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ABSTRACT

Performance Gender-Gap: Does Competition Matter?*

Using data from a natural experiment with high payoffs in education, we examine whether the competitive nature of tournament structure explains the performance gender-gap. We find that performance is statistically lower for women, the variance of performance is higher for men, and the tails of the performance distribution are significantly fatter for men. For the same participants in non-competitive settings with similar academic content, the performance of women first-order-stochastically dominates that of men. We reject differences in risk aversion and ability as reasons for performance gender-gap.

JEL Classification: I29 and J16
Keywords: gender-gap, relative-performance evaluation and tournament

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I. Introduction

Culminating evidence indicates that women are under-represented in top-management positions. For example, Wolfers (2006) finds only 64 female CEOs as opposed to 4,175 male counterparts among S&P 1500 firms over the 1992-2004 period. Similarly, Bertrand and Hallock (2001) find that, in large firms, women represent only 2.5% of the five highest-paid executives. The situation is not different on the other side of the Atlantic, with 11% of women board members, on average, among FTS Eurofirst 300 companies (The Economist, May 1, 2008), and among EuroStoxx 50 firms, only one, Alcatel-Lucent, has a female CEO. The under-representation of women among the management and board of directors is pushing some countries to regulate their presence. For example, as of January 1st 2008 Norwegian companies are required by law to have at least 40% female board members, as opposed to the prevailing average of 7% in 2003 (The Economist, January 3, 2008).

Literature suggests a number of explanations for this under-representation including self-selection (e.g., Polachek 1981), investment in family and child-bearing (e.g., Mincer and Polacheck 1974; Angrist and Evans 1998; Waldfogel 1998), lower human capital investment by women (e.g., Lazear and Rosen 1990), or gender discrimination (e.g., Goldin and Rouse 2001). We would like to examine another explanation, namely that gender-based differences in performance during competitive tournaments may be contributing to the under-representation of women in top-management positions. Importantly, our investigation relies on real-world data where self-selection, child-bearing, human capital, and discrimination explanations for the gender performance gap are ruled out by design.

Following Lazear (1999) we take the view that major career advances are the outcome of a series of competitive selection processes, in which there are a number of candidates, and only one or few top-ranked candidates emerge as winners (see also e.g., Lazear and Rosen 1981; Green and Stokey 1983; Malcomson 1984; Lazear 1999; Main, O'Reilly and Wade 1993; Eriksson 1999; Bognano 2001). Eventually, only the most successful candidates who survive these rounds of competitive tournaments reach the top management positions. If there are gender-based differences that might affect performance in competitive tournaments (as opposed to pass or fail type of assessments in which absolute, rather than relative, measures of performance prevail), then some of the female under-representation that is observed in the corporate world can be attributed to the competitive nature of the selection process.

While this conjecture may sound controversial, existing evidence indicates that there are performance differences among males and females in competitive tournaments. In experiments conducted by Gneezy, Niederle and Rustichini (2003) men's performance increases as the competitiveness of the test increases, while that of females does not. Niederle and Vesterlund (2007) observe that, after experiencing both non-competitive and competitive tournament-type tasks, males show much larger preference for competitive tournament type tasks than females (73% for the former, as opposed to 35% for the latter). Our main contribution is to expand this growing literature on gender-gap in performance by making use of a natural experiment with important real-life stakes. Our field data comes from a series of real world tournaments in a setting where future, career-related, payoffs are high.

Specifically, we examine approximately 5,750 students over the period 2005-2007 taking the competitive entrance exam for admission to the Master of Science in Management (hereafter M.Sc.) at HEC School of Management in Paris, a top-ranked French business school. Only 250 or so students are admitted each year following a series of written and oral exams covering a wide variety of subjects, from mathematics to general culture, including two foreign languages as well as history and geography, and taking place over a three week period.[1] First, we compare the potential performance differences between males and females during the written and oral exam stages of the selection process where candidates compete for a limited number of places that are available. Then, we compare the performances of the same population, pre- and post-entrance exam, during a series of pass-or-fail assessments where everyone above a certain threshold is deemed to be successful (i.e., where there are no pre-set quotas). Our tests mainly focus on the differences in performance in the tails of the performance distributions and, given the competitive structure of the selection process, we specifically consider the upper tail of such distributions. We finally discuss whether the competitive structure reshapes the gender composition of the upper tail of the distribution of performances.

Our dataset is relevant and interesting for several reasons. First, payoffs at stake are very high since HEC's M.Sc. program has been ranked first in Europe by the Financial Times three years in a row (2005, 2006 and 2007). The average annual salary of HEC alumni three years after graduation is approximately 10,000 euros higher than that of the closest followers.[2] Not only do HEC alumni perform very well early in their career, they also do well in the long-

[1] The actual number of initial candidates and admitted students are larger. As discussed further below, we focus on the science-track students to eliminate differences in educational backgrounds as a possible driver of gender performance gap that we observe in competitive settings.
[2] See http://rankings.ft.com/masters-in-management

run: among the 32 French firms ranked in the Financial Time Global 500 in 2007, the 500 world largest companies by market value, 22% have a CEO who graduated from HEC.[3] These examples illustrate short- and long-term rewards from being admitted to the school and the incentives of candidates to perform as well as possible while taking the entrance exam. Second, candidates that we examine share the same science background ruling out differences of orientation in education as possible drivers of the performance gender gap. Third, the national admission exam is set-up so that the written exam stage is anonymously graded even though the oral exam stage is not. This allows us to rule out discrimination as an explanation for any differences in performance that we may observe in the written exam stage. Fourth, given that the proportion of female candidates in the initial candidate pool is slightly larger than the proportion of females graduating from high school over the same period, the self-selection explanation for the potential difference in performance across genders is also ruled out. Fifth, given that the candidates take the HEC entrance exam following the same number of years of schooling, human capital differences are most likely to be driven by innate abilities, as opposed to major differences in backgrounds. Sixth, given the relatively young age of the candidates, potential family/motherhood commitments of females have no bearing in the selection process. Finally, we work with a reliable dataset: being a national examination process for the top French business schools, the administration of the test has to follow a "zero default" production process.

Our main result is that men perform better than women at the HEC admission contest, despite the fact that (i) in the same cohort of candidates, the females performed significantly better than men in the national *baccalauréat* exam (high-school graduation exam) two years prior to the sitting of the HEC admission exam; (ii) among the sub-sample of candidates admitted to the school, females appear to outperform the same males during the first year of the M.Sc. program. Importantly, the HEC entrance exam is based on relative performance (only top performers are retained) whereas the French *baccalauréat* exam and the first-year course performance are based on an absolute performance grading systems. That is, students who obtain an exam average of 10 or higher out of 20 get their *baccalauréat* diploma, and students who show a minimum level of understanding of a given subject matter validate their courses with a passing grade.

[3] In a different vein, Pascal Lamy and Dominique Strauss-Kahn, two HEC alumni, are respectively the Director of the World Trade Organisation (WTO) and the Managing Director of the International Monetary Fund (IMF).

When looking at the HEC entrance-exam performances, we observe that both at written and oral exams, men perform slightly better than women, on average. Splitting the entire sample into quartiles according to aggregate performance (which is a weighted-average grade used in the selection process), we observe that in the top-quartile men perform better than women, the difference in performance being statistically significant at the 5% level, both in the written and oral exams. Furthermore, in the lowest-quartile of written stage performances, men perform *worse* than women, the difference being statistically significant at the 1% level. These findings indicate that the distribution of female candidates' performance is more concentrated around the central tendency of the distribution (i.e., its median) than that of male candidates which has fatter tails. Therefore, as only a small fraction of the initial candidates are admitted to the school, men are more likely to be admitted than women.

We then explore some of the possible explanations for the observed differences in performance. However, in this exercise, we are limited by the data that are at our disposal. We posit that there are two possible explanations. First, male candidates may be adopting riskier strategies when preparing for this competitive exam, in the sense that male candidates may be under-investing in parts of the program needed to be studied. They may do so in order to focus on exams that have a higher weight in the aggregate performance (for example, the mathematics exams). Second, the competitive nature of the selection process may have a different impact on male and women candidates. It should be noted that these hypotheses are not mutually exclusive.

We test the possibility of differences in risk-taking behavior in two ways and cannot reject the null hypothesis that male and female candidates' risk taking behaviors are identical. To test the impact of the selection process on performances, we first compare the distribution of performances at the HEC admission contest with the distribution of the performances, of the same sample of candidates, at the high-school graduation examination. At the *baccalauréat* exam, women perform better than men on average (when performance is measured by the honors obtained by the candidates), the difference being statistically significant at the 1% level. Furthermore, we observe that the distribution of performances of female candidates dominates that of men in the sense of first-order stochastic dominance. Using only the subset of students who have been admitted to the school, we then compare their distribution of performances at the HEC admission to the grade-point-average (GPA) that they obtain during their first year at HEC. We again show that, once admitted, women perform better than men in terms of GPA.

