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Abstract

To investigate whether men and women respond differently to competition and whether this response depends on the gender mix of the group, the author examines outcomes of the Mellon Foundation's Graduate Education Initiative, a competitive fellowship program instituted in 1991 that was aimed at increasing graduation rates and decreasing time to degree. Men's performance, as measured by time to candidacy, increased 10% in response to the program, with the largest gains for men in departments with the highest proportions of female students. Women did not increase performance, on average, but the response of women did differ greatly depending on the gender mix of their peers, with a more positive response when a larger fraction of the group was female. These results suggest that when devising incentive schemes, policy-makers may need to be mindful of an inherent tradeoff between increasing aggregate outcomes through the use of competition and achieving gender equity.

KEYWORDS: Gender Differences in the Response to Competition

GENDER DIFFERENCES IN THE RESPONSE TO COMPETITION

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To investigate whether men and women respond differently to competition and whether this response depends on the gender mix of the group, the author examines outcomes of the Mellon Foundation's Graduate Education Initiative, a competitive fellowship program instituted in 1991 that was aimed at increasing graduation rates and decreasing time to degree. Men's performance, as measured by time to candidacy, increased 10% in response to the program, with the largest gains for men in departments with the highest proportions of female students. Women did not increase performance, on average, but the response of women did differ greatly depending on the gender mix of their peers, with a more positive response when a larger fraction of the group was female. These results suggest that when devising incentive schemes, policy-makers may need to be mindful of an inherent tradeoff between increasing aggregate outcomes through the use of competition and achieving gender equity.

Women occupy only a very small fraction of the top positions in both the private and academic sectors. For example, Bertrand and Hallock (2001) found only 2.5% female representation in a sample consisting of the five highest-paid executives from each of a large number of U.S. firms. Traditional explanations for the under-representation of women in top positions and for the larger issue of gender wage gaps include occupational self-selection, discrimination in hiring and promotion, and lack of long-term commitment to the work force (Blau and Kahn 2000).[1]

Other research has focused on social or psychological differences between men and women as manifested in, for example, approaches to negotiating (Babcock and Laschemer 2003), measures of over-confidence (Barber and Odean 2000), and the response to competition (Gneezy, Niederle, and Rustichini 2003). This last gender difference is particularly important for top positions in business, politics, law, and other domains associated with wealth and power, since the path to prominence in these areas is often characterized by intense forms of competition. A number of recent experimental studies have found that men respond much more strongly than women to competition, but this response appears to vary based on the gender mix of those with whom one is competing.

In this paper, I extend the investigation to a real-life setting where the subjects are graduate students at several high-ranked academic institutions. In 1991, the Mellon Foundation instituted the Graduate Education Initiative (GEI), with the explicit goal of providing funding on a competitive basis to students to encourage them to make quick progress toward completing their doctorates. The GEI

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Copies of the computer programs used to generate the results presented in this paper are available from Joseph Price at Department of Economics, Brigham Young University, 162 FOB, Provo, UT 84602.

[1]Studies providing evidence for these explanations include Polachek (1981) for occupational self-selection, Neumark (1996) for discrimination in hiring, and Cobb-Clark and Dunlop (1999) for discrimination in promotions.

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provided $58 million to 54 departments over a ten-year period. Most of the money was used by the departments to provide fellowships to students after they cleared certain hurdles, the first being advancement to candidacy. The individual departments decided which students to award the money to, but the stated intent of the program was for the money to go to the students who made the quickest progress toward completing their degree.

In the first few years of the GEI, the allocation of awards gave the impression of being both very competitive (only 8% of students got the award) and very rewarding (recipients of the award enjoyed a 64% increase in their stipend). Ultimately the departments participating in the GEI did not allocate funds on a competitive basis, since most students eventually received an award (76% of those who advanced to candidacy), and those who received the award early on did not receive more overall compensation than students who received it later in their studies.

As a result, the GEI created a natural experiment in which a few cohorts of entering students experienced an increased level of perceived competition with their classmates followed by an increase in funding for nearly everyone, allowing us to separate the effects of more resources from the effects of more competition. I use this natural experiment to test whether increasing within-group competition affected men and women differently and to examine how this response differed based on the gender mix of the group. As an additional extension, I also test whether the response differed based on the marital status of the student.

Gender and Competition

Competition is increasingly viewed as an effective way to increase performance in many educational and labor settings. For example, many states have introduced competitive scholarships to students in the top 10% of their graduating class. Scholarships such as these, which pit students against one another, contrast with scholarships students win by competing against a set standard (such as a GPA or SAT score). Firms also often introduce incentive programs that are based on relative performance either within a group or between groups. Nalbantian and Schotter (1997) found that within a firm, introducing inter-group competition is generally one of the cheapest ways to increase overall performance.

