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Program Design and Student Outcomes in Graduate Education

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Program Design and Student Outcomes in Graduate Education *

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Abstract

Doctoral programs in the humanities and related social sciences are characterized by high attrition and long time-to-degree. In response to these long-standing problems, the Andrew W. Mellon Foundation launched the Graduate Education Initiative (GEI) to improve the structure and organization of PhD programs, and in turn reduce attrition and shorten time-to-degree. Over a 10-year period starting in 1991, the Foundation provided a total of $80 million to 51 departments at 10 major research universities. This paper estimates the impact of the GEI on attrition rates and time-to-degree. Our analysis is based on a competing-risk duration model and student-level data spanning the start of the GEI, including data on students at a set of control departments. We estimate that, on average, the GEI had modest impacts on student outcomes in the expected directions: reducing attrition rates, reducing time-to-degree, and increasing completion rates. The overall impacts of the GEI appear to have been driven in part by reductions in cohort size, increases in financial aid, and increases in student quality.

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1. Introduction

Students pursuing a doctorate in the humanities face a long and challenging road. The length of time it takes students to earn a doctorate in the humanities is longer than in any other broad field of study (Hoffer et al. 2003). By the late 1980s, time-to-degree in the humanities had risen 15-20 percent since the mid-1970s to a median figure of approximately nine years (Bowen and Rudenstine 1992). Furthermore, doctoral programs in the humanities are characterized by high attrition. Even in some of the most highly regarded departments in the country, it is common for more than half the students who start a PhD program to leave without earning a doctorate (Bowen and Rudenstine 1992).

Motivated by these trends, the Andrew W. Mellon Foundation launched the Graduate Education Initiative (GEI) in 1991 to improve the structure and organization of PhD programs in the humanities and related social sciences. Such changes were seen as necessary in order to combat high rates of student attrition and long time-to-degree. In terms of these measures, doctoral programs in the humanities fared much worse than programs in any other broad field of study. While attrition and time-to-degree were deemed important in themselves, they were also seen as indicators of the effectiveness of graduate programs. In the humanities, several characteristics of doctoral programs were believed to contribute to high attrition and long degrees, including a proliferation of courses, elaborate and sometimes conflicting requirements, epistemological disagreement on fundamentals, and inadequate funding at the dissertation stage. Finally, projections about faculty shortages in the late 1990s made the goal of reducing student attrition particularly timely (Bowen and Sosa 1989, McMillen 1991).

Over a 10-year period, the Foundation spent a total of over $80 million on the GEI and allocated the funds to 51 departments (or programs) at 10 major research universities. While the

amount of money was indeed substantial, equally important is how the money was spent. Earlier research the Foundation undertook showed that simply giving money to students or institutions was not likely to improve graduate programs (Bowen and Rudenstine 1992). For instance, students in the humanities with generous, multi-year financial support from national fellowship programs had completion rates and times-to-degree at about the same level as other students. Furthermore, high attrition and long time-to-degree were the norm even at highly ranked (and relatively well-funded) departments in the humanities.

The architects of the GEI determined that improvements in graduate education would require changes within departments and their PhD programs. The assumption was that graduate students had problems completing their degrees because programs had become unwieldy, supervision was uneven, expectations were unclear, and support at the time that students needed to finish their dissertations was scarce. In order to achieve changes within departments, the Foundation shifted much of their appropriations from portable grants awarded to students to block grants awarded to universities which then selected departmental recipients.

This paper estimates the impact of the GEI on attrition rates and time-to-degree. Our analysis is based on systematic data on student progress collected annually from the departments that participated in the GEI. The data allow us to track the progress of each student who started PhD programs in participating ("treatment") departments over a 21-year period spanning the introduction of the GEI. To account for external forces (such as the job market for humanities PhDs) that affect all PhD programs, the Foundation also identified a set of roughly comparable departments to serve as a control group. The control departments provided similar data on student progress but did not receive any funding from the Foundation under the GEI.

We use an evaluation design that takes account of pre-program differences between treatment and control departments. Under our difference-in-differences strategy, the impact of the GEI is identified from a comparison of the time trend in treatment departments' outcomes to the time trend in control departments' outcomes. The collection of annual data allows us to model the impact of the program in terms of year-to-year transition probabilities.

We estimate that, on average, the GEI had modest impacts on student outcomes in the expected directions: reducing attrition rates, reducing time-to-degree, and increasing completion rates. The overall impacts of the GEI appear to have been driven in part by reductions in cohort size, increases in financial aid, and increases in student quality. We also find that more generous financial aid has a larger impact on reducing attrition than on encouraging completion. While the impact of aid on attrition is considerable, even the most generous financial-aid packages are associated with considerable attrition. In other words, attrition decisions are not primarily due to financial-support problems.

In addition to providing evidence on the GEI, our paper is significant because of the methodology it applies to the study of student outcomes in graduate education. First, by using data on all entrants to PhD programs, we are able to simultaneously model both reasons that students exit their programs (drop out or completion). In contrast, most recent studies of outcomes in graduate education do not treat the two risks at the same time and tend to focus on one or the other (e.g., Siegfried and Stock 2001).[1] Second, in our analysis of the impact of financial aid on student outcomes, we use an instrumental-variables strategy to account for the

[1] Two exceptions are Ehrenberg and Mavros (1995) and Van Ours and Ridder (2003). The methodology we employ can also be applied to persistence at the undergraduate level; for an example of a related approach to undergraduate persistence, see DesJardins, Ahlburg, and McCall (1999).

endogeneity of aid. This represents an improvement over previous research, which is subject to critique due to the effects of unmeasured ability (Ehrenberg and Mavros 1995).

The remainder of the paper is organized as follows. The next section describes the implementation of the program and describes the student-level data that were collected for the purpose of our evaluation. Section 3 presents our econometric approach to estimating program impacts. Section 4 presents results on estimated impacts, provides evidence on the mechanisms underlying the impacts, and presents some robustness checks. Section 5 summarizes our conclusions.

2. The Graduate Education Initiative: Implementation and Data Collection

2.1 Goals and Implementation

The GEI was designed so as to clarify expectations, rationalize programs, and increase financial support. The premise was that students would be given a series of deadlines and that if they met them, then they could be considered for funding. There were to be no guarantees of funding; rather a competitive situation was supposed to prevail which would motivate all students. It was assumed that making big departmental changes in graduate education would take time and that the program could last as long as a decade. Each participating department committed to the goals of the program and developed detailed strategies to achieve them.