Taken together, these results suggest that the competitive pressure generated by relative performance evaluations has a different impact on men than on women (using the same groups of men and women). This provides an alternative (albeit, by no means the only) explanation for under-representation of women in top management positions, if one takes the perspective that these positions are the reward of the fierce competition for promotion over one's professional career.

The organization of the paper is as follows. Section II provides an overview of the French higher education system and explains in details the two-stage HEC-admission tournament. Sections III and IV present the dataset and the results, respectively. Section V provides a discussion and concludes.

II. The HEC admission exam

During the Renaissance, the French royal power felt the need to create more specialized institutions of higher learning (the, so-called, "grandes écoles") outside the university system. This trend became particularly strong in the 18th century, when new techniques appeared and the first military (and later civil) engineer corps were created. A second wave of professional schools dedicated to the teaching of business and management began to be created in the late 19th Century when the Chamber of Commerce of Paris opened the Ecole des Hautes Etudes Commerciale (HEC School of Management). The university-professional school duality is still present in the French higher education system.

There are two major differences between universities and *grandes écoles*. First, the former are (generally) not allowed to select students who are guaranteed a spot in one of the three universities of their choice upon high-school graduation, whereas entrance at any given *grande école* program follows a selective admission process. Second, whereas entry at university takes place right after high-school, candidates to *grande école* programs follow subject-specific two-year programs which prepare them for the entrance exams. These two-year "prep-schools", which may be thought of being the equivalent of freshman and sophomore years in a U.S. college, do not confer diplomas and are not organically linked with the *grandes écoles* themselves. At the end of these two years, admission is solely based on national entrance exams. While some *grandes écoles* pool the written part of their entrance exams, all conduct their own oral exams. The written exams are based on essays or problem-solving but do not include multiple-choice questions.

The HEC M.Sc. in Management is the direct descendant of the program created over 100 years ago. Since 1920, admission takes place through a competitive exam. Currently, the competition is organized in two steps. First, all applicants (roughly 3,300 a year), to whom we will refer to as *"candidates"*, have to take seven written exams that are anonymously graded. It should be noted that the school does not pre-screen its applicant pool. The best performing 700 or so will be admitted to the oral exams, the second stage of the selection process. We will refer to the cohort taking the oral exams as the "*admissibles*". Based on the grades obtained at the written and oral exam stages, HEC will admit the best 360 or so, to whom we will refer as the "*admitted*". It should also be noted that the school sets no quotas per gender, educational background, nationality, or socio-economic class.

While we will focus on candidates with science background (having majored in science fields, such as mathematics, physics and chemistry, or biology, in high-school and coming from science-oriented prep-schools), there are in fact four types of candidate profiles and, therefore, four sets of exams. The largest cohort (more than 56% of the overall candidate pool) has a scientific background and, hence, goes through an examination process which puts a lot of emphasis on mathematics. Other cohorts include candidates with an economics, literature or technology background and, form the remaining groups, which correspond to 30%, 13% and 1% of the overall sample, respectively. In order to use a coherent database and allow for meaningful comparisons, our study focuses on the largest group with science background. Importantly, relying on the sample of students with the same science background eliminates the possibility that the gender gap that we may observe is due to differences in backgrounds or self-selection of females into non-science studies. Despite limiting ourselves to science-track students, the diversity of subjects (mathematics, history, general culture and foreign languages) upon which these candidates are evaluated still allows us to test whether any performance difference may be driven by mathematics, after controlling for the background of the candidates. Table 1 provides the list of all the written exams and their respective weights in the first-round score, which is the weighted-average written exam grade. For each exam, students receive a mark, ranging between zero and 20, in line with the French primary and secondary education grading scheme. Each mark is then multiplied by the coefficient of the corresponding subject. The average of these coefficient-adjusted grades gives the weighted-aggregate performance based on which *candidates* are ranked to become *admissibles*. A similar procedure is followed in the oral exam stage, except that admission to the school is based on the aggregate performance of both the written and oral stages.

The structure of the entrance examination in fact resembles an iterated elimination tournament where:

- only the best (less than 25%) *candidates* become *admissible* (i.e., admitted to the oral exam stage);
- approximately 50% of the *admissibles* are eventually *admitted* to the school.

This structure is strikingly different than the *baccalauréat*, which all French high-school students have to pass. Contrary to HEC admission process, the *baccalauréat* is not a contest but a pass-or-fail type of exam with three levels of graduation honors (beyond a simple "pass") which we can observe for the sample of candidates in our study. While the *baccalauréat* exam, which takes place over three days, is an important and stressful event, high-school students know, ex-ante, that there are no pre-set quotas involved. Beyond providing a useful control for the ability of the candidate in the multivariate analysis, the *baccalauréat* performance can be used to test whether, for the same cohort of students, the gender-gap existed in a non-competitive, yet stressful, exam two-years prior to the competitive HEC entrance exam.

At the end of the first-round of the HEC admission contest, the Entrance Exam Administration Center (which is not affiliated with the school) ranks all students (irrespective of whether they are of science, economics, literary or technological background) in deciding which *candidates* should become *admissibles* and later which *admissibles* should become *admitted.* The school does not set any admissions quota or minima for any given track, gender, non-French nationals, or any socio-economic background. All that matters for the admission to the second-round oral exams is rank-order based on the weighted-average score obtained at the first-round written exams. During the second stage, four exams (general culture, face-to-face interviews, first and second foreign languages) are common to all tracks and two other exams are track-specific. Table 1 provides the list of all oral exams for the science track and provides their respective weights. The *admissibles* are, then, ranked according to their aggregate performance over the two (written and oral exam) rounds; and the best 360 (all background combined) are admitted in the first year of the M.Sc. in Management program. As a result of this selection process, approximately 250 science-track *candidates* become *admitted*.

Once admitted to HEC, students spend three 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 two years account for the M.Sc. in Management degree.[4] Except for electives, the bulk of the first-year courses consist of the same core-courses for all of the *admitted*. Since each core course is a pass/fail type of task, we also examine the GPA of the core-courses to see whether the differences observed during the entrance exam persist in the first-year of their studies.

III. Dataset and descriptive statistics

The dataset used in the analysis covers 5,743 students who applied to the HEC M.Sc. in Management program in 2005, 2006 and 2007 through the science-track. As part of the application process candidates have to provide personal information including their gender, age, nationality, academic background (economics, scientific, literature, or technology), and have to document any graduation honors they may have obtained in the *baccalauréat* exam and the name of the prep-school they attended. National rankings of these prep-schools are published in the French press every year. Since better-ranked prep-schools are more selective and since the quality of the training received by students for two years may influence their performance in the entrance contest, we use an indicator variable (*Top-20 Prep-School)* for the 20 best-ranked scientific prep-schools as a control variable.[5] The dataset additionally contains all marks (given out of 20) at all the written exams (first round) for all of the *candidates* and all the marks at the oral exams for all of the *admissibles*.

Table 2 provides descriptive statistics at the different stages of the admission process for the science-track *candidates*. Overall, there are slightly more male *candidates* (50.84%) than female ones (49.16%), the difference being marginally significant at the 10% level using a t-test.[6] However, among the *admissibles* the gender composition tips in favor of the males who form 53.68% of the second-stage group while females form 46.32%, a difference that is statistically significant at the 1% level. This discrepancy in the gender composition persists

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[4] The last year is dedicated to a one-year specialization in one area of management (accounting, finance, strategy, marketing, international business, etc.)

[5] Although top-20 ranking choice is ad hoc, using top-10 or -30 ranked prep-schools did not alter the results. There are approximately 90 science-track prep-schools that are geared towards business schools.

[6] There is a higher proportion of females among the science-track candidates than in the general population: of the 161,396 (163,815) students sitting in the science-track of the 2005 (2006) regular *baccalauréat* exam 54.84% (54.57%) were male (official statistics for 2007 were not available). Similarly, of the 136,877 (146,031) students obtaining the regular science-track *baccalauréat* diploma in 2005 (2006) 53.42% (53.85%) were male. It should be noted that there were 324,167 (326,674) students taking the regular *baccalauréat* exam (all tracks combined) in 2005 (2006). About 310,000 students destined for two-year technical schools after high-school took instead the technology or professional *baccalauréat* exams. We do not consider that latter two groups here as only 2 to 3 per year are eventually admitted to HEC.

among the *admitted*: males form 54.08% of the *admitted* whereas females form 45.92%, and the difference is again statistically significant at the 1% level.