Tempering such positive findings, however, are the results of recent experimental research examining whether men and women respond differently to the introduction of competition. These studies, in which participants competed in tasks such as taking a difficult test (Inzlicht and Ben-Zeev 2000), solving mazes (Gneezy, Niederle, and Rustichini 2003), running a footrace (Gneezy and Rustichini 2004), or answering trivia questions (Antonovics, Arcidiacono, and Walsh forthcoming), have indicated that the effects of newly introduced competition may indeed vary greatly by the participants' gender. Thus the gains in performance achieved through the competition may be offset by increased gender inequity.

Gneezy, Niederle, and Rustichini (2003) paid college students to solve mazes and introduced competition by switching from a piece-rate payment system to a tournament setting in which the student who solved the most mazes (within a group of six participants) was the only one who received money. They found that men consistently responded positively to the introduction of competition, but that women responded positively only when they were in groups composed entirely of women. Gneezy and Rustichini (2004) examined nine- and ten-year-old children's behavior when initially solo footraces were put on a competitive basis, with each child running beside another. The switch to competitive racing was associated with large gains in performance for boys, especially when the competitor was a girl, but no performance gains for girls.

A second question in these experiments is whether the performance of men and women in competitive environments depends on the gender mix of the group. Antonovics, Arcidiacono, and Walsh (forthcoming) found that men were more likely to answer a question correctly the larger the fraction of their competitors who were women, while women appeared to be unaffected by the gender of

their opponents. In Inzlicht and Ben-Zeev's (2000) experimental study, several groups of three people took a difficult math and verbal test in the same room. The gender composition of the group was randomly assigned. The performance of men was not influenced by the gender mix of the group, but women did worse when a larger fraction of the group was male. As mentioned earlier, Gneezy, Niederle, and Rustichini (2003) found that women solved more mazes under a competitive-pay scheme only when they were in all-female groups.

Gneezy, Niederle, and Rustichini (2003) suggested various explanations for why men and women respond to competition differently and why the response is influenced by the gender mix of the group. One explanation for women's lower responsiveness to competition is that the cost of increasing the level of effort may be greater for women than for men. Another reason is that women may not like to compete (or the non-monetary benefits of competing may be smaller for them than for men). For example, Niederle and Vesterlund (2007) showed that when given a choice, women were less likely than men to opt into a competitive setting. This aversion to competition may result from socialization that discourages women from competing as much as men or, as Kohn (1999) claimed, from a natural female propensity for cooperation rather than competition.

Similarly, the gender mix of one's peers might affect performance in any of several ways. One possible dynamic is an increase in effort in response to the encouraging supposition that one's sex is in one's favor: a man who believes, correctly or not, that men are better than women at a given task may consequently have a higher expectation of winning a contest involving that task when more women are present in the group, and as a result might exert increased effort in those circumstances. It could also be that men are evolutionarily conditioned to work harder when more women are present (Hawkes and Bird 2002). Finally, women may experience a "stereotype threat" that adds to their level of stress and decreases their performance (Steele 1997). Stereotype threat occurs when members of a group that is stereotyped as less capable in performing a certain task are placed in a situation in which they know they could confirm the stereotype. For example, Spencer, Steele, and Quinn (1999) found that high-achieving women did worse on standardized math tests when the stereotype of girls' math deficiency was mentioned. Also Ulku-Steiner, Kurtz-Costes, and Kinlaw (2000) found that female students in male-dominated departments had lower levels of self-confidence than their counterparts in departments not dominated by males.

The next section describes a program implemented by the Andrew Mellon Foundation that provides an interesting test case of whether (and how) men and women respond differently to competition in an educational setting and how their responses are affected by the gender mix of their peers. Whereas all of the experimental studies discussed above were based on short-term responses to competition, the program examined in this paper involved effort over an extended period of time. This type of extended competition is more relevant to the type of competitive schemes that are often devised for educational or workplace settings.

Graduate Education Initiative

The Andrew Mellon Foundation implemented the Graduate Education Initiative (GEI) in 1991 with the express goal of improving graduate education in the humanities and related social sciences by increasing graduation rates and decreasing time to degree.

The ten institutions participating in the GEI were chosen by the Mellon Foundation because they excelled in enrollment of winners of portable Mellon fellowship awards (which had been in existence for a number of years). Each of these institutions then selected four to six of its departments to participate in the GEI. The $58 million was allocated across these departments during the years 1991–2001. An additional 47 control departments were chosen after the program was implemented. Some of these departments were in the GEI institutions, others in different universities. The control departments are not entirely comparable to

the treatment departments, but the analysis in this paper controls for such observable measures of each department as field, institution, student quality (GRE scores), and the number of students in each entering cohort.[2]

The Mellon Foundation announced the GEI in March 1991. It was the Foundation's intent that "the departments will allocate the Foundation's grants on a competitive basis to individual students making good progress toward their degree."[3] Students needed to advance to candidacy before receiving any GEI awards, and no GEI aid was to be given to students after their sixth year. Within these general guidelines, each individual department distributed the GEI funding, and these departments had complete discretion over the GEI award recipients and amounts. In addition to allocating the funds to students, the departments were encouraged to promote various improvements, such as clarifying program requirements, providing seminars on skills needed to complete a dissertation, and improving faculty-student advising (Ehrenberg et al. 2007). However, most of these additional aspects of the GEI were implemented gradually, whereas the GEI awards were introduced from the very start of the program.

