced from the ENS archives.

Lecture: In 1984-1985, 42 % of female candidates at the written exam came from top Parisian high school, 20 % from top high schools outside Paris and 38 % from other high schools.

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-ability 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 internalisation 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 top Parisian high schools.

What do these female students do instead? They took other elite STEM graduate schools entrance exams and got in. We do not observe a total shift of these missing female candidates and missing admitted students to the ENS to only one other school, but rather that they spread out among different ones, as shown in Figure B12. In particular,

we do not observe a sharp increase in the share of female students admitted to the *Ecole Polytechnique*, which is the main competitor of the ENS Paris.

4.3 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](#)).

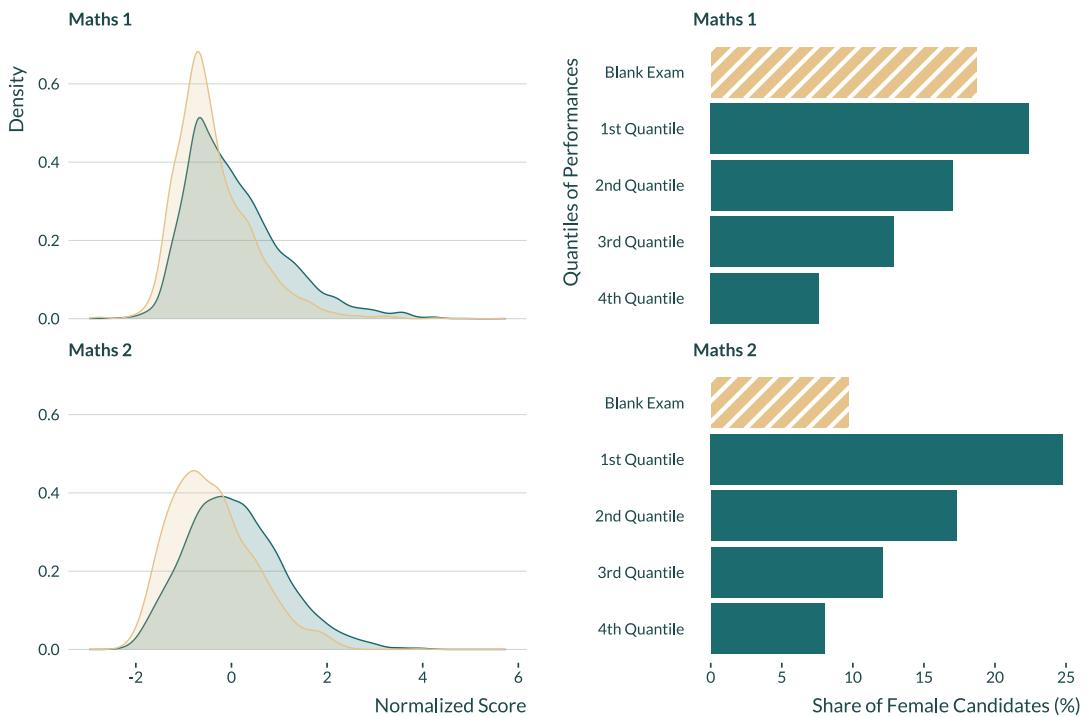
Combined with the weighting scheme applied to each subject, these factors could potentially affect the gender composition of qualified and admitted students. To explore this question, we simulate different weighting schemes and focus on one main aspect: the weights assigned to each mathematics subject (Maths 1 and Maths 2). An analysis of introducing a common written examination for all ENS in 1994 can be found in [Online Appendix Section E](#).

The Two Mathematics Subjects For the mathematics entrance examination to ENS Paris, there are two mathematics exams, called Maths 1 and Maths 2, respectively. Maths 1 is considered to be one of the most challenging examinations in mathematics across all elite graduate schools entrance exams. It lasts 6 hours, which is an unusual format for this type of examination. Indeed, most mathematics written exam for entrance to STEM elite graduate school last 4 hours; students in preparatory programs are thus less trained for this exam. On the other hand, the Maths 2 subject is a more classical mathematics examination: it lasts 4 hours, and is closer in its difficulty and format to other examinations for entry into STEM elite graduate schools. We cannot argue that this specific subject in mathematics is irrelevant to select potential good researchers, which is one the core missions of ENS Paris. However, we find almost no correlation between Math 1 test score and the probability to pursue an academic career in a French public university.

Figure 11 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 of female candidates by quartile of performance (including the share of female candidates who hand in a blank exam), for years 1986-2000. The first quartile represents the worst performers, while the fourth quartile represents the top performers.

Figure 11: 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.

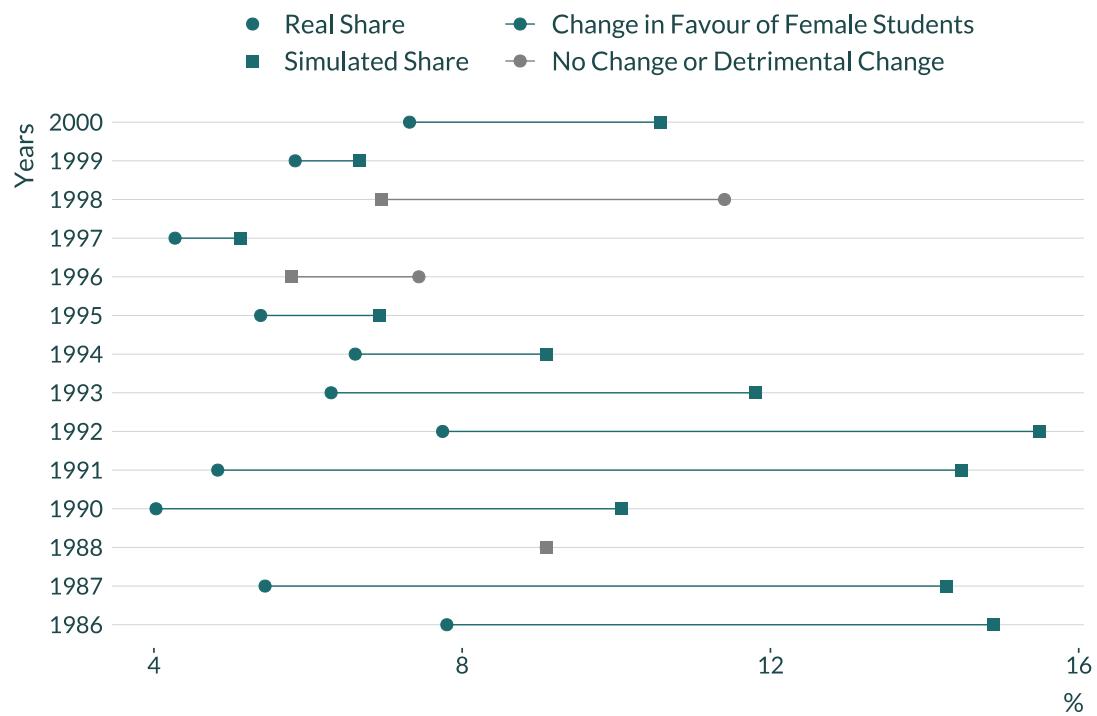
Lecture: In Maths 1, female students represent 19% of handed blank copies, while they represent only 10% of them in the Maths 2 written exam.

First, it does not seem that the two mathematics exams assess the same skills, as the distribution 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 quartile of performances, including at the highest level of performance (4th quartile). 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 prevent these candidates to get

qualified. It seems that women get discouraged at a higher rate than male candidates by this specific exam. It has also been shown in other contexts that female students' written average tend to be dragged down by specific subjects, where male students clearly outperform them.³¹

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



Source: Documentation sourced from the ENS archives.

Lecture: 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 12 displays the real share (circle) and simulated share (square) of female candidates at the qualification stage. Years for which the simulated share of female

³¹For instance, in the case of competitive exams to administrative civil servant school, Meurs and Puhani (2019) show that women are disadvantaged by the “essay on general knowledge” at the written exam, though they are outperforming men on both “on the job” anonymous written and non-anonymous oral evaluations.