The next variable in Table 2 is the honors obtained at the *baccalauréat* exam, in which students get their degree if their weighted-average grade (with weights differing among "majors" or "concentration") is equal to or larger than 10 out of 20. We do not have the exact average grade that candidates obtained at the *baccalauréat* but we know the honors, if any, with which they passed it. There are three types of honors in the *baccalauréat* with grades between 10 to 12 corresponding to "Passable" (i.e., a regular pass with no distinctions), grades between 12 to14 to "Assez Bien" (the equivalent of *cum laude*), grades between 14 to 16 to "Bien" (the equivalent of *magna cum laude*) and grades above 16 to "Très Bien" (the equivalent of *summa cum laude*). The *baccalauréat* performance variable (*Bac_Perf*) is set equal to 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 significantly better than men at the *baccalauréat* exam. Female candidates' *baccalauréat* 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.[7] Moreover, the same observation is made when examining the *baccalauréat* performance differences for the *admissibles* and the *admitted*. Among the *admissibles,* females' average *Bac_Perf* of 3.42 is 0.30 points higher than that of males, whereas among the *admitted* the females' average *Bac_Perf* of 3.58 is 0.29 points higher than that of males. In both cases, the difference is statistically significant at the 1% level. These results indicate that female *candidates*, female *admissibles* and female *admitted* do significantly better in the national high-school finishing exam than their respective male counterparts. We will examine this discrepancy in more detail further below.

We also observe that a higher proportion (51.45%) of female *candidates* come from top-20 science-track prep-schools than male *candidates* (48.06%). Given that the proportion of female graduating from high school every year is approximately of 45.3%, this statistically significant difference (at the 1% level) suggests that, on average, females are not being discriminated against when entering top prep-schools after finishing high-school. When we look at the *admissibles*, we see that the percentage of candidates coming from top-20 prep-

[7] Unsurprisingly, HEC *candidates* are significantly more successful than the general population of students taking the regular *baccalauréat* exam (i.e., excluding students taking technology or professional *baccalauréat* exams). For 2005 and 2006 (year 2007 official results were not available) in the general population females' average *Bac_Perf* is 1.96 as opposed to males' 1.85. If we take into account the *baccalauréat* failures and give them a weight of zero, in the general population females' average *Bac_Perf* becomes 1.74 as opposed to males' 1.58.

schools goes up significantly for both genders. Whereas 80.98% of female that are *admissible* come from top-20 prep-schools, 76.74% of males that are *admissible* come from top-20 prep schools. This significant increase in the proportion of candidates coming from top-20 prep schools for both genders is not surprising: top prep-schools chose the best high-school students who are more likely to succeed in the *grande école* entrance exams after receiving further training. Importantly, the 4.24% difference between the two groups of *admissibles* remains statistically significant at the 5% level. So our sample is not influenced by gender discrimination as females are not being selected against when being offered to attend the best prep-schools. Finally, for the *admitted,* slightly more than 86% of those who are offered a place in the school come from a top-20 prep school. At this last stage of the selection process, there is no longer any difference between the genders on this dimension. These results strongly suggest that top-20 science-track prep-schools select the best high-school candidates, and do not discriminate against women.

Finally, we also look at the proportion of non-French among the candidate pool. Since the entrance exams, with the exception of foreign languages, are conducted in French, we would like to control for the possibility that differences in written and oral expression skills between native (mother-tongue) and non-native French speakers may differ and have an effect on exam performance. Non-French compose 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), 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 1% level). Even though being non-French does not appear to affect the chances of becoming admitted or lead to differences between males and females, we nevertheless control for it in our multivariate analysis.

Next, we conduct a series of univariate tests to examine the potential differences in entrance exam performance between males and females.

IV. Gender differences in performance

1. Univariate analysis

To test for the potential differences in performance at the entrance exam between genders, we first conduct a series of parametric and non-parametric univariate tests. Specifically, we test (i) the equality of the means (across genders) using a t-test (which allows for the differences in variances), (ii) equality of the medians using a non-parametric test and, (iii) the equality of the distributions using the non-parametric Kalmagorov-Smirnov (KS) test. First row of Table 3 provides the results for both the written and oral exam stages for the *candidates* and the *admissibles*, respectively. We observe that men perform slightly better than women at the written exam stage. Men's average (median) is 10.66 (10.69) out of 20 versus women's average of 10.58 (10.52). The observed difference of 0.08 (0.17) between the means (medians) is statistically different from zero at the 10% (5%) level. The KS test marginally rejects (at the 10% level) the null hypothesis that the grades for men and women are drawn from the same distribution. At the oral exam stage, men's mean (median) grade is 10.70 (10.69) and higher than women's average (median) grade by 0.14 (0.15) points. While the observed difference in the means is marginally significant (at 10% level), there is no statistically significant difference between the medians. The KS test cannot reject the null hypothesis that the men and women's oral exam grades come from the same distribution.

We also examine the potential differences between the variances of performances. We observe that for male candidates the standard deviation of written exam grade is 2.49, which is statistically larger (at the 1% level) than the standard deviation of written exam performances for female candidates which is 2.28 (not reported in Table 3).

As stated in the introduction, because of the relative-evaluation nature of the selection process, average or median performances for the whole sample may not be the most appropriate statistics to examine in order to test the origin of the difference across genders in the probabilities of being admitted to the school (i.e., being among the top-quantile of performance). In addition, the fact that the standard deviation of the written-exam-performance distribution is larger for men than it is for women suggests that there may be systematic variations across quantiles of the performance distribution. Therefore, we split the sample into quartiles according to performance measures, the first quartile being that with the lowest performance results. In rows two through five of Table 3, we repeat the parametric and non-parametric tests for the quartiles of the performance distribution. For the first (lowest performance) quartile, we observe that men's average (median) written exam grade is 7.45

(7.70) which is 0.24 (0.17) point lower than that of women, and the observed difference is statistically different at the 1% (5%) level. The equality of the written exam grade-average distributions across genders is also rejected (at the 1% level). In contrast, in the second and third quartiles, there is no difference in performances between men and women. In the highest (best written exam performance) quartile, however, men perform significantly better than women, on average. Men's average written exam grade is 13.73, which is 0.09 points higher than women's average grade, and the difference is statistically different from zero at the 5% level. Conversely, median marks are not statistically different (13.48 for men versus 13.43 for women), which suggests that men's grade distribution in the top-quartile is skewed towards the right. Indeed, the KS test rejects the equality of the top-quartile male and female grade distributions, albeit at the 10% level. Given the selection process, these results provide the first insight. Male candidates' written-exam grades have fatter tails than that of female candidates. Since only the top quartile of candidates are admitted to the oral exam stage, a larger percentage of men become admissible than women. That is, in our particular rank-order tournament men perform better than women because men's performance distribution has fatter tails, resulting in a larger proportion of men being selected. We would like to remind the reader that, in our natural experiment, women did significantly better than men in the *baccalauréat*, and this irrespective of whether they were *candidates*, *admissibles* or were eventually *admitted*. So the women who did relatively worse than men in the top quartile, actually did better in the *baccalauréat* (in terms of high-school graduation honors) than the same men.

We repeat the same tests for the oral stage, using the sample of *admissibles*. Consistent with the results above, we find that on average men who are *admissible* do marginally better than women. The average oral exam grade for men is 10.70, the average for women is 10.56, and the 0.14 points between these two averages is statistically different from zero at the 10% level. We cannot reject the null that the medians of oral grades and the distributions of oral grades are equal to one another across genders. Examining the quartiles of the *admissibles*, we find no statistically significant differences, except for the fourth (highest) quartile. In this last group, the mean (median) for the oral exam for men is 13.27 (13.03) which is statistically different at the 5% level (10% level) from the mean (median) of 13.08 (12.86) for women. Moreover, the null hypothesis that the corresponding distributions are equal to one another is rejected at the 5% level using the KS test. In other words, in the top-quartile of performance in the oral exams, men do significantly better than women.

These univariate tests clearly indicate that men's higher representation among the cohort of admitted students over 2005 through 2007 is due to fatter tails of the distribution of their performance measures. However, given that univariate tests do not allow us to control for the observable characteristics of the candidates, which may explain variation in performance across males and females; we next conduct a series of tests using multivariate regressions.