As part of its monitoring of program effectiveness, the Mellon Foundation collected data annually from both treatment and control departments on the funding (separately by tuition grant, fellowship, RA/TA funding, and Mellon awards) and progress of each student (including the dates of advancement to candidacy and of either graduation or withdrawal). The Mellon Foundation also collected information on student characteristics such as gender, race, citizenship, GRE math and verbal score, and whether the student had a master's degree before starting graduate school. A survey the Mellon Foundation administered in 2003 to all of the students who had entered one of the treatment or control departments provides each student's age and marital status at the start and end of graduate school.[4] My sample includes the 9,664 students who entered any of the GEI or control departments between 1982 and 1995. Of these students, 7,321 completed the survey (76% response rate). Table 1 provides summary statistics for the variables included in the analysis of this paper separately for men and women.

These data provide the three essential pieces of information needed to identify the gender differential in the response to competition: (1) the timing of a shock to the level of competition, (2) the fraction of a student's cohort that was female, and (3) a measure of student outcomes. The following sections briefly describe each of these measures.

Shock to the Level of Competition

The announcement of the GEI explicitly informed the academic community that the GEI awards would be given on a competitive basis and that the primary criterion to be considered in distributing the awards was students' progress toward a degree (with advancement to candidacy being the first milestone). The emphasis on progress toward degree completion was reinforced by the way GEI departments disbursed GEI awards in the first year of the program.

Table 2 shows the amount of funding received by students who first entered GEI departments between 1987 and 1988. These are students who enrolled in GEI departments before the program was announced and who could have been eligible for GEI awards in the first year of the program. The numbers in the left column are the amount of funding received in 1990 and 1991 by students who did not receive a GEI award in 1991, and the right column provides the same information for the 154 students who received a GEI award in 1991. While the two groups of students were getting roughly equivalent

[2]A complete list of the institutions and departments that were used as treatment and control schools, as well as a more complete description of the GEI program, are found in Groen et al. (2008).

[3]Andrew W. Mellon Foundation press release, March 25, 1991.

[4]A more detailed description of the GEI survey is found in Ehrenberg et al. (2007).

Table 1. Summary Statistics by Gender.

Variable	*Women*	*Men*	*Women = Men (t-stat)*[a]
Student Characteristics:[b]			
Master's Degree Prior to Entry	0.203	0.234	**3.68**
GRE Verbal Score	670.5	671.3	0.48
GRE Math Score	616.6	647.0	**16.54**
Married at Start of Graduate School	0.185	0.232	**4.95**
Age at Start of Graduate School	25.86	25.93	0.56
Foreign Student	0.132	0.179	**6.32**
Minority Student (U.S. Citizen)	0.122	0.095	**4.31**
Non-Minority Student (U.S. Citizen)	0.640	0.613	**2.74**
Time to Candidacy	3.021	2.856	**7.52**
Enrolled in Mellon Department	0.656	0.656	0.02
Started Program:			
Pre (1982–85)	0.228	0.245	1.93
Partial (1986–88)	0.227	0.224	0.38
Majority (1989–90)	0.170	0.159	1.44
Post (1991–95)	0.375	0.372	0.26
Field:			
English	0.282	0.176	**12.47**
Political Science	0.107	0.197	**12.22**
History	0.230	0.288	**6.42**
Other	0.381	0.339	**4.21**
Department:			
Entering Cohort Size	15.85	16.50	**3.36**
Fraction Female	0.535	0.411	**36.79**
N	4,528	5,136	

[a]Bold indicates a statistically significant difference between men and women at the 5% level.
[b]Race/citizenship is missing for 10.6% of the sample.

levels of funding in 1990, the students who received the award experienced a significant increase in funding.

The results in Table 2 show that the implementation of the GEI in 1991 sent three signals to students in the participating departments: getting an award would significantly increase one's funding (on average, by $4,074, representing a 64% increase); only a minor fraction of students were getting the awards (8.36% in the first year); and the awards were being given to students who advanced to candidacy the quickest (2.48 years compared to 2.98 years).[5]

[5]The $4,074 change in funding comes from subtracting the average overall stipend of GEI fellowship recipients (including both GEI and department funding but not tuition grants) from the amount received the previous year. This change is $3,600 less than the average GEI award, indicating that the GEI awards displaced some of the funding the student would have received.

It turns out that none of these initial impressions were valid in the long run. Most students eventually got a GEI award (76% of those who advanced to candidacy). Students who were the first to receive GEI awards received the same amount of money over the course of their studies as students who took longer to advance to candidacy. However, what is important for this analysis is that at least a few cohorts of entering students perceived the GEI to be a very competitive program.