Treatment departments allocated the vast majority of the Foundation's grants to individual graduate students on a competitive basis. In accordance with the goal of encouraging students to move expeditiously through their programs, only students making good progress towards their degrees were eligible for funding. In particular, students beyond their sixth year of study were ineligible for funding. Foundation support was designed to address causes for delay. Most departments identified three periods when such delays were like to occur: first, the

transition from coursework to the beginning of dissertation research; second, the "finishing up" (or final year) of the dissertation stage; and third, summers (when students often lost momentum).

Aside from changes in student aid, the GEI affected treatment departments through a variety of structural and programmatic changes. Departments typically used small amounts of the grants to fund program changes such as research colloquia and seminars on pedagogy that contributed to the overall quality of their graduate programs. As a result, departments were "committed not only to advancing the progress of students who may be supported by the Foundation's grants, but to establishing incentives, structures, and attitudes that will improve their programs overall" (AWM Foundation 1991). While each department developed its own proposal for addressing the goals of the GEI program, there was a large overlap in their approaches. The "innovations" made by departments can be classified into several categories. Table 1 presents the categories along with representative examples.

The Foundation intended the grants to supplement, rather than supplant, internal funds for the support of graduate students in the treatment departments. As such, participating institutions were required to maintain the real value of their levels of such internal support over the life of the program.[2] Treatment departments received roughly $150,000 per year on average from the Foundation. On average, GEI funding represented about 8 percent of departments' overall budgets for student support.

[2] Our analysis of data from department financial reports submitted to the Foundation suggests that participating institutions did in fact meet this requirement. In treatment departments, the real value of internal support per student increased by an average of about 2 percent per year over the life of the GEI program.

2.2 Treatment and Control Departments

The treatment departments come from ten universities: UC-Berkeley, Chicago, Columbia, Cornell, Harvard, Michigan, Pennsylvania, Princeton, Stanford, and Yale. These institutions were chosen because they had attracted the largest number of winners of portable Mellon Graduate Fellowships in the Humanities and were therefore regarded as having unusually strong doctoral programs in the humanities. Each of these institutions, in turn, identified four, five, or six departments to participate in the program. Under the program, Foundation grants to participating institutions began in the 1991-92 academic year and continued through the 2000-01 academic year.

The control departments were chosen after the program was under way. The first set of controls was chosen from the participating institutions. During the first five years of the program, the Foundation asked each participating institution to provide data for their departments that were not already participating in the program. In the end, five of the ten institutions agreed to provide data for at least some of these departments. The second set of controls was chosen from non-participating institutions. In the mid-1990s, three universities – UCLA, UC-San Diego, and North Carolina – agreed to provide data for particular departments. Like the treatment departments, the control departments provided data for all entrants to their PhD programs starting with the 1982 entering cohort. The control departments span a similar range of fields as the treatment departments; however, the Foundation did not attempt to match treatment and control departments along dimensions such as quality or size. Our evaluation design accounts for the fact that treatment and control departments are not necessarily comparable at the time the program was implemented.

Our evaluation is based on treatment and control departments in ten fields in the humanities and related social sciences: Anthropology, Art History, Classics, Comparative Literature, English, History, Music, Philosophy, Political Science, and Religion. The list of departments in our study is given in Table 2. These departments accounted for 18 percent of all PhDs awarded nationally in these fields from 1980 to 1991, according to data from the Survey of Earned Doctorates. Among departments ranked in the top 10 of their field by the National Research Council, our study departments represent a much larger percentage of PhDs awarded nationally, 50 percent.[3]

Given the design of the study, especially the fact that the treatment was not randomly assigned, it is useful to compare the treatment and control departments. We collected data on three characteristics of departments from the 1995 National Research Council study of doctoral programs (Goldberger et al. 1995): number of faculty, number of PhD students, and rank of PhD program (based on the scholarly quality of the program faculty). Overall, treatment departments are more highly ranked and larger, in terms of both faculty and PhD students. The typical treatment department is ranked in the top 10, while the typical control department is ranked in the second 10 (average rankings of 8.2 vs. 14.3). Treatment departments have slightly more faculty (32.4 vs. 25.0) and many more PhD students (101.3 vs. 61.5) than do control departments.

2.3 Description of Student-Level Data

The data used in this evaluation were collected from the institutions of the treatment and control departments on an ongoing basis. The data cover all students who started PhD programs

[3] Before the GEI was implemented, students in study departments finished their degrees somewhat faster than students in other departments. The median number of years between entry to graduate school and the awarding of the PhD was 10.1 years for PhDs awarded by study departments from 1980 to 1991 and 11.8 for other departments.

in study departments between 1982 and 2002. Overall, our data represent 22,994 students, including 14,488 students from treatment departments and 8,506 students from control departments.

The dataset includes detailed information on student progress and financial support. For each year that a student is enrolled, the dataset indicates whether the student completed the year and continued in the program, whether the student terminated graduate study during the year, or whether the student graduated with a PhD during the year. Financial support information is also recorded annually and covers four types of support (from internal and external sources): fellowships, teaching or research assistantships, tuition grants, and summer support.

The dataset also includes a variety of student characteristics collected from admissions files. Included among these characteristics are demographic variables such as gender, citizenship, race and ethnicity; information on educational background including whether the student had a master's degree upon entry to the PhD program; and scores on the verbal and math portions of the Graduate Record Examination (GRE).

While the GEI was implemented at a specific time (in the 1991-92 academic year), students in treatment departments were differentially exposed to the GEI depending on their entering cohort. The 1982-1985 entering cohorts had essentially no exposure to the GEI, the 1986-1990 cohorts had some exposure, and the 1991-2002 cohorts were fully exposed to the GEI. Among students who had no exposure to the GEI (the 1982-85 entering cohorts), 53 percent graduated, 45 percent dropped out, and 3 percent were still enrolled 17 years after entry. The bulk of attrition occurs in the first four years of enrollment, as shown in Figure 1. Among dropouts in these cohorts, 30 percent dropped out in the first year and 69 percent dropped out in the first four years. In terms of graduations, the modal years for finishing the PhD are years 6, 7,

and 8, which represent 49 percent of all graduations in these cohorts. There is a significant right tail in the distribution, with 10 percent of graduates in years 12-17.[4]

3. Econometric Approach

We estimate the impact of the GEI on student outcomes using a competing-risk duration model. In the model, time is discrete and measured in years. We directly model student transitions from one year to the next. Conditional on surviving to a particular year of enrollment, students may continue on in their programs to the following year or exit their programs. In turn, students may exit their programs as a result of one of the competing risks: attrition and graduation. Thus, there are three transition probabilities:

P_{1t} = P[attrition in year t | survived through year (t-1)],
P_{2t} = P[graduation in year t | survived through year (t-1)], and
$P_{0t} = 1-P_{1t}-P_{2t}$ = P[continue in program through year t | survived through year (t-1)].