2. Multivariate Regression analysis

We now consider standard OLS regressions where we take successively the performance at the written and the oral tests as the dependent variables. This allows us to control for observable characteristics of the candidates. For the written exam, we control for potential differences in grading distributions across the three years that are in our data using indicator ("dummy") variables for 2006 and 2007 (2005 is the omitted year which forms the base case). We also control for the general ability of the candidates using the honor classifications as a measure of performance at the *baccalauréat*. Given that top prep-schools are highly selective in their admission process, we also use an indicator variable if the candidate attended a top-20 preparatory class (*Top-20 Prep-School*). Finally, we control for the potential performance differences between French and non-French candidates using the *D_nonFrench* indicator variable. Our test variable is the indicator variable *D_female*. For the oral-exam performance regressions, we also use the performance at the written exam to control for the ability differences across *admissibles* in the second stage.

Results are provided in Tables 4.A. and 5.A. for the written and oral stages, respectively. Considering the entire sample at the written-stage, we observe that the dummy *D_female* has a negative coefficient estimate of –0.4002, which is significant at the 1% level: on average, after controlling for the potential differences in grading across years, candidate's ability (using their *baccalauréat* performance), whether they come from a top-20 prep school, and whether they are native French speakers or not, we find that women, on average, do worse than men in the written exams. The regression has a R^2 of 0.3263 and an F-statistic of 455.76 which is significant at the 1% level. These results are in line with the univariate tests in Table 3 using the whole sample of *candidates*: Women's under-representation at the end of the written exam stage is due to their lower performance during the first stage. In another specification (not reported to conserve space) we interacted the female indicator variable with *baccalauréat* performance and top-20 prep-school indicator variable. The interacted variables' coefficient estimates were not significant, but the female indicator variable by itself remained positive and statistically significant.

We then repeat the same regressions for the different quartiles of the written exam performance measure (columns two through five of Table 4.A). We find that for the lowest quartile, the coefficient estimate for the *D_female* dummy is +0.1283, which is significantly different from zero at the 5% level. Conversely, when considering the highest quartile of written exam performance, the coefficient estimate for the *D_female* dummy is –0.2160 which is significantly different from zero at the 1% level. In the two intermediate quartiles, gender has almost no impact on the aggregate performance at the written exam.

These results corroborate those obtained in univariate tests: women under-perform men in the upper tail of performance distributions and over-perform men in the lower tail, suggesting that female candidates performances are less dispersed than those of male candidates. Men's written-exam performance distribution's fatter tails prevail even after controlling for the candidates' observable characteristics: men do significantly worse than women in the bottom quartile of performance, and men do significantly better than women in the top quartile.

Given that mathematics grades account for one-third of the written exam weighting scheme for the science track (Table 1) and given that there appears to be differences across genders in perceptions of own-abilities in scientific and non-scientific fields,[8] we tested whether our results about the dispersion of performances might be driven by differences in performances in the mathematics exams. For this, we run the same OLS specifications separately for the math and non-math exams, after calculating the respective weighted-average performance scores using written exam grades and the original weights described in Table 1. Results are provided in Tables 4.B and 4.C. For the math exams, results are identical to those obtained in Table 4.A using the overall written-exam performance. In column 1 of Table 4.B when considering the entire sample the dummy *D_female* has a negative coefficient estimate of –0.7990 which is significant at the 1% level. When considering the lowest performance quartile, the coefficient estimate for the dummy *D_female* is a positive +0.2219 which is significantly different from zero at the 5% level. Conversely, when considering the

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

highest performance quartile, *D_female* dummy has a negative coefficient estimate of –0.4031 which is significantly different from zero at the 1% level.

For the performances on written non-math exams presented in Table 4.C, when considering the entire sample of candidates, the coefficient estimate for the *D_female* dummy has a negative coefficient estimate of –0.1694 which is significant at the 1% level. When considering the lowest performance quartile, the coefficient estimate for the *D_female* dummy is +0.1224 (significant at the 5% level), as opposed to females' coefficient estimate of –0.1006 (significant at 5% level) in the highest performance quartile. Additionally, in Table 4.C the *D_female* has a negative (and significant) coefficient estimates for the second and third quartiles as well. Together, these regression results show that the gender difference in performances in the various quartiles is not driven by difference in performances in math or non-math exams: women in top (bottom) quartiles under-perform (over-perform) with respect to men, irrespective of whether the exam is based on mathematics or not. Men's performance in the written exam has fat tails across mathematics and non-mathematics fields.

In Tables 5.A through 5.C we present the results of the oral exam performance regressions. Note that we add the written exam grade in order to better control for the knowledge of the subject-matter on which *admissibles* are tested. Regressions results are along the lines of those obtained for the written stage, though with lower levels of statistical significance. Considering the entire sample of *admissibles*, we find that the dummy *D_female* has a negative coefficient estimate of –0.2270 (significant at 5% level) in Table 5.A for the overall oral exam performance, –0.4625 (significant at 5% level) in Table 5.B for mathematics oral exam, and –0.2314 (marginally significant at the 10% level) for the non-math oral exams' grade in Table 5.C. However, when examining the overall oral exam grades in Table 5.A, we do not find any evidence of men out-performing women in the top-performance quartile, and in fact none of the coefficient estimates for the *D_female* dummy is significant for any of the performance quartiles. In other words, the observed over-performance of males with respect to females in the univariate oral exam performance tests disappears in our multivariate regressions. Yet again, when we split the performance between mathematics and non-mathematics exams, we find that in the highest quartile, the coefficient estimate for the *D_female* indicator variable is negative and significantly different from zero at the 5% and 10% levels in Table 5.B (oral math exam) and in Table 5.C (non-math oral exams weighted-average), respectively. Hence, regression results obtained for the oral exams are qualitatively similar, even though weaker, to those obtained for the written exam stage. It should be noted, however, that these weaker results are due to the fact that, since a first selection already occurred at the written stage, the cohort of students passing the oral examination are already in the upper tail of the distribution.

One difference between written and oral exams is that the former are anonymous while the latter are not, yet we find very similar results in both types of exams. Hence, our results suggest that non-anonymity does not play a role in the candidates' performances (implying that there is no gender-based discrimination in the selection process).

V. Discussion and the Related Literature

In the setting of a tournament-like real-world selection process where payoffs at stake are very large, we have shown that (i) the average performance of women is significantly lower than that of men, (ii) the variance of such performance is higher for men than women and, (iii) the tails of the distribution are significantly fatter for men than for women. Several interpretations could be drawn from these results.

1. Potential differences in innate ability

The easiest (but 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, the same outcome should be obtained for any given examination requiring the same kind of academic knowledge, irrespectively of the admission structure. Evidence provided in the previous section shows that this is not the case. Indeed, the performance at the *baccalauréat* exam for the same cohort of students provides information about gender differences in a pass-or-fail type of exam. During the science-track *baccalauréat* exam, similar to the HEC admission process, students have to take written exams which include French literature (both written and oral), mathematics, physics, chemistry, biology, history, geography, philosophy and foreign languages (oral). 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 differences in ability is a possible explanation for the differences in performances observed at the HEC admission contest. The striking difference in outcome between the two processes leads us towards a negative answer.

First, as shown in Table 2, in the sample of HEC-admission candidates, women's average performance at the *baccalauréat* examination is significantly better (at 1% level) than that of men. More importantly, the distribution of performances of women dominates that of men in the sense of first-order stochastic dominance.[9] This difference in performance is analyzed further in Table 6 where *Bac_Perf* is regressed over various dummy variables including the year and gender. In all Table 6 regressions (i.e., considering either the entire sample or quartiles based on performances at the written stage of the HEC admission contest), the coefficient estimate for the dummy *D_female* is positive and significantly different from zero at the 1% level. Hence, among *candidates*, *admissibles*, and *admitted* women do better at the *baccalauréat* exam than their male counterparts.

2. Difference in the degree of risk aversion

A second conclusion one could draw from the fact that the variance of the distribution of grades is larger for men than for women (resulting in fatter tails) is that the latter are more risk-averse than the former. Such a difference in risk aversion could, for example, materialize as follows: women work hard on all subjects during their prep-school whereas men invest more time and effort on some high-coefficient selected subjects (such as mathematics) and spend less time and effort on low-coefficient subjects. In such a setting, the distribution of exam grades at the individual level should be different for female and male candidates.