Thus the focus of this study is the set of students who entered graduate school between 1989 and 1990 (referred to as majority-GEI). These students enrolled before the program was in place, so there could have been no sorting with respect to a taste for competition. The students who entered graduate school between 1986 and 1988 (partial-GEI) also fit this criterion, but the majority of these

Table 2. Funding Levels, GEI Awards, and Time to Candidacy for Students Who Entered GEI Departments in 1987–88.

Dependent Variable	*Students Who Did Not Receive a GEI Award in 1991*	*Students Who Received a GEI Award in 1991*
1990 Stipend (includes RA, TA, and fellowship funding)	$5,948 ($5,145)	$6,367 ($4,594)
1991 Stipend (includes RA, TA, and fellowship funding, as well as GEI award)	$5,748 ($5,559)	$10,442 ($3,408)
1991 GEI Award (included in 1991 stipend)	$0	$7,689 ($3,937)
Mean Time to Candidacy	2.977 Years (1.397)	2.475 Years (.718)
Percentage Who Advanced to Candidacy in Less Than 3 Years	56.1%	78.6%
Observations [fraction of sample]	1,688 [91.6%]	154 [8.4%]

Notes: The sample for this table consists of these students who enrolled in one of the GEI departments between 1987 and 1988. All monetary values are in 1988 dollars. The difference between the two groups in 1990 stipend levels is not statistically different (t-stat = .957). All other differences are significant at the 1% level. Standard deviations are reported in parentheses. All of the amounts refer strictly to stipend levels and do not include any tuition assistance.

students had already advanced to candidacy when the GEI was implemented, which would dilute the impact of the program on time to candidacy. Since the GEI awards were not to be given to students past their sixth year of enrollment, the entering cohorts of 1982–85 (pre-GEI) were never eligible at any point for a GEI award. The primary analytical burden in this paper is to compare the outcomes for the majority-GEI cohorts with the outcomes for the pre-GEI cohorts.

Gender Mix of the Entering Cohorts

Slightly less than half of the students in the GEI sample were women. Table 3 provides the average cohort size and distribution of the gender mix of each cohort by field. The variation in gender mix makes it possible to test the differential response to competition over a continuous range of the fraction of the group that is female. I interact the fraction of students in a cohort who are female with the other variables of interest to test whether male and female students responded to competition differently when more of their classmates were female.

All of the experimental studies described earlier focused on the gender mix of the individuals with whom the subject was competing. In the graduate school setting, the students interact with both their classmates and the faculty. The original Mellon Foundation data include no department-specific information on the gender mix of the faculty, so I used the internet archive to obtain the earliest available department web pages (most are from 1997), which provide the name, rank, and often the picture of each faculty member. The average student-weighted fraction of tenure track faculty who were female at the departments in the GEI sample was 31.4%, with the amount varying from 17.2% at the 10^{th} percentile to 42.7% at the 90^{th} percentile. The fields with the highest fraction of female faculty were comparative literature (39.4%) and English (39.2%), and those with the lowest were philosophy (17.6%) and political science (20.3%).

The overall correlation between the gender mix of the faculty and the gender mix of the students is about .626, part of which is explained by the gender concentration in certain fields. After field-specific fixed effects are included, a simple regression shows that a 10 percentage-point increase in the fraction of female faculty is associated with a 3.9 percentage-point increase in the fraction of female students. Later I test whether the response to competition depended on the

Table 3. Cohort Size and Fraction of Students Who Were Female.

Department	*Average Cohort Size*[b]	*Fraction of Students in the Field Who Were Female*	*Female Fraction of Students in Cohorts That Were at the 10th, 50th, and 90th Percentiles for Proportion Female*[a]		
			10th	*50th*	*90th*
Anthropology	10.13	0.573	0.333	0.590	0.765
Art	8.99	0.664	0.500	0.667	0.833
Classics	5.30	0.449	0.250	0.423	0.714
Comp. Literature	8.11	0.579	0.333	0.571	0.800
English	20.53	0.594	0.405	0.598	0.760
History	25.41	0.438	0.296	0.444	0.600
Music	8.87	0.409	0.176	0.400	0.667
Philosophy	8.11	0.299	0.125	0.286	0.500
Political Science	18.21	0.345	0.200	0.333	0.514
Religion	8.08	0.427	0.200	0.429	0.667
Sample	13.57	0.488	0.250	0.500	0.740

[a]Numbers in the last three columns are obtained by rank-ordering all of the cohorts in each academic field by the fraction of students who were female and then recording the percentage female in the cohorts at the 10th, 50th, and 90th percentiles (corresponding to high, average, and low relative concentrations of female students, respectively). This provides some sense of the degree of variation in cohort gender composition within each field.

[b]Cohort size refers to the number of students who entered a specific department in a particular year.

gender mix either of a student's classmates or of the faculty.

Measure of Student Outcomes

The GEI was designed to provide fellowships to students who were making the quickest progress toward completing their degree. In order to receive funding, a student must have already advanced to candidacy, which in most of the departments involved some form of qualifying exams, a dissertation proposal, and often language requirements. The GEI data report the exact date of advancement to candidacy for each student. Since time to candidacy was the first and primary metric for allocating GEI awards, the GEI created the highest levels of competition among students during the early years of graduate school, thus providing a more direct test of the impact of competition than time to degree.

