The Power of Mentors in Research Training Relationships[1]

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Late-stage training in high-skill occupations often involves apprenticeship-style mentoring that create substantial dependency of mentees on mentors. We examine the consequences of abrupt mentorship termination in scientific research training, looking at faculty deaths as an exogenous shock. Using UMETRICS administrative data linked to obituary records, we study graduate students and postdoctoral researchers. We analyze Ph.D. completion, continued funded employment, and access to research resources. Mentor death significantly reduces Ph.D. completion among graduate students and employment and research expenditures among postdocs, with effects varying by career stage in a way that reflects dependency. These findings reveal substantial downside risk and power asymmetry inherent in mentoring relationships.

1. Introduction

From medical residents to judges' clerks to laboratory trainees, late-stage trainees in high-skill occupations are both an essential input to production and one of its most important "products" — the next generation of highly skilled workers. Such training differs from didactic teaching, as it often takes the form of apprenticeship-like arrangements in which education, mentoring, and production are tightly intertwined. These arrangements provide enormous benefits, but the close dependency they entail also creates unique risks that fall overwhelmingly on the trainee.

In this paper, we ask a simple and fundamental question: what happens to a trainee when a mentoring relationship terminates abruptly? This question speaks to a defining feature of apprenticeship-style training—namely, that trainees bear substantial downside risk when the relationships on which their progress depends are disrupted. At the same time, studying these disruptions provides indirect evidence on the value of mentorship and the degree of influence mentors exert over their trainees. We examine this question in the context of scientific research training, where mentoring relationships are central to the production of knowledge (Stephan, 2012) and directly observable in our administrative data. Moreover, the growing burden of knowledge (Jones, 2009) increases the importance and length of apprenticeships-style training.

[1] The authors thank the Academic Analytics Research Center for data on faculty. The results do not reflect the opinions of the Academic Analytics Research Center.

Our empirical strategy exploits the death of faculty mentors, which exogenously terminates mentoring relationships. Because death is plausibly unrelated to trainees' characteristics or the prospects of their research agendas, it provides a credible source of variation for studying the consequences of disrupted mentorship.

While mentoring relationships can end for many reasons—including intellectual or personality differences, loss of funding, faculty mobility, illness, or death—each type of termination operates through distinct mechanisms. Termination typically entails reduced financial support, diminished access to equipment and space, and the loss of knowledge spillovers or sponsorship, and may also involve substantial psychological or emotional distress. Faculty death captures many of these mechanisms (namely, loss of support and resources, as well as the disruption of professional guidance), while excluding ill will, which may be present in other cases and generate additional costs.[2] For this reason, we interpret the effects of mentor death as a plausible lower bound on the costs to trainees when mentoring relationships terminate.

A central challenge when studying mentor-trainee relationships is to connect graduate students and postdocs to faculty members at a point when it may be hard to do so (e.g., neither publications nor dissertations may be observed to make links). We overcome this challenge using a unique source of administrative level data, UMETRICS, that allows us to link researchers through wage payments on sponsored research projects regardless of whether they publish together or, in the case of graduate students, complete their degrees. These data allow us to observe mentoring relationships as they unfold over time, including funding flows and access to research resources.

We combine UMETRICS with online obituary data to identify faculty deaths and construct treatment and control groups through a faculty-level matching strategy. Our analysis focuses on two populations at different stages of research training: graduate students and postdoctoral researchers. Power asymmetries between mentor and trainee are likely to vary by career stage. Postdocs, with more advanced skills, accumulated human capital, and broader professional networks, may be better positioned to cope with disruptions, whereas graduate students may benefit from stronger institutional protections provided by their departments or universities. How these factors balance out to mitigate—or exacerbate—the effects of mentor loss is not obvious a priori, making it crucial to study both populations.

In our analysis, we examine three professionally meaningful outcomes that capture distinct dimensions of mentorship: Ph.D. completion (measured via ProQuest dissertations), continued employment on sponsored research projects, and non-wage research expenditures that proxy for access to equipment, materials, and services. Together, these outcomes provide a comprehensive picture of how trainees' academic progress and research capacity respond to the loss of a mentor.

Our results show that the consequences of disrupted mentorship are substantial and differ sharply by career stage. Graduate students connected to a faculty member who subsequently dies are about 11 percentage points less likely to complete their Ph.D., relative to a baseline completion rate of roughly 40 percent. The effects are concentrated among students who began collaborating with the

[2] That is, beyond distancing themselves from a mentee, some mentors might (threaten to) engage in activities to harm the mentee, such as spreading negative rumors about them.

mentor two to five years prior to the death, precisely the period when relationship-specific investments and dependence are likely to be greatest. In contrast, we do not find negative effects for students who started their collaboration in the year before the mentor dies. This pattern suggests the results are unlikely to be driven by selection: if students anticipated a mentor's death and the most competitive students avoided ill faculty, we would expect recent trainees to fare worse, which is not what we observe. Similarly, graduate students with independent ties to other faculty members (e.g., via research grants that exclude the deceased faculty member) show no decline in their probability of graduation.

For postdoctoral researchers, we find that those who suffer the death of a connected faculty member are about 9 percentage points (16 percent) less likely to remain employed on a funded project at their institution (measured over the three years following the event), with effects emerging in the first year and persisting thereafter. In addition, non-wage expenditures on the grants employing these postdocs decline by about 71 percent, indicating sharp reductions in access to research equipment. In contrast, we do not find that graduate students' employment on funded projects is negatively affected by the death of a connected faculty member. While grant spending on projects involving these students declines by about 33 percent, this effect remains statistically insignificant, suggesting that institutional protections or alternative funding sources may partially insulate them at least in the short run.

We interpret these findings as evidence of the substantial hold-up power embedded in mentoring relationships, which are by inherently asymmetric. Importantly, the costs of disrupted mentoring relationships are not limited to the moment of termination; the possibility of disruption can also shape behavior throughout the relationship. Trainees may engage in anticipatory obedience, aligning their work and opinions with their mentor's preferences to avoid conflict or loss of support. This dynamic can limit diversity of opinion, even when mentors manage the relationship with integrity. Of course, some mentors exploit dependency by withholding credit for trainees' contributions (Ross, et al., 2022) or, in more severe cases, engaging in misconduct (Cantor, et al., 2015). The effects we estimate capture the consequences of an involuntary and non-strategic termination of mentorship, and thus likely provide a lower-bound measure of the costs that could arise when support is withheld for other reasons. While we caution against extrapolating directly to cases involving abuse or misconduct, our estimates nevertheless illuminate the magnitude of the dependency that characterizes many training relationships.

Related Literature. Our study contributes to several literatures. First, it builds on studies of student-faculty relationships, such as (Waldinger, 2010), who shows that the dismissal of Jewish faculty in German universities reduced student academic achievement, and (Graddy-Reed, Lanahan, & D'Agostino, 2021), who show that providing independent research funding increases coauthored publications with advisors. Other studies examine how matches between advisor and advisee attributes influence outcomes (Gaule & Piacentini, 2018; Corsini, Pezzoni, & Visentin, 2022), while (Roche, 2023) links advisors' entrepreneurial engagement to worse student outcomes. Second, our study relates to the literature on peer effects in science (Azoulay, Wang, & Graff Zivin, 2010; Oettl, 2012; Waldinger, 2012; Cheng & Weinberg, 2025; Ham, Quistorff, & Weinberg, 2025), which generally emphasizes horizontal spillovers or moderate vertical effects

from eminent to less eminent researchers. We focus on highly vertical training relationships and, in contrast to these studies, which generally focus on the benefits of knowledge spillovers,[3] we highlight the risks inherent to training relationships. Finally, to the best of our knowledge, this is the first study to bring postdoctoral researchers, whose numbers and importance have grown substantially over recent decades (Stephan, 2012; Cantwell & Taylor, 2015), fully into an analysis of mentoring disruptions using comprehensive administrative data.