We specify these transition probabilities as functions of explanatory variables using a multinomial logit form:

$$P_{jt} = \frac{\exp(x_t'\theta_{jt})}{\sum_k \exp(x_t'\theta_{kt})}, \text{ j} = 0, 1, 2.$$

The vector of explanatory variables for a particular year is x_t. We allow the parameters of the model to vary freely across years. The sample of students used to estimate the model for a given year is the sub-sample of students still enrolled at the beginning of that year. (For years 1-3 we do not allow the graduation option, so we simply have a binary logit model for continuation vs. attrition.)

This model accommodates both time-varying and fixed explanatory variables. Our baseline model includes explanatory variables for student gender, race/ethnicity, and citizenship.

[4] Median (mean) time-to-degree is 8 (8.16) years and median (mean) time-to-attrition is 3 (3.98) years.

It also includes indicator variables for institutions and fields, in order to capture the effects of institution-wide factors and field-specific factors such as differences in curriculum. In some specifications, we also include indicators for the type of financial aid that each student had in each year.

Three of the explanatory variables identify the effects of the GEI program. The variable *Treatment* is an indicator variable that equals 1 for students in treatment departments and equals 0 for students in control departments. The variable *Post* is an indicator variable that identifies when the GEI program is in effect; it equals 1 for observations in the treatment period and equals 0 for observations in the pre-treatment period. The definition of *Post* depends on a student's entering cohort as well as the year of enrollment. Students in cohorts 1982-1985 have $Post = 0$ for all years and students in cohorts 1991-2002 have $Post = 1$ for all years. Students in cohorts 1986-1990 have $Post = 0$ for years prior to 1991 and $Post = 1$ for years starting in 1991. The third variable is the interaction between the other two variables: $Treatment \times Post$. With these variables, our estimated impacts of the GEI are identified from differential time trends for students in treatment departments relative to those in control departments.

After estimating the model, we use simulations to express the program impacts in terms of cumulative probabilities of attrition and graduation.[5] We start by considering a fixed set of people for the simulations: students who entered treatment departments after the GEI was implemented. For each student, we use his (time-invariant) characteristics ($x_t = x$ for all t) and the estimated parameters to predict his transition probabilities (P_{0t}, P_{1t}, P_{2t}) for each year of

[5] An alternative approach to our duration framework is to specify the model with cumulative rather than transition probabilities. We obtain roughly similar results with this alternative approach. However, we prefer the duration framework because it is more flexible.

enrollment t, supposing that he survived to that year. Then we use these transition probabilities to predict the probabilities of attrition (a_t), graduation (g_t), and continuation (c_t) in each year t:

$$a_t = \left[\prod_{j=1}^{(t-1)} P_{oj}\right] P_{1t} \ , \ g_t = \left[\prod_{j=1}^{(t-1)} P_{oj}\right] P_{2t} \ , \text{ and } c_t = \left[\prod_{j=1}^{t} P_{oj}\right].$$

Finally, we compute cumulative probabilities of attrition (A_t) and graduation (G_t) by the end of each year of enrollment:

$$A_t = \sum_{j=1}^{t} a_j \text{ , t=1-11; and } G_t = \sum_{j=4}^{t} g_j \text{ , t=4-11.}$$

For each student in the simulation sample, we predict two sets of these probabilities, one with $Treatment \times Post = 1$ and one with $Treatment \times Post = 0$. The difference between the two sets of predictions reflects the effect of the GEI program. These probabilities vary across students due to variation in the explanatory variables; our estimates are based on averages of these probabilities over the set of students in the simulation sample. We also compute the impact of the GEI on mean elapsed time-to-degree based on the average cumulative probabilities of graduation.[6] We estimate standard errors for the estimated program impacts using a bootstrap approach. In the bootstrap, we sample clusters of students based on department/cohort cells in order to account for the fact that the identifying variation is across departments and across time.

[6] The estimated impact on time-to-degree reflects the combination of two conceptually distinct impacts. The first is the impact of the program on time-to-degree for students who would have graduated in the absence of the program. The second is the impact on measured time-to-degree of changing the set of students who graduate. The first impact is likely to be a decrease in time-to-degree. The second impact may be an increase or decrease in time-to-degree, depending on whether the marginal students affected by the program have long or short times-to-degree.

4. Results

4.1 Overall Impacts

We present two sets of estimates from our baseline specification. The first set of estimates treats the department as the central unit of analysis and reflects the impact for a typical department. These estimates are relevant because the GEI was designed to affect entire departments, not just students who received GEI funding. We obtain these estimates by weighting each observation by the inverse of the size of the student's entering cohort. In the second set, our estimates reflect the impact for a typical student. We obtain these estimates by giving equal weight to each student in the estimation. The two sets of estimates will differ to the extent that the GEI had different effects in larger and smaller programs.

Appendix Table 1 presents the estimated coefficients on the $Treatment \times Post$ variable, which is the key variable for identifying the impact of the GEI program. A null hypothesis that the coefficients are zero in all years (jointly) can be rejected for attrition, but not for graduation. This result holds regardless of the weighting scheme.

The simulation results for the department-weighted version are shown in Figure 2. The impacts on attrition are shown in the top left panel. There are two lines in this panel; each line indicates the cumulative probability of attrition as of each year of enrollment, as predicted by the model. The solid line shows the probabilities for treatment departments for the case with the GEI program. The dashed line shows the probabilities for treatment departments for the (hypothetical) case without the GEI program. Since the solid line is always below the dashed line, the figure indicates that the program reduced attrition rates. The gap between the lines indicates the magnitude of the program impact. For instance, the probabilities of attrition for year 7 are 0.294 without the program and 0.267 with the program. The average impact over all

years is 0.029 (or 2.9 percentage points), as shown in Table 3. A comparison of the hazard rates for the two groups, shown in the top right panel of Figure 2, indicates that the primary impact of the GEI on attrition occurred in students' first and eighth years of enrollment.

The impacts on graduation are shown in the bottom left panel of Figure 2. In this case, the solid line is always above the dashed line, indicating that the program increased cumulative completion rates. To give an example, the probabilities of graduation for year 8 are 0.402 without the program and 0.431 with the program. The average impact over all years is 0.018 (or 1.8 percentage points), as shown in Table 3. This translates into a reduction in mean time-to-degree (as of year 11) of 0.119 years, or 1.4 months. The small impact on time-to-degree is not surprising if the marginal students affected by the program have long times-to-degree. The hazard rates in Figure 2 indicate that the primary impact of the GEI on graduation was in years 6, 7, and 8 (the modal years of graduation).