Table 4 provides the average time to candidacy, by gender, for both treatment and control departments. The first row in the table shows the time to candidacy of students who first entered the Ph.D. program between 1982 and 1985. The results show that for these pre-GEI cohorts, the students enrolled in GEI departments would advance to candidacy about one-half year more quickly than students enrolled in control departments (2.86 versus 3.32 years for men, and 3.02 versus 3.45 years for women). The other rows in the first set of results report the average time to candidacy for the other time periods.

The second set of results in Table 4 shows the difference in time to candidacy between students who enrolled in the partial, majority, or post-GEI periods and students who enrolled in the pre-GEI period. For example, the second row shows that men who were enrolled in control departments experienced an increase of .159 years in the average time to candidacy between the pre-GEI and majority-GEI periods, while men in GEI departments experienced a decrease of .292 years. The corresponding changes for women were a decrease of .122 years in control departments and a decrease of .166 years in GEI departments.

The third set of results in Table 4 provides the difference between (a) the change in time to candidacy at GEI departments that occurred between two periods and (b) the change in time to candidacy that occurred in control departments between the same two periods. The table shows that men enrolled in GEI departments experienced a relative

Table 4. Average Time to Candidacy by Treatment, Gender, and Time Period.

	Men		*Women*	
Dependent Variable	*Control*	*GEI*	*Control*	*GEI*
Started Program in:				
1982–85 (Pre)	3.320	2.856	3.449	3.024
1986–88 (Partial)	3.494	2.672	3.501	2.854
1989–90 (Majority)	3.479	2.564	3.327	2.858
1991–95 (Post)	3.271	2.630	3.319	2.780
Difference				
Partial – Pre	0.174	–0.184	0.052	–0.170
Majority – Pre	0.159	–0.292	–0.122	–0.166
Post – Pre	–0.049	–0.226	–0.130	–0.244
Difference in Difference: $\Delta GEI - \Delta Control$				
Δ = (Partial – Pre)		–0.358		–0.222
Δ = (Majority – Pre)		–0.451		–0.044
Δ = (Post – Pre)		–0.177		–0.114

Notes: GEI refers to students who enrolled in a department that participated in the GEI. "Pre" refers to students who were never eligible for a GEI award at any point in graduate school. This study focuses on the majority group: students who were enrolled but had not yet advanced to candidacy when the program was implemented in 1991.

decrease of .451 years in the average time to candidacy between the majority-GEI and pre-GEI periods, while women enrolled in GEI departments experienced a relative decrease of only .044 years. These results are descriptive in nature but mimic the difference-in-difference estimation strategy used in the next section.

Empirical Strategy and Results

The impact of the GEI is estimated using the difference between the change in time to candidacy at GEI departments and the change in time to candidacy at control schools,

$$(1)\quad Impact = [Change\ in\ TTC\ in\ GEI\ depts.] - [Change\ in\ TTC\ in\ control\ depts.]$$
$$= [Y_{majority,\ GEI} - Y_{pre,\ GEI}] - [Y_{majority,\ control} - Y_{pre,\ control}],$$

where Y is the time the student takes to advance to candidacy. The change at control departments captures the national-level changes that would have likely influenced the GEI departments in the absence of the program.

The impact of the GEI can be estimated empirically using the following regression model:

$$(2)\quad Y = \beta_0 + \sum_{j=2}^{4} \beta_{1j} \bullet period_j + \beta_2 \bullet GEI + \sum_{j=2}^{4} \beta_{3j} \bullet period_j \bullet GEI + \gamma \bullet X + \varepsilon,$$

where *period* refers to the time period in which the student entered graduate school (pre, partial, majority, or post).

Plugging corresponding regression coefficients from equation (2) into equation (1) yields the following estimator for the impact of the program between the pre-GEI period and the majority-GEI period:

$$(3)\quad Impact = [(\beta_0 + \beta_{13} + \beta_2 + \beta_{33}) - (\beta_0 + \beta_2)] - [(\beta_0 + \beta_{13}) - (\beta_0)] = \beta_{33}.$$

The model in equation (2) is estimated separately by gender, and the results are shown in Table 5. The estimations from which the results shown in the first two columns are derived include controls for individual characteristics (prior master's degree, GRE scores, race) along with fixed effects for the student's institution and field, and the results shown in the second set of columns are from estimations that include fixed effects for the student's individual department. I also estimate all of the models

Table 5. Impact of the GEI on Time to Candidacy, by Gender.