Our findings have implications beyond academic science. Asymmetric mentoring relationships arise in many professions where late-stage training combines production and education. In such settings, the concentration of authority and resources in the hands of a single mentor may deter entry, shape behavior within relationships, and generate unequal risks across trainees. Understanding these dynamics is essential for designing training systems that preserve the benefits of mentorship while mitigating its costs.

2. Data

Our analysis combines administrative data on sponsored research activity with information on faculty deaths. Our main data source is UMETRICS, which provides granular administrative information on wage payments made in each pay period from each grant to the individuals paid on that grant, along with additional information such as job title, year-of-birth bins, and imputed gender (The Institute for Research on Innovation & Science (IRIS), 2024). These data allow us to infer which researchers work on which sponsored projects and to identify collaborative relationships within and across research teams.

We use data from 36 universities that participate in UMETRICS and provide their records to the Institute for Innovation and Science at the University of Michigan, which processes and standardizes these data. Coverage varies by institution, with the earliest observations beginning in 2000 and the latest in 2022 for the data release we use.

Our second data source are online obituaries collected via Legacy.com,[4] which we use to identify deceased faculty members. We describe this procedure in more details in Section 2.2. For each deceased faculty member, we assign an observationally similar "placebo deceased" faculty member drawn from UMETRICS. Graduate students and postdocs connected to placebo deceased faculty members form the control group in our analysis. Details on the matching procedure are provided in Section 2.3. Section 2.4 presents descriptive statistics for faculty members and their connected graduate students and postdocs.

[3] A notable exception is (Azoulay, Wang, & Graff Zivin, 2010), who also study the effect on the coauthors' acquisition of research funds.

[4] https://www.legacy.com, downloaded in 08/2019.

2.1 Connecting graduate students, postdocs and faculty members via joint research grants

UMETRICS records all payments made on sponsored research projects (i.e., grants). While some research money flows to suppliers of research materials, services, and equipment, the majority supports university employees, including graduate students, postdocs, faculty, and staff (Sattari, Bae, Berkes, & Weinberg, 2022). These funds cover graduate student stipends, benefits, and tuition as well as the salaries and benefits of other employees. Unlike in Economics, in most sciences, medicine, and engineering, the bulk of research occurs on sponsored projects and the people who work on those projects are supported at least in part by grants (rather than, for instance, by institutional funds for instruction).

We use joint participation on sponsored research grants to link faculty members to graduate students and postdocs. For each faculty member, we identify all research grants from which they received payments and treat these grants as projects on which the faculty member is involved during the period they are active in the data. We then identify all graduate students and postdocs who received wage payments from these same grants.

Graduate students and postdocs are typically paid from a grant only while actively working on the project. Accordingly, we consider trainees to be linked to a project only during the outer hull of the period in which they receive payments from it.[5] Faculty members, in contrast, appear at rather irregular intervals (e.g., only during the Summer), the timing of payments cannot be used to precisely determine when they join or quit projects. We therefore treat faculty members as connected to a project throughout the lifetime of a grant regardless of the precise timing of their payments, provided they receive a payment from the grant at any point in time.

For each graduate student or postdoc, we record the timing of payments and define the start of their involvement on a project as the month and year of their first payment and the end of their involvement as the month and year of their last payment. We regard all graduate students and postdocs identified in this way as connected to all faculty members associated with the project, including the deceased or placebo-deceased faculty member.[6]

We define the start of a mentoring relationship as the month in which the graduate student or postdoc first receives a payment from a grant shared with the focal faculty member. This definition captures when the trainee is actively working on the project and provides a consistent measure of relationship onset across institutions and fields.[7] We consider individuals to be connected to a

[5] In other words, if we observe that a graduate student is paid on a grant for the first time in January 2010 and for the last time in January 2012, we infer that the student was continuously involved in that project for a period of two years.

[6] To establish connections between graduate students or postdocs and faculty, we exclude grants that involve more than 10 faculty members. Such, larger grants are often center grants, in which it is less likely that all members involved in the project are closely connected.

[7] We recognize that this date may only approximate the actual start of the relationship but believe that this approach is conservative in that people almost surely are working on projects when they are paid from them but may interact with faculty on those projects even before that date.

deceased faculty member only if the start of their involvement in the grant predates the faculty member's death.

2.2 **Identifying deceased faculty members**

We identify deceased faculty members in three steps. First, we obtain faculty rosters for universities participating in UMETRICS from the Academic Analytics Research Center for the years 2009-2018. For three universities that appear in UMETRICS prior to 2009, we supplement these records with faculty rosters covering the years from 2002 onward, which we obtained directly from the institutions.

Second, we search for obituaries corresponding to all listed faculty members using Legacy.com, which aggregates obituaries from newspapers, funeral homes, and other obituary services. We identify potential matches based on names, institutional affiliations, and references to faculty positions.[8]

Third, we manually review all potential matches to verify identities and extract information on the month and year of death. We compare obituary information with UMETRICS records (e.g., we compare the birth year in the obituary to that available in UMETRICS) to minimize the risk of false positives. We treat the month in which the obituary is published as the month in which the death occurred.

Information on cause of death is not consistently reported in obituaries and is therefore not used in the analysis. As a result, we are unable to assess directly whether deaths in our sample were anticipated. In Section 2.4, we provide suggestive evidence that many deceased faculty members remained actively engaged in research close to the time of death.

Using this procedure, we identify 75 distinct deceased faculty members, 71 of whom can be linked to at least one graduate student or postdoc in UMETRICS.

2.3 **Control group matching**

Our empirical strategy compares the outcomes of graduate students and postdocs that are related via a joint research grant to a later-deceased faculty member, to a control group that did not experience the loss of a related faculty member. Because we have considerably more pre-treatment information available for faculty members than for graduate students or postdocs, we perform our match at the level of the deceased faculty member, rather than at the level of the graduate student or postdoc, and then construct our treatment and control groups based on this match.[9] Put

[8] We searched for names and then retain those that have the term "professor" and the relevant institution in the obituary.

[9] A similar approach is taken in (Javarel, Petkova, & Bell, 2018), who match deceased and non-deceased inventors and then study the effect of the inventor's death on their co-inventors' earnings and patenting output.

differently, we identify faculty who are good matches for those who die and then use their graduate students and postdocs as controls for the graduate students and postdocs who do have a related faculty member die.

Specifically, for each deceased faculty member with at least one connected graduate student or postdoc, we identify a pool of potential control faculty members who satisfy the following criteria: (i) employment at the same institution; (ii) same age group (5-year bins for year of birth);[10] (iii) receipt of a research grant that started in the same year as the most recent grant of the deceased faculty member; (iv) assignment to the same standardized sub-organizational unit within UMETRICS (e.g., Medicine, Agriculture, Engineering), which serves as a proxy for broad research areas;[11] and (v) connection to at least one graduate student or postdoc prior to the year of death.

From this pool, we select a single matched control faculty member based on similarity in the number of research grants and publications.[12] We refer to this individual as the "placebo deceased" faculty member and assign them a placebo death date corresponding to the death date of their matched counterpart.

We then link placebo deceased faculty members to graduate students and postdocs using the same procedure described in Section 2.1 and require that joint involvement on a grant predates the placebo death event. We focus on graduate students and postdocs whose first appearance on a joint grant with the deceased or placebo deceased faculty member occurs no more than seven years prior to the (actual or placebo) death event. This reduces the likelihood that our estimates are affected by people who have, for instance, long ago stopped an active relationship with the focal faculty member before the death event.

The availability of suitable controls narrows the sample to 47 deceased faculty members. The final dataset for graduate students includes 529 individuals: 284 connected to 42 deceased faculty members ("treated group") and 245 connected to 42 placebo deceased faculty members ("control group"). The final dataset for postdoctoral researchers includes 221 individuals: 126 connected to 29 deceased faculty members and 95 connected to 29 placebo deceased faculty members.[13]

[10] If the age group of the deceased faculty member is unavailable, we instead require that the earliest year of publication of the non-deceased faculty member is less than 5 years apart from the earliest publication of the deceased faculty member.