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 at 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.

Hence, the format of the entrance exam to ENS Paris can have important consequences on the gender balance of admitted candidates. Improving the representation of female students at ENS Paris requires questioning the organization of its admission process and considering whether gender quotas could mitigate unintended consequences. The next section investigates the long-run consequences of ending the hard gender-based quota at the 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, so implementing 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 the merger. We identify this group by simulating counterfactual lists of admitted candidates. Figure B8 present a visual representation of our simulations. This section is still preliminary, as we are currently collecting more information.

Identifying Candidates Affected by the Merger We identify two groups of candidates affected by the implementation, and then the abrogation, of quota system:

Before the merger: For the years for which we have information on both scores at the written and the oral exams, we rank male and female candidates together³²

³²When score at the oral exam are not available, students are ranked based on their score at the written exam.

to simulate the pool of accepted candidates in the absence of the gender quota. 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 capacity fixed for a given year. We identify our group of male compliers as the male candidates who were not accepted because of the gender quota but who would have been accepted without the gender quota. Reversely, we identify our group of female compliers as the female candidates who were accepted thanks to the gender quota but who would not have been accepted without the gender quota. We use the years 1978, 1979, 1984 and 1985, because we only have the test scores of all students for these pre-merger years.

After the merger: 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 accepted with or without the quota. We identify our group of male compliers as the male candidates who were accepted without gender quota but who would not have been accepted with the gender quota. Reversely, we identify our group of female compliers as the female candidates who were not accepted because of the abrogation of the gender quota but who would have been accepted with the gender quota. We use the years 1986, 1987, 1988 and 1990, because we have the test scores of all students for these first four post-merger years.

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 the 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.

Challenges in the Identification We showed in section 4 that the abrogation of the gender quota lead to a change in the composition of female candidates to the mathematics entrance examination. This implies that the always-takers could also be considered as being affected by the abrogation of the gender quota system. Indeed, we may believe that these individuals might not have been admitted before the merger, the pool of candidates being different. After the merger, they are also likely to have been treated differently once they got into the ENS Paris. For instance, we can assume that the very few post-merger admitted female candidates could have been more followed-up by the ENS Paris department. For these reasons, we cannot consider that female and male always-takers are comparable over time. As a consequence, we cannot study the difference in outcomes between the always-takers and the compliers. However, we can study the gender difference in labor outcomes for both always-takers and compliers candidates, taken together. This group represents the broad sample of students who are “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 actually enrolling in the ENS Paris. Candidates in our group of interest have a positive probability of actually entering the ENS while candidates whose rank is below the last candidate on the waiting list have zero chances of entering the school (see Figures B13 and B14 in appendix).

Outcomes of Interest We construct four outcomes to qualify candidates’ labour 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, or Economics.

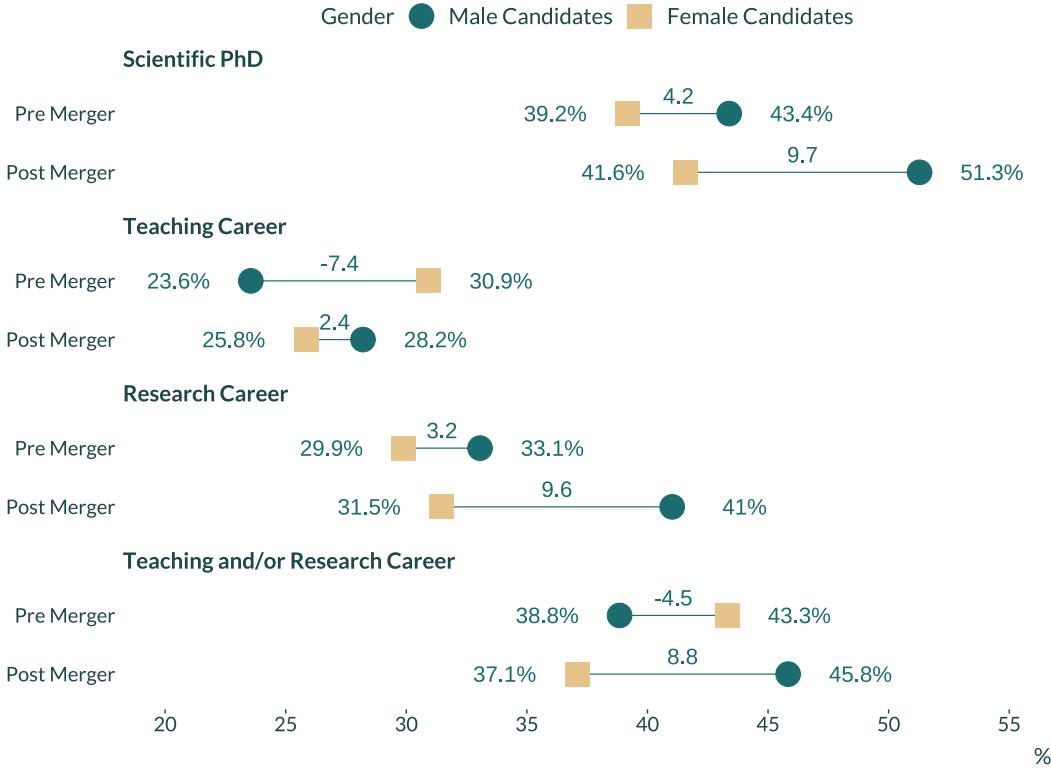
We define having a teaching career as a dummy variable equal to one if the candidate obtained a position as a teacher in a high school, a preparatory class or as an assistant and/or full professor at a university. We define having a research career as a dummy variable equal to one if the candidate holds or held a position as an assistant and/or full

professor at a university, as a researcher in a public institute³³, 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.

Results Our results suggest that the abrogation of the gender quota have increased the gender gap in teaching and research careers. Figure 13 presents the gender gap (male - female) for our four outcomes of interest. Before the merger, 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 merger, the share of candidates who obtained scientific PhDs 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 abrogation of the quota system, from 3.2 to 9.2 percentage points.

³³This includes the CNRS, the CEA, and the INRIA, which are French public research institutions

Figure 13: 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.

Lecture: 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.

The findings related to teaching are particularly noteworthy. Prior to the merger, 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 the merger, 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' enrolment 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 2001, it provided more than 30% of the French public universities professors in ancient languages, mathematics, philosophy, literature, archaeology, astronomy and astrophysics.

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 pre-merger counterfactual simulation show that gender performance gap only explains half of the fall in the number of admitted women. The remaining half is explained by an absolute decrease in the number and the share of female candidates, mostly coming from the top preparatory programs in Paris. This illustrates that women tend to opt-out from mixed competition, especially in performing stereotypically male associated task. 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 Parisian students 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 a special training, and skills that are not directly transferable to the preparation of other competitive exams for elite graduate schools. Hence, women studying in top Parisian 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 maths 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 - suggest 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.

We present some new empirical evidence on the unintended consequences of gender quotas, which suggest that they can reduce gender inequality in access to competitive institutions without incurring high efficiency costs. A hard gender-based system can create a reassuring environment for all women to apply, which allows some high-achieving candidates to get in, who might have not applied in the absence of this gender quota, but did not need it to get in. Recent evidence on the entrance examination to the most prestigious civil servant school in France (*l'École Nationale d'Administration*, ENA) show that women with lower socio-economic status tend to spread themselves between too many competitive exams, reducing their chances in entering the school in the end (Parodi et al., 2022). This is in line with the literature on gender difference in risk-aversion. This points towards an absolute loss of talented female candidates at ENS Paris.