Variable	*Women*	*Men*	*Women*	*Men*
Pre	—	—	—	—
Partial	0.004	–0.028	0.009	–0.052
	[0.085]	[0.078]	[0.080]	[0.067]
Majority	–0.266***	–0.016	–0.253***	–0.103
	[0.093]	[0.080]	[0.079]	[0.069]
Post	–0.277***	–0.136	–0.294***	–0.201***
	[0.078]	[0.071]	[0.074]	[0.065]
GEI	0.160	0.220***		
	[0.096]	[0.082]		
GEI • Partial	–0.177	–0.132	–0.171	–0.119
	[0.109]	[0.101]	[0.098]	[0.083]
GEI • Majority	0.094	–0.269**	0.063	–0.194**
	[0.120]	[0.106]	[0.100]	[0.084]
GEI • Post	–0.006	–0.131	0.009	–0.079
	[0.101]	[0.092]	[0.091]	[0.078]
Cohort Size	–0.005**	–0.006***	–0.005	0.001
	[0.002]	[0.002]	[0.003]	[0.002]
Master's Degree	–0.336***	–0.343***	–0.326***	–0.335***
	[0.043]	[0.036]	[0.043]	[0.035]
GRE Verbal Score	0.010	–0.022	0.009	–0.027
	[0.018]	[0.015]	[0.017]	[0.015]
GRE Math Score	–0.052***	–0.021	–0.041**	–0.011
	[0.016]	[0.014]	[0.016]	[0.014]
Foreign Student	–0.122***	–0.097***	–0.138***	–0.117***
	[0.043]	[0.033]	[0.042]	[0.032]
Minority Student	0.077**	0.100**	0.091**	0.121***
	[0.039]	[0.041]	[0.037]	[0.039]
Constant	3.151***	3.007***	5.286***	4.322***
	[0.184]	[0.169]	[0.379]	[0.402]
Fixed Effects	Field & Institution		Department	
N	4,528	5,136	4,528	5,136
R^2	0.39	0.44	0.44	0.49

Notes: Pre, Partial, Majority, and Post refer to the year the student entered graduate school (see Table 4). GEI is a binary variable indicating whether the student was enrolled in a department that participated in the program. Standard errors are clustered at the cohort level (department/entering year).

**Statistically significant at the .05 level; ***at the .01 level.

using a pooled regression with interactions between the student's gender and all of the included covariates, allowing me to test for gender differences. For clarity, the tables provide the estimates separately by gender. Following the suggestion of Bertrand, Duflo, and Mullainathan (2004), all of the standard errors are clustered at the cohort level (department/entering year).

The results show that the GEI decreased time to candidacy for men by .27 years and had no effect on women. The impact of competition on men drops to .19 years when we include controls for the student's department, which represents a 7% decrease in the time to advance to candidacy or 18% of a standard deviation.[6] To put this magnitude

[6]One possible concern in this analysis is that the GEI may have had a different impact on the attrition rates of men and women. For the majority-GEI group, there was no statistically significant change for men or women, though the point estimate for men was more negative. For the post-GEI group, men experienced a

in perspective, the overall impact of the GEI (with the accompanying changes in funding, advising, clarity of requirements, and so on) on time to degree was about .12 to .14 years (Groen et al. 2008). While time to degree is the most common metric for success for graduate students, from a social welfare perspective time to candidacy is also important, because advancement to candidacy generally represents the point at which the graduate transforms from pure consumer to producer of research.

Also as a point of reference, introducing competition led to a 33% increase in performance for college men in the maze-solving experiments (Gneezy, Niederle, and Rustichini 2003) and a 2% improvement (that is, a 2% faster time) for boys in footraces (Gneezy and Rustichini 2004). Comparing percentage changes found in the experimental studies with those from the present study is clearly problematic given that the experiments only required the subjects to exert effort (physical or mental) for a short period of time, while the graduate student experience spans a few years. However, the results from this real-world natural experiment are roughly in line with the experimental findings.

One concern is that these results could simply reflect the increased levels of resources that accompanied the introduction of the GEI rather than a response to competition. However, three pieces of evidence suggest otherwise. First, the GEI had a slightly lower impact on students who entered GEI departments after the program was fully in place than on those exposed to the initial shock of the program (.079 versus .194). Second, the additional funding was not disbursed until after the student advanced to candidacy, and none of the other aspects of the GEI—such as improved advising and increased clarity in the communication of requirements—were implemented immediately (whereas the GEI awards were provided in the first year of the program). Third, when I interact the average size of the department's GEI awards (using either the absolute amount or the average change in funding for recipients), I find that the response to the GEI was no greater in departments that provided larger average awards (the average awards across departments varied from $4,750 at the 10th percentile to $12,000 at the 90th percentile).[7]

Cohort Gender Mix

The second question is whether the response to competition by men and women differed based on the fraction of the cohort that was female. To answer this question, I interact the time period and treatment variable with measures of the fraction of a student's cohort that was female:

$$(4)\quad Y = \beta_0 + \sum_{j=2}^{4}\beta_{1j} \bullet period_j + \beta_2 \bullet GEI + \sum_{j=2}^{4}\beta_{3j} \bullet period_j \bullet GEI + \beta_4 \bullet fraction\ female + \beta_5 \bullet GEI \bullet fraction\ female + \sum_{j=2}^{4}\beta_{6j} \bullet period_j \bullet GEI \bullet fraction\ female + \gamma \bullet X + \varepsilon.$$

