Performance Gender Gap: Does Competition Matter?

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Using data for students undertaking a series of real-world academic examinations with high future payoffs, we examine whether the differences in these evaluations' competitive nature generate a performance gender gap. In the univariate setting we find that women's performance is first-order stochastically dominated by that of men when the competition is higher, whereas the reverse holds true in the less competitive or noncompetitive tests. These results are confirmed in the multivariate setting. Our findings, from a real-world setting with important payoffs at stake, are in line with the evidence from experimental research that finds that females tend to perform worse in more competitive contexts.

I. Introduction

A new line of research, mainly experimental, suggests that there are performance differences among males and females in competitive environments. For example, Gneezy, Niederle, and Rustichini (2003) find that men's

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performance increases as the competitiveness of the experimental test increases, while that of females does not. Similarly, Niederle and Vesterlund (2007) observe that, after experiencing both noncompetitive and competitive tournament-type tasks in experiments, males show a much larger preference for competitive tournament-type tasks than females (73% for the former as opposed to 35% for the latter). However, evidence from more recent empirical studies that use field data does not necessarily point to a performance difference across genders in competitive setups. While Kleinjans (2009) finds that women have a greater distaste for competition, Lavy (2008b) finds no gender-based difference in a rank-order tournament among high school teachers in which prizes are based on their students' performance, whereas Paserman (2010), examining the performance of highly competitive professional tennis players during grand-slam tournaments, finds no difference in forced errors across genders during critical points of the game. In a recent addition to this literature, Jurajda and Munich (2011) examine multiple university entrance exams taken by the same individuals and find that women do not shy away from applying to more competitive institutions, but men perform better than women in entrance exams for these more prestigious institutions, even though no such difference exists for the exams of the less competitive schools.

The main contribution of our article is to add to this growing literature on gender gap in performance by comparing real-world academic achievement examinations between men and women in contexts characterized by different levels of competition for the same group of subjects. Our field data come from a series of academic tests for the same individuals in a setting in which future, career-related, payoffs are economically high. While these academic achievement tests are not directly comparable with the more controlled environment of laboratory experiments used in the literature, our findings suggest in a parallel vein that performance differences arise across genders when the competitiveness of the tests increases.

Specifically, we examine three cohorts of candidates over the period 2005–7 taking the competitive entrance exam for admission to the Master of Science in Management (hereafter MSc) at Ecole des Hautes Etudes Commerciales in Paris (hereafter HEC; recently changed officially to HEC Paris), a business school that is ranked first in France and in Europe. Only 380 out of approximately 3,400 candidates are admitted each year following a series of written and oral exams. The entrance exam takes place over 3 weeks and covers a wide variety of subjects, including mathematics, history and geography, French, two foreign languages, and "general culture" (a mixture of sociology, philosophy, and current events) as well as the ability to debate a

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topic. In our analysis, we first compare the performance differences between males and females coming from similar educational backgrounds during the written and oral exam stages of the selection process in which the candidates compete for a limited number of places that are available.[1] Then we compare the performances of the same population before and after the entrance exam during the high school finishing exam (the French *baccalauréat*) and during their first-year core courses at HEC (for candidates admitted to the school).

Unlike the HEC entrance exam, the *baccalauréat* does not have a predetermined number of seats for the successful candidates and has drastically lower failure rates (approximately 15% as opposed to an 89% failure rate for the entrance exam). Once admitted to the school, the students face a series of academic assessments in a much less competitive environment. While HEC asks professors to follow a grading scheme based on a "curve" and suggests that the bottom 10% of the grade distribution can be given an F, less than 1% of the first-year core courses' letter grades are fails. In fact, the proportion of students failing and having to repeat their first year is approximately 1% of the 380 who are admitted to the school. These differences suggest that the HEC entrance exam, which selects the highest-ranked 380 candidates, is a much more competitive setting than the latter two academic evaluations. Given the structure of the HEC selection process, we specifically consider the upper tail of the performance distributions.

Our main result is that men perform better than women at the very competitive HEC admission contest, despite the fact that (i) in the same cohort of candidates, the females performed significantly better than men in the "noncompetitive" national *baccalauréat* exam (since the number of diplomas awarded is not predetermined and one candidate obtaining the diploma has no bearing on the other candidates) 2 years prior to the sitting of the HEC admission exam; and (ii) among the subsample of candidates admitted to the school, females appear to outperform the same males during the first year of the HEC's MSc program (where grades are based on relative performances in a very loose sense) but only in the nonmathematics-oriented classes.[2]

More precisely, using quantile regressions, we show that men perform better than women during the written exam stage at the 25th, 50th, 75th, and 90th percentiles (but not at the 10th percentile), the observed perfor-

[1] As discussed further below, in order to eliminate differences in educational backgrounds as a possible driver of a gender performance gap that we observe, we focus on a sample of 5,750 science track candidates (over three cohorts), which form the largest group among the candidate pool. While there are no quotas for any type of background, approximately 250 of the 380 admitted to HEC come from a scientific background in high school.

[2] The fact that we deem the *baccalauréat* as noncompetitive and the first-year of HEC as less competitive does not mean that these are nonstressful events. What we claim is that the resulting pressures during the latter two exams are lower, in a relative sense, than those engendered by the HEC entrance exam.

mance differences being statistically significant at the 1% level. As only roughly a quarter of the initial candidate pool is allowed to proceed to the oral exams' stage of the admission process, the men's proportion increases during the second round of the admission process. Estimates of quantile regressions for the oral exams at the 25th, 50th, and 75th percentiles suggest that females' overall performance remains lower than that of males only at the 75th percentile, a result that is statistically significant at the 10% level. Consequently, more men are admitted to HEC than women.

To examine the impact of the selection process on the performance of the same cohorts, we first estimate linear probability models for the *baccalauréat* honors using ordinary least squares (OLS).[3] We observe that the probability of obtaining honors is higher for women compared to men, the result being statistically different from zero at the 1% level, irrespective of the honors level considered. When we run OLS regressions using first-year grade point average (GPA) or letter grades and control for all the observable characteristics at our disposal, we find some evidence that women perform better than men: overall, women's GPA or course grades are higher than those of men, but only in the nonmathematics-oriented courses (we observe no statistically significant difference in performance when we consider all the grades or the mathematics grades). This is surprising: a priori, we would not expect to find any performance difference among a group of students who have excelled in a highly competitive elimination process and succeeded in entering HEC. Taken together, these results suggest that the higher competitive pressure in the exam that puts more emphasis on relative performance has a different impact on men than on women.

Next, we consider alternative explanations for the changes in performance that we observe for the same subjects in settings in which competitiveness differs in a relative sense. One possibility is that gender discrimination or bias by exam evaluators may be driving our results (as in Goldin and Rouse 2000). For example, while the written exam copies are graded after being rendered anonymous, we cannot rule out the possibility that some graders may be able to discern the genders thanks to the candidates' handwriting style. However, we do not believe that this or a similar discrimination during the oral exams would result in a bias that is material enough to affect our results for three reasons. First, even if some graders may be able to discern the gender of the candidate through handwriting style differences, they would need to be biased toward one gender or the other, which is not obvious given that the examiners come from both sexes (e.g., Lavy 2008a). Second, our main performance metric is a weighted average of all (written or oral) exam grades in different subjects. For any

[3] Because of data restrictions, honors are the only performance metric available to us for the *baccalauréat* exam.

potential gender discrimination to affect our results systematically, one or more fields would have to be graded by one or more groups of examiners with a similar bias. This is difficult to achieve given that the number of copies to be graded in the science track alone is 1,900 per year on average per subject matter. The fact that we are using weighted-average exam scores across different fields suggests that any possible bias that a few individual examiners may exhibit would be largely diluted. Finally, it is highly unlikely that HEC administration would have given us access to the data if there were any suspicions of gender bias in the admission exam: given the predominant status of the institution among French business schools, our research question is a delicate one for the general public and HEC.[4]

Our results are also unlikely to be explained by a "women shying away from competition" argument: in our data set the proportion of female candidates in the initial candidate pool with a science background (49.2%) is 2%–3% higher than the proportion of females graduating from high school with a science major over the same period (46.6% in 2005, 46.2% in 2006, and 47.3% in 2007). The fact that there are more females in the candidate pool than among the relevant population of high school graduates rules out stories based on a selection mechanism that men and women share in common, even though we cannot rule out, on the basis of this information, more general stories involving different selection mechanisms for men and women.[5]

Given that the candidates who take the HEC entrance exam follow the same number of years of schooling, human capital differences are most likely to be driven by innate abilities as opposed to differences in backgrounds. It is possible that women's attitudes toward family and childbearing may engender differences in their investment in education (see, e.g., Ge 2011), which may explain the lower initial proportion of female candidates (49.16% vs. 50.84% for males) in the applicant pool. However, these potential differences in attitudes are unlikely to explain differences in performance during the entrance exam or the systematic change that we observe in the *baccalauréat* or the first year of HEC.

We also explore whether gender differences in mathematics affinity may matter for our results. While we observe some statistically significant per-

[4] In fact, an earlier version of this article was covered in the French press (e.g., *Le Monde* 2009), generating a nonnegligible amount of debate about the findings.

[5] Evidence suggests that genders' attitude toward competition has a cultural component: Gneezy, Leonard, and List (2009) find that while men among the Maasai in Tanzania, a patriarchal society, tend to participate in competitive tasks at twice the rate of women, the reverse is observed in the matrilineal society of the Khasi in India. We do not know of any study that examines the variation in the differences that genders exhibit regarding their participation in competitive tasks for different subsamples that share the same culture.

formance differences across genders involving subjects that are mathematics and nonmathematics oriented, these are not systematic enough to explain all our main findings. In certain cases we obtain similar results with the mathematics and the nonmathematics exams. For example, in quantile regressions of the written exam performance, males perform better than females at the 25th, 50th, 75th, and 90th percentiles of the data, irrespective of whether the content is mathematics or nonmathematics oriented. In other cases, we observe differences that indicate that females do worse in nonmathematics fields. For example, in quantile regressions of oral exam performance, females do worse (a result that is statistically significant) than males at the 75th percentile in the nonmathematics exams, while we observe no such difference at the 75th percentile of the mathematics exam. Yet again, in other instances women do better in nonmathematics-oriented subjects, for example, during the first-year courses, while they do no worse in the mathematics-oriented courses. We also note that the implicit weights given to mathematics-related fields in the three different academic evaluations that we examine do not vary systematically to disadvantage the females during the entrance exam, while giving them an edge in the other two tests.[6] We then conclude that the gender-related academic performance differences that we observe are closely linked with the differences in the competitive pressures inherent in these evaluations.

Our data set is relevant and interesting for the study of the gender differences in performances for several reasons. First, payoffs at stake are very high since the *Financial Times* (FT) has ranked HEC's MSc in Management program first in Europe in 2005, 2006, and 2007, the three years in our sample.[7] For these three years the average annual salary of HEC MSc alumni 3 years after graduation is approximately US$13,000 (international purchasing power parity adjusted as reported by the FT) higher than that of the closest follower in France. This amount corresponds to 24.5% of the average salary ($53,000 over 2005–7) of the alumni of the business school that is typically ranked the second in France (ESSEC). The salary spread increases to almost $24,000 between HEC and the last-ranked French business school in the FT survey during 2005–7 (which corresponds to 57% of the average salary for alumni of the least-well-ranked French school in the FT classification).[8] Even in 2011, when HEC was ranked fourth in the FT rankings for MSc in Management, the average starting salary of its graduates was more than $8,600 higher than that of the graduates of the first-ranked

[6] We also note that other unobservable differences across genders, such as risk aversion, may play a role in our findings. Unfortunately, we are limited by the data at our disposal in exploring the role, if any, of these additional factors.

[7] The HEC MSc in Management program was ranked first in Europe in 2008, second in 2009, third in 2010, and fourth in 2011.

[8] See http://rankings.ft.com/businessschoolrankings/masters-in-management.

business school in France (Ecole Supérieur de Commerce de Paris [ESCP]) in that year, a difference that equals 13% of the average salary of the latter school's alumni. Not only do HEC alumni perform very well early in their career (which they typically start at the age of 24), they also do well in the long run: among the 32 French firms ranked in the FT Global 500 in 2007, which includes the world's 500 largest companies by market value, 22% have a chief executive officer who graduated from HEC. The school's alumni also include seven French government ministers. In a different vein, Pascal Lamy and Dominique Strauss-Kahn, two HEC alumni, are, respectively, the director of the World Trade Organization and the ex–managing director of the International Monetary Fund. These examples illustrate short- and long-term rewards, and hence the incentives, of being admitted to the school.

Second, a priori, we should not observe any difference in performance across genders in this pool of candidates given that we examine highly competitive individuals compared to their age group in the general French population since (i) they are among the very best-performing French high school seniors as measured by the honors that they obtain in the *baccalauréat*,[9] (ii) they have chosen to apply to and have been admitted to selective preparatory schools that train students during 2 years for business school entrance exams, and (iii) they self-select to sit for the toughest of such exams despite the fact that they are guaranteed admission to a French university in any year following their high school graduation. As a result, the research question that we examine is not trivial. If anything, the competitive nature of the group of students that we examine should make it more difficult for us to find any differences in performance across genders.

Third, we are able to observe the performance of this motivated group of individuals in academic evaluations that exhibit large differences in their conditions for success. One particularity of the setups that we examine is that the success at the HEC entrance exam is based on relative performance in a strict sense for a given year (only the top 380 performers are admitted). In contrast, in the *baccalauréat* exam, there is no predetermined number of high school diplomas to be granted. Students who obtain an average grade of 10 or higher out of 20 get their diploma. For these reasons we consider the *baccalauréat* to be a noncompetitive setting. Competition is also very mild in the HEC first-year core course phase. The school follows the European Credit Transfer System (ECTS) standard for grading distributions, which suggests that 10% of the class be given an F.[10] In our sample the proportion of failing grades is less than 7.5% of the distribution if one were to consider

[9] As we explain further below, this holds true even for those candidates who fail the HEC entrance exam.

[10] ECTS is a pan-European grading standard under which a typical academic year of higher education corresponds to 60 ECTS credits. The corresponding grading

all grades below a D and less than 1% if one considers only letter grade F (after taking a makeup exam). In fact, HEC requires that students validate 50 ECTS credit hours out of the 60 needed for the year. By this criterion, the number of students failing their first year and repeating it the next year is approximately 1% of the entering class: of the 2005, 2006, and 2007 entering classes, three, three, and four students, respectively, repeated part or all of their first year. As a result, the intensity of the competition for 380 spots out of 3,400 during the entrance exam is drastically higher than that for the first-year HEC courses but also much higher than that for the *baccalauréat* exam.

Since the *baccalauréat* and the HEC first-year exams' difficulty and their evaluations are most likely to change over time, we do not consider them as being based on fixed standards that remain constant over time (even when the nominal threshold for a pass may remain constant, as in the case of the *baccalauréat*). What matters for our purpose is the fact that these two sets of exams be relatively less competitive than the HEC entrance exam.

Finally, our sample allows us to rule out differences of earlier orientation in education during high school as possible drivers of the gender performance gap. For that purpose, we focus on science majors, the largest cohort in the HEC entrance exam, and control for the potential differences among the submajors (i.e., mathematics, physics and chemistry, and life sciences) that they chose in the last year of high school. Not only do we test for differences in the gender composition of different science submajors, but we also explicitly control for them in a multivariate analysis to account for potential differences in mathematics affinity across genders.

The article is organized as follows. Section II reviews the related literature. Section III provides an overview of the French higher education system and explains in detail the two-stage HEC admission tournament. Sections IV and V present the data set and the results, respectively. Section VI provides a discussion, and Section VII presents conclusions.

II. Related Literature

Even though the setup we examine is a not direct real-life counterpart to the experimental studies of Gneezy et al. (2003) and Niederle and Vester-

system is very similar to the one used in US universities: course letter grades range from an A for the best-performing students in a class to an F for those who fail the class, with the addition of an E, which is a passing grade that is worse than a D. The ECTS system was introduced in 1999 as part of the so-called Bologna Process that seeks to harmonize educational standards within the European Higher Education Area with a view to facilitate educational transfers across countries (http://ec.europa.eu/education/lifelong-learning-policy/doc48_en.htm).

lund (2007), our results expand the literature on performance differences across genders and complement their results. Gneezy et al. observe that as the competitiveness of the environment increases, men's performance increases while that of women does not. Furthermore, they find that the performance of women is significantly higher in single-sex tournaments than in noncompetitive treatments, suggesting that the competitive environment in which women operate can affect their performance. In the experiments run by Niederle and Vesterlund, participants are asked to solve tasks in a noncompetitive environment and then in a competitive tournament environment. In a second step, participants are asked to select in which of the two environments they want to operate: while 73% of the men choose to enter the competitive tournament, only 35% of the women decide to do so.