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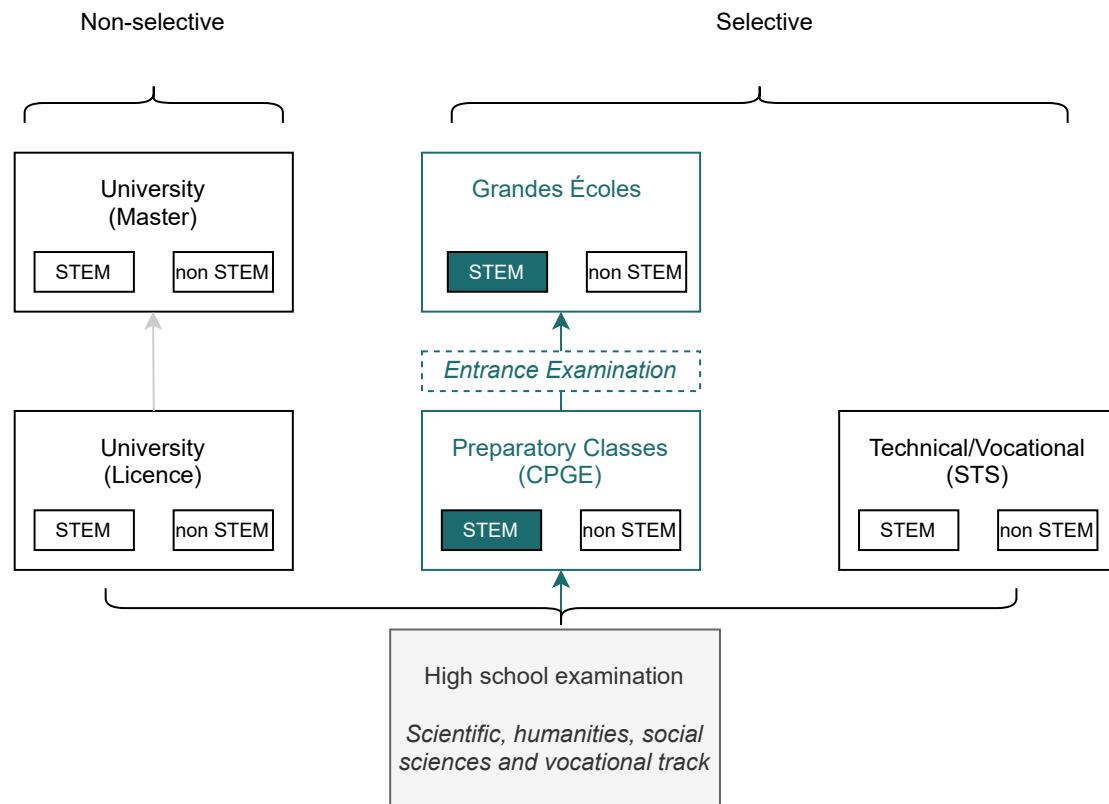
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Appendix

A Institutional Background

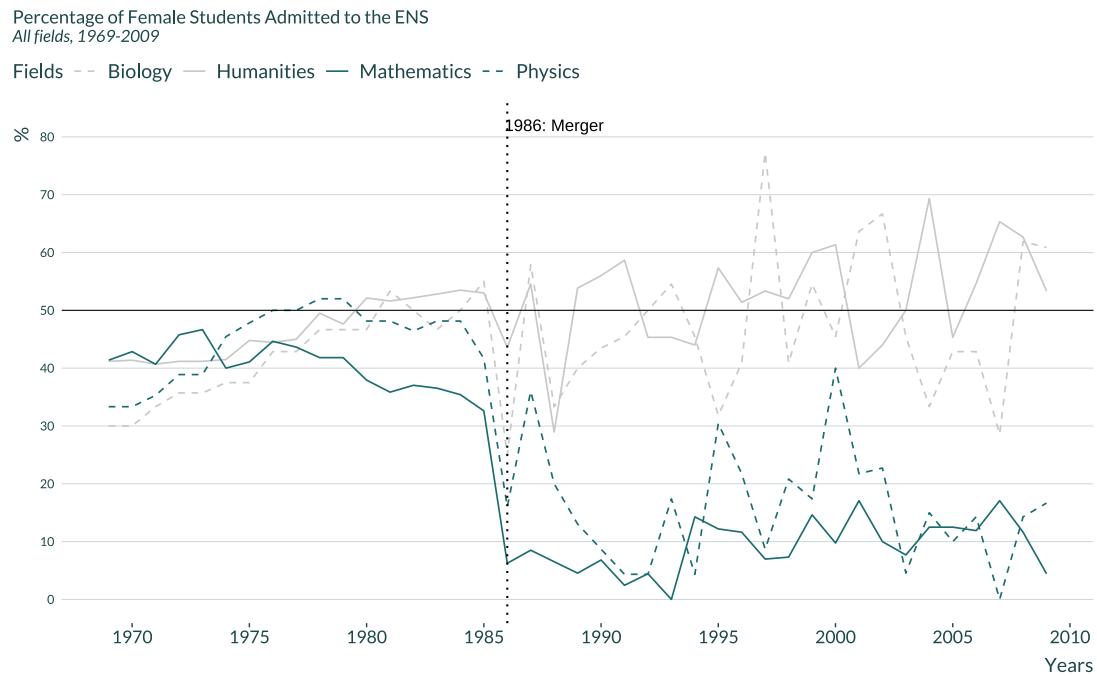
Figure A1: Tracks in Secondary and Post-Secondary Education in France



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

B Additional Figures and Tables

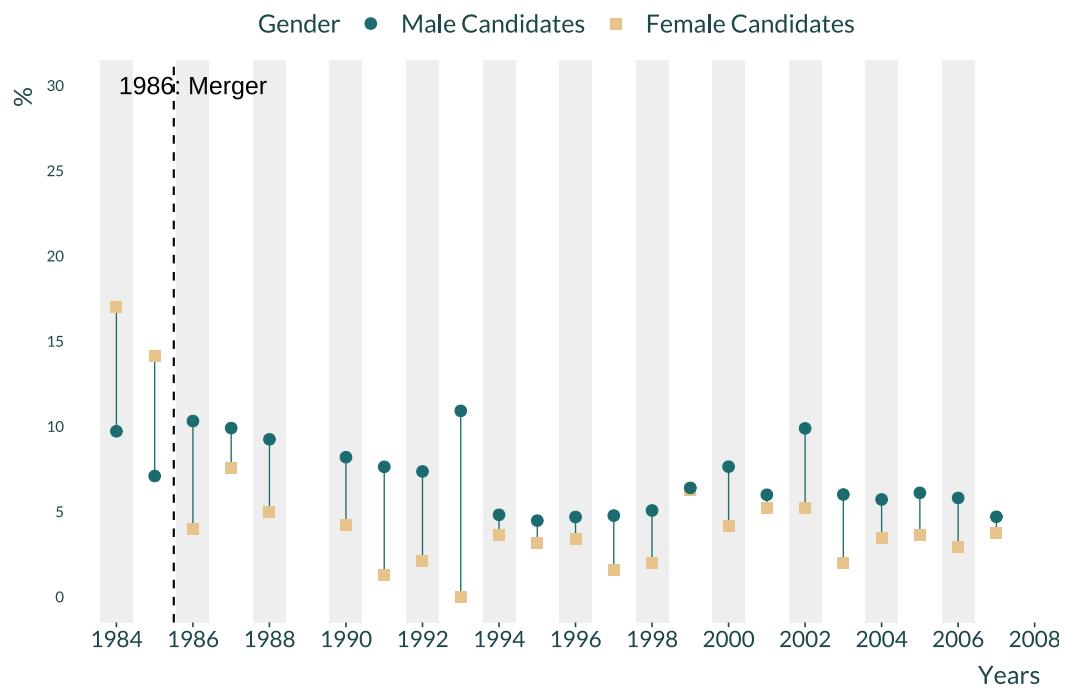
Figure B1: Percentage of Female Students Admitted to the ENS Paris (Ulm & Sèvres)
All fields, 1969 - 2009



Source: Documentation from the ENS archives.