We test for this conjecture in two different ways. First, using all of the written exam scores obtained by each candidate, we compute the standard deviation of the grades for each individual (hereafter, individual-standard deviation). The average of men's individual-standard deviations for the written exam grades is 3.0578 as opposed to women's average of 3.0370. A t-test (t-statistic = 0.8387) cannot reject the null hypothesis that the averages of the individual-standard deviations for men and women are equal to each other. Conducting a non-parametric test of the equality of the medians of individual-standard deviations for men (=3.0006) and women (=2.9512), we obtain the same result (χ^2-statistic=2.2710 is not statistically significant). In fact, the null hypothesis of the equality of the distributions for individual-standard deviations for men and women using a KS-test cannot be rejected either. We then repeat these tests after calculating individual based standard deviations of oral exam grades. The mean of men's individual-standard deviation of oral grades (which is 3.4965) cannot be distinguished from that of women (which is 3.5258) using a t-test (t-statistic = –0.4609). Using a non-parametric test, we cannot reject the null hypothesis that the medians of the individual-standard deviation for male (=3.4429) and female (=3.4302) are different for the oral tests (χ^2-statistic=0.0117 is not statistically significant). Finally, the non-parametric

[9] In contrast, it can be inferred from Paglin and Rufolo (1994, Table 4) that in the GRE-quantitative exam, a relative performance setting, men's performance dominates that of women in the first-stochastic order sense

test of the equality of the distributions for the individual-standard deviations of oral exam grades for males and females cannot be rejected either.

We conducted a second set of tests to examine whether men might be concentrating on high-coefficient subjects and work less on low-coefficient subjects. We split the sample of candidates into separate quartiles according to their mathematics and non-mathematics written exam grade averages (using the subject exam-weights indicated in Table 1). The variable QM_i equals one if the candidate belongs to the i^{th} quartile according to the mathematics written exam grade, with i={1, 2, 3, 4}. Similarly, the variable QNM_j equals one if the candidate belongs to the j^{th} quartile according to the non-mathematics written exam grade, with j={1, 2, 3, 4}. We then calculate Spearman rank-order pair-wise correlations between the math and non-math indicator variables first for the males and then for the females. If the male candidates focus on math exams and put less effort in other subjects, then there should be a positive correlation between being in the higher math-grade quartiles and the lower non-math grade quartiles. This is not what we observe in Table 7. In fact, there is a positive correlation between belonging to the best (worst) math performance quartile and belonging to the best (worst) non-math performance quartile, and this irrespective of the fact that the candidate is a male or female. If we consider Table 7 to be a 4x4 matrix, with math performance quartiles (QM) as columns (i) and non-math performance quartiles (QNM) as rows (j), we observe that there are positive and statistically significant correlations in cells (4,4) and (1,1) for both men or women. Similarly, there are negative and statistically significant correlations in cells (4,1) and (1,4).

The results of these two sets of tests go in the same direction: we find no evidence that male and female candidates differ in their risk-taking behavior as far as the HEC-admission contest is concerned. However, the results of our tests should not be construed as evidence that there is no difference in the risk-aversion of men and women in general. Several recent experimental studies investigate the difference toward risk of men and women respectively. Evidence from gamble-based experiments suggests greater risk aversion by women, this greater risk aversion being even more significant when using field data. Johnson and Powell (1994) use betting decision on horses and dog races in United Kingdom and find that men are more risk-prone than women in their betting habits. In a different vein, Bajtelsmit and VanDerhei (1997) study the pension allocation decisions of 20,000 employees of a large US firm. They find that women held a significant larger share of their account balances in lowrisk fixed income investments and a significantly higher share in high-risk firm stock.[10] Our test set-up differs from these in the sense that our conjecture about risk-aversion is very specific to the context of the entrance exam, and our data reject evidence of difference in risk-taking behavior.

3. Are women potentially less competitive than men?

As already mentioned, a striking result 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. A possible interpretation of our results is that men and women perform differently in different institutional environments and notably, women under-perform in a more competitive environment. We investigate this explanation further by considering the performance during their first year at HEC of students admitted to the school. This provides additional insight since, once admitted, the grading system is not based on a relative performance scheme but on pass/fail type absolute performance measures. During their first year, HEC students take 11 compulsory courses: accounting, economics, finance, marketing, law, theory of organizations, supply chain, statistics, quantitative methods, modeling with Excel, and English as first foreign language. Each of these courses is weighted by the corresponding European Credit Transfer and Accumulation System (ECTS) credits, which are equivalent to the U.S. credit-hours. 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, for a total of 44 ECTS credits for the mandatory courses. There are also a number of elective courses worth 16 ECTS points. But since students differ in their elective course choices, we do not include the non-mandatory courses in our analysis in order to be able to have a common performance metric. The HEC grading system is very similar to the one used in the U.S. universities: course letter grades range from A for best performing students in a class to F for those who fail the class, with the addition of an E which is a passing grade that is worse than a D. To obtain a grade point average (GPA) we map each A obtained in a course to a 4 out of four, B to a 3, C to a 2, D to a 1, E to 0.5, and F to a 0. The letter grade for each course is then weighted by the ECTS credits for the course; the total is divided by 44 to obtain the first-year core-curriculum GPA.

[10] See Jianakoplos and Bernasek (1998) and Sunden and Surette (1998) for more on this issue. See Eckel and Grossman (2008) for a review of the literature.

We examine the first-year performance of the cohorts that have been admitted in 2005 and 2006.[11] The results are presented in Table 8. As for the *baccalauréat*, we get that the performance of women first order stochastically dominates that of men. This is illustrated as follows. Looking at the cumulative distribution of grades, we observe that of all the grades obtained by women in their mandatory classes 28.7% are A's, whereas the same proportion is 27.1% for men. This difference is marginally significant at the 10% level. However, 59.94% of the grades obtained by women in these courses are A's or B's, while the same proportion is 57.82% for men, this difference being statistically significant at the 5% level. Similarly, 83.5% of the grades obtained by women are C's or above, while the same proportion is 80.19% for men (the difference being statistically significant at the 1% level); and 93.99% of the grades obtained by women in these courses are D's or above, while the same proportion is 92.41% for men (this difference is statistically significant at the 5% level). Finally, 98.38% of the grades obtained by women in these courses are E's or above, while the same proportion is 97.29% for men (this difference is statistically significant at the 1% level).

These results clearly show that women perform better than men in their first year in the school despite the fact that the same men did better in the school's entrance exam that their female classmates. The only difference is that, like the *baccalauréat* exam, the first-year performance is based in a non-competitive setting as there are no set quotas for success or failure rates. Hence, our result clearly show that the gender difference in performance at the HEC entrance competitive exam cannot be attributed to differences in ability but, rather, to the competitive aspect of the selection process.

Additional evidence suggests that our findings are not specific to the French education system. Observations made in papers on academic performance in the U.S., whose findings are summarized in Table 9, indicate a pattern that is similar to the one that we find.[12] This literature typically observes that women's GPA in high-school and/or in college is higher than that of men, despite the fact that women's SAT scores are lower than that of men. While research has drawn attention to the fact that women do worse than men in the SAT, GRE or GMAT (for example, Gallagher, Bridgeman and Calahan, 2002), it has not linked, as we do, the observed gender gap to the relative nature of performance measurement in standardized aptitude tests. In our view such tests can be likened to competitive tournaments, as academic ranking of the college (graduate school) in which a student is offered admission is highly

[11] The year 2007 cohort, whose grades were not yet available, cannot be added to this sample, since the first-year curriculum was subject to a major reform which came into effect in September 2008: some of the courses were moved to the second year, whereas others were given less number of hours (hence less ECTS credits).

[12] We limit our literature survey in Table 9 to those papers that provide descriptive statistics across genders.

correlated with higher SAT (or GRE, GMAT or LSAT for graduate school) score (as columns 3 and 5 of Table 9 clearly attest).

However, there are a number of differences that set our paper apart from the academic performance prediction literature summarized in Table 9. First, we examine the gender gap in performance in tournament versus pass/fail-type exams. In contrast, the focus of the literature on academic performance is on the prediction of college or graduate school performance based on observable characteristics of admitted students (for example, Elliott and Strenta 1988; McCornack and McLeod 1988; and Young 1991). Second, while a number of papers in this literature have documented the gender gap in academic performance (for example, McCornack and McLoed 1988; Bridgeman and Wendler 1990; Bridgeman and Lewis 1996; and Gallagher, Bridgeman and Calahan 2002), none of them study whether the observed difference is due to the relative versus absolute nature of the performance tests. Third, we have data on all of the candidates prior to the entrance exam, during the selection process and, for those who are admitted, during the first year of their studies. As such, our sample includes those rejected during the various stages of the entrance exam as well those who are admitted. In contrast, the academic performance literature typically relies on the samples of students admitted to college, which generates a selection bias when evaluating pre-college academic performance using high-school GPA or SAT score (Rothstein 2004). Finally, we believe that our performance metrics are better than those used in the academic performance literature, the reason being that we observe the admitted students before they decide on their majors at HEC. Hence, our first-year performance measure is based on the same set of courses (i.e., it excludes all electives), as opposed to the Freshman-year or cumulative-GPAs listed in Table 9, which typically include students from various colleges taking different elective courses. This is an important difference, as the gender gap in the choice of major field is shown to result in differences in human capital across genders (Brown and Corcoran, 1997, Turner and Bowen, 1999). Our results are not affected by a similar orientation bias.