The estimated program impacts in the department-weighted version of our baseline specification are in the intended direction but modest in magnitude. In contrast, the student-weighted estimates are smaller. The average impacts across years in the student-weighted version are -2.0 percentage points for attrition, 0.5 percentage points for graduation, and -.041 years for time-to-degree (Table 3). A comparison of the two sets of results suggests that the GEI had larger impacts in smaller departments, which receive greater weight in the department-weighted analysis than in the student-weighted analysis.[7]

[7] This finding is confirmed by a variation on our model that allows the estimated program impacts to vary across sub-groups of departments based on department size. We classified departments into three categories based on average cohort size for the 1982-1990 entering cohorts, and the estimated program impacts were largest for the small departments (those with an average cohort size of 7.5 or fewer).

4.2 Potential Mechanisms

In addition to measuring the size of the impacts, it is critical to understand the mechanisms by which the GEI influenced outcomes. While this is a challenge in any evaluation, it is particularly difficult here because each department implemented the GEI somewhat differently. Furthermore, implementing the GEI was a dynamic process involving extensive experimentation at the departmental level. In this section, we explore the role of cohort size, student quality, and financial aid in explaining the measured impact of the GEI.

We evaluate the role of these potential mechanisms in a two-step process. First, we estimate the impact of each variable on student outcomes by including it among the explanatory variables in our duration model. For this purpose, we use a simplified version of our model in which the dependent variable represents the cumulative probabilities of attrition, graduation, and completion for year 8. Second, we estimate the impact of the GEI on each variable by using it as the dependent variable in a linear regression with $Treatment$, $Post$, $Treatment \times Post$, institutional indicators, and field indicators as explanatory variables. The estimated impacts for this second step are reported in Table 4. The impacts for the first step are reported in Table 5 as average marginal effects on the probabilities of attrition and graduation.

Cohort Size and Student Quality

Reducing the size of entering cohorts was often an explicit goal of treatment departments. The logic was that with smaller cohorts, departments could concentrate their faculty and financial resources on fewer students and each student would have a better change at success. We find that the GEI did in fact lead to a decrease in cohort size. According to the point estimate in Table 4, the GEI reduced cohort size by 2-3 students. A comparison of means (not shown) reveals that cohort size fell over time in both treatment and control departments and the

reductions occurred primarily in the larger departments. In addition, we find that cohort size increases the probability of attrition but has almost no impact on the probability of graduation (Table 5).

The reductions in cohort size, together with increases in financial support from the GEI, would be expected to lead to increases in the quality of students who enrolled in treatment departments. We find some evidence of this in GRE scores. We estimate that the GEI increased GRE verbal scores by about 10 points on average; however, we find no impact on GRE math scores (Table 4). We also find that higher GRE verbal scores are associated with lower attrition (Table 5); thus, the change in GRE scores can explain some of the measured impact of the GEI on attrition.[8]

Another indicator of student quality, the share of students who held a master's degree at the start of their PhD program, decreased because of the GEI (Table 4). This change is consistent with the change in GRE verbal scores, since students with a prior master's degree have lower GRE scores than other students. However, having a prior master's degree is a strong predictor of success in a PhD program; we estimate that it lowers the probability of attrition by 13 percentage points and increases the probability of graduation by 11 percentage points (Table 5). Thus, the reduction in the share of students with a prior master's degree worked against the goals of the GEI.

One way to summarize the role of changes in student quality and cohort size in the GEI is to include them as control variables in our duration model and see how this changes the

[8] Interestingly, the results in Table 5 show differences between the GRE verbal and math scores as predictors of student outcomes. Higher GRE verbal scores decrease the probability of attrition but have no impact on the probability of graduation. By contrast, higher GRE math scores increase the probability of graduation but have no impact on the probability of attrition. These results point to differences in the skill requirements between the coursework and dissertation stages.

measured impact of the GEI. Doing this decreases the estimated impacts of the GEI somewhat (Table 3). This indicates that reductions in cohort size and increases in student quality can explain a small part of the impact of the GEI.

Financial Support

Another route through which the GEI might have been expected to influence times-to-degree and attrition rates is through the improvements in financial support that it enabled departments to provide to students enrolled in their programs. Overall, the GEI appears to have led to an increase in financial support. We find that the share of students with academic-year fellowships, assistantships, and summer support increased by more at treatment departments than at control departments (Table 4). However, the GEI led to a decrease in average stipends for assistants at treatment departments relative to control departments. This suggests that control departments may have responded to the GEI program by increasing their own financial support for graduate students in order to remain competitive in the quest for top students.

We examine the impact of aid on student outcomes by including indicators for each type of aid (fellowship, TA/RA, tuition grant, summer support) in the duration model.[9] We use simulations to examine the impact of aid on cumulative probabilities of attrition and graduation. We follow the basic structure of our earlier simulations but make some changes because students' financial-aid packages can vary across years of enrollment. We consider several hypothetical financial-aid profiles and compare outcomes across profiles. Each profile contains a financial package for each year of enrollment from year 1 through year 6; after year 6, all profiles contain no aid of any type. In the simulation for a given profile, we assign the profile to

[9] In this version of the model, we include cohort size and student quality measures among the explanatory variables, but do not include the set of three variables that identify the effects of the GEI program.

all students and then use the estimated model to predict cumulative probabilities of attrition and graduation for each year of enrollment. We then take averages of these probabilities across students to produce a path of probabilities by year of enrollment for each financial-aid profile.[10]

A potential problem with this model is that the measured relationship between aid and student outcomes reflects unobserved student ability as well as the true impact of aid. This is a possibility if financial aid is awarded systematically to students who have lower expected probabilities of attrition and/or a higher probabilities of graduation. Therefore, we use an instrumental-variables (IV) strategy with the instruments based upon two sets of variables. The first set measures a student's GRE scores relative to the average in her department, cohort, and year of enrollment. The second set is the proportions of students receiving each type of aid in the department, cohort, and year of enrollment.[11] Our IV strategy is an improvement over previous research, which is subject to critique due to the effects of unmeasured ability (Ehrenberg and Mavros 1995).

Table 6 summarizes the simulation results for each profile with cumulative probabilities of attrition and graduation by the end of particular years. The first four profiles are prototypes: each has a single type of aid for years 1-6. For example, the first profile has no aid and the second profile has a tuition grant. Comparing these profiles indicates that having a tuition grant lowers attrition by year 2 by 26.7 percentage points and by year 4 by 23.0 percentage points. The figures on graduation indicate that having a tuition grant raises the probability of graduation by year 7 by 6.5 percentage points.

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[10] These simulations are similar in sprit to the approaches taken by Ehrenberg and Mavros (1995) and DesJardins, Ahlburg, and McCall (2002).