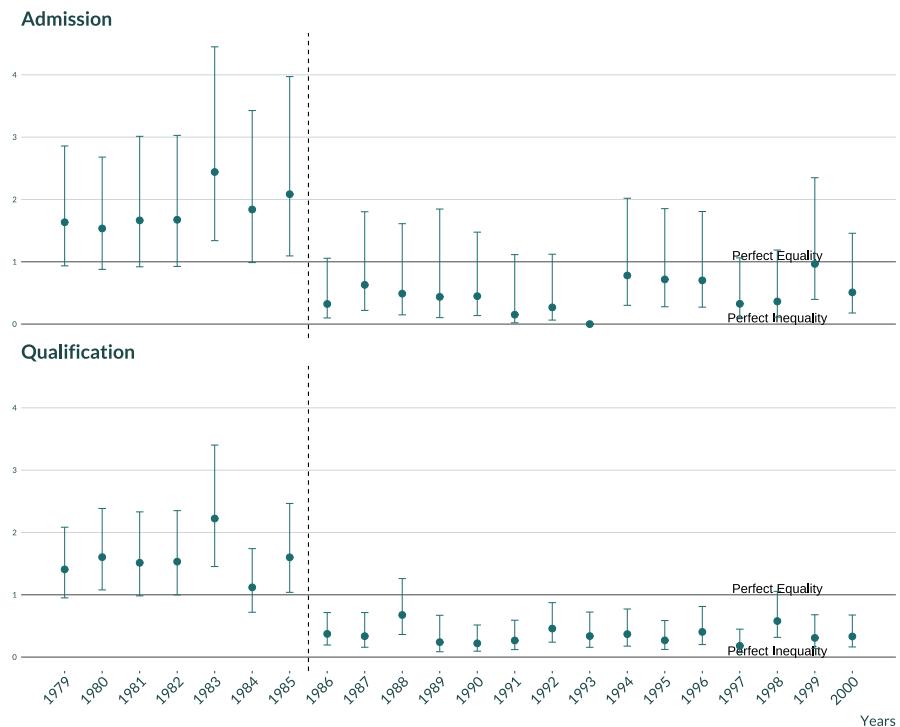
Lecture: In 1987, there were 8,7 % of female students admitted to the ENS in the mathematics track; 36,0 % in the physics track; 54,5 % in the humanities track; and 57,9 % in the biology track.

Figure B2: Success Rates in Admission to the ENS Mathematics Track, by Gender, Pool of Candidates which Took the exam, 1984 - 2007



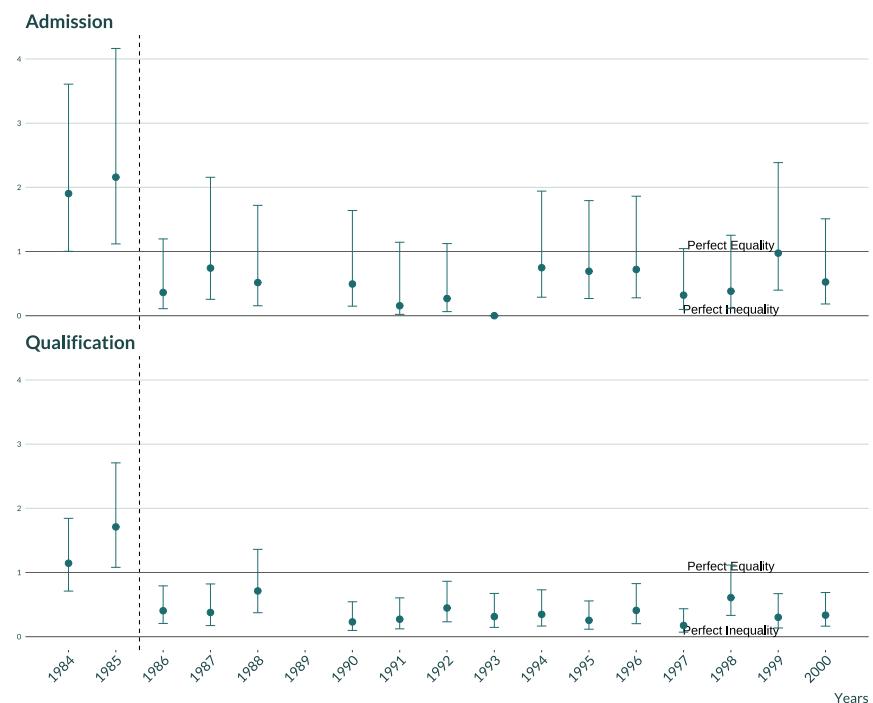
Source: Documentation sourced from the ENS archives.

Figure B3: Odds Ratios, Admission and Qualification, 1978 - 2000



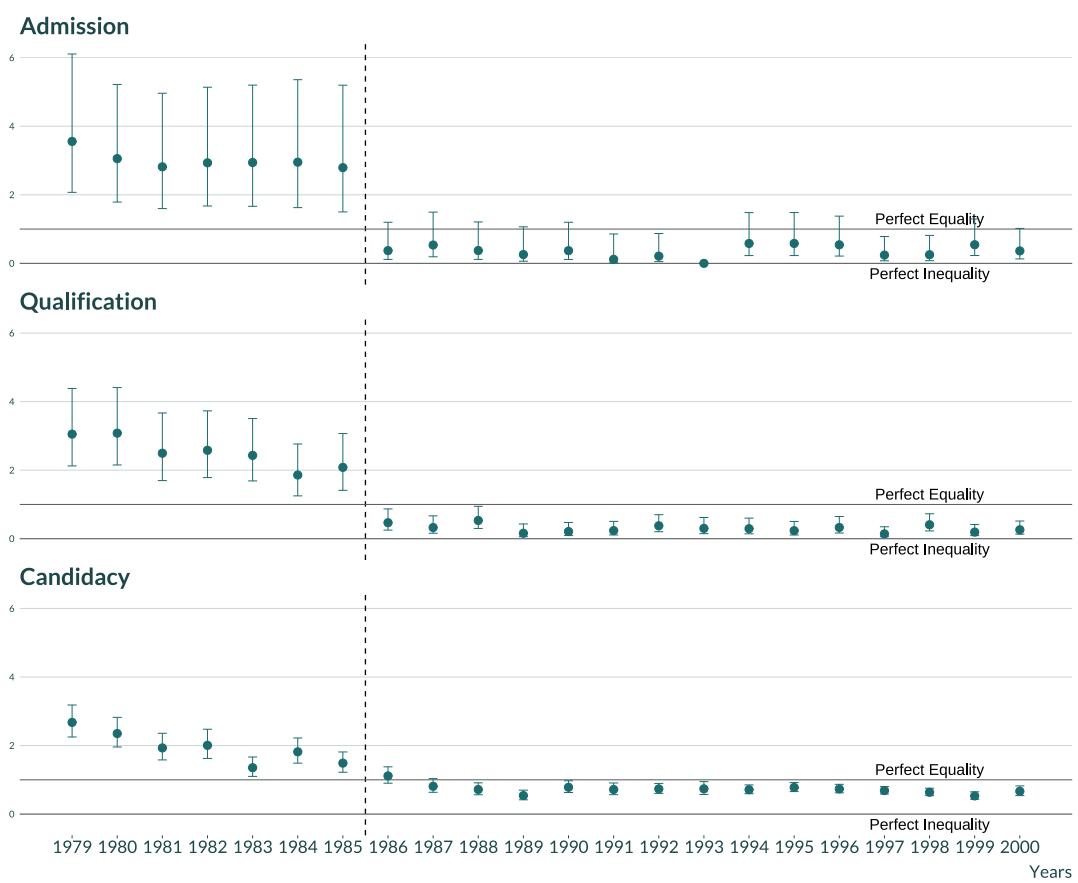
Source: Documentation sourced from the ENS archives.