Our results also provide strong support, in a real life setting, to the experimental findings of Gneezy, Niederle and Rustichini (2003), and Niederle and Vesterlund (2007). In the first study, the authors observe that as the competitiveness of the environment increases, men's performances increase while those of women do not. Furthermore, they find that the performance of women is significantly higher in single-sex tournaments than in non-competitive treatments, suggesting that the competitive environment in which women operate can affect their performance. In the experiment run by Niederle and Vesterlund (2007), participants are asked to solve tasks in a non-competitive environment and then in a tournament environment. In a second step, participants are asked to select in which of the two environments they want to operate. It is observed that only 35% of women choose to enter the competitive tournament while 73% of men decide to do so.

In contrast to experimental studies, our contribution is to examine performance gender gap using a natural experiment with significant real-life payoffs. Given the resulting large sample we are not restricted to studying average performances but can compare performances in the tails of the performance distributions. Furthermore the natural experiment that we rely upon comprises many tasks (written and oral expression abilities, mathematical problem solving versus verbal skills) and high stake payoffs for the subjects that constitute our sample.

VI. Conclusion

Using a unique database, we have analyzed gender difference in performance in a two-round elimination-type tournament: the admission exams to HEC Paris' Master of Science in Management. Given that this program is ranked first in Europe in its category, payoffs at stake are very high. We find that men perform better than women in this competitive exam despite the fact that, in the same cohort of candidates, the females performed significantly better at an earlier pass/fail type of national exam (the *baccalauréat*) *and*, once admitted, during the first-year of their studies (composed of a series of pass/fail courses). While men perform better than women among the top-10% of the applicant pool (i.e., those who are eventually admitted to the school), they perform worse than women when the bottom quantile is concerned. The general picture is then that of a larger dispersion of performances among men.

Considering various possible explanations for these results, we find no evidence of differences in ability or in risk-taking behavior between male and female candidates. Hence, consistent with earlier experimental studies, we believe that the difference in performance is explained by the competitive aspect of the contest. Given that discrimination and self-selection were ruled in our natural experiment, our results can potentially provide another explanation for the under-representation of women in top positions. Top executives are outliers, few outstanding managers who emerge from the employee or potential candidate pool. If the selection process for the top-management positions can be likened to a series of competitive tournaments, as opposed to pass/fail type of evaluation processes, then men's higher performance in competitive setting may help explain their predominance in top-executive positions. Therefore, if men out-perform women in competitive settings, as it is suggested by our natural experiment, then these outliers are more likely to be men than women. Moreover, if the structure of selection process indeed impacts gender performance, then the under-representation of women may start early and a competitive exam approach (as notably used in France) may be detrimental to the representation of women in top positions.

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Table 1. Structure of the HEC Admission Exam

	Written Exam (1st Stage)		Oral Exam (2nd Stage)	
Common Exams	**Duration**	**Coefficient**	**Duration**	**Coefficient**
French	3 hours	3		
First foreign language	4 hours	4	15 mins	4
Second foreign language	3 hours	2	15 mins	3
General Culture			20 mins	6
Debate			40 mins	6
Track-specific Exams				
General culture	4 hours	4		
Mathematics 1	4 hours	6	30 mins	9
Mathematics 2	4 hours	5		
History and Geography	4 hours	6	20 mins	8
Total		30		36

Table 2: Descriptive Statistics

Equality of the means tested using a one-sided t-test (which allows for the inequality of the sub-sample variances). ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Candidates **(Written Exam Sample)**				***Admissibles*** **(Oral Exam Sample)**				***Admitted***			
	Male	**Female**	**t-stat**		**Male**	**Female**	**t-stat**		**Male**	**Female**	**t-stat**	
Gender composition (%)	50.84	49.16	1.28	*	53.68	46.32	2.73	***	54.08	45.92	2.22	***
(N)	(2,920)	(2,823)			(737)	(636)			(398)	(338)		
Baccalauréat Performance (/ 4)	2.69	2.98	–12.72	***	3.13	3.43	–7.88	***	3.29	3.58	–6.15	***
(N)	(2,911)	(2,819)			(735)	(635)			(396)	(338)		
Top 20 Science Prep-School (%)	48.06	51.45	–2.55	***	76.74	80.98	–1.92	**	86.18	86.39	–0.08	
(N)	(2,886)	(2,803)			(735)	(636)			(398)	(338)		
Non-French (%)	5.92	9.03	–4.48	***	4.75	8.81	–2.96	***	5.53	9.47	–2.01	**
(N)	(2,920)	(2,823)			(737)	(636)			(398)	(338)		

Table 3. Descriptive Statistics on HEC Entrance Exam Performance

Test of the equality of the means is one-sided t-test (which allows for unequal variances for the two subsamples). A positive (negative) t-stat means that mean for males is larger than the mean for females. The equality of the medians is a non-parametric test that the medians are drawn from the same population that is distributed chi-squared with one degree of freedom. The third statistic is the non-parametric Kalmagorov-Smirnov (KS) test for the equality of male and female distributions. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

		Written Exams' Average				Oral Exams' Average			
		Male	Female			Male	Female		
Whole Sample	Mean [t-tsat]	10.66	10.58	1.27	*	10.70	10.56	1.31	*
	Median [χ^2-stat]	10.69	10.52	3.79	**	10.69	10.54	1.50	
	(N)	(2,889)	(2,810)			(735)	(636)		
	KS-test [D-value]			0.035	*			0.055	
1st Quartile (lowest)	Mean [t-tsat]	7.45	7.69	-4.26	***	8.15	8.16	-0.10	
	Median [χ^2-stat]	7.70	7.87	4.27	**	8.33	8.42	0.55	
	(N)	(725)	(699)			(183)	(159)		
	KS-test [D-value]			0.106	***			0.073	
2nd Quartile	Mean [t-tsat]	9.79	9.75	1.41	*	9.94	9.94	-0.03	
	Median [χ^2-stat]	9.80	9.76	1.06		9.96	9.95	0.03	
	(N)	(682)	(743)			(172)	(171)		
	KS-test [D-value]			0.050				0.045	
3rd Quartile	Mean [t-tsat]	11.44	11.48	-1.26		11.25	11.20	-0.92	
	Median [χ^2-stat]	11.45	11.48	0.37		11.22	11.22	0.35	
	(N)	(710)	(750)			(186)	(157)		
	KS-test [D-value]			0.052				0.077	
4th Quartile (highest)	Mean [t-tsat]	13.73	13.64	1.64	**	13.27	13.08	1.74	**
	Median [χ^2-stat]	13.48	13.43	0.21		13.03	12.86	3.26	*
	(N)	(772)	(653)			(194)	(149)		
	KS-test [D-value]			0.067	*			0.146	**

Table 4.A: Performance at the Written Exam (1st Stage)

This table presents OLS regressions where the dependent variable is the weighted-average of written exam grades. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Candidates		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)	
Constant	6.8053	***	6.8320	***	9.5778	***	11.2674	***	12.2976	***
	(68.91)		(75.49)		(182.12)		(194.30)		(86.26)	
D_2006	0.7196	***	0.0688		0.0636	**	0.0460		0.0968	
	(11.12)		(1.06)		(1.99)		(1.38)		(1.28)	
D_2007	0.8988	***	0.0193		0.0860	***	0.0533		0.2003	***
	(13.88)		(0.29)		(2.69)		(1.58)		(2.70)	
D_female	–0.4002	***	0.1283	**	–0.0517	*	0.0153		–0.2160	***
	(7.56)		(2.32)		(1.95)		(0.57)		(3.86)	
D_non-French	–0.1970	*	–0.2282	***	–0.0113		0.1070	**	0.2351	**
	(1.96)		(2.60)		(0.21)		(1.99)		(2.02)	
Bac_Perf	0.9456	***	0.2610	***	0.0534	***	0.0296	*	0.3546	***
	(28.74)		(7.74)		(3.01)		(1.70)		(9.07)	
Top-20 Prep-School	1.6311	***	0.4266	***	0.0690	**	0.0861	***	0.2560	***
	(29.68)		(6.20)		(2.53)		(3.16)		(3.80)	
N	5635		1385		1410		1420		1420	
R^2	0.3263		0.0958		0.0144		0.0104		0.0739	
F-statistic	455.76	***	25.43	***	4.44	***	3.49	***	19.88	***