Our work is also closely related to a growing body of papers on performance gender gap using real-life data with conflicting results. Paserman (2010) finds no difference in forced errors across genders during critical points of grand-slam tennis tournament matches. His results suggest that, in the context of same-sex tournaments, women do no worse than men when competitive pressure increases. Lavy (2008b) examines the effects of a rank-order tournament among mathematics and language teachers with important cash prizes that are based on the performances of their students. He finds no gender-based difference among teachers in terms of performance rank, rate of winning, or prize won. Moreover, the gender composition of the pool of competitor-teachers in the same school does not appear to matter, even though women appear to be more pessimistic about teaching outcomes and more realistic about their chances of winning a prize. In a similar vein, Delfgaauw et al. (2009) introduce a performance competition among the stores of a Dutch retail chain, but in contrast to Lavy (2008b), they find a positive and statistically significant effect on sales-based performance when the manager and most of the employees have the same gender, irrespective of whether a cash prize was proposed or not.

Our work contributes to this line of literature and is closely related to the recent article by Jurajda and Munich (2011), who study performance differences across genders during the entrance exams for Czech universities. They find that while women perform as well as men in entrance exams of lower-ranked universities, their probability of being admitted to top universities is lower than that of men with similar abilities (as measured by their score in a national high school graduation exam).

Our work is different from that of Jurajda and Munich (2011) in several ways. First, whereas Jurajda and Munich can observe each candidate's multiple university applications, we observe the same candidates in three different exam settings: in the noncompetitive *baccalauréat* exam, during the highly competitive HEC entrance exam, and during the somewhat competitive first year of their studies once admitted. Thus, we can observe whether the gender performance gap observed during the entrance exam exists prior to and after this contest, in less competitive environments. Second, the entrance exam that we focus on proceeds in two steps, one written and one oral, as opposed to a single set of written evaluations in Jurajda and Munich's study. As a result, we can test for a gender performance gap in written versus oral settings. Third, while our data are limited to a single school's entrance exam, as opposed to many universities' admission exams, the admission procedure that we examine is richer in that it examines students over a larger set of subject matters (e.g., mathematics, history and geography, languages, and "general culture" during the entrance exam but also accounting, economics, finance, etc. during the first year) rather than just mathematics and language skills as in Jurajda and Munich's study. Hence, we are able to examine whether mathematics affinity is the driver of the gender difference in performance. As such, our findings extend and complement those of Jurajda and Munich.

III. The French Higher Education System and the HEC Admission Exam

This section presents an overview of the French higher education system so as to provide a better understanding of the competitive pressure and the economic incentives that the subjects we study face during the different academic evaluation tests that we examine.

A. A Two-Tiered Higher Education System

At present, higher education in France is dispensed through 81 public universities and 202 *grandes écoles*. The history of the current system can be traced back to the earlier years of the thirteenth century, when the three oldest French universities (Paris, Toulouse, and Montpellier) were created. The first institution of higher learning that was not affiliated with a university, le Collège Royal de Paris (now called le Collège de France), was created in 1530, followed by the first military oceanography and artillery schools in the seventeenth century. During the eighteenth century, technological advances increased the demand for engineers among army corps officers and led to the creation of other military engineering schools by the royal power.[11] Following the French Revolution, similar institutions continued to be created (including Ecole Polytechnique, the most prestigious of French engineering schools), with the appearance of nonmilitary independent schools such as the Ecole Normale (to train secondary school teachers after the expulsion of Jesuits who fulfilled that role) and the transformation of law and medicine faculties of universities into independent law and medi-

[11] These include some of the best French engineering schools of the current day, e.g., Ecole des Ponts et Chaussées, Ecole des Mines, and Ecole des Arts et Métiers.

cal schools (these would be subsequently reattached to universities). These independent institutions of higher learning outside the university system, which were typically attached to a military corps or to a government ministry, will eventually become what is known as the *grandes écoles* system. In the nineteenth century, a second wave of occupational schools dedicated to the teaching of business and management began to be created, including the HEC, by the Chamber of Commerce and Industry of Paris (CCIP) in 1881.[12]

The university–*grande école* duality is still very much present in French higher education and boils down to three major differences among these institutions. First, the former are not typically allowed to select students who are legally guaranteed a spot in one of the three universities of their choice in the *académie* of their high school upon graduation, irrespective of their academic level.[13] In contrast, starting as early as the eighteenth century, admission to *grande école* programs involves an entrance exam whose difficulty and selectiveness are very tightly associated with the quality and ranking of the school. Differences in the admission procedures and selection criteria are reflected in the number of students enrolled in the universities and the *grandes écoles*: during the period 2005–7 (years in our sample), approximately 1.4 million students were enrolled in universities (all fields and years combined) compared to approximately 160,000 in all types of *grandes écoles* put together (RERS 2007). This general difference in selectivity is further exacerbated by the competition among the highest-ranked *grandes écoles* that select the very best candidates through separate entrance exams. The difficulty of getting into one of the top-ranked schools is closely related with job market outcomes. It is not too far-fetched to state that typically a French employer, the country's establishment, and even the French public at large would consider the last-ranked candidate entering the first-ranked *grande école* in a given field to be a better student than the first-ranked student entering the second-ranked school. In fact, when offered admission from a number of schools, few of those admitted to the first-ranked school would go to a second- or lower-ranked school. In the case of HEC, out of 381

[12] HEC is the eighth French business school to be created, the first one being another school created by the CCIP, the ESCP. Almost all French business schools are affiliated with, and partially financed by, a chamber of commerce. The latter receives a tax, called *taxe d'apprentissage*, which businesses headquartered in its geographical area are required to pay. Nevertheless, French business schools require a tuition that many prestigious engineering *grandes écoles* do not thanks to their historic affiliation with a ministry of the French state.

[13] The French national education system is split into 26 regional units called *académies* that cover administrative aspects of primary, secondary, and higher education. These academies typically cover a *région*, which is a geographic administrative unit of the French state, though some large metropolitan areas, such as the greater Paris region (namely, Ile de France), are split into more than one academy.

admitted in 2005 and 380 in 2006 and 2007, only 18, 15, and 11, respectively, chose to go to another school.[14]

Second, whereas entry at a university takes place right after high school, candidates to *grande écoles* follow subject-specific preparatory programs for 2 years, which prepare them for the competitive entrance exams. These 2-year prep schools (*classes préparatoires*, or simply *prépa* in French) follow curricula defined at the national level and may be thought of as being the equivalent of freshman and sophomore years in a US college. Even though these schools do not confer diplomas, students who drop out of them after the first year or fail to enter a *grande école* of their choice can be awarded ECTS credit hours that they can use toward a university degree's credit hour requirements.[15] The prep schools are typically associated with public or private high schools but are not organically linked with the *grandes écoles*.[16]

Admission to one of the 406 existing prep schools also follows a very selective process. During their last year of high school, students wishing to enter a prep school of their choice fill out application forms (mainly providing grades obtained in their last 2 years of high school). In contrast to the university system, students can be rejected from all the prep schools that they apply to. In fact, prep schools offer different programs given the type of *grande école* targeted (i.e., engineering or business) and are ranked by field (i.e., mathematics, science, economics, or literature), with the selectivity being especially stringent at the very best institutions. Importantly for us, admission decisions to business prep schools, though conditional on successfully obtaining the high school diploma, are typically made public before the *baccalauréat* exam takes place. In other words, business prep school programs do not select students on the basis of their *baccalauréat* exam performances. For example, a top-ranked business prep school pro-

[14] The students who chose not to attend HEC typically enrolled in Ecole Normale Supérieur, a research-oriented *grande école* that prepares for a PhD in economics, humanities, and sciences. Few students chose a lower-ranked business school over HEC. The school does not offer additional admissions to replace the students who chose not to enroll.

[15] A student can transfer up to 60 (120) ECTS credit hours toward her or his university degree upon successful completion of the first year (second year) of prep school.

[16] As of 2007 there were approximately 1,550 public and 1,070 private high schools in France. The latter group is further subdivided into two. The first group, called *sous-contrat avec l'état* (i.e., under contract with the state), includes institutions that follow the French national curriculum, lead to a French *baccalauréat*, receive aid from the state that appoints some of its teachers, and charge anywhere between €500 and €4,500 per year for tuition. The overwhelming majority of these institutions are denominational (typically Catholic) schools. The second group comprises private high schools that follow other curricula (American, English, or German, e.g.), lead to international diplomas (such as American or Swiss international baccalaureate or UK A-levels), do not receive any state aid, and charge much higher amounts for tuition (anywhere between €10,000 and over €25,000 per year).

gram that rejects a candidate on the basis of high school grades will not typically revisit its decision even if the student in question eventually graduates at the *baccalauréat* with honors (more information on the equivalence of French high school honors is provided below).[17] This suggests another reason why the *baccalauréat* can be seen as a noncompetitive exam for students admitted to the prep schools: superior performance during the high school finishing exam has no bearing on the prep school's admission decision, which the student already knows by the time of the *baccalauréat* exam. Moreover, prep schools are highly competitive environments, typically posting the rankings of their students within a class after exams and eventually asking poorly performing ones to leave (e.g., *Le Monde* 2012).

Third, while students graduating from high school are guaranteed a spot in one of the three universities in the *académie* of their high school, irrespective of their academic performance as long as they obtain their high school diploma, they have to take different competitive entrance exams for different *grandes écoles*. The fact that few schools pool their entrance exams limits the number of *grandes écoles* a student can apply to.[18] Candidates have to optimize their time and efforts over a large number of entrance exams, a fact that contributes to the selectiveness of the *grande école* system.

Fourth, upon graduation, job market prospects are drastically different for *grande école* and university graduates. The nonselectivity of the university admission process combined with (i) the increasing proportion of 18-year-olds in the general population obtaining a *baccalauréat* over the decades and (ii) a mismatch between the labor market demand and the number of students graduating in various fields implies that French universities often confer diplomas with little value in the job market (with few notable exceptions, such as medicine). For example, in 2006, French universities had approximately 65,000 psychology students (one-fourth of the European students in the field) and roughly 45,000 "sports science" students (*Economist* 2006).[19] In contrast, *grandes écoles* provide engineering or business education with much better employment opportunities. In fact, the salary gap between HEC and other business school graduates that we noted in the introduction is even larger with respect to university graduates. During the last year of their studies, HEC students typically get multiple job offers

[17] High school students can typically apply to up to three universities and up to 12 prep schools before taking their *baccalauréat* exam. Many prep schools shortlist candidates and may accept students after the *baccalauréat* exam if the students offered admission choose to attend another prep school and free up space.

[18] HEC pools its written exams with ESCP, traditionally the third-best-ranked business *grande école* in France, even though each school conducts its own set of oral exams. Both schools are affiliated with the CCIP.

[19] Such large numbers can be explained, in part, by the fact that France's 81 universities are public, requiring fees of only less than a few hundred euros per year. In

before they obtain their diplomas, with a nonnegligible number of offers being for positions in other countries, such as the United Kingdom. A diploma from a top-ranked *grande école* also gives access to a large and established alumni network within and outside of France. As such, getting admission into a *grande école* drastically changes career prospects for the candidates, all the more so if the candidate is admitted to the best school in its field. This context explains the high level of pressure and competition that is built into the entrance exam of a top-ranked *grande école* such as HEC.

B. HEC Admission Process

The HEC MSc in Management is the direct descendant of the program created 110 years ago. Since 1920, admission takes place through a competitive exam. Historically an all-male establishment, in 1973 the school started to admit women, whose proportion rose from approximately 30% in 1985 to just below 50% in 2007. The competitive entrance exam is organized by la Direction des Admissions et Concours (the Admissions and Entrance Exam Administration Center [AEEAC]), which is not directly affiliated with HEC, and proceeds in two steps. First, all applicants (on average 3,400 per year during the period 2005–7), whom we will refer to as *candidates*, have to take seven written exams. In a second stage, the highest-ranked 700 or so, whom we will refer to as *admissibles*, will be allowed to take a series of oral exams. On the basis of the weighted sum of all grades obtained at the written and the oral exam stages, HEC will admit the highest-ranked 380, whom we will refer to as the *admitted*. The school does not set any quotas per gender, educational background, nationality, or socioeconomic class. Admission is solely based on the final ranking of the candidate among all other candidates using the weighted sum of written and oral exam scores. The weights used in this evaluation differ depending on the educational background of the candidate. There are four different educational backgrounds or *tracks*: science (approximately 56% of the candidate pool), economics (30%), literature (13%), and technology (1%).[20] It should be noted that the rankings are done across the board for these four tracks (i.e., a literature candidate who has a better total weighted sum would be placed higher than a science candidate with a lower score). During the selection process, the written exams are based on essay-type questions or involve solving mathematical problems but do not include multiple-choice questions. The oral exams typically

contrast, even though many of the best engineering *grandes écoles* are public and tuition free, business *grandes écoles* are attached to regional chambers of commerce and typically require tuition, which may be up to €12,000 per year (as in the case of HEC). That said, it is easy for students admitted to HEC to obtain bank loans to finance their studies, and the school provides need-based scholarships.

[20] The last group has a *baccalauréat* from a technological high school. France has three types of high schools and *baccalauréats*, a degree obtained by roughly two-thirds of 18-year-olds in the country: (i) generalist (introduced in 1808), (ii) tech-

involve 15–30 minutes of testing on a question or problem that is drawn randomly from a question bank.

Our study focuses on the largest group of candidates: those with a science major in high school, who have to specialize in a submajor during the last year of high school in mathematics, physics and chemistry, or life and earth sciences (i.e., biology and geology). We rely on the sample of students with the same science background in order to reduce the possibility that the gender gap we observe is due to differences in backgrounds or self-selection of females into nonscience fields.[21] This group typically attends science-oriented prep schools that prepare students for entrance exams of *grandes écoles* in management.[22] Even though attending a prep school is not a prerequisite for taking the *grande école* entrance exam, 93.96% of the candidates in our sample attend these institutions.

In the first stage of the entrance exam, all candidates, irrespective of their track, are evaluated on their expression skills in French as well as two foreign languages (one of which is typically English). Candidates also sit for track-specific exams depending on their educational background. The candidates with a science background take two written exams in mathematics, one in history and geography, and one in general culture. Table 1 provides the complete list of different written and oral exams for the science track. For each exam, students receive a mark, ranging between zero and 20, in line with the French primary and secondary education grading scheme.[23] The weights indicated in table 1 are used in the calculation of the weighted sum

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nological (introduced in 1964), and (iii) vocational (introduced in 1985). The generalist *baccalauréat*, which 99% of HEC candidates possess, is the most sought-after degree, obtained by 54% of French high school seniors. Middle school students who are unable to perform adequately in the generalist institutions are directed toward technological or vocational high schools. Technological high schools educate students in the fields of engineering and management with a view toward training technicians and clerical staff (such as accountants) who will eventually pursue a shorter higher education program without necessarily attending a university or a *grande école*. Vocational high school students train to become artisans or skilled workers in various industries.

[21] We would have had a much more heterogeneous sample if we had analyzed the full sample of all candidates: to make the point, among high school students who graduated in 2005 with a generalist *baccalauréat*, 46.6% of science majors were females, whereas the same proportion was 63.5% for economics and social science majors and 81.6% for literature majors in high school.

[22] Science-oriented prep schools follow different curricula dependent on whether they prepare students for management or engineering *grandes écoles*.

[23] While there is no official correspondence between the French grading system out of 20 and the American system based on letter grades, the Fulbright Commission in France suggests the following equivalence scheme (for eleventh and twelfth grades): 18–20 A+, 16–17 A, 13–15 A−, 12 B+, 11 B, 10 B−, 9 C+, 8 C, 7 C−, 6 D+, 5D, 4 D−, and 3 and below F (http://www.fulbright-france.org/docs/2010170242_Balzactoolkitfrench.pdf, 12). A French student needs an average of 10/20 to validate an academic year or the *baccalauréat*.