[11] For a given student in a department/cohort/year cell, the proportions are computed using data for students in the cell except the given student. We limit the sample to department/cohort/year cells where at least 80% of the observations have complete data on the financial-aid and student-quality variables and to observations within these cells that contain complete data on those variables.

The general pattern in the comparison of the prototypes is that more generous financial aid reduces the probability of attrition and increases the probability of graduation. This finding, together with the evidence that the GEI led to an increase in aid, suggests that financial aid is an important mechanism in accounting for the estimated impacts of the GEI on student outcomes. In addition, the analysis of financial aid reveals some more general findings. First, while more generous aid reduces the probability of attrition, even the most generous financial-aid packages are associated with considerable attrition. This result points to the role of factors other than financial support problems in accounting for attrition from doctoral programs. Second, more generous aid has a larger impact on reducing attrition than on encouraging completion. This result points to differences between the coursework stage and dissertation stages of PhD programs.

The remaining profiles in Table 6 form the basis for more subtle comparisons of the timing and mix of financial aid. These are examples of the types of funding decisions that departments are likely to face in practice. These comparisons suggest that the timing of a teaching or research assistantship is crucial. Having an assistantship in the early years of PhD programs (compared to having a fellowship) increases attrition, but having an assistantship in the middle years does not increase attrition or discourage completions. Another comparison suggests that summer support does not reduce attrition or encourage completions.

To summarize our findings in this section, we find some evidence that increases in financial aid, reductions in cohort size, and increases in student quality can account for part of the impact of the GEI on student outcomes. In a related paper, we examine the impact of the GEI on more detailed measures of departmental characteristics, including advising, course requirements, and department culture (Ehrenberg et al. 2005). These descriptions come from a

recent survey of students who started PhD programs in treatment and control departments between 1982 and 1997. The findings in that paper suggest that the GEI reduced attrition rates and improved graduation rates through the routes of improving clarity of departmental expectations and encouraging students to finish their dissertations as quickly as possible.

4.3 Robustness Checks

Our estimated impacts of the GEI on student outcomes may understate the true impact of the GEI due to treatment contamination. Generically, treatment contamination exists in an intervention when some of the controls are affected by the treatment. To the extent that this occurs, the affected controls are not suitable for use in the evaluation. In this study, the most plausible case of treatment contamination is that control departments in participating institutions (i.e., institutions with treatment departments) were directly influenced by the GEI program. Five universities in the study have both treatment and control departments: Cornell, Michigan, Princeton, Stanford, and Yale (see Table 2). Control departments at these institutions could have been affected by the program through at least two channels. First, institutions could have responded to the increased external support in treatment departments by reallocating internal funding towards control departments. Second, control departments could have mimicked structural changes that were being made by treatment departments.

We test for contamination by distinguishing between control departments at participating and non-participating institutions. We add variables to our baseline model that allow us to produce two sets of program impacts based on the time pattern of student outcomes in treatment departments relative to (1) control departments in participating institutions or (2) control

departments in non-participating institutions.[12] If contamination exists, the introduction of the GEI should be associated with similar changes at treatment departments and control departments in participating institutions. In this case, the measured impact of the GEI using control departments in participating institutions would be smaller than the measured impact using control departments in non-participating institutions.

The results of this test are shown in Table 7. Using control departments at participating institutions as the comparison group for treatment departments produces estimates of program impacts that are larger than (in the case of attrition) or about the same as (in the case of graduation) estimates using control departments at non-participating institutions. Thus, the results provide no evidence for this form of treatment contamination. Of course, changes that may have occurred at treatment departments to improve their graduate programs may have been known to control departments at non-participating institutions as well. This in turn may have caused these departments to make similar changes in their programs for competitive reasons. If this were true, all control departments would be somewhat affected by the GEI and our estimates would represent lower bounds on the true effects of the GEI on student outcomes.

Another reason that our estimates may understate the true impact of the GEI is that the changes took place gradually over time. Treatment departments envisioned big changes in their departments and that is one reason the Foundation funded the GEI for ten years. With changes taking place gradually over time, students in the initial cohorts that were exposed to the GEI may not have been affected very much, but students in later cohorts may have been affected more. We test for this by re-defining the timing of program introduction from the simple pre/post

[12] In addition, we drop the institutional indicators from the model. We cannot include them in the contamination model because in some fields there is only a single department of a given type of control. However, omitting these variables from our baseline model has only a small effect on the measured impact of the GEI (see Table 7).

definition to one involving three time periods. In treatment departments, the 1982-1985 entering cohorts had essentially no exposure to the GEI, the 1986-1990 cohorts had some exposure, and the 1991-2002 cohorts were fully exposed to the GEI. Estimated program impacts for the fully-exposed cohorts are much larger than for the transition cohorts (Table 7). This supports the presumption that structural change was a gradual process in treatment departments and the impacts of this change (as well as the direct impact of financial aid) increased with exposure. Relative to the impacts from the baseline model, the estimated program impacts for the fully-exposed cohorts are about one-third larger.

5. Conclusions

The Graduate Education Initiative was a ten-year program of funding from the Andrew W. Mellon Foundation to improve the structure and organization of PhD programs in the humanities and related social sciences, and in turn to reduce high rates of student attrition and long time-to-degree. This paper provides estimates of the impact of the GEI on student outcomes using detailed student-level data for 21 cohorts of students spanning the introduction of the GEI.

We estimate that, on average, the GEI had modest impacts on student outcomes in the expected directions: reducing attrition rates, reducing time-to-degree, and increasing completion rates. The overall impacts of the GEI appear to have been driven in part by reductions in cohort size, increases in financial aid, and increases in student quality. Prior to the GEI, the typical department in our study had an attrition rate of 42 percent and a completion rate of 48 percent (by year 11). According to our point estimates, the GEI reduced the attrition rate in a typical department by 3 percentage points (e.g. from 42% to 39%) and increased the completion rate by 2 percentage points (e.g. from 48% to 50%). However, these estimates may represent lower

bounds on the true effects due to the possibility of treatment contamination and competitive responses by control departments.

In addition to assessing the GEI, our paper has also provided more general evidence on several aspects of graduate education in the humanities. For example, we find that more generous financial aid has a larger impact on reducing attrition than on encouraging completion. While the impact of aid on attrition is considerable, even the most generous financial-aid packages are associated with considerable attrition. In other words, attrition decisions are not primarily due to financial-support problems.

An important subject for future research is the influence of the academic job market on completion rates and times-to-degree. It is believed that the job market provides students with strong incentives to finish their dissertations (Breneman 1976). In a strong job market, the opportunity costs to remaining enrolled are large; conversely, a weak job market may induce students to delay graduation in order to polish their dissertations to better compete for scare positions. If the job market does in fact exert a strong influence on completion rates and times-to-degree, reform efforts (such as the GEI) that primarily involve changes to doctoral programs may not have large impacts on student outcomes.