[11] In cases in which this information is missing, or in cases in which we are unable to find any matching non-deceased faculty members, we relax condition 4) and instead require that the deceased and non-deceased faculty member share at least one common sponsoring institution (e.g., NIH, DOE) in their funding history.

[12] More precisely, we minimize the squared deviation in total number of research grants (that they received payments from), total number of publications reported in the Web of Science, and total number of publications in PubMed.

[13] While we identify placebo-deceased faculty "with replacement" (i.e., the same placebo-deceased faculty member could, in principle, be selected as a placebo for more than one deceased faculty member), in practice, there are no cases where the same placebo-deceased faculty member is used as a control for more than one deceased faculty member. There are 2 graduate students who are included as placebos for the graduate students of 2 deceased faculty members and hence appear twice in our control sample. No such cases exist for postdocs.

2.4 **Sample characteristics**

Figures 1-4 summarize key characteristics of the faculty members and trainees in our sample. Figure 1 presents information on deceased faculty members. Panel A shows the distribution of death years; with two exceptions, all deaths occur between 2010 and 2018, with peaks in 2014 and 2017. Panel B shows that 72 percent of deceased faculty members received payments from grants that started in the year of death or the year prior, and 91 percent received payments from grants that started within three years of death, indicating continued research activity close to the time of death. Panel C shows the distribution of faculty birth cohorts; deceased faculty members were on average approximately 63 years old at the time of death. Panel D reports the distribution of standardized sub-organizational units to which faculty members belong.

Figure 2 shows the distribution of the number of connected graduate students and postdocs for deceased and placebo deceased faculty members. While this characteristic is not targeted in the matching procedure, the distributions are broadly similar. On average, deceased faculty members connected to graduate students are linked to 6.0 graduate students, compared to 5.2 for placebo deceased faculty members; corresponding figures for postdocs are 2.7 and 2.0, respectively. This imbalance stems from a higher proportion of faculty members in our treatment group who are connected to 15 or more graduate students or postdocs. In robustness checks, we reduce the influence of such faculty by capping the number of graduate students or postdocs per faculty member at 5, 10, or 15.[14]

Figure 3 presents characteristics of connected graduate students and postdocs. Panels A and B show the distribution of the starting year of collaboration relative to the year of (actual or placebo) death. We find no visual evidence of a decline in the number of graduate students or postdocs beginning collaborations prior to death, consistent with faculty members remaining active up to the time of death. Panels C and D show the distribution of birth cohorts for graduate students and postdocs; the median birth-year range is 1984-1988 for graduate students and 1979-1983 for postdocs.

Figure 4 plots the timing of the last wage payment from joint grants prior to death.[15] A substantial share of graduate students and especially postdocs remain employed on joint grants very close to the time of death. For graduate students, we observe no systematic differences between treated and control groups. For postdocs, there appear to be minor differences.

3. Results

In this section, we compare outcomes for graduate students and postdoctoral researchers connected to faculty members who subsequently die to outcomes for comparable trainees connected to

[14] Specifically, we randomly select graduate students or postdocs up to the set cap for each faculty member and exclude the remaining ones.

[15] Although we assume that the first payment from a joint research grant with a faculty member marks (or at least approximates) the start of their collaborative relationship, we do not expect that the relationship necessarily ends when the graduate student or the postdoc stops receiving payments from a joint grant in a subsequent period.

matched control faculty members. We study two sets of outcomes that capture distinct dimensions of mentoring support. We first examine Ph.D. completion, a long-run training outcome that reflects cumulative disruptions to mentoring relationships. We then turn to continued employment on sponsored research projects and access to research resources, shorter-run outcomes (i.e., continued grant employment and access to research resources) that are relevant for both graduate students and postdoctoral researchers and which shed light on the mechanisms through which mentor loss affects trainees.

A central identification concern is that graduate students and postdocs connected to later-deceased faculty members may differ systematically from those in the control group. Because we do not observe whether deaths were anticipated or preceded by illness, the trainees' choice to collaborate with a faculty member who subsequently dies may reflect unobserved characteristics, such as attitudes toward risk. We believe that this concern is mitigated by two features of our empirical setting. First, a large share of graduate students and postdocs began collaborating with the faculty member several years prior to death (78 percent and 82 percent, respectively). Second, in many STEM fields, graduate students and postdocs are sponsored by faculty members prior to matriculation, limiting their ability to select mentors based on short-run considerations. We further assess these concerns below.

3.1 Degree completion

We begin our analysis by examining whether the loss of a faculty mentor affects graduate students' likelihood of graduating. Ph.D. completion is the central long-run outcome of graduate training and reflects the cumulative consequences of disruptions to funding, guidance, and institutional support. Because postdoctoral researchers do not face a comparable graduation event, our analysis of degree completion focuses exclusively on graduate students.

As a measure of graduation, we determine whether a graduate student has a dissertation in ProQuest, which is required at all UMETRICS universities for degree completion. Our empirical strategy compares graduation probabilities between graduate students connected to deceased faculty members and those connected to matched placebo deceased faculty members. The baseline OLS linear probability model we estimate is given by:

$$graduate_i = \alpha + \tau\, D_i + \gamma_{t'(i)} + \beta\, X_i + \varepsilon_i \qquad (1)$$

where the dependent variable is an indicator equal to one if graduate student i has a dissertation entry in ProQuest, with outcomes measured through 2019. To account for potential truncation issues, we include a set of fixed effects, γ, for the year in which the student first appeared on a joint grant with the connected faculty member, which we interpret as the start of their collaboration.

The vector of control variables, X_i, includes several additional covariates. First, we include a categorical variable capturing the time difference between the death event, t^d, and the year the

collaboration began, t', which flexibly controls for cohort effects.[16] Second, we include indicators for whether the graduate student was connected to other faculty members through grants prior to the event, distinguishing between connections that are independent of the focal faculty member and those that are jointly held with them.[17] Finally, X_i includes the student's imputed gender and a categorical variable indicating the number of months between the student's last payment from a joint grant and the death of the connected faculty member.[18]

For students connected to control faculty members, all variables are defined analogously using the matched placebo death event. The indicator variable D_i equals one if graduate student i is connected to a faculty member who dies and zero if they are connected to a placebo faculty member. The coefficient τ is the parameter of interest which captures the effect of losing a connected mentor on the likelihood of graduating. Standard errors are clustered at the level of the connected faculty member.

We do not differentiate between students who graduate after the (placebo) death event and those who graduate before the event, as focusing solely on the former could bias our estimates in either direction. On the one hand, if deaths are anticipated, students may "rush to finish;" on the other hand, if an illness impairs the work of the faculty member already prior to their death, students may be impacted and graduate later.

Column 1 of Table 1 presents the estimates of a parsimonious specification that includes only fixed effects for the starting year of collaboration. Graduate students connected to a deceased faculty member are 11.4 percentage points (pp) less likely to complete their Ph.D. than students in the control group. Column 2 adds the full set of controls and yields a nearly identical estimate (-11.2 pp). For context, the average graduation rate in the control group is 40.4 percent, implying a decrease of more than one quarter in terms of graduation.

We next examine heterogeneity by the timing of the mentoring relationship. Graduate students who have been working with a faculty member for a number of years before the death event may have developed relationship-specific investments in skills, research topics, and personal and professional ties, making them particularly adversely affected by their mentor's death. By contrast, graduate students who have just started a mentoring relationship may have not made many specific investments and may be able to switch advisors at a lower cost. Conversely, graduate students, who are close to completion may be somewhat insulated by being close enough to or having already graduated.

Column 3 interacts the treatment indicator with the number of years between the start of collaboration and the death event. This analysis serves two purposes: it sheds light on the role of relationship-specific investments and provides a test for anticipatory selection. We find that the decline in the graduation propensity for the treated group is most pronounced for cohorts of

[16] We partition the sample into following cohorts and create a set of dummy variables, one for each of four groups: students who started collaborating with the deceased faculty member in the year of death or the year prior to death, 2 or 3 years prior to death, 4 or 5 years prior to death, and 6 or 7 years prior to death.