Table 1
Structure of the HEC Admission Exam

	Written Exam (First Stage)		Oral Exam (Second Stage)	
	Duration	Coefficient	Duration	Coefficient
Common exams:				
French	3 hours	3		
1st foreign language	4 hours	4	15 minutes	4
2nd foreign language	3 hours	2	15 minutes	3
General culture			20 minutes	6
Debate			40 minutes	6
Exams specific to the science track:				
General culture	4 hours	4		
Mathematics 1	4 hours	6	30 minutes	9
Mathematics 2	4 hours	5		
History and geography	4 hours	6	20 minutes	8
Total		30		36

of grades, which the AEEAC uses to rank the candidates. We calculate an equivalent weighted-average score (out of 20) that we use as the performance metric. Even though we limit ourselves to science track students, the diversity of subjects on which these candidates are evaluated still allows us to test whether any performance difference that we observe may be driven by differences in mathematics affinity across genders. This is important because for the science track candidates, mathematics accounts for 36.67% of written exam weights and 25% of oral exam weights. In fact, the structure of the entrance examination resembles an iterated elimination tournament in which (1) less than 25% of the approximately 3,400 candidates per year become admissibles and (2) approximately 55% of the admissibles (which corresponds to 11% of candidates) are eventually admitted to the school.

Once admitted to HEC, students spend 3 years on campus and take an interim year to do a series of internships. Their first year ends the bachelor cycle initiated in prep school, whereas their last 2 years correspond to the MSc in Management degree.[24] Except for a few elective courses, the bulk of the first year consists of the same core courses for all the admitted, which allows us to examine whether the differences observed during the entrance exam persist in the first year of HEC studies.

C. The Baccalauréat Exam

The *baccalauréat* exam, first introduced in 1808 by Napoléon, is the product of a highly centralized system run by the French Ministry of Na-

[24] The last year is dedicated to a 1-year specialization in one area of management (accounting, finance, strategy, marketing, international business, etc.). It should be noted that no diploma or certificate is conferred at the end of the first year of HEC when the bachelor cycle is completed.

tional Education. It differs in many aspects from the US high school diploma, which is the product of a decentralized system. The *baccalauréat* degree is obtained following a series of national written tests (and oral tests for foreign languages) typically spread over 5 days. The composition of the exams in terms of subject matters (French literature, mathematics, physics, chemistry, life sciences [biology and geology], philosophy, and foreign languages) and the different weights given to these fields vary according to the major chosen at the end of *seconde* (the equivalent of tenth grade in the United States) and the submajor chosen at the end of *première* (the eleventh grade).

The interaction of gender and acquaintance cannot affect the results we observe for the *baccalauréat*. Grading of this exam is anonymous: teachers coming from other and typically nonneighborhood high schools grade blinded-exam papers.[25] The evaluation of the exam copies is based on the answer key and grading scheme provided by the Ministry of National Education. There is no "curve" involved either for individual topics or for the *baccalauréat* as a whole: only students who obtain a weighted average of 10 out 20 obtain their diploma.

The *baccalauréat* exam is inherently different from the HEC entrance exam for two reasons. First, in contrast to the HEC admission process, which is clearly a contest for a fixed number of spots, the *baccalauréat* is in essence a pass-or-fail type of exam with three levels of graduation honors beyond a simple "pass." The 300,000–325,000 high school students who are about to take the general *baccalauréat* exam each year know that any student who manages to obtain a weighted-average *baccalauréat* score (with weights that are predetermined for each of the submajors) of 10 out of 20 will necessarily obtain his or her diploma. In other words, students taking the *baccalauréat* do not directly compete against each other: the success of a candidate does not imply the failure of another one. Moreover, instead of a curve, a standardized grading scheme is applied to the same set of questions for all the high school seniors in a given track. In that sense the *baccalauréat* provides a fixed standard for a given year. Finally, as already mentioned, for high school students who have been admitted to a prep school (93.96% of candidates in our sample), since admission is known before the *baccalauréat* they need only a pass in this exam. Conversely, when they sit for the HEC entrance exam, candidates know that there will be only 380 admitted students, irrespective of the number of candidates.

Second, the success rates at the two exams are clearly of very different magnitudes. The success rates in the 2003, 2004, and 2005 general *baccalauréat* (which correspond to the 2005, 2006, and 2007 candidate cohorts in our sample, respectively) were 83.7%, 82.7%, and 84.3%, respectively,

[25] Moreover, testing centers typically seat students from different high schools in alphabetical order.

for all majors combined and 84.8%, 83.0%, and 84.8%, respectively, for the science majors. As noted earlier, the proportion of students successfully validating their first year at HEC is approximately 99%. These rates are very different from the 11% success rate at the HEC entrance exam. In our opinion, these differences render the entrance exam a very competitive and stressful setting, whereas the *baccalauréat* is in fact a noncompetitive exam that is relatively less stressful.

One could argue that the possibility for prep school students to be able to transfer to a university degree program without losing a year (provided that the prep school year is successfully completed) reduces the pressures involved in the HEC entrance exam. However, it should also be noted that the large salary gaps noted earlier between HEC and other business schools, let alone universities, create important economic incentives that increase the stakes for the HEC entrance exam.

While we cannot observe *baccalauréat* exam grades, our data set includes honors obtained during the high school finishing exam. Beyond providing a useful control for the ability of the candidate in the multivariate analysis of the HEC entrance exam and during the first-year courses at HEC, we use the *baccalauréat* performance to test whether, for the same cohort of students, the gender gap existed in a noncompetitive, (relatively) less stressful exam 2 years prior to the competitive entrance exam (at least for our set of candidates, who are among the best high school students in their year).

D. First-Year Core Courses at HEC

We also look at the performance of students admitted in 2005 and 2006 in their core courses in the first year of HEC when they take 11 compulsory classes that account for 44 (73.33%) of the 60 ECTS credits needed for the academic year:[26] accounting, economics, finance, marketing, law, theory of organizations, supply chain, statistics, quantitative methods, modeling with Excel, and English as a first foreign language. The first seven of these courses are worth 5 ECTS credits, statistics and quantitative methods 2.5 ECTS credits, and the last two courses 2 ECTS credits. There are also a number of elective courses worth 16 ECTS points. Since students differ in their elective course choices, we do not include the nonmandatory courses in our analysis in order to be able to have a common performance metric.

In contrast to the entrance exam or the *baccalauréat*, exam copies are not anonymously graded during the first-year courses at HEC. One could

[26] The 2007 cohort cannot be added to this analysis since the first-year curriculum was subject to a major reform that came into effect in September 2007: some of the first-year courses were moved to the second year, whereas others were given

argue that an interaction between gender and personal acquaintance could theoretically play a role in our empirical analysis of the first-year performance. However, we do not believe that this is a serious concern for two reasons. First, when performance is measured by the first-year (core course) GPA, we note that (i) there are 78 professors teaching the 11 core courses, (ii) no professor teaches all the sections of a given class in a given year, and (iii) the GPA is a weighted average of 11 courses that would largely dilute any potential bias. Second, when using the individual letter grades as the performance metric, we include year, course, and professor indicator variables in our specifications to account for differences in average grades across years, courses, and professors.

IV. Data and Descriptive Statistics

The data set used in the analysis covers 5,743 students who applied to the HEC MSc in Management program in 2005, 2006, and 2007 to take the science track of the admission exam. As part of the application process the candidates have to provide to the AEEAC official documents that attest to their identity, gender, age, nationality, and the name of the prep school they attended. Since better-ranked prep schools are more selective and since the training received by students for 2 years may influence their performance in the entrance exam, we use prep school indicator variables (i.e., fixed effects) to control for the quality of the scientific prep schools or, alternatively, the rankings of prep schools that are published in the French press. The candidates also have to provide a copy of their *baccalauréat* diploma that explicitly states the high school major, submajor, as well as any honors (but not the average grade) the student may have received during the high school graduation exam. The proprietary data set made available to us by AEEAC contains all the entrance exam marks (given out of 20) at all the written exams for all the candidates, all the marks at the oral exams for all the admissibles, and an indicator variable for the admitted. During the written (oral) exam stage, the examiners do not have access to the candidates' *baccalauréat* (and written) exam grades or honors.

Table 2 provides descriptive statistics at the different stages of the admission process for the science track candidates, admissibles, and admitted. In a first series of tests, we examine the evolution of the fraction of females through the stages of the admission exam using two-tailed binomial tests for the equality of the observed (i.e., estimated) proportions (for which, see, e.g., Siegel and Castellan [1988, 38–44]). First, we test the null hypothesis (H_0^1) that the observed proportion of females is equal to 50%.

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a smaller number of credit hours (hence fewer ECTS credits). As a result, we cannot make meaningful comparisons of first-year performance for 2005 and 2006 cohorts with that of 2007.

Table 2
Descriptive Statistics for Gender Compositions and Control Variables

	Candidates (Written Exam Sample)			Admissibles (Oral Exam Sample)			Admitted		
	Male	Female	z-Statistic	Male	Female	z-Statistic	Male	Female	z-Statistic
Gender composition: Pr(X)	.5084	.4916		.5368	.4632		.5408	.4592	
	(2,920)	(2,823)		(737)	(636)		(398)	(338)	
H_0^1: Pr(F$_i$) − .5000 = 0			−1.2800			−2.7258***			−2.2116**
			[.2006]			[.0064]			[.0270]
H_0^2: Pr(F$_i$) − Pr(M$_i$) = 0			−1.8102*			−3.8548***			−3.1277***
			[.0703]			[.0001]			[.0018]
H_0^3: Pr(F$_{candidates}$) − Pr(F$_{admissibles}$) = 0			1.8872*						
			[.0591]						
H_0^4: Pr(F$_{admissibles}$) − Pr(F$_{admitted}$) = 0						.1748			
						[.8613]			
H_0^5: Pr(F$_{admitted}$) − Pr(F$_{candidates}$) = 0									−1.6513*
									[.0987]
Baccalauréat honors (/4):									
Science majors	2.69	2.98	{−12.72}***	3.13	3.43	{−7.88}***	3.29	3.58	{−6.15}***
	(2,911)	(2,819)	[.0000]	(735)	(635)	[.0000]	(396)	(338)	[.000]
Mathematics submajors	2.72	2.99	{−10.62}***	3.14	3.41	{−6.49}***	3.28	3.58	{−5.57}***
	(2,070)	(1,958)	[.0000]	(575)	(497)	[.0000]	(321)	(266)	[.0000]
Physics and chemistry submajors	2.62	2.92	{−5.21}***	3.09	3.49	{−3.32}***	3.39	3.51	{−.71}
	(427)	(447)	[.0000]	(77)	(59)	[.0012]	(28)	(35)	[.4799]
Life sciences submajors	2.67	2.96	{−4.60}***	3.11	3.44	{−2.69}***	3.28	3.65	{−2.40}**
	(351)	(368)	[.0000]	(72)	(68)	[.0081]	(40)	(31)	[.0193]
Science prep school rank	27.62	24.75	{4.99}***	14.21	12.93	{1.80}*	11.53	10.36	{1.41}
	(2,746)	(2,656)	[.0000]	(718)	(616)	[.0722]	(391)	(327)	[.1584]
Non-French nationals (%)	5.92	9.03	{−4.48}***	4.75	8.81	{−2.96}***	5.53	9.47	{−2.01}**
	(2,920)	(2,823)	[.0000]	(737)	(636)	[.0032]	(398)	(338)	[.0453]

NOTE.—Under gender composition, five hypotheses are tested using two-tailed tests for which the z-statistics are provided. First, we test for the equality of the estimated proportions of females (Pr(F)) to .5000 for the sample of candidates, admissibles, and admitted (i.e., H_0^1: Pr(F$_i$) = .5000, where i denotes the sample of candidates, admissibles, or admitted). Second, we test for the equality of the estimated proportions of females and males in a given sample (i.e., H_0^2: Pr(F$_i$) − Pr(M$_i$) = 0, where i denotes the sample of candidates, admissibles, or admitted). Third, we test for the equality of the estimated proportions of females for the candidates with that for the admissibles (i.e., H_0^3: Pr(F$_{candidates}$) − Pr(F$_{admissibles}$) = 0). Fourth, we test for the equality of the estimated proportions of females for the admissibles with that for the admitted (i.e., H_0^4: Pr(F$_{admissibles}$) − Pr(F$_{admitted}$) = 0). Fifth, we test for the equality of the estimated proportions of females for the admitted with that for the candidates (i.e., H_0^5: Pr(F$_{admitted}$) − Pr(F$_{candidates}$) = 0). In the remainder of the table the equality of the means for the variables *baccalauréat* honors, science prep school rank, and non-French nationals is tested using a two-tailed t-test that allows for unequal variances (t-statistics are provided in braces). Test-statistic p-values are provided in brackets and sample sizes in parentheses.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

We cannot reject H_0^1 for the candidates, of which 49.16% are female.[27] In contrast, we reject H_0^1 for the admissibles (46.32%) and the admitted (45.92%) at the 1% and 5% levels, respectively. Second, we test the null hypothesis (H_0^2) that the fractions of males and females are equal at a given stage of the admission exam. There are slightly fewer female candidates (49.16) than male ones (50.84), the difference being statistically significant at the 10 level. This gender gap increases among the admissibles, where the females constitute 46.32 of the candidates retained for the oral exam compared to 53.68 for males, a difference that is statistically significant at the 1% level. This discrepancy in the gender composition persists among the admitted, of which 45.92% are female, whereas males constitute 54.08%, with H_0^2 being rejected at the 1% level. Third, we test the null hypothesis (H_0^3) that the observed fraction of females among the candidates (49.16%) is equal to that among the admissibles (46.32%): H_0^3 is rejected at the 10% level. Fourth, we cannot reject the null (H_0^4) that there is no difference in the estimated proportions of females among the admissibles (46.32%) versus the admitted (45.92%). Finally, we observe that the null hypothesis (H_0^5) of the equality of the observed fraction of females between the admitted (45.92%) and the candidates (49.16%) is rejected at the 10% level, in line with the rejection of H_0^3 and the nonrejection of H_0^4. These binomial tests of the equality of estimated proportions suggest that the proportion of females decreases following the written stage and stays roughly constant during the oral stage.

In table 2, in a second series of tests, we examine the gender differences in honors obtained at the *baccalauréat* exam for the candidates, the admissibles, and the admitted.[28] There are three types of honors in the *baccalauréat*, with grades between 10 and 12 (out of 20) corresponding to *passable* (i.e., a simple pass with no distinctions), grades between 12 and 14 to *assez bien* (the equivalent of cum laude), grades between 14 and 16 to *bien* (the equivalent of magna cum laude), and grades above 16 to *très bien* (the equivalent of summa cum laude). We code the *baccalauréat honors* variable as 1, 2, 3, or 4 when the *baccalauréat* has been successfully obtained with a simple pass or with honors that are the equivalent of cum laude, magna cum laude, or summa cum laude, respectively. On average, women perform much better than men at the *baccalauréat* exam. Female candidates' *bacca-*

[27] The proportion of science track female candidates in our sample is higher than that observed in the comparable population of students in the final year of high school: in the 2003 (2004, 2005) cohorts of high school science majors that correspond to the cohorts of candidates in our sample, of the 159,673 (156,814, 161,396) students who sat for the science track *baccalauréat* exam, 44.6% (44.7%, 45.2%) were female. Of the 135,374 (130,225, 136,877) students who succeeded and obtained a science major *baccalauréat* diploma in 2003 (2004, 2005), 46.2% (46.3%, 46.6%) were female (http://www.education.gouv.fr/stateval).

[28] Unfortunately, we do not have the candidates' average *baccalauréat* grades, which would have permitted more precise tests.

lauréat honors average is 2.98 out of 4, whereas the men's average is 2.69, and the 0.29 difference between the two groups is statistically significant at the 1% level in a two-tailed *t*-test. Moreover, the same observation is made when examining the *baccalauréat* performance differences for the admissibles and the admitted. Among the admissibles, females' average *baccalauréat* honors of 3.43 is 0.30 points higher than that of males, whereas among the admitted, the females' average *baccalauréat* honors of 3.58 is 0.30 points higher than that of males. In both cases, the difference is statistically significant at the 1% level in two-tailed *t*-tests.

In the next section in table 2 we check whether the results for the *baccalauréat* honors still hold if we consider separately the different submajors (mathematics, physics and chemistry, or life sciences) that science majors can specialize in as seniors in high school. We observe that for different science submajors, females' *baccalauréat* honors is always statistically higher than that of males for candidates, admissibles, and admitted categories (see under *baccalauréat* honors in table 2). The only exception is the group of admitted physics and chemistry submajors, where the females' higher honors average (3.51/4.00) is not statistically different from that of males (3.39/4.00).[29] Overall, these results indicate that female candidates, admissibles, and admitted do significantly better in the French high school finishing exam than their respective male counterparts. We reexamine this discrepancy in a multivariate setting below in Section V.B.