Table 4.B: Performance at the Written Mathematics Exams

This table presents OLS regressions where the dependent variable is the weighted-average of written exam grades with the weighting scheme determined by the Centre des Concours for each track: the dept variable is the performance measure for written part of the "concours". . ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Candidates		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)	
Constant	5.2324	***	4.4147	***	8.8024	***	11.8021	***	15.0045	***
	(27.99)		(30.53)		(104.35)		(114.11)		(66.17)	
D_2006	0.9561	***	0.2042	**	0.0661		0.1745	***	–0.0732	
	(7.81)		(1.99)		(1.24)		(2.80)		(0.59)	
D_2007	1.3335	***	–0.0721		0.0821		0.1661	***	0.3122	**
	(10.88)		(0.68)		(1.50)		(2.69)		(2.54)	
D_female	–0.7990	***	0.2219	**	–0.0796	*	0.0438		–0.4031	***
	(7.98)		(2.57)		(1.77)		(0.88)		(4.20)	
D_non-French	–0.1913		–0.4711	***	0.0110		–0.0795		0.2593	
	(1.01)		(3.20)		(0.13)		(0.77)		(1.35)	
Bac_Perf	1.3394	***	0.3186	***	0.0952	***	–0.0015		0.3597	***
	(21.51)		(6.20)		(3.33)		(0.05)		(5.45)	
Top-20 Prep-School	2.7356	***	0.4342	***	0.1058	**	0.2736	***	0.4069	***
	(26.30)		(4.20)		(2.28)		(5.36)		(3.68)	
N	5635		1392		1412		1412		1419	
R^2	0.2438		0.0682		0.0132		0.0226		0.0469	
F-statistic	303.72	***	17.96	***	4.14	***	6.45	***	12.63	***

Table 4.C: Performance at the Written Non-Mathematics Exams

This table presents OLS regressions where the dependent variable is the weighted-average of written exam grades with the weighting scheme determined by the Centre des Concours for each track: the dept variable is the performance measure for written part of the "concours". ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Candidates		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)	
Constant	7.7159	***	7.2381	***	9.7476	***	11.0878	***	12.5432	***
	(83.63)		(86.19)		(235.37)		(231.74)		(108.21)	
D_2006	0.5826	***	0.0933		0.0326		0.0441		0.1220	*
	(9.64)		(1.59)		(1.25)		(1.52)		(1.89)	
D_2007	0.6472	***	0.1611	***	0.0257		0.0476	*	0.0778	
	(10.69)		(2.64)		(1.00)		(1.66)		(1.20)	
D_female	–0.1694	***	0.1224	**	–0.0627	***	–0.0420	*	–0.1006	**
	(3.43)		(2.43)		(2.90)		(1.84)		(2.04)	
D_non-French	–0.2003	**	–0.2359	***	–0.0258		–0.0202		0.2793	***
	(2.13)		(2.83)		(0.63)		(0.44)		(2.71)	
Bac_Perf	0.7175	***	0.2069	***	0.0305	**	0.0327	**	0.1595	***
	(23.34)		(6.72)		(2.17)		(2.17)		(4.87)	
Top-20 Prep-School	0.9917	***	0.3373	***	0.0421	*	0.0745	***	0.1461	***
	(19.32)		(5.83)		(1.92)		(3.16)		(2.70)	
N	5635		1379		1418		1418		1420	
R^2	0.2095		0.0870		0.0095		0.0132		0.0276	
F-statistic	249.78		22.88		3.26		4.15		7.71	

Table 5.A: Performance at the Oral Exam – Science Track

This table presents OLS regression where the dependent variable is the weighted-average of <u>oral</u> exam grades with the weighting scheme determined by the Centre des Concours for each track: the dept variable is the performance measure for written part of the "concours". ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Admissibles		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)	
Constant	0.9267		5.5084	***	9.3765	***	10.5096	***	10.0829	***
	(1.51)		(7.03)		(28.89)		(39.25)		(15.91)	
D_2006	–0.6183	***	–0.1192		–0.0221		0.0681		–0.2883	**
	(5.01)		(0.92)		(0.38)		(1.30)		(2.21)	
D_2007	–0.9725	***	–0.4103	***	–0.0791		–0.0209		–0.3695	***
	(7.56)		(3.06)		(1.30)		(0.38)		(2.69)	
D_female	–0.2270	**	–0.0262		–0.0240		0.0280		–0.1417	
	(2.30)		(0.27)		(0.52)		(0.65)		(1.33)	
D_non-French	0.3308	*	–0.0472		0.0965		–0.0313		0.1050	
	(1.68)		(0.24)		(0.90)		(0.41)		(0.51)	
Bac_Perf	0.4191	***	0.0560		0.0510	*	0.0584	*	0.0708	
	(5.98)		(0.85)		(1.68)		(1.89)		(0.81)	
Top-20 Prep-School	0.9031	***	0.2805	***	0.0045		0.0681		0.2376	
	(7.56)		(2.82)		(0.09)		(1.15)		(1.40)	
Written Exam Score	0.6037	***	0.1878	***	0.0326		0.0344	*	0.2059	***
	(12.75)		(3.04)		(1.32)		(1.74)		(4.44)	
N	1366		341		341		343		341	
R^2	0.2015		0.0541		0.0003		0.0250		0.0680	
F-statistic	50.21	***	3.78	***	1.01		2.25	**	4.54	***

Table 5.B: Performance at the Oral Mathematics Exam – Science Track

This table presents OLS regressions where the dependent variable is the weighted-average of oral exam grades with the weighting scheme determined by the Centre des Concours for each track: the dept variable is the performance measure for written part of the "concours". ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Admissibles		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)	
Constant	–0.1475		2.7665	***	7.2784	***	10.6829	***	12.7111	***
	(0.22)		(5.16)		(22.12)		(29.69)		(15.65)	
D_2006	–0.6765	***	–0.0830		–0.2431	**	–0.2472	**	–0.1061	
	(2.91)		(0.39)		(2.25)		(2.21)		(0.45)	
D_2007	–1.8708	***	–0.8942	***	–0.1552		–0.1608		0.0817	
	(7.80)		(4.40)		(1.35)		(1.29)		(0.32)	
D_female	–0.4625	**	–0.1921		–0.1152		–0.0478		–0.4164	**
	(2.42)		(1.15)		(1.34)		(0.49)		(2.05)	
D_non-French	0.5100		0.5993	*	0.0355		–0.0652		–0.1133	
	(1.34)		(1.76)		(0.21)		(0.32)		(0.30)	
Bac_Perf	0.3546	***	0.1704		0.1058	*	0.1244	*	0.0342	
	(2.66)		(1.54)		(1.74)		(1.79)		(0.24)	
Top-20 Prep-School	1.0125	***	0.2554		0.1556		–0.2003	*	–0.3811	
	(4.39)		(1.45)		(1.44)		(1.73)		(1.30)	
Written Exam Score	0.6071	***	0.1683	***	0.0767	***	0.0446	**	0.1737	***
	(16.96)		(5.51)		(4.30)		(2.26)		(3.96)	
N	1366		340		341		342		343	
R^2	0.2103		0.1298		0.0593		0.0232		0.0589	
F-statistic	52.93	***	8.22	***	4.06	***	2.16	**	4.06	***

Table 5.C: Performance at the Oral Non-Mathematics Exam – Science Track

This table presents OLS regressions where the dependent variable is the weighted-average of oral exam grades with the weighting scheme determined by the Centre des Concours for each track: the dept variable is the performance measure for written part of the "concours". ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Admissibles		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)	
Constant	4.9797	***	7.3124	***	10.5347	***	11.9454	***	13.1277	***
	(9.31)		(15.01)		(46.34)		(41.88)		(23.31)	
D_2006	–0.4321	***	–0.0969		0.0010		–0.0426		–0.1072	
	(2.97)		(0.72)		(0.02)		(0.59)		(0.79)	
D_2007	–0.4354	***	–0.1274		0.0254		0.0569		–0.1978	
	(2.96)		(0.95)		(0.41)		(0.79)		(1.43)	
D_female	–0.2314	*	0.0498		–0.0170		–0.0837		–0.2148	*
	(1.94)		(0.46)		(0.34)		(1.44)		(1.91)	
D_non-French	0.3260		0.0212		–0.0534		0.0215		–0.1620	
	(1.36)		(0.10)		(0.46)		(0.18)		(0.79)	
Bac_Perf	0.5717	***	0.1484	**	0.0426		0.0420		0.2567	***
	(6.81)		(2.02)		(1.24)		(1.01)		(2.91)	
Top-20 Prep-School	1.0137	***	0.1217		–0.0008		–0.0111		–0.0317	
	(7.02)		(1.08)		(0.01)		(0.14)		(0.17)	
Written Exam Score	0.3479	***	0.0773	**	0.0085		0.0277		0.0656	*
	(8.62)		(2.01)		(0.50)		(1.39)		(1.66)	
N	1366		341		342		342		341	
R^2	0.1289		0.0143		–0.0139		0.0028		0.0303	
F-statistic	29.87		1.70		0.33		1.14		2.52	