[17] More detailed on the construction of this variable are provided at the end of this section.

[18] We consider the following categories: within 11 months before death, between 12 and 23 months before death, between 24 and 35 months before death and more than 35 months.

graduate students who started collaborating with the deceased mentor 2-3 years (-22.3 pp, p=0.015) and 4-5 years (-26.0 pp, p<0.001) prior to the death event.[19] In contrast, for graduate students who started collaborating with the deceased faculty member in the year before or in the year of the faculty's death, the estimated effect on graduation is positive but statistically insignificant (+5.9 pp, p=0.459). This pattern is inconsistent with anticipatory sorting and instead suggests that the effects operate through accumulated dependence on the mentoring relationship. Finally, graduate students who started collaborating with the deceased faculty member 6 or 7 years prior to death also do not exhibit a decline in their graduation propensity (+10.2 pp, p=0.420), presumably because many of them are close to or have already graduated before the death occurred or the situation of the connected faculty member worsened.

We next examine whether connections to other faculty members mitigate the impact of mentor loss. Graduate students may be connected to additional faculty either through grants independent of the deceased faculty member or through grants jointly held with them. Independent connections plausibly provide alternative sources of mentorship and support, while joint connections may not. To explore this possibility, we link the graduate students in our sample to additional faculty members through their participation in research grants. These connections are categorized based on whether they involve grants independent of those associated with the deceased faculty member, which we anticipate will be highly protective, or include grants that were jointly held with the deceased faculty member, which we expect to be less protective.

In Column 4, we examine the interaction effect with an indicator variable set to one if the graduate student is connected to at least one faculty member through grants independent of the deceased faculty member. Such connections suggest mentorship or employment relationships that are not directly tied to the deceased faculty member and are therefore less likely to be disrupted by their loss. Approximately 25% of the graduate students in the treatment group and 29% in the control group possess such ties. We find that having ties to another faculty member fully offsets the adverse effects of a faculty mentor's death, with the difference in the effect between students with such ties and those without being positive and statistically significant (+26.1 pp, p=0.005). Combining this interaction with the main effect of a faculty mentor's death reveals that graduate students with additional ties do not experience a reduction in their graduation propensity (+7.7 pp, p=0.361).

In Column 5, we consider an indicator variable set to one if the graduate student is connected to at least one other faculty member through grants that are joint with the deceased faculty member. The majority of graduate students have such connections (83% in the treatment group and 82% in the control group). Such ties do not mitigate the impact of losing a connected faculty member, as the difference in the likelihood of graduating is negative for students with these ties compared to those without, albeit not statistically significant (-9.6 pp, p=0.358). As robustness, we also examined the number of other faculty members involved in joint grants as an explanatory variable, instead of using the dichotomous variable, but found no systematic differences.

[19] These figures are obtained from Table 1 by summing the estimated treatment effect of the (omitted) baseline category and the treatment effect for the indicated category. The p-value is obtained from testing the hypothesis that this sum equals zero.

Finally, in Column 6 we explore heterogeneity by student gender. While the point estimates suggest larger effects for female graduate students (-19.0 pp vs -7.6 pp), the difference is not statistically significant (p=0.274) and should therefore be interpreted with caution.

As a robustness check, we limit the number of graduate students per faculty member in our sample to a maximum of 5, 10, or 15. Our aim is to mitigate the influence of faculty members who contribute a disproportionally large number of graduate students to the sample. Specifically, we randomly select graduate students up to the set cap for each faculty member and exclude the remaining ones. The results of this approach are shown in Appendix Table . Our main findings are robust to these alternative samples.

3.2 Grant employment

While Ph.D. completion captures the long-run consequences of mentor loss for graduate students, it does not reveal the short-run channels through which disruptions might operate, nor is it defined for postdoctoral researchers. In this section, we turn our attention on the effect of losing a connected faculty member on the probability that trainees receive support in the form of paid employment on sponsored projects. Additionally, we assess potential disruptions in access to research equipment by tracking non-wage expenditures ("vendor expenses") made from grants on which these trainees are employed. These expenditures likely require faculty involvement and/or approval. As continued support and purchases of materials, supplies, and services, unlike graduation, are relevant for postdocs as well as graduate students, we study both groups here.

Employment on sponsored projects is observed repeatedly over time, allowing us to control for time-invariant characteristics of the trainee. We estimate difference-in-differences models that compare changes in outcomes following the death of a connected faculty member to changes for trainees in the control group:

$$award_empl_{it} = \alpha_i + \gamma_t + \tau_{i,t} D_i \times \{t \geq t^d(i)\} + \delta_{t-t^*(i)} + \varepsilon_{it} \qquad (2)$$

where the dependent variable is an indicator equal to one if postdoc, or graduate student, i is employed (i.e., received wage payments) on at least one sponsored project that is joint with a faculty member in year t,[20] or the logarithm of the sum of all non-wage expenditures made from these grants in year t. We track this outcome through 2021. Aside from year- and trainee-fixed effects, we include a fixed effect, δ, for the number of years that have passed since the first appearance of the postdoc or graduate student in UMETRICS, denoted t^*, to control for postdocs' and graduate students' "life cycle" (e.g., typically graduate students obtain their PhD after 5 or 6 years after joining a certain institution). [21] We interact the treatment indicator, D, with the timing of the death event (which occurs in year t^d). The coefficient τ is our parameter of interest,

[20] Specifically, this means a grant from which a faculty member has received payment at any point, including joint grants with the deceased faculty member.

[21] The first appearance is marked by the first time that they receive a wage payment from any grant, not just from joint grants with the deceased faculty member.

capturing the effect of losing a connected faculty member on grant employment. Standard errors are clustered at the level of the related faculty member.

We construct a balanced panel by including exactly three pre-treatment periods, the year of the connected faculty member's death, and three post-treatment periods for each trainee in our sample. Due to the staggered timing of treatment, which occurs at different times for different trainees, we employ the estimator proposed by (Borusyak, Jaravel, & Spiess, 2024). This method is robust to heterogeneity in the treatment effects across different treatment years. We report the average of the post-treatment coefficients across trainees for all included years, up to three years following the death event. Additionally, we closely adhere to the methodology described by (Borusyak, Jaravel, & Spiess, 2024) in constructing event-study plots, which report estimated average effects for individual years surrounding the death event.

3.2.1 Postdocs

The results for postdocs are detailed in Table 2. Column 1 indicates an 8.9 percentage points decrease (p=0.015) in the likelihood of postdocs receiving funding from an award in UMETRICS in the four years following the death of a connected faculty member, including the year of the death. For context, the mean of the dependent variable is 0.48 one year before death, 0.54 two years prior, and 0.55 three years prior. Therefore, our estimates suggest a relative decline of about 16-18% in employment on sponsored projects.

Panel A of Figure 5 presents the corresponding event study plot again for postdocs. Following (Borusyak, Jaravel, & Spiess, 2024), the coefficients for two years before the death (t=-1 and t=-2) reflect changes relative to the base period, which is three years prior to the death (t=-3). The post-treatment coefficients quantify changes relative to the entire pre-treatment phase (t<0). Our analysis reveals a significant grant employment decline of approximately 10.7 pp starting in the year of the death. In subsequent years, the treatment effect ranges from 8.0 pp to 8.6 pp, demonstrating sustained impact.

Column 2 of Table 2 indicates a substantial decrease of approximately 71.3% (equivalent to exp(-1.248), p=0.029) in non-wage expenditures on the grants on which postdocs are employed. This reduction reflects adjustments along two dimensions: postdocs losing their positions on some grants and, for those retaining employment, a reduction in spending. For context, the average non-wage expenditure in the year prior to the faculty member's death was approximately $53,800.