We also compare the average *baccalauréat* honors for candidates for the HEC entrance exam with the one that we calculated for the population of science majors taking the high school finishing exam 2 years prior to our sample cohort-years. Unsurprisingly, HEC candidates are much more successful than the general population of students taking the regular *baccalauréat* exam (i.e., excluding students taking technology or vocational *baccalauréat* exams). For 2003, 2004, and 2005, the years in which the 2005, 2006, and 2007 cohorts in our sample took the scientific versions of the high school finishing exam, the females' average *baccalauréat* honor was 1.75 out of 4 (compared to 2.98 in our sample), whereas that of males was 1.64 (compared to 2.69 in our sample). It should be noted that even the candidates who are eliminated after the first-round (written) exams have much higher *baccalauréat* performance: for this group the *baccalauréat* honors average is 2.84 for females and 2.55 for males. These statistics suggest that the benchmark group in the HEC entrance exam has much higher academic abilities than the general population of students obtaining the *baccalauréat*.[30]

[29] These tests are also less precise given the lower number of observations involved (63 and 71, respectively).

[30] Note that the actual *baccalauréat* performance gap between the HEC candidates and the population of science track majors in high school is even larger, since the averages that we report here do not take into account the fact that 15% of high school seniors fail the high school graduation exam.

In the second to last row in table 2, we look at prep school rankings and any differences that may exist in this dimension across genders at various stages of the entrance contest. There are 236 institutions in our initial sample that offered a business *grande école* prep school program, all types of tracks (science, economics, and literature) combined. Of these, 91 that provided a science track prep school were ranked (*La Lettre de L'Etudiant* 2006).[31] We coded the ranked prep schools in decreasing order; that is, the top-ranked institution is coded 1 and the last-ranked is coded 91. Out of 5,743 candidates in our data set, 5,396 (93.96%) had attended one of these 91 ranked institutions. The ranking variable was coded 92 for the 219 candidates attending one of the 27 nonranked science track prep schools and as 93 for the 128 candidates for whom no prep school name is provided. The average prep school ranking for the male candidates is 27.62 compared to 24.75 for females, the difference being statistically significant at the 1% level in a two-tailed t-statistic. In other words, female candidates attend better-ranked prep schools than males, on average. If anything, this almost three-position higher rank potentially gives an advantage to females given the fact that candidates coming from a top 20 prep school are more successful in entering HEC: 49.26% of the candidates attended a top 20 prep school, compared to 78.59% of the admissibles and 86.28% of the admitted. In table 2, the higher average prep school ranking of females persists among admissibles (12.93 for females vs. 14.21 for males) and the admitted (10.36 for females vs. 11.53 for males), but the observed difference is only marginally statistically significant for the admissibles (at the 10% level) but not statistically significant for the admitted.

In the last row of table 2, we also examine the proportion of non-French among the candidate pool since the entrance exams, with the exception of foreign languages, are conducted in French. Non-French make up 7.45% of the candidates, compared to 7.34% of the admitted (not reported in table 2). The observed 0.11% difference is not statistically different from zero. The non-French male-to-female ratio remains similar at different stages of the entrance exam. The percentage of female non-French candidates is 9.03% versus 5.92% for males (the difference is statistically significant at the 1% level in a two-tailed t-test), whereas among the admitted the percentage of non-French females is 9.47% versus 5.53% for the males (the difference is statistically significant at the 5% level). Even though being non-French does not appear to affect the proportion of females or the chances of becoming admitted, we nevertheless account for it in our multivariate analysis in order to control for the possibility that differences in written and oral expression skills between native (mother tongue) and nonnative French speakers may have an effect on exam performance.

[31] Different prep school rankings are published in various French newspapers and magazines. We use the most comprehensive ranking list.

Restricting ourselves to science majors in high school does not necessarily guarantee homogeneity in gender composition. Science submajors may have different gender compositions if, for example, males are more likely to choose mathematics or physics and chemistry submajors while females are more likely to choose life sciences (biology and geology). In table 3, we document the gender composition of the three science subspecialties in the *baccalauréat* that form 98.10% of our sample: mathematics, physics and chemistry, and life sciences (biology and geology) submajors, which represent 70.30%, 15.25%, and 12.55% of our sample, respectively.

First, we use a two-tailed binomial test for the equality of the observed (i.e., estimated) proportions to check whether there are statistically significant differences in the gender composition of submajors and present the results in brackets in column 3 of table 3. The proportion of male candidates in the mathematics submajor (51.39%) is higher than that of females (48.61%), a difference that is statistically significant at the 5%

Table 3
Gender Composition of Candidates with a Science *Baccalauréat* by Submajor in High School

High School Science Major by Submajor	Number of Males (1)	Number of Females (2)	H_0: Pr(Male) − Pr(Female) = 0 (3)	Submajor Total (4)
Mathematics	2,070	1,958		4,028
	(71.11)	(69.46)	(1.3684)	(70.30)
	[51.39]	[48.61]	[2.4957]**	
Physics and chemistry	427	447		874
	(14.67)	(15.86)	(−1.2507)	(15.25)
	[48.86]	[51.14]	[−.9567]	
Life sciences (biology and geology)	351	368		719
	(12.06)	(13.05)	(−1.1385)	(12.55)
	[48.82]	[51.12]	[−.8966]	
Engineering and agronomy	47	16		63
	(1.61)	(.57)	(3.7996)***	(1.12)
	[74.60]	[25.40]	[5.5234]***	
Other majors in science track in admission exam	16	30		46
	(.55)	(1.06)	(−2.1821)**	(.78)
	[34.78]	[65.22]	[−2.9192]***	
Total	2,911	2,819		5,730
	(100.00)	(100.00)		(100.00)

NOTE.—This table provides information on the gender composition for the 5,730 candidates with a science background that form the main sample by submajors that they have chosen in high school. In cols. 1, 2, and 4, numbers in parentheses are percentages with respect to the total at the bottom of each column, whereas the numbers in brackets are percentages with respect to the submajor total on the left of each row; in col. 3, numbers in parentheses and brackets are the corresponding two-tailed binomial test statistics for the null hypothesis that col. 1 minus col. 2 difference equals zero.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

level. While the proportion of female candidates is higher for physics and chemistry and life sciences submajors, the observed differences for the latter two groups are not statistically significant. Second, always using a two-tailed binomial test, we check for the equality of the observed proportions of males and females in different submajors as a percentage of the total number of males and females in the overall sample, respectively. The results are reported within parentheses in table 3. We find that the ratio of males with a submajor in mathematics to the total number of males (71.11%) is slightly higher than that of females (69.46%), a difference that is not statistically significant. We also find that the proportion of males with a submajor in physics and chemistry (life sciences) with respect to the total number of males, which is 14.67% (12.06%), is lower than that of females, which is 15.86% (13.05%). These differences are not statistically significant either. We also conduct these two sets of proportionality tests for the engineering and other nonspecified submajors and find statistically significant differences. However, these two subsamples form less than 2% of our sample and hence are unlikely to have a major influence on our results. Finally, we conduct a Kolmogorov-Smirnov (KS) equality-of-distributions test after coding a mathematics submajor as 1, physics and chemistry as 2, life and earth sciences as 3, and so forth (for the KS test, see, e.g., Siegel and Castellan [1988, 144–51]). We obtain a KS test statistic of 0.0165 with a p-value of .829: when the whole distribution is taken into account, the KS test does not reject the null hypothesis that the science submajors' frequency distributions for males and females are equal, a result that is not surprising given the previous set of proportion test results.

Despite the test results in table 3, we nevertheless control for potential differences in the gender composition of the different submajors (i) by including submajor indicator variables in our multivariate regressions and (ii) by reestimating our multivariate specifications for the different submajors (these last regressions are reported in the online appendix). Next, we focus on the differences in entrance exam performance between males and females using univariate tests and multivariate regressions.

V. Gender Differences in Performance

A. Univariate Analysis

To test whether there are any differences in performance between genders, we start by conducting a series of parametric and nonparametric univariate tests. First, we examine the overall (weighted-average) written and oral exam grades. Second, for the same sample, we test for differences in performance during the *baccalauréat* and first year of HEC. Third, we explore if the differences that we observe may be driven by potential differences in affinity toward mathematics across genders by examining mathematics and nonmathematics grades.

In table 4, we present two-tailed test results for the equality of the medians, means, variances, and distributions as well as the frequency distributions for the HEC weighted-average entrance exam grades. Tests of central tendencies for the written and oral exams (panels A and B of table 4) provide weak evidence that males may be outperforming females. The median of the written (oral) exam grades for males is 10.69 (10.69) compared to 10.52 (10.54) for females. The null hypothesis of the equality of the medians across genders is rejected in a nonparametric test for the equality of the medians for the written exam but cannot be rejected for the oral exam.[32] The mean written (oral) exam score for males is 10.66 (10.70) compared to 10.58 (10.56) for females; the null hypotheses of the equality of the means across genders cannot be rejected in two-sided t-tests for either type of exam.[33]

Since the entrance exam selects admissibles and admitted using ranking-based cutoffs in the upper tails of the written and oral exams, respectively, we focus our attention on the frequency distributions of the exam grades. When we use a nonparametric KS test, the equality of the frequency distributions is rejected for the written exams score at the 10% level but not rejected for the oral exams. Eyeballing different percentiles of the data reported in panels A and B of table 4, we observe that, compared to the frequency distributions of grades for the women, the men's frequency distributions have fatter right tails in the written and oral exams starting with the medians of these distributions (see further below in this section for a formal statistical test of stochastic dominance). These findings suggest that any acceptance rule that sets a threshold above the median would lead to a higher percentage of men among the admissibles and the admitted.

These observed differences in performance across genders in the univariate setting may be due to potential differences in mathematics affinity across genders (for a discussion, see Niederle and Vesterlund [2010]). To check for this possibility, we repeat the tests described above for the mathematics and nonmathematics parts of the written and oral exams separately (using the weights of table 1 to calculate weighted averages).

Results are presented in panels C and D of table 4. For the written mathematics exams, we observe a higher median and mean for males and fatter tails that lead to statistically significant differences in frequency distribution and variance tests (all test results are statistically significant at the 1% level); for the written nonmathematics exams, we reject the equality of the distributions at the 10% level and the equality of the variances at the 1% level, but we cannot reject the equality of the means or medians. For the oral exams, the two-sided t-test for the null hypothesis of the

[32] See Siegel and Castellan (1988, 124–28) for a description of this test.

[33] The Wilcoxon-Mann-Whitney test (e.g., Siegel and Castellan 1988, 128–37), the nonparametric equivalent of a t-test, rejects the equality of the means for the written test at the 10% level.

Table 4
Descriptive Statistics on HEC Entrance Exam Performance

	A. Written Exam: Overall Grade		B. Oral Exam: Overall Grade		C. Written Exam				D. Oral Exam			
					Math Exam		Nonmath Exams		Math Exam		Nonmath Exams	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Observations	2,889	2,810	735	636	2,889	2,810	2,889	2,810	735	636	735	636
Median	10.69	10.52	10.69	10.54	10.79	10.30	10.49	10.54	10.00	10.00	11.48	11.52
Median test	3.79**		1.50		9.53***		.36		1.79		.01	
Mean	10.66	10.58	10.70	10.56	10.92	10.58	10.52	10.58	10.47	9.93	11.64	11.64
t-test	1.28		1.31		3.01***		−1.26		2.62***		.05	
WMW rank-sum test	1.64*		1.19		3.04***		−.66		2.27**		.02	
KS test (D-statistic)	.04*		.06		.05***		.03*		.05		.04	
1st percentile	4.76	5.66	6.47	6.33	1.83	2.27	5.56	6.07	3.00	1.00	6.84	6.92
5th percentile	6.62	6.98	7.36	7.47	3.69	4.02	6.94	7.40	4.00	4.00	7.92	8.16
10th percentile	7.38	7.61	8.14	8.15	5.00	5.40	7.69	8.09	6.00	5.00	8.48	8.76
25th percentile	8.87	8.90	9.22	9.22	7.71	7.55	9.04	9.18	8.00	7.00	9.92	10.08
50th percentile	10.69	10.52	10.69	10.54	10.79	10.30	10.49	10.54	10.00	10.00	11.48	11.52
75th percentile	12.42	12.20	12.03	11.86	14.15	13.55	11.99	12.00	13.00	13.00	13.40	13.32
90th percentile	13.88	13.61	13.36	13.08	17.06	16.24	13.33	13.21	16.00	15.00	14.88	14.56
95th percentile	14.76	14.33	14.08	13.86	18.47	17.75	13.93	14.00	17.00	16.00	15.56	15.32
99th percentile	16.03	15.78	15.42	14.94	20.00	19.68	15.12	15.19	19.00	18.00	17.04	16.64
Standard deviation	2.49	2.28	2.03	1.91	4.41	4.09	2.13	2.00	3.90	3.76	2.37	2.22
Variance test	1.19***		1.13		1.16***		1.14***		1.08		1.15*	

Note.—All tests are two-tailed. The null hypothesis for the nonparametric median test is the equality of the medians across genders. The null hypothesis for the t-test is the equality of the means across genders allowing for unequal variances. The Wilcoxon-Mann-Whitney (WMW) rank-sum test is the nonparametric equivalent of the t-test. The null hypothesis for the variance test is that the ratio of variances is equal to one. The null hypothesis for the nonparametric Kolmogorov-Smirnov (KS) test is the equality of distributions.
* $p < .10$.
** $p < .05$.
*** $p < .01$.

equality of the means is rejected only for the oral mathematics exam. These results indicate that we need to repeat our multivariate analyses for the mathematics and nonmathematics performance metrics to rule out the possibility that any difference that we may observe is driven by differences in mathematics affinities across genders.

While the tests described above help us understand differences in various characteristics of performance metrics, they cannot help answer whether the distribution of males' performance dominates that of females in the sense of first-order stochastic dominance (FOSD). To answer this question, we use the KS-type FOSD test proposed by Barrett and Donald (2003).[34] This test allows us to check for FOSD even when the test variable takes on a limited number of values (as in the case of the *baccalauréat* honors or the letter grades during the first year of HEC) and when the sample sizes differ across males and females.

Weak FOSD is formally defined as follows: given $\mathrm{M}(x)$ and $\mathrm{F}(x)$, the CDF for a variable x for males and females, respectively, M weakly dominates F in the FOSD sense if $\mathrm{M}(x) \leq \mathrm{F}(x)$ for any x. A rejection of the null hypothesis H_0: $\mathrm{F}(x) \leq \mathrm{M}(x)$ (in col. 1 of table 5) combined with a failure to reject H_0': $\mathrm{M}(x) \leq \mathrm{F}(x)$ (in col. 2 of table 5) would suggest that males' performance weakly dominates that of females in an FOSD sense, while the converse finding would suggest that females' performance weakly dominates that of males. A failure to reject both null hypotheses would suggest that $\mathrm{F}(x)$ and $\mathrm{M}(x)$ cannot be ranked in the FOSD sense.

We observe that in the written exam, the performance of males dominates that of females in the FOSD sense: in row 1 of table 5 we reject H_0 ($\mathrm{F}(x) \leq \mathrm{M}(x)$) but we cannot reject H_0' ($\mathrm{M}(x) \leq \mathrm{F}(x)$). Similarly, the test results presented in row 2 of table 5 indicate that during the first stage of the entrance exam, males' mathematics performance dominates that of females in the FOSD sense. In contrast, the tests of row 3 indicate that females' nonmathematics performance dominates that of males in the FOSD sense. These results indicate once more that we need to repeat our multivariate regressions for the mathematics and nonmathematics parts of the entrance exam separately.

Interestingly, these results do not extend to the oral stage of the entrance exam, where the CDFs for the performance of males and females cannot be ranked in the FOSD sense: in rows 4, 5, and 6 of table 5, neither of the two null hypotheses H_0 and H_0' can be rejected. In other words, during the oral exams, neither group dominates the other one in an FOSD

[34] Their approach has the advantage of avoiding the problem of test inconsistency by comparing cumulative distribution functions (CDFs) of the test variable across the two groups on a continuous basis (instead of a fixed number of arbitrary points, say 5 or 10 as in Anderson [1996] or Davidson and Duclos [2000]). To conduct the Barrett and Donald (2003) test, we use the GAUSS codes available on Garry Barrett's website: http://www.economics.unsw.edu.au/GarryBarrett.

sense when using global or mathematics versus nonmathematics performance metrics. Of course, this conclusion is obtained in a univariate setting and need not hold in a multivariate setting, something we focus on in Section V.B below.