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Table 1. Innovations in Graduate Education Initiative

Category of Innovation	Examples
Clarification of expectations	Establish clear deadlines for tasks
Monitoring progress	Yearly progress review by Director of Graduate Studies Required to submit progress reports while writing dissertation
Group workshops/colloquia	Required seminars on prospectus preparation Optional brown bag lunches/seminars to encourage *esprit de corps*
Dissertation writing workshops	Required meetings with fellow students during writing stage Required to present chapters to seminars
Curricular changes	Streamline curriculum and reduce requirements Change format of comprehensive exams
Methods of enforcing deadlines	Funding conditional on being "on time" Change in policy on "incomplete" grades
TA-related changes	Ineligible for TA position if prospectus not completed by 4th year
Reduction of size of entering cohort	Accept fewer students in a given class
Make better use of summers	Define tasks students expected to accomplish during summer Fund students for specific tasks during summer
Faculty/staff resources	Establish a placement director Fund a language teacher to prepare for language exams
Funding conditional on timely progress	Eligible for summer funding to prepare for comprehensive exam *only* if met deadline for coursework Eligible for 6th year fellowship funding to write up research results *only* if bulk of research was completed by end of 5th year

Table 2. Treatment and Control Departments in Study

Field	Treatment	Control
Anthropology	Columbia, Harvard, Princeton, Stanford, Yale	Cornell, North Carolina, UCLA, UC-San Diego
Art History	Harvard, Michigan, Princeton, UC-Berkeley, Yale	Cornell, Stanford, UCLA
Classics	Michigan, Pennsylvania, UC-Berkeley	Cornell, North Carolina, Princeton, Yale, UCLA
Comparative Literature	Cornell, UC-Berkeley	Princeton, Michigan, UCLA, Yale
English	Chicago, Columbia, Cornell, Harvard, Michigan, Pennsylvania, Stanford, UC-Berkeley, Yale	Princeton, UCLA, UC-San Diego
History	Chicago, Cornell, Michigan, Pennsylvania, Princeton, Stanford, UC-Berkeley, Yale	North Carolina, UCLA, UC-San Diego
Music	Columbia, Pennsylvania, Yale	Cornell, Michigan, Princeton, Stanford, UCLA, UC-San Diego
Philosophy	Chicago, Columbia, Stanford	Cornell, North Carolina, UCLA, UC-San Diego, Yale
Political Science	Chicago, Cornell, Harvard, Princeton	North Carolina, Stanford, UCLA, UC-San Diego, Yale
Religion	Columbia, Harvard	Princeton, Stanford, Yale

Note: Overall, there are 44 treatment departments and 41 control departments in the study.

Table 3. Estimated Impacts of the GEI on Student Outcomes

A. Baseline model

	Weighting	
	Dept/Cohort	Student
Attrition	-.029	-.020
	(.016)	(.014)
Graduation	.018	.005
	(.015)	(.013)
Time-to-degree	-.119	-.041
	(.100)	(.084)

B. Baseline model with additional controls: cohort size and student quality

	Weighting	
	Dept/Cohort	Student
Attrition	-.026	-.014
	(.016)	(.014)
Graduation	.015	.003
	(.015)	(.013)
Time-to-degree	-.104	-.062
	(.098)	(.081)

Notes: Results labeled "Student" are from unweighted regressions on student-level data; those labeled "Dept/Cohort" are from regressions on student-level data weighted by the inverse of cohort size. The first number in each cell is an average (over years of enrollment) program impact on the cumulative probability of attrition or graduation; for time-to-degree, the first number is the program impact on the average number of years between entry to the PhD program and the awarding of the PhD (for those who finished in 11 years or less). The second number in each cell is a bootstrap standard error that is based on 1,000 replications and accounts for clustering of students by department and cohort.

Table 4. Changes in Cohort Size, Student Quality, and Financial Aid

	Sample Mean	Program Impact
Cohort Size	13.2	-2.166
		(1.619)
GRE Verbal	666.2	9.650
		(6.405)
GRE Math	635.9	-3.740
		(6.317)
Prior Master's Degree	0.26	-0.111
		(0.039)
Fellowship	0.48	0.053
		(0.035)
TA or RA	0.40	0.050
		(0.033)
Tuition Grant	0.62	0.003
		(0.039)
Summer Support	0.20	0.034
		(0.036)
Any Aid (excl. summer)	0.71	0.039
		(0.038)
Fellowship Amount	$7,655	$366
		($374)
TA/RA Amount	$6,895	-$1,423
		($335)
Tuition Grant Amount	$9,569	-$656
		($337)

Notes: Each row comes from a separate regression. All amounts are in 1991 dollars. Analysis of amounts is based on observations with positive amounts only. Standard errors are in parentheses and account for clustering of student observations by department and pre-/post-GEI.

Table 5. Effects of Explanatory Variables on Student Outcomes

	Impact on Pr(attrition)	Impact on Pr(graduation)
Cohort Size	0.0023	-0.0010
	(0.0006)	(0.0006)
GRE Verbal / 100	-0.0207	0.0104
	(0.0053)	(0.0052)
GRE Math / 100	-0.0077	0.0225
	(0.0045)	(0.0045)
Prior Master's Degree	-0.1262	0.1140
	(0.0094)	(0.0103)
Female	0.0155	-0.0304
	(0.0077)	(0.0077)
Non-U.S. Citizen	-0.0632	0.0888
	(0.0112)	(0.0119)
U.S. Citizen, Non-White	0.0242	-0.0362
	(0.0128)	(0.0119)

Notes: The first number in each cell is the average marginal effect of the characteristic on the cumulative probability of attrition or graduation. The second number in each cell is the associated standard error. The results are based on a cumulative probability model with outcomes as of the 8th year of enrollment. Student weighting is used for all characteristics except cohort size, which is based on department/cohort weighting. As of the 8th year enrollment, 37% had graduated, 37% has dropped out, and 26% were continuing.