Panel B of Figure 5 illustrates a similar trend for non-wage expenditures as observed with employment. The expenditures drop immediately by about 73.0% in the year of death of the faculty member, with these reductions persisting in the subsequent years.

Results that limit the number of postdocs per faculty member to a maximum of 5, 10 or 15 are presented in Appendix Table (Columns 1 and 2) and show no substantial differences from our main findings.

3.2.2 Graduate Students

Columns 3 and 4 of Table 2 report analogous estimates for graduate students. In contrast to postdocs, graduate students do not experience a reduction in grant employment following the death of a connected faculty member. The point estimate is small and statistically insignificant (+1.83 pp, p=0.564). Furthermore, a one-sided test allows us to rule out effects of the magnitude observed for postdocs for graduate students at the 5% significance level (p=0.025). Panel C in Figure 5 confirms this finding across the full post-treatment period, showing no significant differences in the effect over time. None of the coefficients for individual post-treatment years suggest a decline. The mean of the dependent variable is 0.45 one year before death, 0.46 two years prior, and 0.44 three years prior.

Column 4 of Table 2 reports a modest, though insignificant, decrease of about 32.8% in non-wage expenditures from grants employing graduate students (p=0.307). Panel B in Figure 5 indicates that the treatment coefficients for individual years post-treatment vary between -17.5% and -49.4%, although all the estimates are insignificant. The mean of the dependent variable in the year before the death is approximately $115,500.

Finally, we explore the heterogeneity in the effect on grant employment by focusing on factors that previously mitigated or exacerbated the effect on the graduation propensity. Specifically, we examine the time difference between the death event and the starting year of collaboration with the deceased faculty member, as well as connection to other faculty members through grants independent of the deceased faculty member. Our analysis, shown in Table 3, reveals only statistically insignificant differences in the effects for either outcome variable between graduate students who began collaborating with the deceased faculty member 2-5 years prior to the death event and those who started at other times. Similarly, we find insignificant differences between graduate students with ties to other faculty members and those without such connections. These findings suggest that the factors influencing graduation propensity operate through mechanisms distinct from those affecting grant employment.

In Appendix Table , we present results from capping the number of graduate students per faculty member to a maximum of 5, 10 or 15. They do not deviate from our main findings.

4. Discussion and Conclusion

Our study documents the consequences that the death of a faculty mentor has for the graduate students and postdoctoral researchers working with them on sponsored research projects. Graduate students exposed to such a loss are less likely to complete their doctoral degrees, with effects concentrated among those who had been collaborating for two to five years, a period when relationship-specific investments and dependence are likely to be greatest. Postdoctoral researchers experience sharp declines in employment on funded projects and in access to purchased research resources.

We interpret these effects as evidence of the hold-up power embedded in highly asymmetric mentoring relationships. The consequences of mentor death plausibly mirror those that would

occur if a faculty member withdrew support, net of ill will or strategic behavior. This interpretation is specific to the nature of the relationship we study. In collaborative relationships between established researchers, which have been the focus of much of the literature on peer effects in science (Azoulay, Wang, & Graff Zivin, 2010; Oettl, 2012; Waldinger, 2012), either party withdrawing imposes costs on all collaborators, limiting the scope for unilateral leverage. In contrast, asymmetric mentoring relationships allow faculty members to impose substantial costs on trainees with relatively few immediate repercussions, creating pronounced power imbalances.

Several limitations are worth noting. First, mortality events are rare, and our sample size is therefore limited, which contributes to noisy estimates in some specifications. Second, although our empirical design mitigates concerns related to anticipation, we cannot directly observe whether deaths were expected. Third, we observe employment funded through sponsored research projects; in principle, some funding losses could be offset through instructional or departmental sources, although institutional context suggests this is uncommon. Finally, grief and emotional distress may contribute to the effects we observe, alongside the loss of financial and professional support.

Despite these limitations, our findings highlight a vulnerable period in graduate training—after substantial relationship-specific investments have been made—when trainees face heightened risk. Policies that improve trainees' bargaining position within mentoring relationships, such as facilitating advisor changes or strengthening misconduct reporting systems, may mitigate these risks. Similarly, measures that increase transparency about students' progress, such as milestone reporting or departmental oversight committees, could reduce dependence on a single mentor. More fundamentally, graduate programs might reduce risks by redesigning apprenticeship structures or shortening their duration. For example, programs that front-load general coursework before assigning advisors may reduce early dependence relative to those that place students under faculty supervision immediately.

Graduate students and postdoctoral researchers depend on faculty mentors not only for funding but also for intellectual, professional, and personal guidance. This dependence gives research funders an opportunity to influence trainee outcomes. One implication of our findings is that a greater share of research support could be directed to trainees themselves rather than exclusively through faculty-controlled grants. Attaching at least part of funding to individuals, rather than to mentors, could reduce dependence on a single faculty member and provide trainees with greater flexibility.

More broadly, our findings underscore the systemic risks faced by research trainees and the limited safeguards embedded in current training structures. If mentoring relationships in academia involve especially high hold-up power, these risks may deter entry into research careers or induce selection based on resilience rather than aptitude, with potentially unequal impacts across groups (e.g., by gender or minority status).[22] Similar dynamics are likely to arise in other professions where late-stage training pairs apprentices closely with senior mentors. Understanding and addressing these

[22] Evidence from surveys of graduate students suggest that preferences for particular job characteristics and work conditions correlate with academic aspirations (Sauermann & Roach, 2010).

risks is essential for designing equitable and effective training environments in science and beyond.