Next, using the same cohorts of students, we conduct FOSD tests using academic performance metrics before and after the entrance exam. Row 7 of table 5 presents FOSD test results for *baccalauréat* honors. We observe a nonrejection of the null hypothesis in column 1 together with a rejection in column 2 at the 1% level. This suggests that science major female candidates' performance at the end of high school as measured by *baccalauréat* honors dominates that of men in the FOSD sense.

We revisit the potential concern that differences in *baccalauréat* performance may, at least in part, be driven by potential differences in mathematics ability across genders, which is likely to be reflected in the submajor choices. In rows 8, 9, and 10 of table 5, we repeat the same FOSD tests for the three largest categories of science submajors (mathematics, physics and chemistry, and life sciences). We find that the females' *baccalauréat* performance continues to dominate that of males for all the science submajors at the 1% significance level, which suggests that females' superior performance during the *baccalauréat* does not appear to be driven by implicit differences in gender distributions across submajors.

We also provide FOSD tests of performance during core courses in the first year of HEC when the admitted take 11 compulsory classes. To increase the power of our tests, we use letter grades obtained in all compulsory first-year courses (5,046 observations) rather than students' GPAs (459 observations).[35] Results provided at the bottom of table 5 indicate that women's performance dominates that of men in the FOSD sense: in row 11 we cannot reject H_0, but we reject H_0', albeit at the 10% level. Then, we repeat weak FOSD tests after splitting the 11 first-year courses into two groups: five mathematics-oriented courses (economics, finance, quantitative methods, statistics, and supply chain management) and six nonmathematics-oriented courses (accounting, business law, English as a first foreign language, marketing, modeling with Excel, and theory of organizations). For the mathematics-oriented classes (row 12 of table 5), we cannot reject either H_0 or H_0'. In contrast, for the nonmathematics-oriented classes (row 13), we cannot reject H_0 while we reject H_0' at the 1% level: females weakly dominate males in the FOSD sense in the nonmathematics courses during the first year. In row 14 of table 5 we obtain a similar, albeit weaker, result with the subsample of students who were a mathematics submajor in

[35] All of the 459 first-year students (with a science background) in our sample (226 in 2005 and 233 in 2006) took the 11 core courses. However, we have 5,046 letter grade observations, rather than 5,049 ($= 459 \times 11$), because three letter grades are missing in our data. In our empirical analysis, we do not take into account the differences in ECTS credits across these 11 courses when using letter grades.

Table 5
Tests of First-Order Stochastic Dominance

	H_0: $F(x) \leq M(x)$ (1)	H_0': $M(x) \leq F(x)$ (2)
HEC entrance exam:		
1. Written exams: overall grade (weighted average)	1.3279**	1.0171
	(.0294)	(.1263)
	[males: 2,889]	[females: 2,810]
2. Written math exams (weighted average)	1.7470***	.7246
	(.0022)	(.3499)
	[males: 2,889]	[females: 2,810]
3. Written nonmath exams (weighted average)	.5704	1.2865**
	(.5217)	(.0365)
	[males: 2,889]	[females: 2,810]
4. Oral exams: overall grade (weighted average)	1.0203	.2657
	(.1247)	(.8683)
	[males: 735]	[females: 636]
5. Oral math exam	.9705	.0000
	(.1520)	(1.000)
	[males: 735]	[females: 636]
6. Oral nonmath exams (weighted average)	.5728	.6708
	(.5188)	(.4065)
	[males: 735]	[females: 636]
Baccalauréat honors:		
7. Science major	.0000	5.0031***
	(1.0000)	(.0000)
	[males: 2,911]	[females: 2,819]
8. Science major, mathematics submajor	.0000	4.1480***
	(1.0000)	(.0000)
	[males: 2,070]	[females: 1,958]
9. Science major, physics and chemistry submajor	.0000	2.1001***
	(1.0000)	(.0001)
	[males: 427]	[females: 447]
10. Science major, life sciences submajor	.0000	1.8965***
	(1.0000)	(.0007)
	[males: 351]	[females: 368]
HEC first-year letter grades:		
11. All letter grades combined and all submajors combined	.0000	1.1926*
	(1.0000)	(.0582)
	[males: 2,767]	[females: 2,279]
12. First-year letter grades for mathematics-oriented classes	.0041	.9997
	(.9999)	(.1355)
	[males: 1,262]	[females: 1,048]

Table 5 (*Continued*)

	H_0: F(x) ≤ M(x) (1)	H'_0: M(x) ≤ F(x) (2)
13. First-year letter grades for nonmathematics-oriented classes	.0000	1.9395***
	(1.0000)	(.0005)
	[males: 1,505]	[females: 1231]
14. First-year letter grades for mathematics submajors	.0000	1.0917*
	(1.0000)	(.0922)
	[males: 2,288]	[females: 1818]
15. First-year letter grades for physics and chemistry submajors	.1273	.1487
	(.9681)	(.9567)
	[males: 185]	[females: 241]
16. First-year letter grades for life sciences submajor	.0123	.5375
	(.9997)	(.5611)
	[males: 228]	[females: 178]

Note.—This table presents the results of (weak) first-order stochastic dominance (FOSD) tests of Barrett and Donald (2003). H_0: F(x) ≤ M(x) (H'_0: M(x) ≤ F(x)) corresponds to the null hypothesis that females' (males') performance weakly first-order stochastically dominates that of males (females). A rejection of H_0 combined with a failure to reject H'_0 suggests that males' performance dominates that of females in an FOSD sense. p-values are provided below test statistics within parentheses; sample sizes are within brackets. GAUSS codes for the FOSD tests are obtained from http://www.economics.unsw.edu.au/GarryBarrett.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

high school: we cannot reject H_0, but we reject H'_0 at the 10% level. When we repeat the FOSD tests with the physics and chemistry (row 15) or life sciences (row 16) submajors, we fail to reject both hypotheses. We conclude that the women's FOSD results during HEC's first year are driven by the mathematics submajors in high school, but through their nonmathematics-oriented classes.

Given the HEC entrance selection process, these results provide a first insight. The distribution of male candidates' written-exam scores has a right tail that is fatter than that of female candidates. Since roughly only the top quartile of candidates are admitted to the oral exam stage, a larger percentage of men become admissible than women. This result contrasts with those obtained for the (noncompetitive) *baccalauréat* exam: (the same) women in our sample did significantly better than the same men in the *baccalauréat* exam (in terms of high school graduation honors), irrespective of whether they were candidates or admissibles or were eventually admitted. In other words, the women who did relatively worse than men in the top quartile for the HEC entrance contest, which roughly corresponds to the admissibles, actually did better than the same men at the *baccalauréat* exam. When examining the written exam scores, we observe that the male candidates have performed better in mathematics than females, with the roles reversed for nonmathematics-related exams. Once the selection is made and the top quartile of candidates becomes the admissibles, this observed performance difference disappears in the oral exam setting.

These univariate tests do not allow us to control for the observable characteristics of the candidates, which may explain part or all of the observed variation in performance across males and females. As a result, in the next subsection we conduct a series of tests using multivariate regressions that also have the advantage of absorbing the residual variance, which allows for more precise estimates of the differences across genders.

B. Multivariate Regression Analysis

Because we would like to examine how the observed difference varies at the tails of the distribution for our academic performance metrics, we use quantile regressions with bootstrapped standard errors (obtained with 5,000 replications) that are simultaneously estimated for different percentiles. We limit ourselves to the 10th, 25th, 50th, 75th, and 90th percentiles because (i) they are commonly used in the literature and (ii) the 75th percentile of candidates (top 1,420 observations) approximately corresponds to the admissibles (1,371 observations) whereas the 90th percentile of candidates (top 570 observations) very roughly approximates the admitted (736 observations).

We include a number of indicator ("dummy") variables (preceded by *D_*) in our specifications to control for the various characteristics of candidates. First, we control for potential differences in the grading distributions across the 3 years in our data using indicator variables for years 2006 and 2007 (*D_2006* and *D_2007*).[36] Second, we account for the fact that non-French candidates' performance may be affected in a series of exams conducted in French through the indicator variable *D_non-French*. Third, we control for the science submajor chosen during the last year of high school using the indicator variables *D_mathematics_submajor*, *D_physics_and_chemistry_submajor*, and *D_life_sciences_submajor*. Fourth, we account for the academic ability of the candidates using indicator variables for any honors they have received during the *baccalauréat*: *D_cum_laude*, *D_magna_cum_laude*, and *D_summa_cum_laude*. Finally, we account for the quality of the 2-year preparation that the candidate followed prior to taking the entrance exam through indicator variables for the individual prep schools. These prep school "fixed effects" (whose coefficients are not reported to conserve space) allow us to control for the unobservable quality of all the prep schools, including the quality of the nonranked ones.[37] They also allow us to implic-

[36] The year dummies would account for the changes in the quantiles of the grading distributions across the years for both genders. We have no reason to suspect that the potential changes in grading standards would evolve differently for each of the genders.

[37] In alternative specifications we used the logarithm of the prep school ranking, which cannot take into account the quality of the nonranked institutions as these latter are given the same rank. The resulting estimates (which are reported in the

itly control for the unobservable academic abilities of the candidates, albeit at the prep school level, that would have played a part in these institutions' admission decisions. Following the inclusion of all the indicator variables mentioned above, the constant term picks up the average grade for the omitted group, which includes French males who were not in one of the three most prestigious science submajors in high school, who did not receive any honors during the 2005 *baccalauréat*, and who did not attend a prep school to prepare for the entrance exam. Given the focus of our study, *D_female* is our test variable. For the oral exam performance regressions, we also use all the grades obtained in the individual written exams, as well as their squared values, in order to be able to extract the maximum amount of information from the data that are at our disposal.

Regression results in which the overall written exam score is the dependent variable are presented in table 6. First, we focus on the 50th percentile (the median regression) column to get a sense of the coefficient estimates for the various indicator variables included in our specification. The coefficient estimates for *D_2006* and *D_2007* are 0.7954 and 0.9799, respectively, and are statistically significant at the 1% level, suggesting that there are differences in the performance and/or grading of the candidates across the years. As we expected, the non-French tend to do less well (the coefficient estimate, which is statistically significant at the 1% level, is equal to −0.4711). There are no discernible differences in the performance of the candidates coming from different science submajors in high school (namely, mathematics, physics and chemistry, and life sciences) compared to the excluded group. We observe that the *baccalauréat* honors are very good predictors of performance at the HEC entrance exam: compared to students with no honors, students with a cum laude obtain an average grade 0.8994 points higher (out of 20), those with magna cum laude 1.5976 points higher, and those with summa cum laude 2.5888 points higher, all of which are statistically significant at the 1% level. To put these coefficient estimates into perspective, we note that the written exam threshold for a candidate to become admissible was 11.64 (out of 20) in 2005, 12.58 in 2006, and 12.76 in 2007, with the highest overall written exam grade obtained being 16.99 in 2005, 17.47 in 2006, and 18.30 in 2007. These findings for the median regression generally extend to the quantile regressions for the 10th, 25th, 75th, and 90th percentiles, with the exception of (i) mathematics submajors whose performance is higher only in the regression for the 10th percentile (albeit statistically significant at the 10% level) and (ii) non-French candidates whose performance is worse than that of the French candidates (coefficient estimates are negative and statistically significant) in the regressions for the 10th and 25th percentiles, but not in the regressions for the 75th and 90th percentiles.

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online appendix to conserve space) are not materially different from the ones we report.

Table 6
Performance in the Written Exam (First Stage of the Entrance Exam)

	Percentile				
	10th	25th	50th	75th	90th
Constant	3.6483***	3.9600***	5.1538***	6.6423***	8.5749***
	(.4635)	(.3744)	(.4994)	(.4828)	(.7569)
*D*_2006	.7593***	.8100***	.7954***	.8033***	.8004***
	(.1027)	(.0827)	(.0820)	(.0962)	(.1138)
*D*_2007	.8300***	.9200***	.9799***	1.0180***	.9404***
	(.1084)	(.0876)	(.0794)	(.0927)	(.1176)
*D*_female	−.1357	−.2562***	−.3488***	−.5153***	−.6646***
	(.0873)	(.0728)	(.0634)	(.0767)	(.0940)
*D*_non-French	−.4823***	−.4105**	−.4711***	−.2937	−.2448
	(.1845)	(.1618)	(.1342)	(.1875)	(.2558)
*D*_mathematics_submajor	.6330*	.4835	.1546	.1080	.3444
	(.3361)	(.2955)	(.2869)	(.2743)	(.2112)
*D*_physics_and_chemistry_submajor	.1960	.0852	−.3354	−.4367	−.1567
	(.3533)	(.3044)	(.2957)	(.2819)	(.2388)
*D*_life_sciences_submajor	.2297	.0625	−.1342	−.0700	.0678
	(.3566)	(.3098)	(.2995)	(.2861)	(.2493)
*D*_cum_laude	.5747***	.8833***	.8994***	.8223***	.7611***
	(.1922)	(.1343)	(.1759)	(.1912)	(.2175)
*D*_magna_cum_laude	1.2200***	1.5917***	1.5976***	1.4490***	1.5257***
	(.1880)	(.1374)	(.1822)	(.1950)	(.2239)
*D*_summa_cum_laude	2.1303***	2.5487***	2.5888***	2.3780***	2.5923***
	(.2128)	(.1587)	(.1929)	(.2094)	(.2455)
Prep school fixed effects	Yes				
Observations	5,635				
Pseudo-R^2	.2594	.2609	.2652	.2499	.2420

Note.—This table presents quantile regression models that are simultaneously estimated, where the dependent variable is the weighted average of written exam grades, with subject matter weights as detailed in table 1. Indicator variables are preceded by the prefix *D*_. The regression model includes prep school fixed effects (not reported). Bootstrap standard errors (presented within parentheses below the coefficient estimates) are obtained with 5,000 replications.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

For our test variable, results in table 6 show that the coefficient estimate for the D_female variable is −0.1357 in the regression for the 10th percentile, −0.2562 for the 25th percentile, −0.3488 for the 50th percentile, −0.5153 for the 75th percentile, and −0.6646 for the 90th percentile, all of which are statistically significant at the 1% level except the first one, which is not statistically significant.[38] Hence, after controlling for the potential differences in grading and/or cohorts' ability across the years, candidates' affinity for mathematics (indirectly, through the high school submajor indicator variables), candidates' academic ability (directly using the *baccalauréat* honors they received 2 years ago as well as indirectly using the prep school fixed effects), and whether they hold French nationality or not, we find that women, on average, do worse than men in the written exam in the regressions for the 25th, 50th, 75th, and 90th percentiles.

To get a sense of the economic significance of the observed difference for the females, we look at the effect of hypothetically adjusting the threshold for admission for the females. In this exercise we recalculate the proportion of females among the admissibles after decreasing the year-specific written exam threshold to become admissible by 0.3488 (the coefficient estimate for D_female in the quantile regression for the median) and after applying this hypothetical threshold to females alone. As a result of this exercise, which is admittedly unfair to males, the proportion of females among the admissibles increases from 46.32% to 50.64%, suggesting that the effects we observe are economically nonnegligible. Another way to argue for the economic significance for the underperformance is to note that females with no honors would need to have cum laude honors compared to males with no honors in order to be able to compensate for their lower performance during the written exam.[39]

We conclude that the results of table 6 corroborate those obtained in univariate tests: in the written exam, women underperform men in the regressions at the 25th, 50th, 75th, and 90th percentiles of the performance distribution, while there is no statistically significant performance difference between the two genders at the 10th percentile regression. We should note that while women outperform men in the lower tail of the written exam average in a univariate setting (e.g., at the 10th percentile of the distribution in table 4), we find no such difference in a multivariate setting (the coef-

[38] In an alternative specification, which uses the logarithm of prep school rank instead of prep school fixed effects, we obtain quantitatively similar results. These estimates are reported in app. table A1.

[39] That said, obtaining cum laude honors would overcompensate for the females' underperformance given that the positive coefficient estimate in table 6 for D_cum_laude is larger than the negative coefficient estimate for D_female. For example, in the regression for the 50th percentile regression, the coefficient estimate for D_female is equal to −0.3488 whereas the coefficient estimate for D_cum_laude is equal to 0.8994 (both of them statistically significant at the 1% level).

ficient estimate for D_female, which is equal to −0.1357, is not statistically significant). These findings suggest that it is important to control for the observable characteristics of the candidates before reaching any conclusions.