Table 6. Impact of Financial Aid on Attrition and Graduation

	Financial Aid Profile (Years 1-6)				Pr(Attrition)*100			Pr(Graduation)*100		
	Fellowship	TA/RA	Tuition	Summer	2	4	7	6	7	9
[Prototypes]										
1.	--	--	--	--	40.4	47.6	52.4	13.9	22.9	34.1
2.	--	--	1-6	--	13.7	24.6	33.6	16.3	29.4	45.8
3.	--	1-6	1-6	--	15.3	22.9	29.1	18.1	31.9	49.2
4.	1-6	--	1-6	--	8.4	17.8	28.9	12.3	27.7	47.0
2-1	Tuition vs. No Aid				-26.7	-23.0	-18.8	2.4	6.5	11.7
3-2	TA/RA vs. Tuition Only				1.6	-1.7	-4.5	1.8	2.5	3.4
4-3	Fellowship vs. TA/RA				-6.9	-5.1	-0.2	-5.8	-4.2	-2.2
[Impact of Summer Support]										
5.	1-2,5-6	3-4	1-6	--	8.4	16.6	27.7	13.5	28.8	48.1
6.	1-2,5-6	3-4	1-6	2-3	8.4	17.8	28.7	13.3	28.5	47.5
Diff					0.0	1.2	1.0	-0.2	-0.3	-0.6
[Fellowship vs. TA in Middle Years]										
7.	1-6	--	1-6	--	8.4	17.8	28.9	12.3	27.7	47.0
8.	1-2,5-6	3-4	1-6	--	8.4	16.6	27.7	13.5	28.8	48.1
Diff					0.0	-1.2	-1.2	1.2	1.1	1.1
[Timing of TA, Early vs. Late]										
9.	1,4-6	2-3	1-6	--	11.7	19.2	30.1	12.1	27.3	46.2
10.	1-3,6	4-5	1-6	--	8.4	18.1	27.8	14.3	29.4	48.4
Diff					-3.3	-1.1	-2.3	2.2	2.1	2.2

Notes: Figures in table are cumulative probabilities of attrition or graduation (multiplied by 100) by the end of particular years of enrollment. All profiles involve no aid for years 7-11. Results based on student-weighted model with instruments for aid, as described in the text.

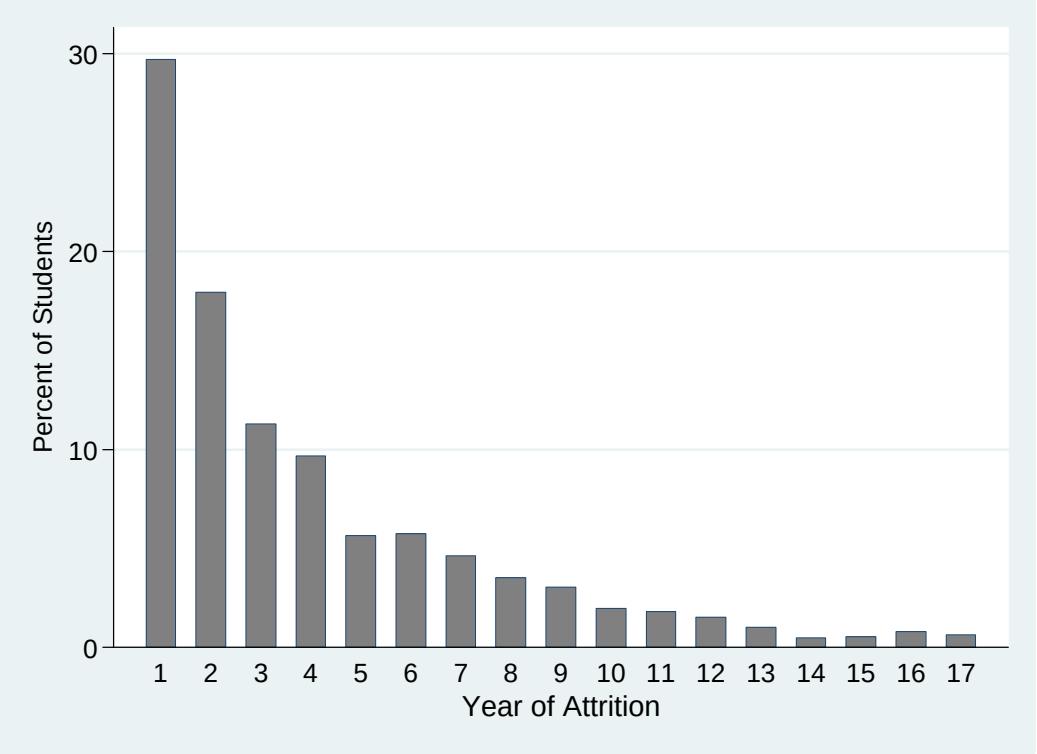
Table 7. Impact of the GEI on Outcomes: Robustness Checks

		Weighting: Dept/Cohort		
		Attrition	Graduation	Time to Degree
1.	Baseline (Table 3)	-.029	.018	-.119
		(.016)	(.015)	(.100)
1a.	Baseline without Institutional Indicators	-.026	.019	-.136
		(.018)	(.017)	(.109)
2.	Contamination Model			
	Treatment vs. Controls in Participating Institutions	-.041	.014	-.091
		(.029)	(.023)	(.149)
	Treatment vs. Controls in Non-Participating Institutions	-.011	.019	-.086
		(.020)	(.025)	(.168)
3.	Timing of Program Introduction			
	Post-GEI Cohorts (1991-2002) vs. Pre-1986 Cohorts	-.039	.024	-.111
		(.025)	(.018)	(.117)
	Transition Cohorts (1986-1990) vs. Pre-1986 Cohorts	-.007	.009	-.145
		(.021)	(.017)	(.112)

Notes: The contamination model does not include institutional indicators. For a description of weighting, point estimates, and standard errors, see the notes to Table 3.