Table 6: Baccalauréat Performance

This table presents OLS regressions where the dependent variable is Bac_Perf which is equal to 1 if high-school *baccalauréat* is obtained without honors, otherwise equal to 2, 3 or 4 if obtained with the honors *cum laude, magna cum laude* or *summa cum laude*, respectively. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

	Candidates		1st Quartile (lowest)		2nd Quartile		3rd Quartile		4th Quartile (highest)		Admissibles		Admitted	
Constant	2.6289	***	2.2536	***	2.6003	***	2.8457	***	3.1049	***	2.9543	***	3.0842	***
	(114.77)		(53.54)		(64.97)		(64.96)		(68.94)		(94.01)		(76.49)	
D_2006	0.1143	***	–0.0721		0.0119		0.0028		0.0838		0.1986	***	0.1576	***
	(4.17)		(1.36)		(0.24)		(0.06)		(1.62)		(5.14)		(3.15)	
D_2007	0.0992	***	–0.0859		0.0163		–0.0119		–0.0052		0.1402	***	0.1503	***
	(3.63)		(1.60)		(0.34)		(0.23)		(0.10)		(3.60)		(3.00)	
D_female	0.2870	***	0.3358	***	0.2458	***	0.3155	***	0.2839	***	0.3213	***	0.3424	***
	(12.99)		(7.60)		(6.14)		(7.82)		(7.57)		(10.13)		(8.36)	
D_nonFrench	–0.1673	***	–0.1889	***	–0.0286		–0.0269		–0.0339		0.0492		0.0201	
	(3.95)		(2.62)		(0.35)		(0.32)		(0.43)		(0.76)		(0.26)	
N	5730		1421		1423		1421		1422		2058		1127	
R^2	0.0327		0.0423		0.0232		0.0388		0.0401		0.0588		0.0662	
F-statistic	49.45	***	16.69	***	9.46	***	15.31	***	15.82	***	33.14	***	20.96	***

Table 7. Spearman Pairwise Rank-Order Correlations

This table presents the Spearman pair-wise correlation coefficients between two sets of indicator (dummy) variables that are equal to 1 if the observation belongs to mathematics and non-mathematics performance quartile i (i=1, 2, 3, 4) in the written exam, and zero otherwise.

Males (N=2,920)

			Mathematics							
			QM_1 (lowest)		**QM_2**		**QM_3**		**QM_4 (highest)**	
Non-Mathematics	**QNM_1 (lowest)**	rho	0.2825	***	0.0266		–0.0909	***	–0.1956	***
		p-value	0.0000		0.1514		0.0000		0.0000	
	QNM_2	rho	0.0099		0.0380	**	0.0286		–0.0600	***
		p-value	0.5926		0.0399		0.1223		0.0012	
	QNM_3	rho	–0.0945	***	0.0041		0.0527	***	0.0497	***
		p-value	0.0000		0.8241		0.0044		0.0073	
	QNM_4 (highest)	rho	–0.1879	***	–0.0552	***	0.0253		0.2231	***
		p-value	0.0000		0.0029		0.1718		0.0000	

Females (N=2,823)

			Mathematics							
			QM_1 (lowest)		**QM_2**		**QM_3**		**QM_4 (highest)**	
Non-Mathematics	**QNM_1 (lowest)**	rho	0.2060	***	0.0436	**	–0.0580	***	–0.1941	***
		p-value	0.0000		0.0207		0.0020		0.0000	
	QNM_2	rho	0.0581	***	0.0310	*	–0.0245		–0.0613	***
		p-value	0.0020		0.1000		0.1926		0.0011	
	QNM_3	rho	–0.0652	***	–0.0170		0.0393	**	0.0514	***
		p-value	0.0005		0.3674		0.0366		0.0063	
	QNM_4 (highest)	rho	–0.1900	***	–0.0507	***	0.0485	***	0.2072	***
		p-value	0.0000		0.0070		0.0099		0.0000	

Table 8. Proportion of Letter Grades Obtained During First-Year of HEC.

This table presents the distribution of letter grades among mandatory (core) courses during the first-year of HEC. ***, ** and * denote statistical significance at 1%, 5% and 10% levels, respectively.

Grade	Total (5,046)	Men (2,767)	Women (2,279)	z-score (1-sided)		Total Cumulative (5,046)	Men Cumulative (2,767)	Women Cumulative (2,279)	z-score (1-sided)	
A	27.8% (1,404)	27.1% (749)	28.7% (655)	–1.32	*	27.8% (1,404)	27.1% (749)	28.7% (655)	–1.32	*
B	31.0% (1,562)	30.8% (851)	31.2% (711)	–0.34		58.78% (2,966)	57.82% (1,600)	59.94% (1,366)	–1.52	**
C	22.9% (1,156)	22.4% (619)	23.6% (537)	–1.00		81.69% (4,122)	80.19% (2,219)	83.50% (1,903)	–3.02	***
D	11.4% (577)	12.2% (338)	10.5% (239)	1.92	**	93.12% (4,699)	92.41% (2,557)	93.99% (2,142)	–2.21	**
E	4.7% (235)	4.9% (135)	4.4% (100)	0.82		97.78% (4,934)	97.29% (2,692)	98.38% (2,242)	–2.61	***
F	2.2% (112)	2.7% (75)	1.6% (37)	2.6	***	100.00% (5,406)	100.00% (2,767)	100.00% (2,279)		

Table 9. Summary of Findings of the College Performance Prediction Literature

This table summarizes the statistics observed by the college performance literature. When GPA and aptitude test scores were provided for different sub-samples (such as in-state versus out-of-state students), a weighted-average GPA or aptitude test-score was calculated. When sub-sample observations numbers were not provided, the simple average of the sub-sample statistics was calculated. * indicates statistical significance in those cases where a test of male-female GPA or test-score difference was conducted. # indicates instances where statistical difference was observed for the quantitative part of the SAT, but not the verbal part. "n.a." indicates that no statistical test was conducted.

Article	Tables	Sample	High-school GPA (/4.00)			SAT			College GPA (/4.00)		
			Male	Female		Male	Female		Male	Female	
Elliott and Strenta (1988)	5-6	Approximately 600 Dartmouth College psychology majors over a 10 year period.	n.a.	n.a.		1,260	1,241	n.a.	3.02	3.15	n.a.
									cum-GPA		
McCornack and McLeod (1988)	1	Over 27,000 students enrolled in a large U.S. urban state university in the 1985-86 academic year. Freshman-GPA based on 88 introductory courses.	2.95	3.09	n.a.	939	887	n.a.	2.39	2.36	n.a.
									Freshman-GPA		
Bridgeman and Wendler (1991)	1	12,124 students from 9 third-tier U.S. colleges.	3.12	3.29	*	1,040	987	#	n.a.	n.a.	
Young (1991)	1	1,564 students of Stanford University's class of 1986.	3.78	3.76		1,284	1,238	#	3.15	3.12	
									cum-GPA		
Jackson, Gardner and Sullivan (1993)	1-2	Approximately 450 students from the Michigan State Univ. College of Engineering from 1986-87 academic-year.	3.45	3.65	n.a.	1,168	1,145	n.a.	2.97	3.06	n.a.
									Freshman-GPA		
Bridgeman and Lewis (1996)	1, 5	More than 33,000 freshman from 43 colleges during the 1982-85 academic year	n.a.	n.a.		617	581	n.a.	2.47	2.59	n.a.
						SAT-Q only			1^{st}-year calculus		
Hancock (1999)	1	269 University of Louisville MBAs.	3.19	3.30	*	540	507	*	3.56	3.58	
			Undergrad-GPA			GMAT			MBA-GPA		
Gallagher, Bridgeman and Calahan (2002)	1-4	1,401 individuals' SAT scores	n.a.	n.a.		1,109	1,065	*	n.a.	n.a.	
		56,657 individuals' GRE scores	n.a.	n.a.		1,011	984	*	n.a.	n.a.	
		3,465 individuals' GMAT scores	n.a.	n.a.		66	59	*	n.a.	n.a.	
Rothstein (2004)	4	More than 18,500 students admitted to the University of California's 8 campuses as 1993 class. OLS regression coefficients reported, raw data not provided by gender.	Males<Females		*	Males>Females		*	Males<Females (Freshman-GPA)		*
Grubb (2006)	1	3,557 University of Delaware seniors from 1991-92 academic-year.	n.a.	n.a.		1,065	1,018	n.a.	2.74	2.91	n.a.
									4^{th}-year GPA		