Next, we explore whether our findings of lower performance for females in the written exam might be driven by differences in performance in the mathematics versus nonmathematics tests, for two reasons. First, the univariate test results reported in tables 4 and 5 suggest that there are performance differences between genders across the written mathematics versus nonmathematics exams. Given that mathematics grades account for one-third of the written entrance exam's total score for the science track candidates (see table 1), we would like to rule out the possibility that our results are actually driven by the mathematics scores. Second, there appear to be differences across genders in perceptions of own abilities in scientific and nonscientific fields (see, e.g., Niederle and Vesterlund [2010] for a discussion).[40] To examine whether potential mathematics affinity differences across genders play a role, we run the same quantile regressions separately for the mathematics and nonmathematics parts of the written exam, using their respective weighted-average exam scores. Results are reported in tables 7 and 8, respectively. For the written mathematics and nonmathematics exams, results are qualitatively similar to those obtained in table 6 using the overall written exam performance. Focusing on our test variable, D_female, for the weighted-average score of the two mathematics exams taken during the first stage, we find that the coefficient estimate in table 7 is equal to −0.1267 for the regression at the10th percentile, −0.3877 at the 25th percentile, −0.7830 at the 50th percentile, −1.1051 at the 75th percentile, and −1.2504 at the 90th percentile. All these coefficient estimates are statistically significant at the 1% level except that for the 10th percentile, which is not statistically significant. Importantly, we observe a similar pattern in table 8 for the nonmathematics exams' weighted-average score with all the written exams except the two mathematics exams. The coefficient estimate for D_female is equal to −0.0632 for the regression for the 10th percentile, −0.1453 for the 25th percentile, −0.2242 for the 50th percentile, −0.2747 for the 75th percentile, and −0.2968 for the 90th percentile. These estimates are all statistically significant (at the 5% or 1% level) except for the 10th percentile regression. Together, these results indicate that the performance difference that we observe for females in table 6 for the global written exam

[40] For example, Beyer (2002) finds differences in self-valuation between men and women in a mathematics test but no difference in an English test or in a history and geography test. Similarly, Beyer et al. (2004) provide evidence that female undergraduate students majoring in management information systems underestimate their ability to a greater extent than do male students, while Beyer, Rynes, and Haller (2004) find that women have lower confidence levels than men in their ability in computer sciences.

Table 7
Performance in the Written Mathematics Exams

	Percentile				
	10th	25th	50th	75th	90th
Constant	−.8088	−.0401	2.3261***	5.2027***	7.5724***
	(.5593)	(.6712)	(.8132)	(1.1866)	(1.1572)
*D*_2006	1.0891***	1.1576***	1.2403***	.9194***	.8625***
	(.1795)	(.1479)	(.1587)	(.1854)	(.1957)
*D*_2007	1.0900***	1.4165***	1.6309***	1.4416***	1.4384***
	(.2031)	(.1541)	(.1541)	(.1954)	(.2189)
*D*_female	−.1267	−.3877***	−.7830***	−1.1051***	−1.2504***
	(.1520)	(.1214)	(.1248)	(.1301)	(.1573)
*D*_non-French	−.6639*	−.5846**	−.7109**	−.3524	−.1439
	(.3487)	(.2981)	(.3208)	(.3735)	(.3191)
*D*_mathematics_submajor	.7358*	.6159	.2136	−.2579	.1739
	(.3836)	(.4654)	(.5853)	(.5936)	(.5080)
*D*_physics_and_chemistry_submajor	−.1458	−.5297	−.8336	−1.7625***	−1.3622**
	(.4175)	(.4719)	(.6034)	(.6113)	(.5467)
*D*_life_sciences_submajor	−.4824	−.4699	−.5485	−.9803	−.7027
	(.4104)	(.4817)	(.6119)	(.6140)	(.5353)
*D*_cum_laude	.9830***	1.3456***	1.3230***	1.4089***	1.3260***
	(.3189)	(.2576)	(.2790)	(.3290)	(.4245)
*D*_magna_cum_laude	2.0470***	2.5822***	2.4788***	2.5501***	2.5019***
	(.3290)	(.2583)	(.2961)	(.3418)	(.4422)
*D*_summa_cum_laude	3.3097***	3.7271***	3.8791***	4.0954***	3.8859***
	(.3642)	(.2849)	(.3317)	(.3693)	(.4690)
Prep school fixed effects	Yes				
Observations	5,635				
Pseudo-R^2	.2107	.2180	.2248	.2321	.2227

Note.—This table presents quantile regression models that are simultaneously estimated, where the dependent variable is the weighted average of written mathematics exam grades (of which there are two), with subject matter weights as detailed in table 1. Indicator variables are preceded by the prefix *D*_. The regression model includes prep school fixed effects (not reported). Bootstrap standard errors (presented within parentheses below the coefficient estimates) are obtained with 5,000 replications.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

Table 8
Performance in the Written Nonmathematics Exams

	Percentile				
	10th	25th	50th	75th	90th
Constant	4.8968***	5.7095***	6.9189***	8.4358***	10.3874***
	(.4872)	(.3897)	(.4424)	(.5012)	(.7809)
*D*_2006	.4211***	.5916***	.5916***	.5568***	.5137***
	(.0995)	(.0812)	(.0808)	(.0910)	(.1128)
*D*_2007	.6800***	.6723***	.6916***	.5874***	.4653***
	(.1016)	(.0821)	(.0831)	(.0852)	(.1069)
*D*_female	−.0632	−.1453**	−.2242***	−.2747***	−.2968***
	(.0855)	(.0693)	(.0694)	(.0696)	(.0911)
*D*_non-French	−.3663**	−.3874***	−.3337**	−.2168	−.1789
	(.1866)	(.1341)	(.1529)	(.1633)	(.2097)
*D*_mathematics_submajor	.4947*	.5067**	.3716	.0926	−.3137
	(.2988)	(.2480)	(.3219)	(.3357)	(.4270)
*D*_physics_and_chemistry_submajor	.4547	.4407*	.2853	−.0232	−.3895
	(.3203)	(.2604)	(.3318)	(.3439)	(.4341)
*D*_life_sciences_submajor	.4274	.5782**	.4789	.1232	−.2400
	(.3269)	(.2636)	(.3304)	(.3467)	(.4390)
*D*_cum_laude	.4211**	.5860***	.6642***	.5305***	.2737
	(.1641)	(.1310)	(.1419)	(.2031)	(.2127)
*D*_magna_cum_laude	.7347***	.9249***	1.0347***	.9453***	.7705***
	(.1736)	(.1339)	(.1430)	(.2040)	(.2122)
*D*_summa_cum_laude	1.3663***	1.7312***	1.9011***	1.8411***	1.5368***
	(.2001)	(.1539)	(.1599)	(.2119)	(.2316)
Prep school fixed effects	Yes				
Observations	5,635				
Pseudo-R^2	.1886	.1715	.1653	.1565	.1438

Note.—This table presents quantile regression models that are simultaneously estimated, where the dependent variable is the weighted average of written nonmathematics exam grades, with subject matter weights as detailed in table 1. Indicator variables are preceded by the prefix *D*_. The regression model includes prep school fixed effects (not reported). Bootstrap standard errors (presented within parentheses below the coefficient estimates) are obtained with 5,000 replications.

* $p < .10$.

** $p < .05$.

*** $p < .01$.

grade for the various percentiles is not driven by differences in mathematics alone: in the regressions at the 25th, 50th, 75th, and 90th percentiles, men's performance is higher than women's, with the differences being statistically significant irrespective of whether the evaluations are based on mathematics or not.[41]

While we observe a similar pattern of increasing differences in the gender performance gap for mathematics and nonmathematics exams, the coefficient estimates reported in tables 7 and 8 are not directly comparable since the standard deviation of written mathematics exams' score (4.25) is more than twice as large as that for nonmathematics exams (2.07). To make the coefficient estimates of *D*_female comparable across tables 7 and 8, we standardize the coefficient estimates by multiplying each with the standard deviation of the explanatory variable and dividing by the standard deviation of the dependent variable. The standardized coefficient estimates (not reported) suggest that the wedge between the performance of males and females is larger for mathematics: the standardized coefficient estimates for *D*_female for mathematics exams are 1.3, 1.7, 1.9, and 2.0 times larger than the standardized estimates for nonmathematics exams in the regressions at the 25th, 50th, 75th, and 90th percentiles, respectively. It should also be noted that the weight of the nonmathematics fields in the overall written exam score is 63.33%, which is almost double that of the mathematics weight. Together, these two observations suggest that, for example, at the 90th percentile of the (overall) written exam performance distribution, the mathematics and nonmathematics fields contribute approximately equally to the observed difference in performance. In other words, men's higher performance in mathematics is not the sole driver of the gender performance gap that we observe in the written exam: even though the mathematics exams have a higher impact than those in the nonmathematics-related fields, the latter, compared to the former, have almost twice the weight in the overall performance metric for the written exam.

Finally, given the differences observed in table 3 in the proportion of genders across mathematics submajors on the one hand (48.61% females) and the physics and chemistry or life sciences submajors (51.14% and 51.12% females, respectively) on the other, we also reestimate the simultaneous quantile regressions of table 6 for these subsamples separately: the results for the mathematics submajor in high school on the one hand (in online app. table A4) and the physics and chemistry and life sciences submajors on the other (in app. table A5) mirror very closely those of table 6. We conclude that our results are not solely driven by the mathematics submajor as the univariate tests of table 3 may have suggested.

[41] We obtain similar results if the logarithm of prep school rank is used to control for quality of the preparation received. These estimates are presented in online app. tables A2 and A3 to conserve space.

Next, we turn our attention to the second stage of the entrance exam. Table 9 presents the results of the oral exam performance regressions using simultaneous quantile regressions, with bootstrapped standard errors (with 5,000 replications), for the 25th, 50th, and 75th percentiles. The choice of these percentiles is guided by the fact that the admitted roughly correspond to the 75th percentile of the admissibles sample taking the oral exams.[42] On the right-hand-side of the oral exam performance specification, we add the grades for all the written exams in various subjects as well as their squared values in order to better control for the academic aptitudes of the admissibles as reflected in the grades of the first stage. Results for the weighted-average oral exams (with the weights as detailed in table 1), reported in columns 1–3 of table 9, indicate that the performance difference at the higher end of the distribution that we observe for females during the first stage of the entrance exam remains during the second stage: D_female coefficient estimates are −0.2052, −0.2036, and −0.2780 for the quantile regressions at the 25th, 50th, and 75th percentiles, respectively. However, these results are weaker, with only the coefficient estimate at the 75th percentile being marginally significant at the 10% level. We would like to note that, given the smaller sample size for the admissibles versus the candidates (1,366 vs. 5,635 observations, respectively), the coefficient estimates of the oral exam performance regressions are less precise than those of the written exam.

The oral mathematics exam results (cols. 4–6 of table 9) also indicate a lower performance for females, but only at the 25th percentile: coefficient estimates for the dummy variable D_female are −0.7340, −0.2992, and −0.2679 for the regressions at the 25th, 50th, and 75th percentiles, respectively, with only the coefficient estimate for the 25th quartile being statistically significant (at the 5% level). The results for the weighted average of oral nonmathematics exams (cols. 7–9 of table 9) mirror those of columns 1–3: the coefficient estimates for D_female are −0.0383, −0.1632, and −0.3574 for the quantile regressions at the 25th, 50th, and 75th percentiles, respectively, with only the coefficient estimate at the 75th percentile being statistically significant at the 5% level. These results are weaker than those obtained for the written exams. They nevertheless suggest that the females still underperform males in the highest quartile, with the observed effect being driven by nonmathematics-related fields, which is surprising given the results of univariate tests reported in table 4. In fact, this finding is comforting since it suggests that the selection process is not solely driven by the potentially higher mathematics affinity of males. However, it should also be noted that the coefficient estimates for the oral exams are also less precise: the sample size of admissibles in table 9 is roughly one-fourth of the sample size of candidates in table 6. Finally, we reestimate the regressions of table 9 for the subsample of

[42] We do not consider the 10th or the 90th percentiles because of the lower number of observations for the admissibles.

admissibles who majored in mathematics (app. table A6) and those who majored in physics and chemistry or the life sciences (app. table A7). In appendix table A6, women's underperformance results for the 1,069 admissibles who are mathematics submajors are stronger than those of table 9 (in terms of estimates with statistical significance). In contrast, we find no evidence of underperformance for the physics and chemistry or the life sciences majors, noting that we have only 275 observations for this subsample in the oral exam stage.

Next, we turn our attention to the less competitive academic evaluations that the same students went through: the noncompetitive *baccalauréat* exam 2 years prior to the entrance exam and the less competitive first-year core courses at HEC. To examine performance differences across genders in the *baccalauréat* exam, we estimate a series of linear probability models. In the main set of regressions, the dependent variable is equal to one if the candidate obtained the high school diploma with at least a certain level of honors (cum laude, magna cum laude, or summa cum laude) and zero for the group that got a simple pass (with no honors). For example, for the group that has obtained the *baccalauréat* with at least magna cum laude, the dependent variable is equal to one if the candidate has obtained the high school diploma with magna cum laude or summa cum laude and zero if the candidate got no honors; the candidates with cum laude honors are excluded. In these regressions, where the base case is always the group with no honors, we control for the two characteristics of the candidates that were observable as of the date of the exam: the category of science submajor in high school and whether the candidate is a non-French national. We also include the year indicator variables to control for changes in the difficulty of the *baccalauréat* and/or the distribution of its evaluation standards across the years. In these regressions we use heteroskedasticity-consistent (i.e., "robust") standard errors because the linear probability models are heteroskedastic by construction.

The results, presented in columns 1–3 of table 10, indicate that the female candidates, who eventually do worse than males during the HEC entrance exam, actually do better than the same male candidates during the *baccalauréat* exam. Irrespective of the honors type, the coefficient estimate for D_female is positive and statistically significant at the 1% level: the probability of a candidate obtaining the *baccalauréat* degree with honors is higher for females. The coefficient estimate for D_female is 0.0503 (col. 1) for the group with at least cum laude (which is inclusive of all honors groups), 0.0782 (col. 2) for the group with at least magna cum laude, and 0.2129 (col. 3) for the group with at least summa cum laude. The relative probability of a female obtaining an honor appears to increase with the level of the honors.[43]

[43] We do not provide a formal test of equality of coefficient estimates across equations as all the models in table 10 are estimated with overlapping data.