Figure 1. Distribution of Attrition and Graduation for Pre-Program Cohorts

A. Attrition



B. Graduation

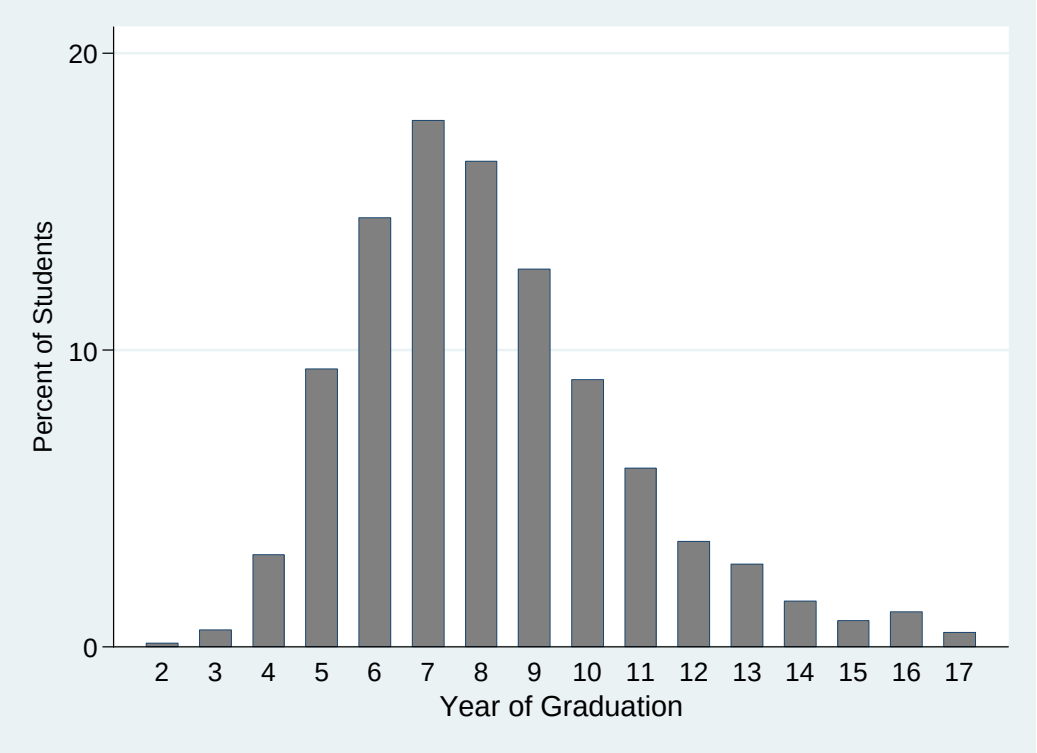
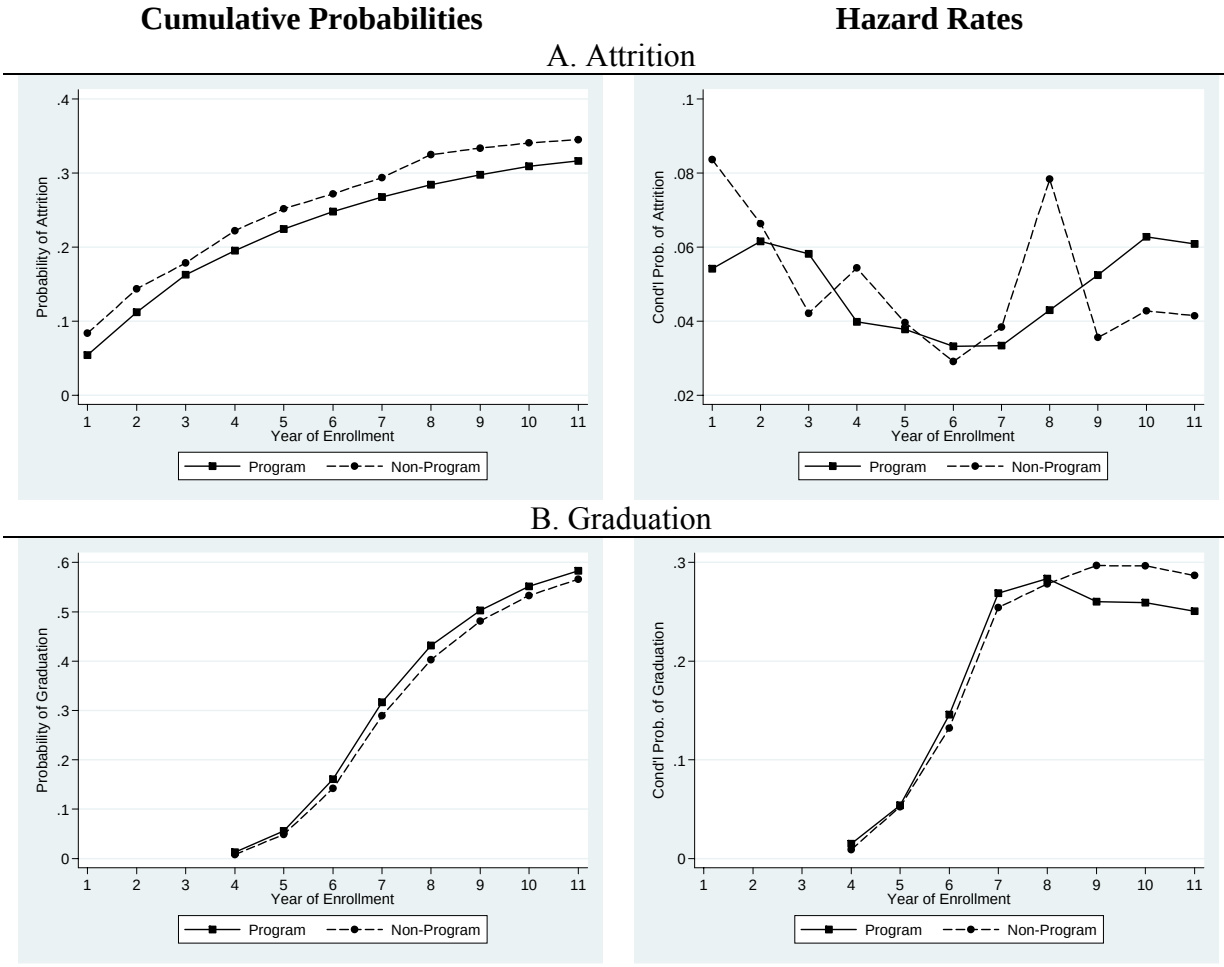


Figure 2. Program Impacts on Attrition and Graduation



Note: The figures are from regressions weighted by the inverse of cohort size and correspond to the "Department/Cohort" results in Table 3.

Appendix Table 1: Coefficients on *Treatment* × *Post* Variable from Transition Models

	Year of Enrollment									
Weighting	1	2	3	4	5	6	7	8	9-11	p-value for H_0: β=0
Dept/Cohort										
Attrition	-0.489	-0.081	0.344	-0.323	-0.048	0.158	-0.123	-0.672	0.365	0.029
	(0.171)	(0.153)	(0.183)	(0.204)	(0.255)	(0.281)	(0.306)	(0.476)	(0.295)	
Graduation				0.503	0.027	0.124	0.073	-0.029	-0.163	0.611
				(0.308)	(0.195)	(0.171)	(0.174)	(0.188)	(0.157)	
Student										
Attrition	-0.543	-0.024	0.411	-0.133	-0.052	-0.019	0.114	-0.022	0.115	0.000
	(0.126)	(0.115)	(0.131)	(0.156)	(0.205)	(0.229)	(0.258)	(0.302)	(0.228)	
Graduation				0.161	-0.083	0.127	-0.021	-0.096	-0.082	0.882
				(0.252)	(0.157)	(0.14)	(0.138)	(0.15)	(0.125)	

Notes: Standard errors in parentheses. These results correspond to models in top panel of Table 3.