Figure B4: Odds Ratios, Admission and Qualification, 1978 - 2000, Pool of Candidates which Took the Exam



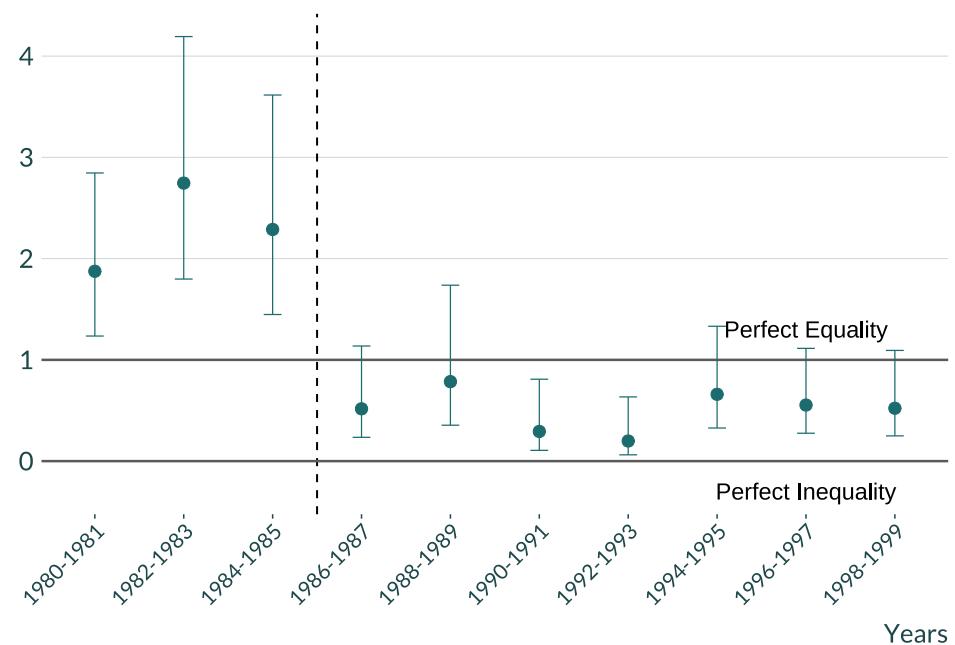
Source: Documentation sourced from the ENS archives.

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



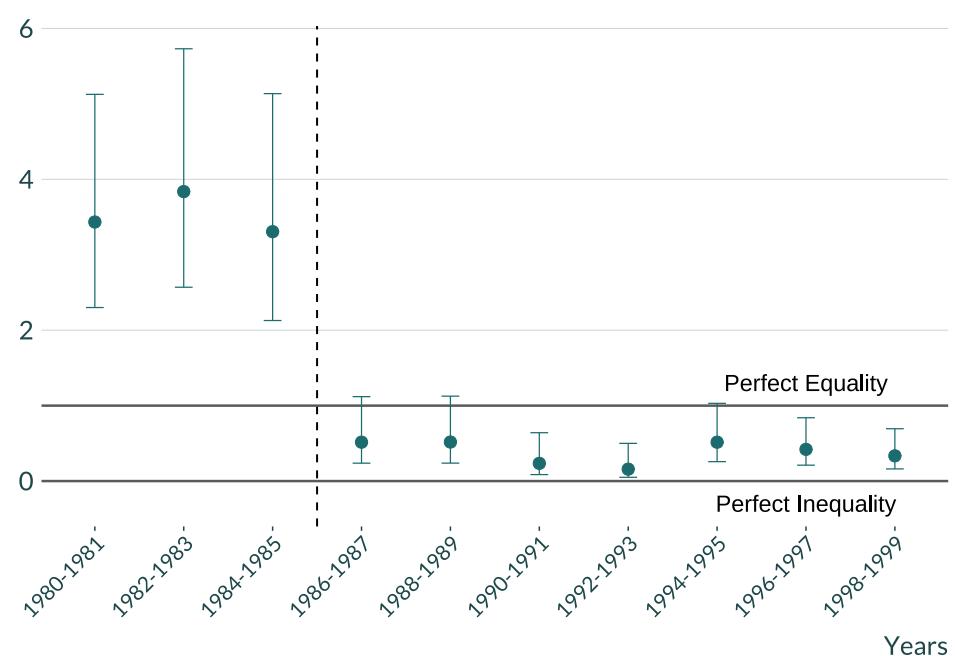
Source: Documentation sourced from the ENS archives.

Figure B6: 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 B7: 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 B8: Simulation of Counterfactuals

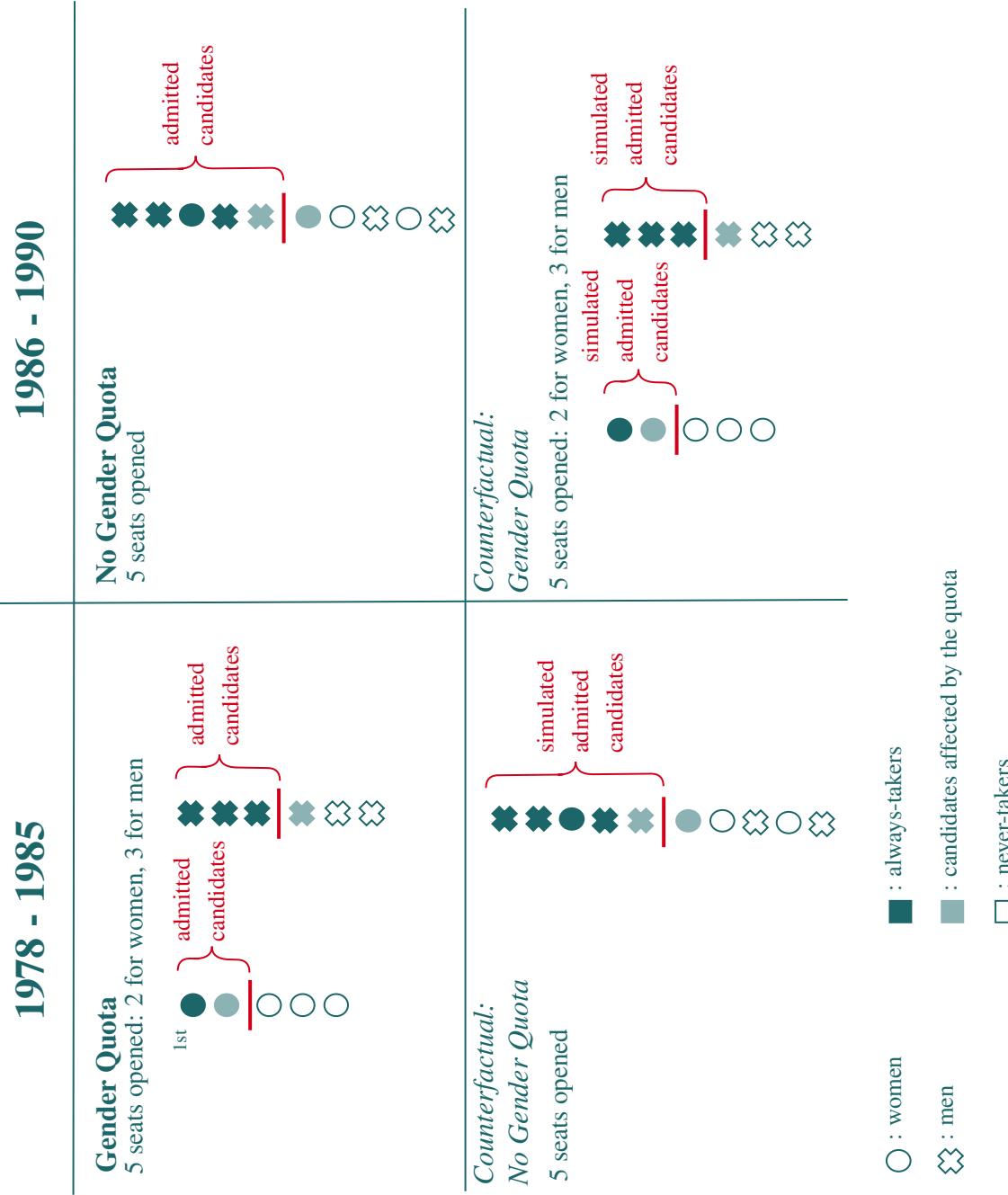
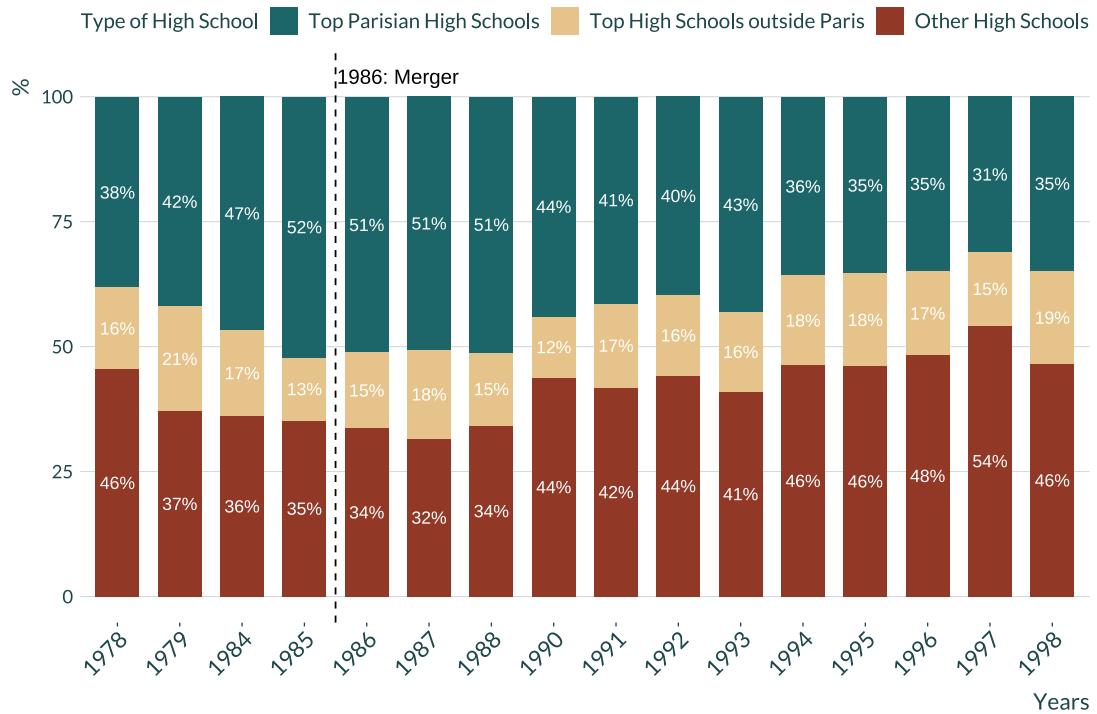