Table 9
Performance in the Oral Exam Stage (Second Stage of the Entrance Exam)

	Oral Exams' Weighted Average			Oral Math Exam Score			Oral Nonmath Exams' Weighted Average		
	25th (1)	50th (2)	75th (3)	25th (4)	50th (5)	75th (6)	25th (7)	50th (8)	75th (9)
Constant	.1519	3.2684	.9274	−5.3016	2.6698	5.0089	−.8097	2.5187	4.5078
	(3.9768)	(3.4318)	(3.4665)	(6.8063)	(7.2069)	(2.10e+15)	(4.8357)	(4.8375)	(4.6549)
*D*_2006	−.5110***	−.5887***	−.5470***	−.7120*	−.8320**	−.8269	−.5297**	−.4374*	−.4897**
	(.1884)	(.1837)	(.1993)	(.3637)	(.3480)	(36.4133)	(.2082)	(.2247)	(.2377)
*D*_2007	−.9577***	−.9107***	−.8060***	−2.3084***	−2.0342***	−1.8457	−.4977**	−.5996**	−.5484**
	(.2020)	(.1837)	(.2074)	(.3657)	(.3982)	(4.7525)	(.2241)	(.2530)	(.2370)
*D*_female	−.2052	−.2036	−.2780*	−.7340**	−.2992	−.2679	−.0383	−.1632	−.3574**
	(.1430)	(.1417)	(.1641)	(.3021)	(.2798)	(34.1885)	(.1688)	(.1707)	(.1791)
*D*_non-French	.4425	−.0943	.0316	.3879	.4438	.4932	.1384	−.3831	−.1497
	(.3320)	(.3107)	(.3549)	(.6645)	(.7756)	(27.8762)	(.3331)	(.3987)	(.4210)
*D*_mathematics_submajor	.0932	−.3686	.2601	.6507	1.0308	.0695	.3399	−.9109	−.1752
	(.9696)	(.5967)	(.6388)	(.9632)	(1.3325)	(2.10e+15)	(1.0444)	(1.0622)	(.6540)
*D*_physics_and_chemistry_submajor	−.0477	−.5339	.1168	.6600	.3537	−1.1585	.3623	−.5828	.0683
	(.9921)	(.6394)	(.6758)	(1.0164)	(1.3743)	(2.10e+15)	(1.0751)	(1.0930)	(.7008)
*D*_life_sciences_submajor	.2008	−.2870	.1338	.2340	.4914	−1.0325	.7217	−.7348	.0016
	(.9890)	(.6187)	(.6634)	(1.0604)	(1.3797)	(2.10e+15)	(1.0686)	(1.0794)	(.6841)
*D*_cum_laude	−.0343	−.7193	−.6550	1.1421	−.6792	−3.0924	.3431	−.4871	−.1984
	(.8094)	(.5871)	(.7258)	(1.7636)	(2.1715)	(21.6885)	(.7052)	(.7095)	(.7588)
*D*_magna_cum_laude	.0021	−.2616	.0342	1.5505	.4018	−2.2778	.4463	−.1914	.4890
	(.8088)	(.5845)	(.7253)	(1.7608)	(2.1593)	(8.7715)	(.6731)	(.7154)	(.7445)
*D*_summa_cum_laude	.3631	.0966	.3020	2.0534	.6911	−1.6610	.7539	.1741	.6758
	(.8215)	(.5967)	(.7465)	(1.7920)	(2.1743)	(47.5180)	(.6915)	(.7341)	(.7463)
1st_foreign_language	.3710	.2676	.3643	−.3129	−.1552	−.3660	.7044***	.6671**	.8288***
	(.2587)	(.2280)	(.2892)	(.4622)	(.4968)	(7.0348)	(.2595)	(.2735)	(.2901)

1st_foreign_language^2	−.0106	−.0065	−.0097	.0119	.0031	.0118	−.0210**	−.0186*	−.0254**
	(.0101)	(.0089)	(.0108)	(.0180)	(.0188)	(.6309)	(.0102)	(.0104)	(.0109)
2nd_foreign_language	.0911	−.0447	−.0075	−.0110	.2571	.0517	.0423	−.2331	−.3840
	(.3055)	(.2235)	(.2512)	(.3829)	(.4282)	(13.6046)	(.3335)	(.3411)	(.2556)
2nd_foreign_language^2	.0008	.0060	.0035	.0012	−.0093	−.0012	.0039	.0141	.0208**
	(.0120)	(.0090)	(.0101)	(.0158)	(.0173)	(.5041)	(.0132)	(.0134)	(.0103)
French	−.4447***	−.2398*	−.1151	−.3776	−.1878	.3494	−.2197	−.2908*	−.2826
	(.1658)	(.1373)	(.1425)	(.2962)	(.2511)	(20.6002)	(.2001)	(.1691)	(.1725)
French^2	.0202***	.0120**	.0074	.0169	.0092	−.0110	.0103	.0136**	.0136*
	(.0067)	(.0057)	(.0058)	(.0123)	(.0105)	(.7992)	(.0081)	(.0069)	(.0072)
General_culture	−.0857	−.0184	.0626	.2705	−.0959	.1202	−.0737	−.0701	.0784
	(.1295)	(.1214)	(.1287)	(.3012)	(.2485)	(11.7207)	(.1615)	(.1583)	(.1536)
General_culture^2	.0052	.0025	−.0009	−.0121	.0020	−.0054	.0053	.0045	−.0005
	(.0054)	(.0048)	(.0052)	(.0121)	(.0102)	(.7941)	(.0065)	(.0063)	(.0063)
History_and_geography	.1639	.1949	.2822*	.1180	.1442	.1058	.1328	.1999	.3668*
	(.1514)	(.1299)	(.1572)	(.2836)	(.2900)	(55.8069)	(.1742)	(.1696)	(.1899)
History_and_geography^2	−.0033	−.0045	−.0082	−.0007	−.0045	−.0021	−.0014	−.0038	−.0116
	(.0060)	(.0052)	(.0061)	(.0109)	(.0110)	(2.3093)	(.0068)	(.0067)	(.0074)
Mathematics_1	−.1458	−.0462	−.0057	.5127	−.1514	.2156	−.1967	−.2732	−.1089
	(.1985)	(.1862)	(.1719)	(.3617)	(.3828)	(96.8642)	(.2090)	(.2201)	(.2481)
Mathematics_1^2	.0092	.0052	.0043	−.0057	.0160	.0039	.0072	.0109	.0052
	(.0067)	(.0063)	(.0058)	(.0122)	(.0127)	(3.0688)	(.0071)	(.0075)	(.0084)
Mathematics_2	.2805	.0898	.0598	.0669	.0109	.2955	.0425	.1681	.0583
	(.1937)	(.2113)	(.2164)	(.3428)	(.3808)	(85.2075)	(.2429)	(.2796)	(.2897)
Mathematics_2^2	−.0057	.0006	.0012	.0043	.0097	−.0008	.0000	−.0040	−.0018
	(.0064)	(.0068)	(.0070)	(.0116)	(.0124)	(2.7233)	(.0080)	(.0091)	(.0094)
Prep school fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,366			1,366			1,366		
Pseudo-R^2	.1977	.2039	.2200	.1706	.1748	.1872	.1805	.1818	.1967

NOTE.—This table presents simultaneous quantile regression models for the 25th, 50th, and 75th percentiles, where the dependent variable is the weighted average of oral exam grades, with subject weights as in table 1. Indicator variables are preceded by the prefix *D*_. The regression model includes prep school fixed effects (not reported). Bootstrap standard errors are obtained with 5,000 replications.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

Table 10
Performance in the *Baccalauréat*: Linear Probability Models

	At Least Cum Laude (1)	At Least Magna Cum Laude (2)	At Least Summa Cum Laude (3)	At Least Cum Laude (4)	At Least Magna Cum Laude (5)	At Least Summa Cum Laude (6)
Constant	.9062***	.8593***	.6147***	.9338***	.9154***	.8550***
	(.0250)	(.0362)	(.0886)	(.0414)	(.0486)	(.1012)
*D*_2006	.0184**	.0274**	.0947***	.0170**	.0216**	.0592***
	(.0081)	(.0109)	(.0253)	(.0075)	(.0090)	(.0175)
*D*_2007	.0115	.0191*	.0636**	.0158**	.0219**	.0454**
	(.0082)	(.0111)	(.0259)	(.0076)	(.0093)	(.0190)
*D*_female	.0503***	.0782***	.2129***	.0328***	.0496***	.1034***
	(.0064)	(.0088)	(.0203)	(.0060)	(.0074)	(.0150)
*D*_non-French	−.0163	−.0304	−.1237***	.0134	.0018	−.0312
	(.0132)	(.0186)	(.0467)	(.0145)	(.0164)	(.0298)
*D*_mathematics_submajor	−.0014	.0033	.0109	−.0080	−.0007	−.0258
	(.0244)	(.0356)	(.0869)	(.0232)	(.0299)	(.0715)
*D*_physics_and_chemistry_submajor	−.0102	−.0126	−.0412	.0099	.0229	−.0111
	(.0256)	(.0371)	(.0906)	(.0242)	(.0314)	(.0739)
*D*_life_sciences_submajor	−.0056	−.0045	.0054	.0048	.0097	.0456
	(.0259)	(.0374)	(.0904)	(.0242)	(.0311)	(.0744)
Prep school fixed effects	No	No	No	Yes	Yes	Yes
Observations	5,635	4,140	1,621	5,635	4,140	1,621
Adjusted R^2	.0105	.0199	.0742	.1647	.3382	.6037
F-statistic	9.56***	12.98***	19.56***	10.42***	19.39***	24.96***

Note.—This table presents linear probability model estimates for the probability of obtaining the *baccalauréat* with at least a certain level of honors. In cols. 1 and 4 the dependent variable is equal to one if the student has obtained the *baccalauréat* diploma with at least cum laude (i.e., with cum laude, magna cum laude, or summa cum laude) or zero if the student obtained the high school diploma with a simple pass (no honors). In cols. 2 and 5 the dependent variable is equal to one if the student has obtained the *baccalauréat* diploma with at least magna cum laude (i.e., with magna cum laude or summa cum laude) or zero if the student obtained the high school diploma with a simple pass (no honors); those who obtained cum laude are excluded. In cols. 3 and 6 the dependent variable (at least summa cum laude) is equal to one if the student has obtained the *baccalauréat* diploma with at least summa cum laude or zero if the student obtained the high school diploma with a simple pass (no honors); those who have obtained cum laude or magna cum laude are excluded. Linear probability models in cols. 4–6 include prep school fixed effects. Heteroskedasticity-consistent (i.e., robust) standard errors are reported within parentheses below the coefficient estimates.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

In alternative linear regression models, presented in columns 4–6 of table 10, we reestimate the same set of linear probability models after including fixed effects for prep schools, which allow us control for the candidates' unobservable academic characteristics, albeit in an indirect way. The admission decisions of prep schools are based on candidates' academic qualities (through grades and high school professors' appreciations as reflected in grade bulletins and reference letters) that are unobservable to us: prep schools vary in the degree of selectiveness in their admission process, with the best ones admitting the best high school seniors. Moreover, these institutions make their admission decisions before the candidates pass their *baccalauréat* exams. As a result, introducing prep school fixed effects allows us to better control for candidates' unobservable characteristics (as revealed by these institutions' admission decisions) as of the date of the *baccalauréat* exam, albeit at the prep school level.

The results presented in columns 4–6 of table 10 are very similar to those of columns 1–3. We observe that after we control for the unobservable academic qualities that lead to prep school admission decisions, female candidates have a higher relative probability of obtaining their *baccalauréat* with honors. In columns 4–6 of table 10, $D_$female coefficient estimates corresponding to at least cum laude, at least magna cum laude, or at least summa cum laude honors are equal to 0.0328, 0.0496, and 0.1034, respectively (all are statistically significant at the 1% level).

Finally, given the differences in the proportion of female candidates in different subsamples in table 3, we reestimate table 10 regressions separately for the subsample that majored in mathematics (app. table A8) and the subsample that majored in physics and chemistry or life sciences (app. table A9). The results of these subsample regressions are very similar to those presented in table 10. We conclude that female candidates, whose performances were below those of males in the very competitive HEC entrance exam, did significantly better than the same males 2 years prior in a series of noncompetitive exams.

In the final part of our multivariate analysis, we examine the performance of the admitted during the first year of the HEC *grande école* program. Univariate tests presented in table 5 using core course letter grades suggest that females' performance dominates that of males in an FOSD sense when we combine all letter grades. To revisit these results, first, we regress students' GPA, which is based on 11 core courses they have to take, on all the observable characteristics of the admitted. Similarly to our analysis of the written and oral stages of the HEC entrance exam, we also reestimate the first-year regressions using a GPA based on the five mathematics-oriented courses and another GPA based on the six nonmathematics-oriented subjects. These GPAs are calculated using course letter grades and respective ECTS credit hours.[44]

[44] Accounting, economics, finance, marketing, law, theory of organizations, and supply chain courses are worth 5 ECTS credits each; statistics and quantitative

Before commenting on the GPA regression results, we note that, in a multivariate setting, we do not expect to find any differences in performance between males and females during the first-year core courses for two reasons. First, this is a group of highly talented students who excelled in the *baccalauréat*, who were typically admitted to the best prep schools, and who survived the competitive HEC entrance exam. We have no a priori reason to believe that any differences in performance across genders would remain for such a group of highly competitive and ex post successful individuals. Second, despite the above-mentioned FOSD test results presented in table 5, in the first-year performance regressions we are including "everything but the kitchen sink," which allows us to control for all the observable student characteristics.

When we examine the first-year GPA (col. 1 of table 11), the coefficient estimate for D_female is positive and equal to 0.0342 but is not statistically significant. We also find no effect when examining GPA of the mathematics-oriented classes (col. 2): the coefficient estimate for D_female is equal to −0.1118 but is not statistically significant. Nevertheless, when we run the GPA regression for the nonmathematics-oriented classes, we find a coefficient estimate of 0.1521, which is statistically significant at the 5% level (col. 3). So we have some evidence that women do better than men when we examine the first-year GPAs, albeit for nonmathematics-oriented courses alone.

However, the first-year GPA regressions may not be precise enough. First, the GPA is an ECTS credit weighted-average performance metric in which professor or course-specific grade distribution differences cannot be accounted for. Second, the number of observations with which GPA regressions can be run is somewhat limited: we have 457 students, but these have obtained a total of 5,046 letter grades.

Given this, we run similar regressions using the individual first-year core course letter grade as the dependent variable, after including separate time-varying professor and course fixed effects to the existing prep school fixed effects. Given that we use all the core course letter grades obtained by an individual, we cluster the standard errors at the student level. Results are reported in table 11, columns 4–6. In column 4, where we consider all individual course grades, the coefficient estimate for D_female is equal to 0.0420, which is statistically insignificant. In column 5, the corresponding coefficient estimate based on the mathematics-oriented course grades is equal to −0.0942, which is not statistically significant either. The D_female coefficient estimate in column 6 in the regression for the nonmathematics-

methods 2.5 ECTS credits each; and modeling with Excel and English as a first foreign language 2 ECTS credits each, for a total of 44 ECTS credits for the 11 mandatory courses. We exclude the first-year elective courses (worth 16 ECTS credits) since students differ in their elective course choices, and we would like to have a common performance metric.

oriented course grades is equal to 0.1506 and is statistically significant at the 5% level. We note that the GPA and course grade regressions yield *D*_female coefficient estimates that are similar in size and statistical significance, even though GPAs are weighted by ECTS credit hours whereas the individual letter grades are not. We interpret these results, which are limited to nonmathematics-oriented courses, as weak evidence of higher performance by women in the first year at HEC. We would like to stress that our prior was to find no systematic performance difference among this highly competitive group of students admitted to the school. Finally, we also revisit the regression models of table 11 with the subsamples' mathematics submajors as well as physics and chemistry and life sciences submajors in high school. The results are presented in appendix table A10: the coefficient estimate for *D*_female is not statistically significant except for the letter grade regression for the physics and chemistry or life sciences submajors, for which it is negative but statistically significant only at the 10% level.

VI. Discussion

In this section, we revisit our findings within the context of the related literature on performance differences across genders. We have shown that in the setting of a tournament-like real-world academic selection process (the HEC entrance exam), where payoffs at stake are large and economically important, women tend to do worse than men, while they perform as well as or better than the same men in academic evaluations where competition is either absent or less intensive. The findings of the univariate tests are corroborated in multivariate regressions in which we control for all the observable characteristics that are available to us as of the date of the said evaluation. We find that, typically, the right tail of the performance distributions is significantly fatter for men than for women. Given that only 380 candidates are admitted to the school, this results in more men being admitted to the top French business school than women.