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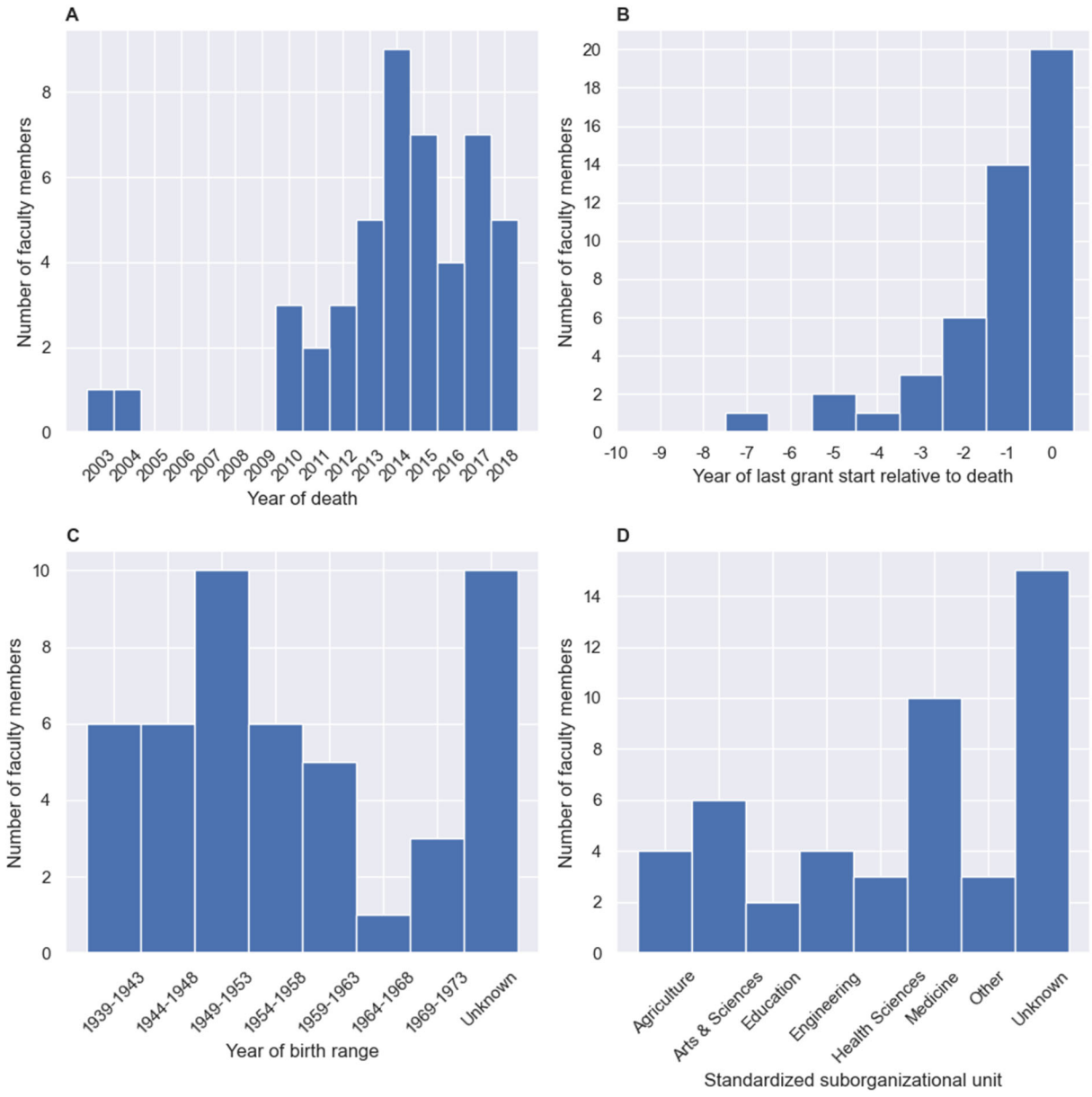
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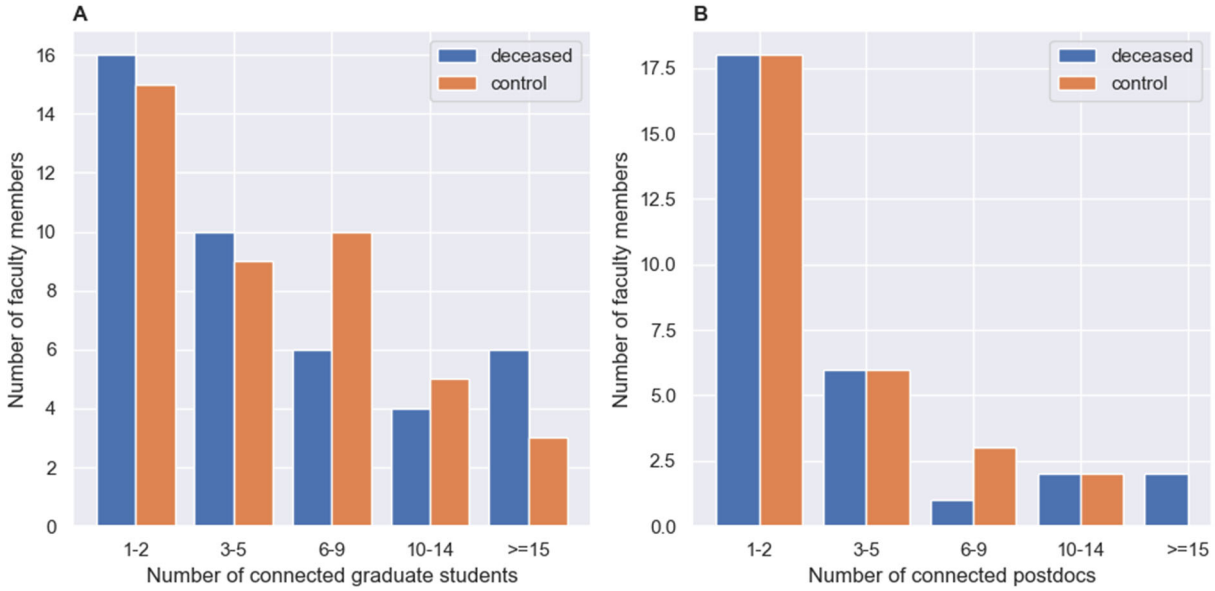
Figures

Figure 1: Distribution of characteristics of deceased faculty members



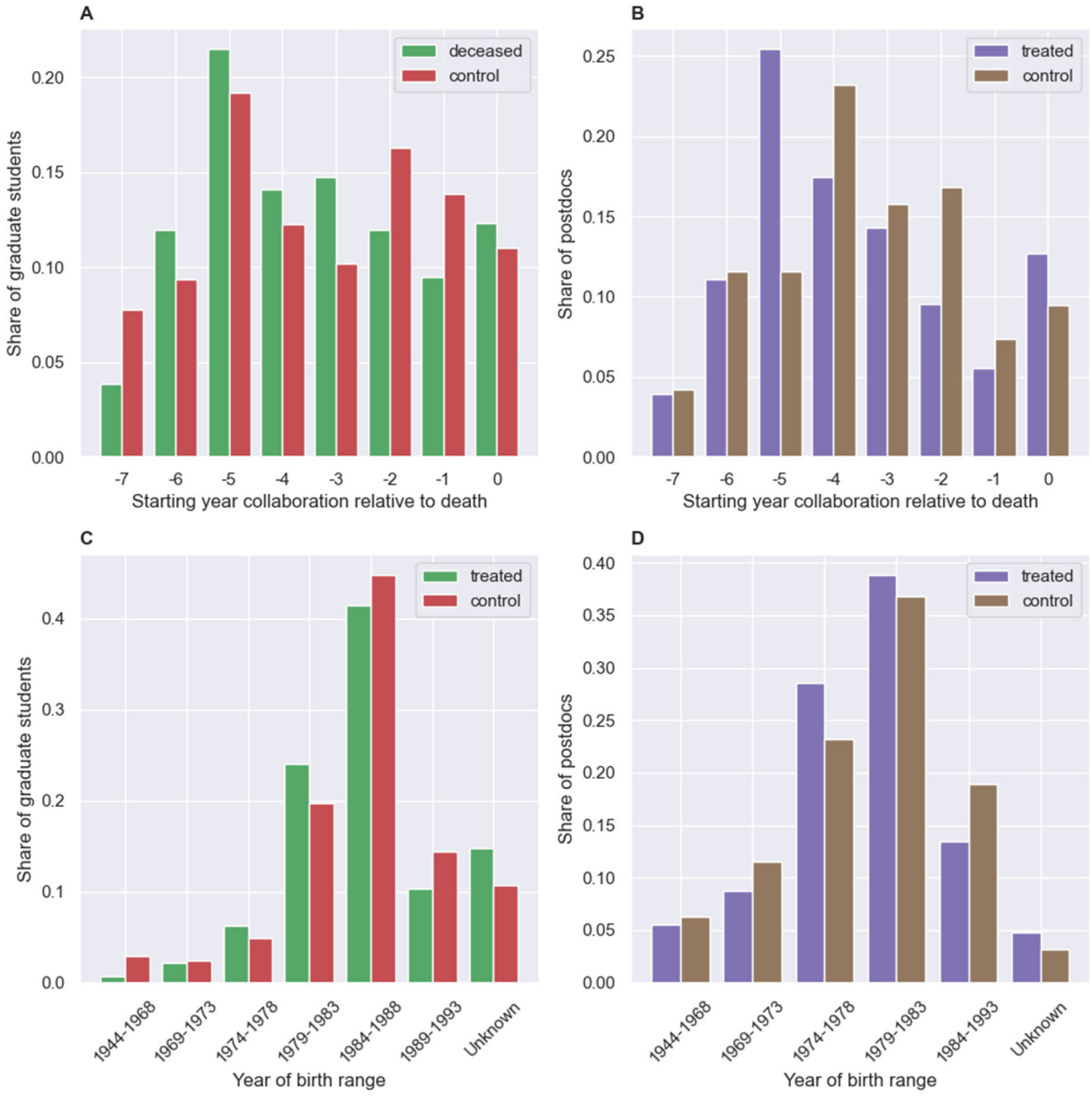
Note. The figure reports descriptive statistics for our sample of deceased faculty members.