Table B1: Share of Female Among Admitted and Waiting-List Candidates

	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		<i>with gender quota</i>		
	36%	36%	27%	27%
Simulated Share		<i>without gender quota</i>		
Raw Scores	33%	38%	20%	25%
Transformed Scores	22%	14%	27%	25%

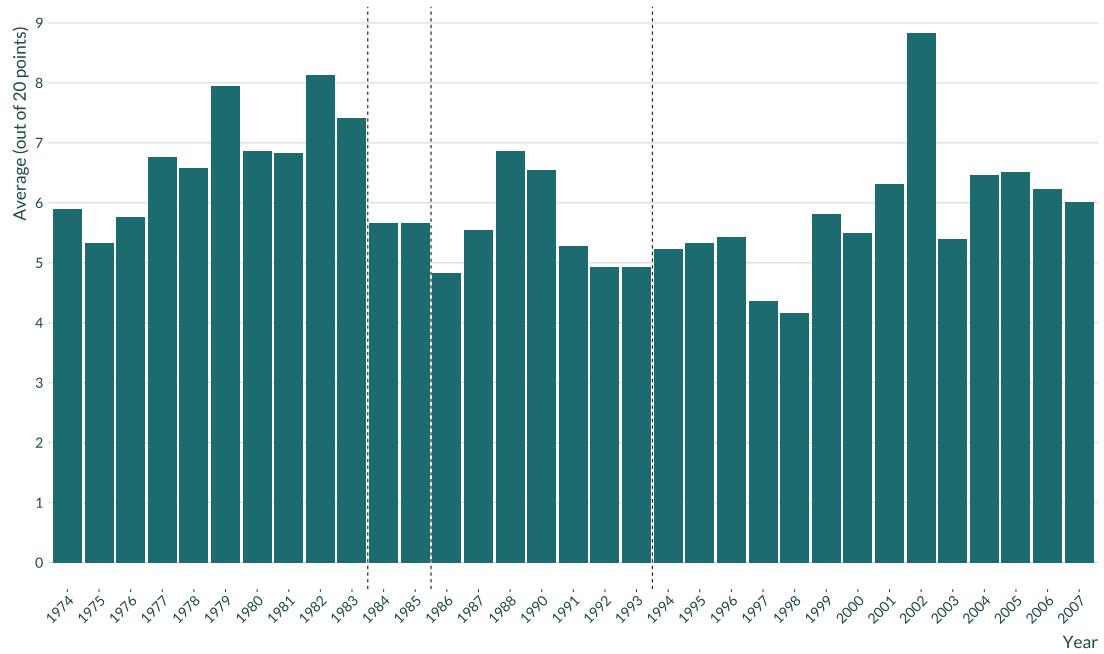
Source: Documentation sourced from the ENS and French National Archives. We use the transformed test scores for the year 1978, 1979 and 1984 to simulated the admitted students.

Figure B9: Share of Male Candidates Coming From Top Parisian High Schools, Top High Schools Outside of Paris and Other High Schools



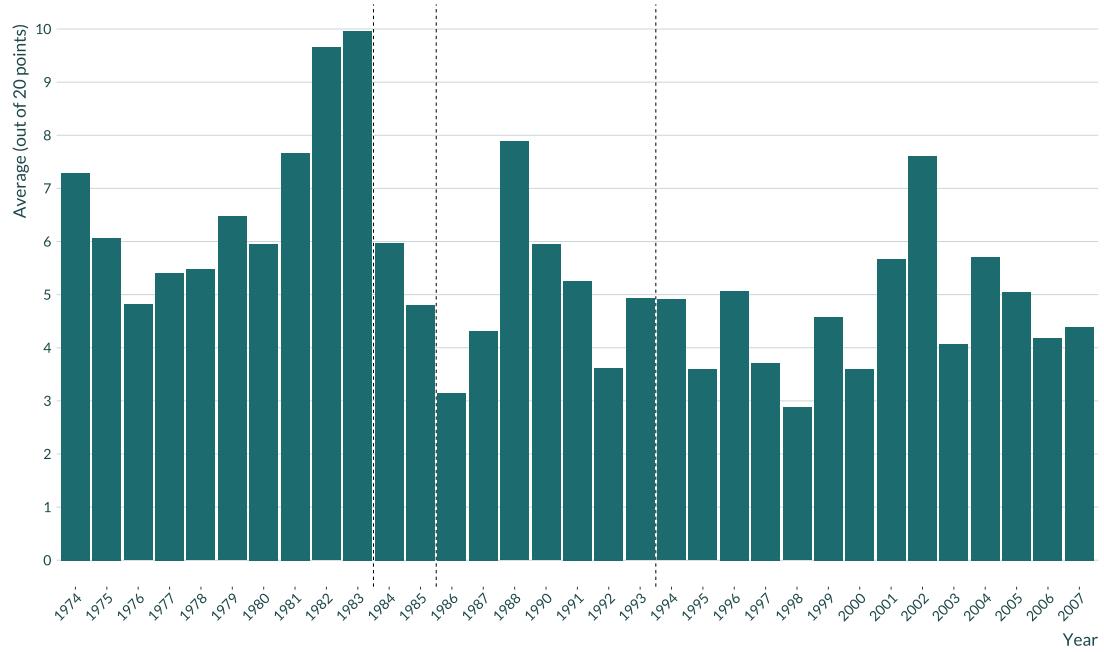
Source: Documentation sourced from the ENS archives.