The variable *fraction female* is a measure of the fraction of a student's entering cohort that was female and is measured in two ways: first, by a set of three indicators for whether female students made up fewer than 40% of the cohort (male-dominant), between 40% and 60% (equally balanced), or more than 60% (female-dominant); and second, by a continuous measure of the fraction of the entering cohort that was female. The coefficient of interest is that on β_{63}, a term representing the interaction of three variables:

6 percentage point decrease in attrition, while women experienced a statistically insignificant increase of 2.7 percentage points. These findings would indicate that the results in this section understate the gender difference in response to the program, since the male students who were deterred from dropping out were likely less capable, on average, than the other men, and their presence thus probably increased the measured time to candidacy of the men in the treatment sample.

[7]While it may seem odd that the response would be no larger when the rewards are greater, this pattern is consistent with Karlan and List's (2007) finding that although offering a matching grant on charitable giving increased donations, increasing the size of the match ratio (from 1:1 to 3:1) had no additional impact.

Table 6. Impact of the GEI on Time to Candidacy, by Student Gender and Cohort Gender Mix.

Variable	*Women*	*Men*	*Women = Men (t-stat)*
Non-Linear Effect			
(GEI • Majority) Interacted with:			
Male-Dominant	0.399	–0.043	1.70**
	[0.311]	[0.194]	
Equally Balanced	0.252	–0.346	2.72***
	[0.220]	[0.184]	
Female-Dominant	–0.261	–0.997***	2.25**
	[0.207]	[0.313]	
N	3,576	4,057	
R^2	0.42	0.46	
Linear Effect			
(GEI • Majority) Interacted with:			
Fraction of Cohort That Is Female	–1.82**	–1.64**	0.19
	[0.867]	[0.649]	
N	3,576	4,057	
R^2	0.41	0.46	

Notes: The test statistic is based on a pooled regression and involves testing for a difference in the interaction between female and the coefficient listed. Each model includes all the variables from the right two columns in Table 5, including field and institution controls. Each model also includes the main effects for male-dominant, equally balanced, and female-dominant, along with their interaction with Partial, Post, and GEI. The analysis is limited to cohorts with at least 10 students. Standard errors are clustered at the cohort level (department/entering year).

**Statistically significant at the .05 level; ***at the .01 level.

whether the student was in a department that participated in the GEI, whether he or she entered graduate school during the majority-GEI time period, and the fraction of the entering cohort that was female. The analysis is restricted to cohorts with at least 10 students.

The results in the upper panel of Table 6 show that the impact of competition on men's performance was greatest in departments in which there was a larger fraction of female students, with no significant impact in cohorts that were less than 40% female. These results are consistent with the finding of Antonovics et al. (forthcoming) that men perform better when more of their competitors are female. For women, the results indicate that competition may have had a slightly positive effect in cohorts with a large fraction female and a negative impact in male-dominant cohorts, though these results are significant only at the 10% level. The non-linear pattern of results in the lower panel of Table 6 confirms that both men and women responded more positively to competition when a larger fraction of their peers were women.

The estimate for the female response to competition in majority female groups of –.261 years is significant at the 10% level. If we extrapolate the results from the linear model in panel B, women's predicted response to the GEI in an all-female environment would be to advance to candidacy .766 years more quickly. This matches the findings of Gneezy, Niederle, and Rustichini (2003), and extends their analysis to show that women will start to compete when they are in groups that are at least 58% female.[8]

The linear effect in panel B also shows that while men and women may have differed in their average response to competition, the incremental change in their response to competition as their group became more female was nearly the same (–1.82 versus –1.64, t-stat –0.19). This is consistent with

[8]The main effect on the *mellon • majority* coefficient in panel B is 1.06, so the break-even point after which women will respond to competition is (1.06/1.82), or .58

Gneezy, Niederle, and Rustichini's (2003) hypothesis that if individuals believe (whether correctly or incorrectly) that women are less capable than men, an increase in the fraction of one's competitors who are female will raise the expectation of winning and hence the effort exerted. The similar results for men and women in panel B suggest that both groups perceived female students to be less capable than male students. This finding differs from that of Antonovics, Arcidiacono, and Walsh (forthcoming), who found in their sample of game-show contestants that men performed better against female opponents than against male opponents, whereas women's performance was unaffected by the opponent's gender.

The idea of an inverse relationship between effort and the perceived strength of the competition contrasts intriguingly with the findings of studies investigating peer effects among workers who are rewarded on a piece-rate basis, such as fruit pickers (Bandiera, Barankay, and Rasul 2007) and grocery store checkers (Mas and Moretti 2006). In those settings, a worker's productivity increases with the productivity of the worker's peers. The results in the present paper are suggestive, on the contrary, of a *negative* peer effect.