Figure 2: Number of connected graduate students and postdocs per faculty member



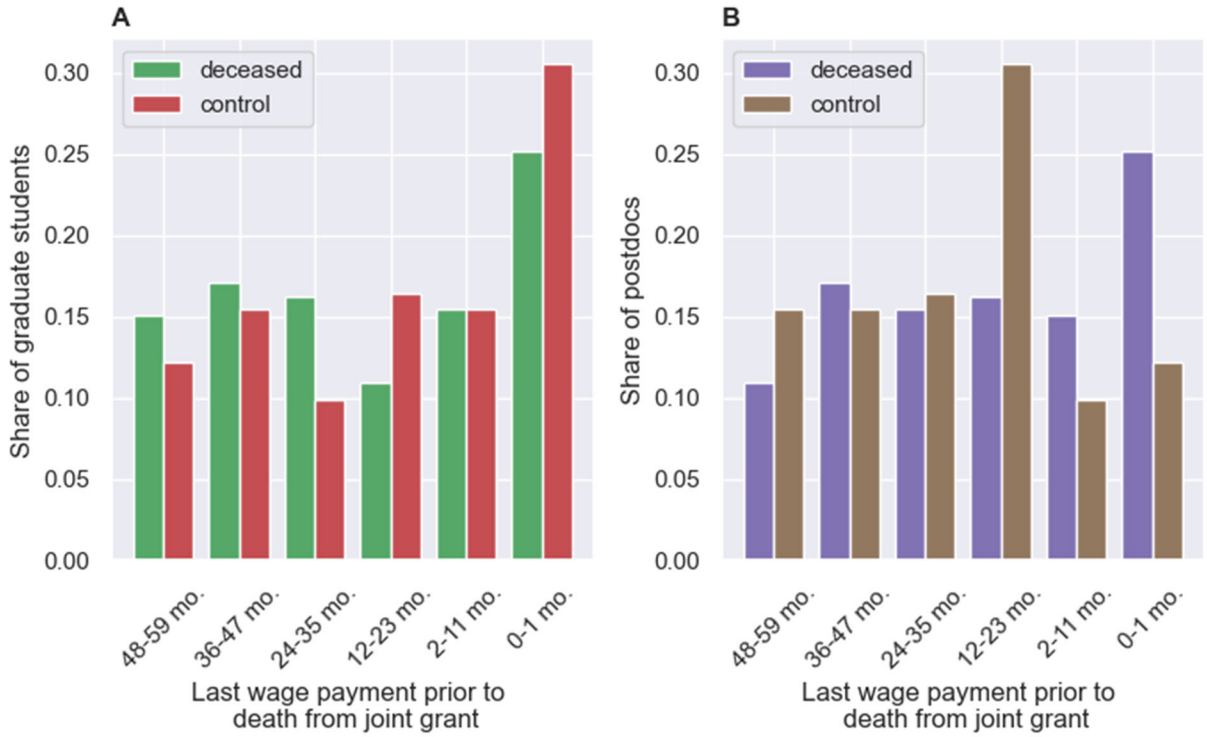
Note. The figure reports the frequency distribution of the number of deceased faculty members and controls by the number of graduate students (Panel A) and postdocs (Panel B) who are connected to them

Figure 3: Characteristics of graduate students and postdocs



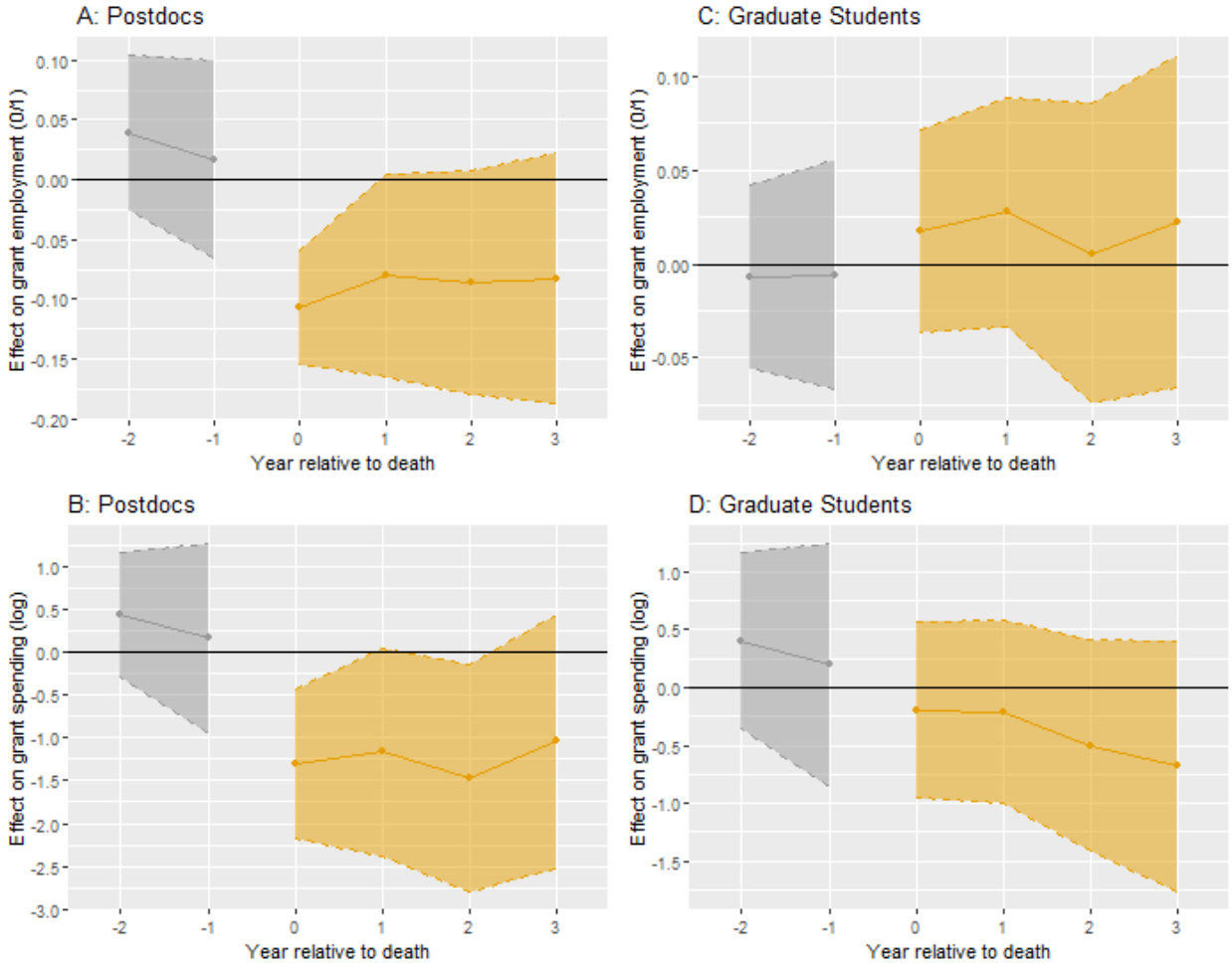
Note. The figure reports the distribution of the number of years before the death that the graduate student (Panel A) or postdoc (Panel B) began collaborating with the deceased faculty member or control. Panels C and D display the birth year distribution for graduate students (Panel C) and postdocs (Panel D) connected to a deceased faculty member or matched control.

Figure 4: Timing of Last Wage Payment Relative to Faculty Death (or Control Pseudo-Death)



Note. The figure shows the distribution of the last wage payment prior to the death of the faculty member (or the control's pseudo-death) for graduate students (Panel A) and postdocs (Panel B) on research grants involving the focal faculty member, where "0–1" indicates the last payment occurred in the same or previous month, "2–11" indicates 2–11 months prior, and so on.