Figure 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

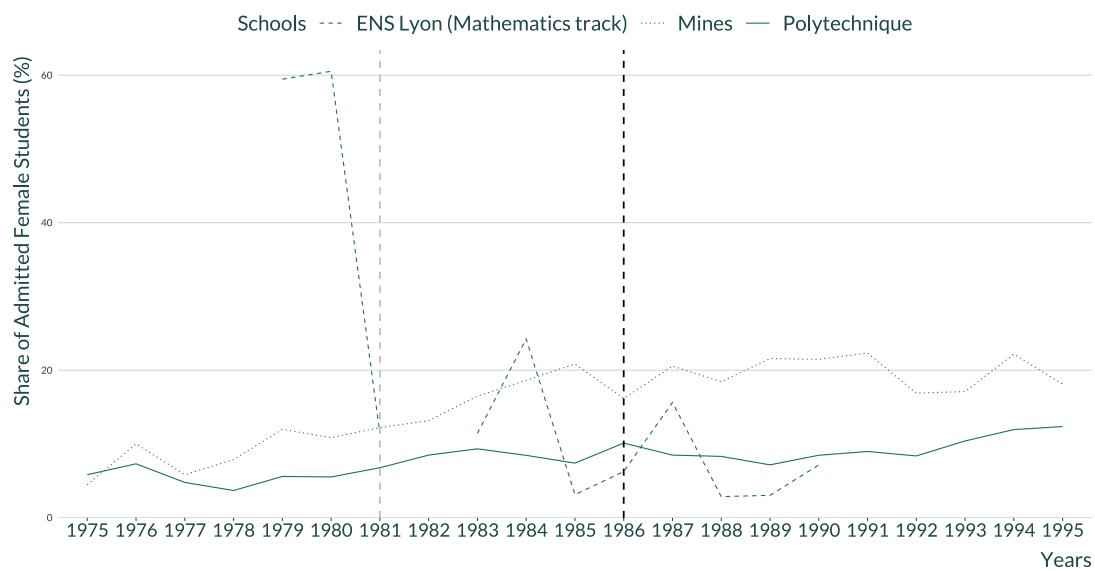


Source: Documentation sourced from the ENS archives.

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
62								
Panel A. Actual Number of Seats Opened for...								
<i>Gender Quota</i>								
Male Candidates				46	46	61	61	0
Female Candidates				46	46	61	61	0
<i>No Gender Quota</i>								
Male Candidates				0	0	0	0	0
Female Candidates				0	0	0	0	0

Figure B12: Percentage of Female Students in Other Sciences Schools, 1975-1995



Source: [Bataille \(2011\)](#) and Stéphane Benveniste's database on elite graduate school in France.

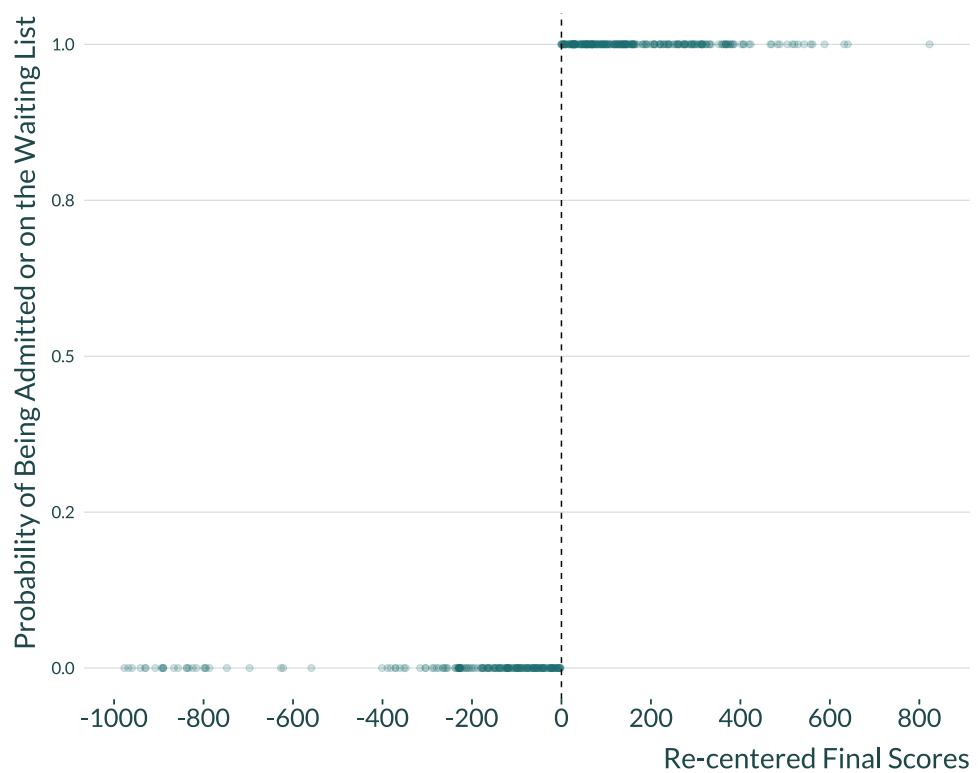
Note: the grey dashed line displays the merger of the ENS de Fontenay-aux-Roses (female only) and the ENS de Saint-Cloud (male only) into the the ENS de Lyon in 1981.

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.

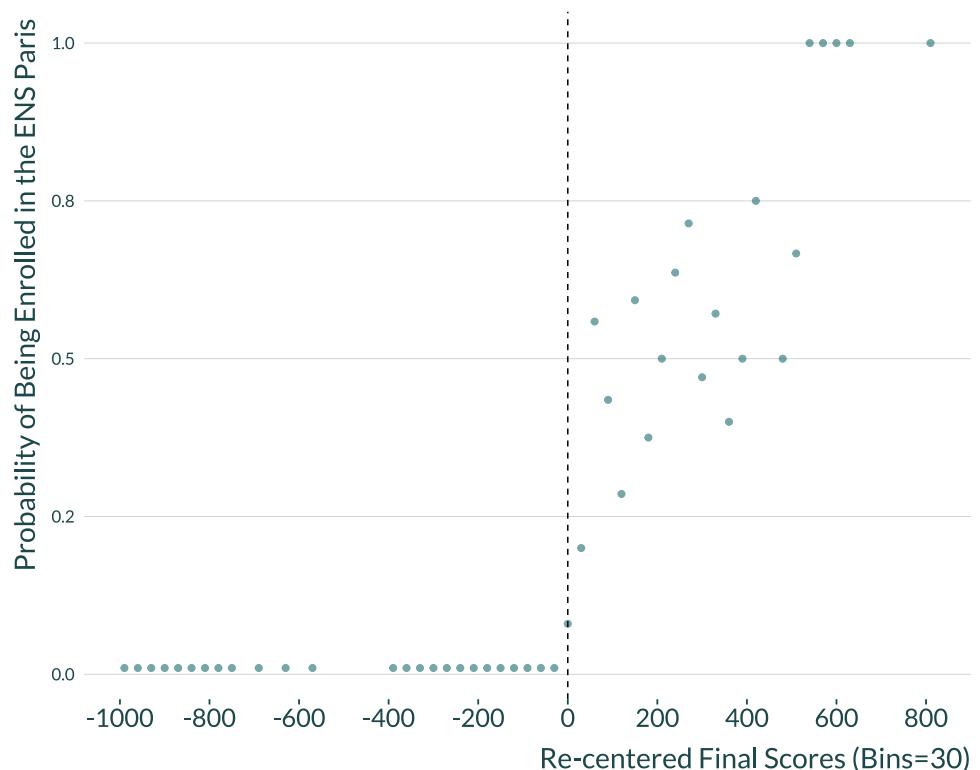
Figure B13: Probability of Being Admitted or on the Waiting list for the Mathematics Track as a Function of Re-Centered Total Scores, 1987-1990