Throughout this analysis I have implicitly assumed that time to candidacy is simply a measure of the student's effort. However, advancing to candidacy also requires the support and approval of the faculty. Given the correlation (about 0.66) between the gender mix of the students and the gender mix of the faculty in a department, the differences in response to competition based on classmates' gender mix could simply reflect a differential impact of the faculty gender mix.

In additional analysis, substituting the gender mix of the faculty for the gender mix of classmates has no impact on the drops in time to candidacy in the majority period, but there is some evidence of an additional drop in the post period for both men and women. The post period was characterized by increases in funding, clarity of expectations, and advising (but not in competition), indicating that students benefited more from the additional programs when more female faculty were present. This evidence suggests either that female faculty complied more fully than male faculty with the goals of the program or that inputs of female faculty were better complements to the programs the GEI implemented.

However, when the fraction of faculty who are female is interacted with the triple interaction of treatment, majority period, and cohort gender mix, I find no statistically significant differences based on the gender mix of the faculty, with one exception. Female students in female-majority cohorts responded more strongly to competition when more of the faculty were also female. A standard deviation increase in the fraction of faculty that was female (that is, from 31% to 41%) would decrease time to candidacy for women in female-dominant cohorts by .344 years. This provides some suggestive evidence in support of the stereotype threat hypothesis according to which women feel less threatened to compete or perform well when there are more women in their environment (among both classmates and faculty, in this case).

Marriage

A final question is whether the difference in the response of men and women to competition depends on their marital status. Table 7 provides the same analysis as earlier but with disaggregation by both gender and marital status at the start of graduate school. The results reported above remain essentially unchanged except for a further decrease of .20 years in time to candidacy for single men. This analysis also suggests that the GEI increased the time to candidacy of married women by .37 years, but this result is not statistically significant.

In a pooled regression (run separately for each gender), the difference between single and married men is .394 years (standard error of .170, p-value = .021) and the difference between single and married women is .452 years (standard error of .197, p-value = .022). Thus, for both men and women, the increased competition that accompanied the introduction of the GEI had a more pronounced effect (positive or negative) on single students than on married students.

One possible explanation for this result is

Table 7. Impact of the GEI on Time to Candidacy, by Gender and Marital Status.

	Men		*Women*	
Dependent Variable	*Single*	*Married*	*Single*	*Married*
Partial	–0.114	–0.238	–0.002	0.038
	[0.082]	[0.139]	[0.092]	[0.187]
Majority	–0.102	–0.116	–0.226**	–0.514**
	[0.092]	[0.143]	[0.092]	[0.209]
Post	–0.202**	–0.283**	–0.331***	–0.233
	[0.083]	[0.135]	[0.088]	[0.164]
GEI	–0.845	–0.486	–0.899***	–0.161
	[0.563]	[0.407]	[0.218]	[0.474]
GEI • Partial	–0.029	0.025	–0.165	–0.123
	[0.103]	[0.165]	[0.112]	[0.221]
GEI • Majority	–0.198	–0.065	0.017	0.381
	[0.109]	[0.182]	[0.111]	[0.259]
GEI • Post	–0.099	0.144	0.043	–0.089
	[0.098]	[0.161]	[0.105]	[0.204]
Constant	4.605***	3.703***	4.932***	3.698***
	[0.559]	[0.342]	[0.198]	[0.463]
N	2,959	894	2,883	655
R^2	0.54	0.45	0.47	0.46

Notes: The measure of marriage here is based on the student's marital status at the start of graduate school and does not account for students who get married during graduate school. Each equation includes all of the same controls shown in Table 5 along with department fixed effects. Standard errors are clustered at the cohort level (department/entering year).

**Statistically significant at the .05 level; ***at the .01 level.

that marriage often provides incentives for students to use their time more effectively even in the absence of competition and puts married students under tighter time constraints, especially when children are present—as was more often than not the case in our graduate school sample, in which 58% of married men and 51% of married women had children. Thus when competition is introduced, married students have less excess capacity with which to increase effort.

Another possibly relevant consideration is that many of the single students in the sample were involved in the marriage market during graduate school; 32% of the single men and 31% of the single women in the sample got married during graduate school. Studies in evolutionary biology show that men and women have, over time, adopted different mate attraction tactics, and that for men the primary tactic has usually been through the "acquisition and display of material resources" (Buss 1988). Thus single men have more to gain through winning the GEI award than do women or married men because of the additional value it has in potentially attracting a spouse.

Conclusion

This analysis has shown that male graduate students experienced a 7% decrease in time to candidacy in response to the introduction of a competitive fellowship program, while women experienced no change, on average. Both men and women responded in a more positive way to the program when a larger fraction of their group was female. The results also suggest that the introduction of competition had a more positive impact on single students than on married students.

These results indicate that when devising an incentive scheme for graduate students (and perhaps for persons in other work-related settings), policy-makers and administrators need to be aware of an inherent tradeoff

between increasing aggregate outcomes through the use of competition and achieving gender equity. Increasing the level of competition within a group may increase average performance, but it may also increase the achievement gap between men and women. Future research might explore the degree to which the level of competition affects the gender wage gap within a particular occupation or industry.

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