A. Potential Differences in Innate Ability

The easiest (but, in our opinion, erroneous) conclusion one could draw by focusing on the data obtained from the HEC entrance examination is that men are more skilled than women. For such an explanation to hold, we should observe systematically lower performance for females in the three academic evaluations taken by the same individuals. Evidence provided in Section V shows that this is not the case. For the same cohort of students, women's performance is higher during the *baccalauréat*, which is a noncompetitive exam (in the sense that the success of one student does not hinder another student's attainment of the degree during the *baccalauréat*). For the admitted, during the first year of HEC, which is less competitive than the entrance exam (in the sense that the ex ante failure probabilities given the HEC-suggested grade distributions as well as the ex post

Table 11
Performance in the First-Year HEC Core Courses

	Grade Point Average (out of 4.00) in First-Year Core Courses at HEC			Letter Grades (out of 4.00) in First-Year Core Courses at HEC		
	GPA (1)	GPA for Math-Oriented Courses (2)	GPA for Nonmath-Oriented Courses (3)	Letter Grades (4)	Letter Grades for Math-Oriented Courses (5)	Letter Grades for Nonmath-Oriented Courses (6)
Constant	−1.0150	−1.3955	−.7819	.2580	−.7180	.7132
	(1.6890)	(2.1157)	(1.7479)	(1.4516)	(1.7071)	(1.5369)
*D*_2006	−.1564**	−.1557*	−.1720***	−.8172***	−.3522	−.5119**
	(.0635)	(.0795)	(.0657)	(.2659)	(.2273)	(.2151)
*D*_female	.0342	−.1118	.1521**	.0420	−.0942	.1506***
	(.0601)	(.0752)	(.0621)	(.0498)	(.0608)	(.0538)
*D*_non-French	−.0669	.0749	−.2102	−.0441	.0146	−.1481
	(.1315)	(.1647)	(.1360)	(.1168)	(.1381)	(.1265)
*D*_mathematics_submajor	−.1805	−.1586	−.2022	−.2612	−.2812	−.2296
	(.2261)	(.2832)	(.2340)	(.2185)	(.2187)	(.2397)
*D*_physics_and_chemistry_submajor	−.2424	−.2897	−.1973	−.2976	−.3759	−.2522
	(.2434)	(.3048)	(.2518)	(.2352)	(.2425)	(.2564)
*D*_life_sciences_submajor	−.1602	−.1258	−.2002	−.2506	−.2381	−.2393
	(.2454)	(.3075)	(.2540)	(.2393)	(.2465)	(.2617)
*D*_cum_laude	.1111	.0687	.1283	.0823	.1205	.0233
	(.2481)	(.3107)	(.2567)	(.2002)	(.2892)	(.2010)
*D*_magna_cum_laude	.2242	.1917	.2360	.2259	.2336	.1937
	(.2336)	(.2926)	(.2418)	(.1912)	(.2757)	(.1899)
*D*_summa_cum_laude	.4645*	.4238	.4767*	.4344**	.4613	.3944**
	(.2403)	(.3010)	(.2487)	(.2010)	(.2872)	(.1997)
1st_foreign_language (written)	−.2635**	−.2660*	−.2694**	−.2365**	−.1892*	−.2966***
	(.1176)	(.1473)	(.1217)	(.0994)	(.1147)	(.1079)
1st_foreign_language^2 (written)	.0098**	.0099*	.0100**	.0088**	.0071*	.0112***
	(.0043)	(.0054)	(.0045)	(.0037)	(.0043)	(.0041)
2nd_foreign_language (written)	.0292	.0352	.0205	.0554	.0323	.0525
	(.1103)	(.1382)	(.1142)	(.1052)	(.1243)	(.1052)

2nd_foreign_language^2 (written)	.0003	.0007	.0002	−.0007	.0006	−.0010
	(.0044)	(.0055)	(.0045)	(.0041)	(.0048)	(.0042)
French (written)	.0167	−.0776	.0898	.0070	−.0588	.0623
	(.0541)	(.0677)	(.0559)	(.0454)	(.0542)	(.0498)
French^2 (written)	−.0006	.0030	−.0034	−.0003	.0021	−.0024
	(.0022)	(.0028)	(.0023)	(.0019)	(.0023)	(.0020)
General_culture (written)	.0404	.0439	.0376	.0270	.0327	.0226
	(.0518)	(.0649)	(.0536)	(.0497)	(.0596)	(.0514)
General_culture^2 (written)	−.0010	−.0008	−.0011	−.0004	−.0005	−.0004
	(.0021)	(.0027)	(.0022)	(.0021)	(.0025)	(.0021)
History_and_geography (written)	.0898	.1044	.0802	.0921*	.0949	.0858
	(.0564)	(.0706)	(.0583)	(.0541)	(.0625)	(.0577)
History_and_geography^2 (written)	−.0029	−.0031	−.0028	−.0030	−.0030	−.0029
	(.0022)	(.0027)	(.0023)	(.0021)	(.0024)	(.0022)
Mathematics_1 (written)	−.0043	.0189	−.0210	.0088	.0303	−.0255
	(.0769)	(.0963)	(.0796)	(.0743)	(.0892)	(.0780)
Mathematics_1^2 (written)	.0007	.0006	.0007	.0004	.0002	.0010
	(.0025)	(.0032)	(.0026)	(.0024)	(.0029)	(.0025)
Mathematics_2 (written)	.1645	.1362	.1956*	.1359	.1129	.1468*
	(.1026)	(.1286)	(.1062)	(.0859)	(.1133)	(.0855)
Mathematics_2^2 (written)	−.0044	−.0030	−.0057*	−.0035	−.0024	−.0042
	(.0032)	(.0040)	(.0033)	(.0027)	(.0035)	(.0027)
1st_foreign_language (oral)	−.0013	−.0209	.0286	.0047	−.0251	.0303
	(.0574)	(.0720)	(.0594)	(.0493)	(.0616)	(.0511)
1st_foreign_language^2 (oral)	.0005	.0012	−.0007	−.0000	.0013	−.0010
	(.0021)	(.0027)	(.0022)	(.0018)	(.0023)	(.0019)
2nd_foreign_language (oral)	.0197	−.0235	.0631	.0042	−.0346	.0503
	(.0701)	(.0878)	(.0726)	(.0652)	(.0720)	(.0753)
2nd_foreign_language^2 (oral)	−.0007	.0011	−.0026	−.0003	.0015	−.0022
	(.0025)	(.0032)	(.0026)	(.0024)	(.0027)	(.0027)
Debate (oral)	.0158	.0109	.0214	−.0211	−.0393	−.0077
	(.0780)	(.0977)	(.0807)	(.0601)	(.0731)	(.0615)
Debate^2 (oral)	−.0011	−.0006	−.0016	.0007	.0018	−.0001
	(.0033)	(.0041)	(.0034)	(.0026)	(.0032)	(.0026)

Table 11 (*Continued*)

	Grade Point Average (out of 4.00) in First-Year Core Courses at HEC			Letter Grades (out of 4.00) in First-Year Core Courses at HEC		
	GPA (1)	GPA for Math-Oriented Courses (2)	GPA for Nonmath-Oriented Courses (3)	Letter Grades (4)	Letter Grades for Math-Oriented Courses (5)	Letter Grades for Nonmath-Oriented Courses (6)
General_culture (oral)	.0256	.0296	.0199	.0271	.0227	.0282
	(.0413)	(.0517)	(.0427)	(.0371)	(.0432)	(.0389)
General_culture^2 (oral)	−.0012	−.0014	−.0010	−.0014	−.0012	−.0013
	(.0021)	(.0026)	(.0021)	(.0019)	(.0022)	(.0019)
History_and_geography (oral)	.0444	.0826**	.0130	.0420	.0691**	.0217
	(.0296)	(.0371)	(.0307)	(.0279)	(.0330)	(.0303)
History_and_geography^2 (oral)	−.0014	−.0031**	.0000	−.0015	−.0028**	−.0006
	(.0012)	(.0016)	(.0013)	(.0012)	(.0014)	(.0013)
Mathematics (oral)	.0422	.0610	.0266	.0249	.0479	.0124
	(.0460)	(.0576)	(.0476)	(.0400)	(.0512)	(.0411)
Mathematics^2 (oral)	−.0005	−.0006	−.0005	.0002	−.0001	.0003
	(.0019)	(.0024)	(.0020)	(.0017)	(.0021)	(.0017)
Fixed effects:						
Prep school	Yes	Yes	Yes	Yes	Yes	Yes
Professor × D_2006	No	No	No	Yes	Yes	Yes
Course × D_2006	No	No	No	Yes	Yes	Yes
Observations	457	457	457	5,024	2,300	2,724
Clustered standard errors	No	No	No	Yes	Yes	Yes
Adjusted R^2	.2624	.2827	.2123	.2945	.3014	.3309
Regression F-statistic	3.13***	3.36***	2.62***			

Note.—This table presents (i) pooled OLS regressions in which the dependent variable is HEC first-year GPA in core courses (cols. 1–3) and (ii) individual letter grades in core courses (cols. 4–6). All regressions are with prep school fixed effects (for which the coefficient estimates are not reported). "Everything but the kitchen sink" regressions (cols. 4–6) with letter grades as the dependent variable also include time-varying professor and time-varying course fixed effects (for which the coefficient estimates are not reported). Standard errors are reported within parentheses below coefficient estimates. In cols. 4–6, heteroskedasticity-consistent standard errors are clustered at the student level.

* $p < .10$.
** $p < .05$.
*** $p < .01$.

class failures are very low), we also find, albeit weaker, evidence that female students do better than male students. We also would like to note that there are similarities in content that are important, allowing us to focus on the differences in the level of competition. For example, during the science track *baccalauréat* exam, similarly to the HEC admission process, students have to take written exams that include French literature (both written and oral), mathematics, history, geography, philosophy, and foreign languages (oral).[45] Hence, the comparison of the distributions of performances both at the *baccalauréat* exam and at the HEC admission contest provides a way of testing whether difference in ability is a possible explanation for the differences in performances observed at the HEC admission contest. We observe striking differences when we compare the results of tables 6–9, where females underperform in the HEC entrance exam, with those of table 10, where they outperform in the *baccalauréat* exam. Importantly, this reversal of performances persists even when we reestimate the multivariate regression models for the different science submajors. Moreover, when considering the much less competitive HEC first-year core courses (where only 1% of students obtain an F), we observe that in multivariate "everything but the kitchen sink" regressions of individual letter grades, women who underperform during the entrance exam do better than the same men in nonmathematics-oriented classes once admitted to the school. These findings therefore suggest that differences in innate abilities are unlikely to explain the lower performance of females during the HEC entrance exam.

B. Potential Differences in Mathematics Affinity

The accumulating evidence indicates that males perform better in mathematics in more competitive settings (see Niederle and Vesterlund [2010] for a thorough review of this literature). Our evidence indicates that some of the gender gap in performance that we observe may be driven by the higher mathematics affinity of males in our sample. In both univariate tests and multivariate regressions, we observe that the males' (females') tendency to do better in mathematics or mathematics-related (nonmathematics-related) subjects relative to females (males) can be detected in our data. This result is consistent with the results of Guiso et al. (2008), who find that (i) gender differences in mathematics performance are positively correlated with the World Economic Forum Gender Gap Index and that (ii) France scores low in that index. This said, the differences of genders in mathematics affinity could not be said to be the main driver of our results. First, women's performance dominates that of men during the *baccalauréat* exam irrespective of the submajor, even in fields such as life sciences or physics and chemistry, where females make up a relatively higher fraction of the students. Second, in the written stage of the entrance exam, women underperform men in

[45] Science majors also have to sit for examinations in physics, chemistry, and life sciences (biology and geology) during the *baccalauréat* (see table 12 below).

both mathematics and nonmathematics-related fields (see tables 7 and 8). Third, we would like to emphasize the fact that in the overall performance metrics (the dependent variable in table 6 and cols. 1–3 of table 9), the weight of mathematics is 36.67% in the written stage and 25% in the oral stage (more on this in Sec. VI.C below). If anything, given men's apparently higher affinity for mathematics and women's apparently higher affinity for nonmathematics-related subjects, the way mathematics are weighted in the entrance exam is likely to put men at a disadvantage, potentially biasing the exam in favor of women. That said, our results also indicate that, while we observe no difference in performance across genders when all courses together or when mathematics-oriented first-year courses are considered, women appear to be doing better in nonmathematics-oriented classes once admitted to HEC.

C. Weights Associated with Mathematics-Oriented Fields in Performance Metrics

Another possibility for the observed gender difference in performances is that the implicit weights involved in the calculation of the weighted-average grades in the three academic evaluations that we examine favor males during the entrance exam and females during the *baccalauréat* and first-year core courses at HEC. This could be a plausible explanation given that we observe differences in the mathematics affinity of males and females in our sample (as reflected in the results reported in table 5, table 7 vs. table 8, as well as table 9). To explore this possibility, in tables 12, 13, and 14, we provide detailed information about the weights given to each of the subject matters included in the three academic evaluations that we analyze. In table 12, we provide weights in the *baccalauréat* per science submajor. For the mathematics and physics and chemistry submajors (which form 87.45% of our sample), the weights given to the fields that lend their names to them account for 37.5% of the *baccalauréat* grade, with the remaining 62.5% accounted for by the fields that we label as nonmathematics-oriented (life sciences, French, history and geography, first and second foreign [or a regional] language, philosophy, and physical education).[46] In contrast, the weight of mathematics during the written part of the entrance exam is a slightly lower 36.67% (table 13). If anything, the slightly higher weight given to mathematics-oriented fields during the *baccalauréat* should favor men's performance. However, we observe the opposite. The slightly lower weights for mathematics and physics and chemistry for the life sciences submajors, which form 12.55% of our sample, are unlikely to explain the differences we observe between tables 6 (written exam regressions) and 10

[46] We choose not to classify the life sciences (biology and geology) submajor and exams as mathematics oriented, something that is potentially open to debate, so as not to "inflate" mathematics-oriented fields' weights in the *baccalauréat*.

Table 12
Subject Weights in the *Baccalauréat* Exam

	Mathematics Submajor (70.30% of the Sample)		Physics and Chemistry Submajor (15.25% of the Sample)		Life Sciences Submajor (12.55% of the Sample)	
Science Majors	Coefficient	Weight (%)	Coefficient	Weight (%)	Coefficient	Weight (%)
Mathematics	9		7		7	
Physics and chemistry	6		8		6	
Math-oriented fields' subtotal	15	37.5	15	37.5	13	32.5
Life sciences (biology and geology)	6		6		8	
French	6		6		6	
History and geography	3		3		3	
1st foreign language	3		3		3	
2nd foreign/regional language	2		2		2	
Philosophy	3		3		3	
Physical education (sports)	2		2		2	
Other fields' subtotal	25	62.5	25	62.5	27	67.5
Total	40	100.0	40	100.0	40	100.0

Table 13
Subject Weights in the HEC Entrance Exam

	Writen Exam Stage		Oral Exam Stage	
	Coefficient	Weight (%)	Coefficient	Weight (%)
Mathematics 1	6		9	
Mathematics 2	5			
Mathematics subtotal	11	36.67	9	25.00
French	3			
1st foreign language	4		4	
2nd foreign language	2		3	
General culture	4		6	
History and geography	6		8	
Debate			6	
Other fields' subtotal	19	63.33	27	75.00
Total	30	100.00	36	100.00

Table 14
Subject Weights in the HEC First-Year Courses

	ECTS Credits	Weight (%)
Economics	5	11.36
Finance	5	11.36
Quantitative methods	2.5	5.68
Statistics	2.5	5.68
Supply chain	5	11.36
Math-oriented courses' subtotal	20	45.45
Accounting	5	11.36
English as a 1st foreign language	2	4.55
Business law	5	11.36
Marketing	5	11.36
Modeling with Excel	2	4.55
Theory of organizations	5	11.36
Nonmath-oriented courses' subtotal	24	54.55
Total	44	100.00

or 11 (*baccalauréat* regressions). In fact, as mentioned before, females' higher performance during the *baccalauréat* persists when we examine the mathematics submajors (see app. tables A8 and A9).

D. Alternative Explanations

One potential explanation for the observed difference in performance across genders is risk aversion. As detailed in the literature surveys of Eckel and Grossman (2008) and Croson and Gneezy (2009), the findings of the experimental studies indicate that women tend to be more risk averse than men in various settings. Unfortunately, the data that are at our disposal do not allow us to construct a statistical test that would clearly indicate whether or not the observed differences in performance could be linked to differences in risk aversion across genders.[47]

E. Are Women Potentially Less Competitive than Men?

As already mentioned, a striking result of our study is the reversal of the performance gender gap at the HEC admission exam (an elimination-type tournament) compared to the French *baccalauréat* (a pass-or-fail exam), even though the academic content of both exams is similar. For the driver of these results to be women's underperformance in relatively more competitive environments, we should observe, during the first year of HEC, a pattern that is similar to that of the *baccalauréat*. As a matter of fact, this is what we observe, albeit only for the nonmathematics-oriented courses, when we look at the GPA or individual course letter grades in our "everything but the kitchen sink" regressions presented in table 11. Note that many (but not all) courses at HEC are based on a curve system, whose resulting letter grade distribution could be a priori known by the students. So, we do not claim that there is no competitive pressure during HEC's first year. Instead we only suggest that once students are admitted to the school, this pressure is much lower than that prevailing during the school's entrance exam.

VII. Conclusion

Using a unique database, we analyze gender differences in performance in a two-round elimination-type tournament: the admission exams to HEC Paris's MSc in Management. Given that this program is ranked first in Europe in its category and given the important differences in salary upon graduation, payoffs at stake are very high for the candidates we examine. We find that men perform better than women in this competitive exam despite the fact that, for the same cohorts of candidates, the women performed significantly better at an earlier pass/fail type of exam (the national *baccalauréat* exam) and, once admitted, during the less competitive first year of their studies at HEC, though our evidence, which is limited to nonmathematics-oriented courses, is somewhat weaker in the latter case. While during the entrance exam men perform better than women among the top 10% of the applicant pool (i.e., those who are eventually admitted to the school), there is no statistically significant gender difference in performance as far as the bottom 10% is concerned. The general picture is then that of a larger dispersion of performances among men.

[47] We do not, e.g., have experimental data on objective probability lotteries or field data on gambles for the individuals who are in our data set so as to be able to test whether measures of risk aversion vary across genders.

Consistent with earlier experimental studies, our results, which are based on real-world data, indicate that the competitive aspect of the contest may lead to differences in performance across genders. This in turn has implications for the successful pool of candidates, which ends up containing more males than females.

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