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 B14: Probability of Enrolling in the ENS Paris in the Mathematics Track as a Function of Re-Centered Total Scores, 1987-1990

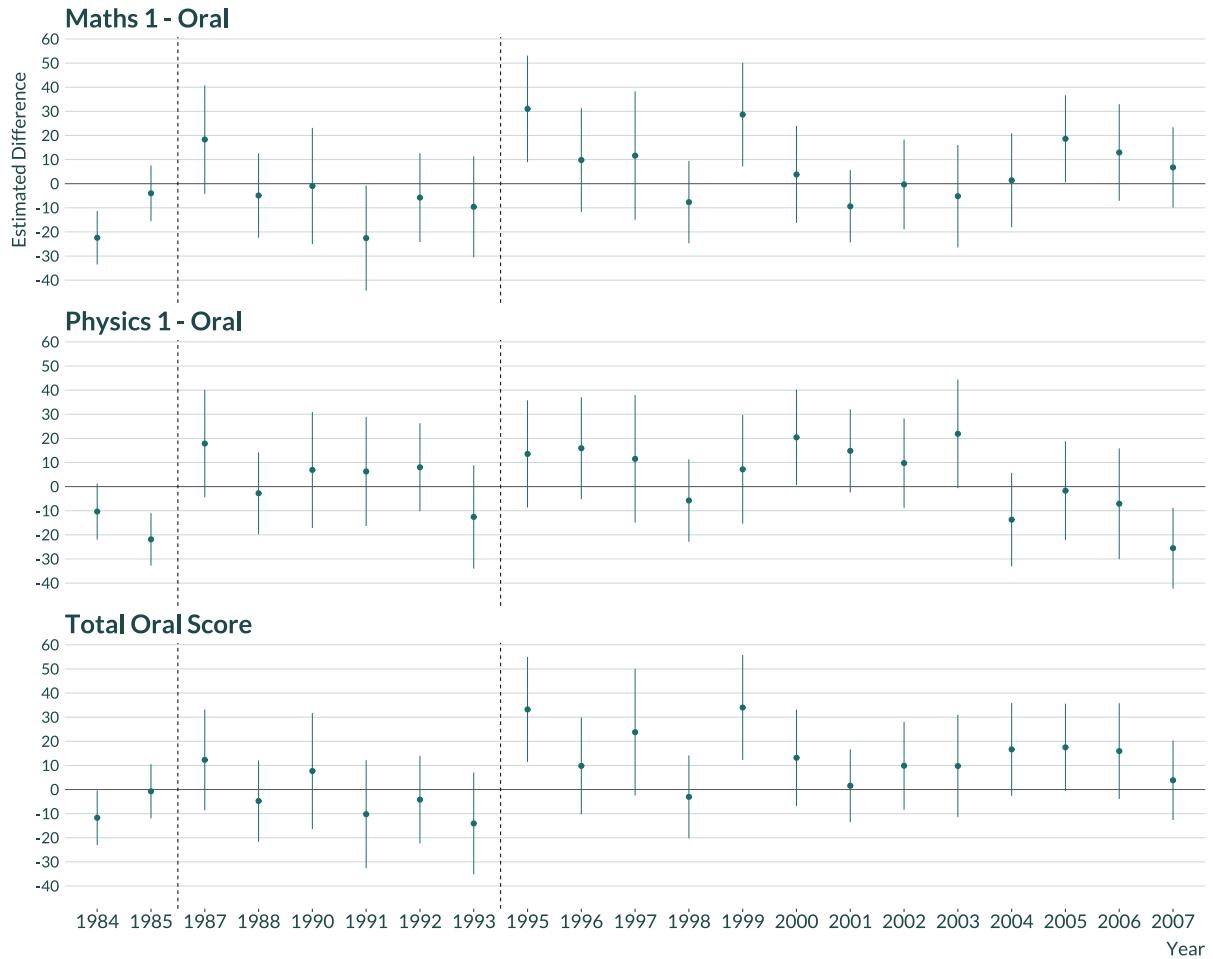


Source: Documentation sourced from the ENS archives.

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



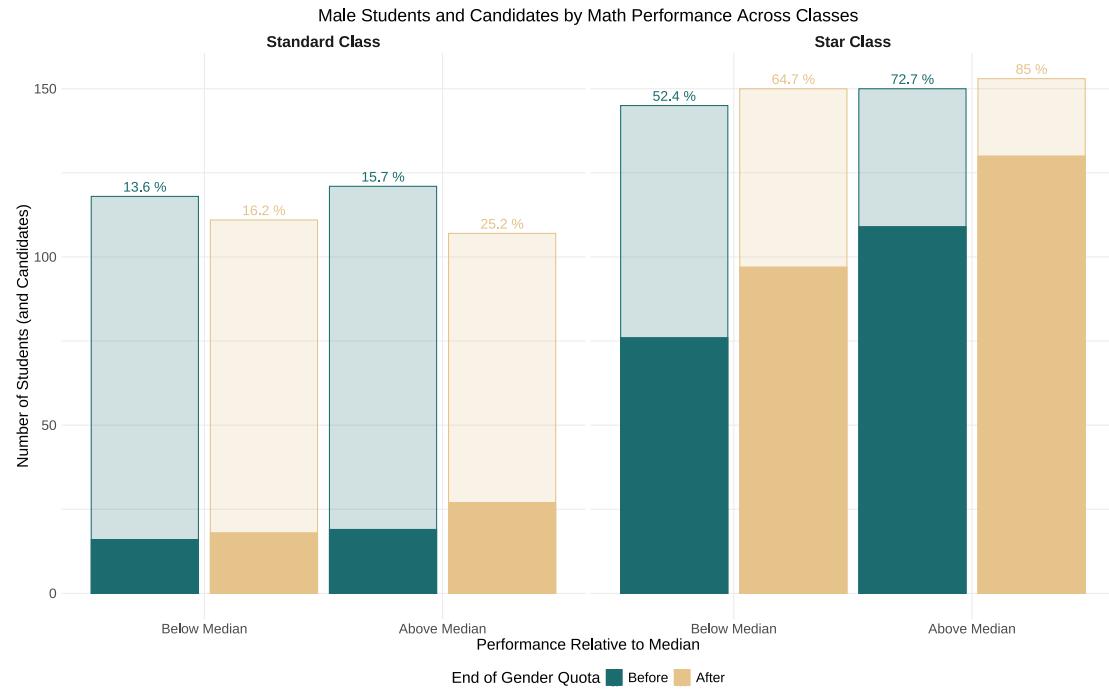
Source: Documentation from the ENS archives.

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 male 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 Prep Program



Source: Documentation sourced from the *Louis le Grand* and ENS archives.

Notes: The sample consists of male students who are in second year in the best mathematics preparatory program in France, *Louis le Grand* in 1982, 1984 and 1985 (Before) and in 1986-1988 (After). They are ranked by their mathematics GPA at the end of the school year, just prior taking the ENS entrance exam. In the second year of maths prep program, students are placed either in star or standard class, depending on their achievement at the end of their first year. Star classes concentrate the best students. Therefore, one can consider that a student below the median in a star class has higher academic ability than another student who is above the median in a standard class.

Reading: There were 97 male students who were below the median in star class in our cohorts after the end of the gender quota (1986-1988), and 64.7% of them applied to the ENS, while there were 76 before (1982, 1984, 1985) and 52.4% of them took the ENS entrance exam.