Figure 5: Event study plots for grant employment outcomes



Notes: Panel A (C) shows the effect on the propensity to be employed on at least one sponsored project for postdocs (graduate students) connected to a deceased faculty member, compared to the control group, based on the model $award_empl_{it} = \alpha_i + \gamma_t + \tau_{i,t} D_i \times \{t \geq t^d(i)\} + \delta_{t-t^*(i)} + \varepsilon_{it}$ (described in Section 3.2). Panel B (D) trends in non-wage expenditures made from these grants for postdocs (graduate students). We use methods from *(Borusyak, Jaravel, & Spiess, 2024)*; the pre-treatment coefficients measure the change relative reference period t=-3, while the post-treatment coefficients measure the change relative to the reference periods t<0.

Tables

Table 1: Effect on graduation propensity

Dependent variable	(1) Phd degree (0/1)	(2) Phd degree (0/1)	(3) Phd degree (0/1)	(4) Phd degree (0/1)	(5) Phd degree (0/1)	(5) Phd degree (0/1)
Sample	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.
Treated	-0.114**	-0.112**	0.0590	-0.184***	-0.0322	-0.0761
	(0.0508)	(0.0482)	(0.0793)	(0.0514)	(0.0891)	(0.0530)
treated x (2-3 years of collab.)			-0.282**			
			(0.126)			
treated x (4-5 years of collab.)			-0.319***			
			(0.105)			
treated x (>5 years of collab.)			0.0425			
			(0.155)			
treated x (collab. with other faculty on separate grant)				0.261***		
				(0.0897)		
treated x (other faculty on joint grant with deceased)					-0.0958	
					(0.104)	
treated x female student						-0.114
						(0.104)
Starting year of collab. FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	Y	Y	Y
Students	529	529	529	529	529	529
Faculty	84	84	84	84	84	84
R-squared	0.115	0.139	0.164	0.152	0.140	0.142

Notes: This table presents estimates of the difference in the propensity to graduate (0/1) for graduate students connected to deceased faculty members compared to students from the control group, based on the model $graduate_i = \alpha + \tau\, D_i + \gamma_{t'(i)} + \beta\, X_i + \varepsilon_i$ (described in Section 3.1).

Table 2: Effect on grant employment and expenditures

Dependent variable	(1) Grant employed (0/1)	(2) Log(1+Grant spending)	(3) Grant employed (0/1)	(4) Log(1+Grant spending)
Sample	Postdocs	Postdocs	Grad. stud.	Grad. stud.
Treated post death	-0.089**	-1.248**	0.0183	-0.397
	(0.0366)	(0.570)	(0.0317)	(0.389)
Graduate student/Postdoc FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Yrs since first award empl. FE	Y	Y	Y	Y
Obs.	1,547	1,547	3,702	3,702
Graduate students/Postdocs	221	221	529	529
Faculty	58	58	84	84

Notes: This table presents estimates of the effect of losing a connected faculty member on a) the propensity to be employed on at least one grant (0/1) following the death event for postdocs (column 1) and graduate students (column 3); and b) on the non-wage expenditures (log) made on the grants on which people are employed following the death event for postdocs (column 2) and graduate students (column 4). Estimates follow the methodology of *(Borusyak, Jaravel, & Spiess, 2024)* and are based on the model $award_empl_{it} = \alpha_i + \gamma_t + \tau_{i,t} D_i \times \{t \geq t^d(i)\} + \delta_{t-t^*(i)} + \varepsilon_{it}$ (described in Section 3.2). Note that the estimates in columns (2) and (4) combine effects along the extensive margin (i.e., whether people are employed on grants, reported in columns (1) and (3)) and intensive margin (i.e., the amount of purchased materials, supplies, and services conditional on employment on one or more grants).

Table 3: Heterogeneity in the effect on grant employment and expenditures

Dependent variable	(1) Grant employed (0/1)	(2) Grant employed (0/1)	(3) Log(1+Grant spending)	(4) Log(1+Grant spending)
Sample	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.
Treated post death x (2-5 years of collab.)	0.0400		-0.285	
	(0.0378)		(0.498)	
Treated post death x (<2 years or 6-7 years of collab.)	-0.0178		-0.584*	
	(0.0284)		(0.344)	
Treated post death x (collab. with other fac. on separate grant)		-0.0012		-0.711
		(0.0653)		(0.520)
Treated post death x (no collab. with other fac. on separate grant)		0.0247		-0.295
		(0.0295)		(0.414)
p-value difference (Chi-sq test)	0.151	0.685	0.571	0.447
Graduate student/Postdoc FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Yrs since first award empl. FE	Y	Y	Y	Y
Obs.	3,702	3,702	3,702	3,702
Graduate students/Postdocs	529	529	529	529
Faculty	84	84	84	84

Notes: This table presents estimates of the heterogeneity in the effect of losing a connected faculty on grant employment and expenditures. This analysis follows the methodology of *(Borusyak, Jaravel, & Spiess, 2024)*; we present the estimates for the two different groups (τ_0, τ_1) and the p-values associated with the test $H_0: \tau_0 = \tau_1$. See notes to Table 2.

Table A.1: Robustness graduation propensity: capping the maximum number of graduate students per faculty member

Dependent variable	(1) Phd degree (0/1)	(2) Phd degree (0/1)	(3) Phd degree (0/1)	(4) Phd degree (0/1)	(5) Phd degree (0/1)	(5) Phd degree (0/1)
Sample	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.	Grad. stud.
A: Maximum of 15 graduate students per faculty member						
Treated	-0.102*	-0.102**	0.0673	-0.182***	-0.0382	-0.0736
	(0.0534)	(0.0506)	(0.0828)	(0.0507)	(0.0907)	(0.0543)
treated x (2-3 years of collab.)			-0.300**			
			(0.131)			
treated x (4-5 years of collab.)			-0.293***			
			(0.109)			
treated x (>5 years of collab.)			-0.0303			
			(0.160)			
treated x (collab. with other faculty on separate grant)				0.296**		
				(0.0947)		
treated x (other faculty on joint grant with deceased)					-0.0784	
					(0.107)	
treated x female student						-0.0918
						(0.108)
Students	477	477	477	477	477	477
B: Maximum of 10 graduate students per faculty member						
Treated	-0.125**	-0.123**	0.0640	-0.218***	-0.0924	-0.0869
	(0.0557)	(0.0526)	(0.0793)	(0.0514)	(0.0956)	(0.0544)
treated x (2-3 years of collab.)			-0.289**			
			(0.130)			
treated x (4-5 years of collab.)			-0.332***			
			(0.115)			
treated x (>5 years of collab.)			-0.0115			
			(0.181)			
treated x (collab. with other faculty on separate grant)				0.358***		
				(0.104)		
treated x (other faculty on joint grant with deceased)					-0.0385	
					(0.114)	
treated x female student						-0.116
						(0.110)
Students	415	415	415	415	415	415
C: Maximum of 5 graduate students per faculty member						
Treated	-0.122*	-0.109*	0.130	-0.192***	-0.0632	-0.0762
	(0.0641)	(0.0646)	(0.103)	(0.0630)	(0.128)	(0.0739)
treated x (2-3 years of collab.)			-0.367**			
			(0.155)			
treated x (4-5 years of collab.)			-0.447***			
			(0.138)			
treated x (>5 years of collab.)			0.0155			
				0.327**		
treated x (collab. with other faculty on separate grant)				(0.150)		
treated x (other faculty on joint grant with deceased)					-0.0577	
					(0.142)	
treated x female student						-0.0963
						(0.137)
Students	287	287	287	287	287	287
Starting year of collab. FE	Y	Y	Y	Y	Y	Y
Controls	N	Y	Y	Y	Y	Y
Faculty	84	84	84	84	84	84

Notes: Panel A, B and C shows estimates for the effect of losing a connected faculty member on the propensity to graduate (0/1) when limiting the maximal number of graduate students per faculty member at 15, 10 or 5 respectively. Specifically we select graduate students up to the set cap for each faculty member and exclude the remaining ones. See notes to Table 1.

Table A.2: Robustness grant employment and expenditures: capping the maximum number of postdocs per faculty member

Dependent variable	(1) Grant employed (0/1)	(2) Log(1+Grant spending)	(3) Grant employed (0/1)	(4) Log(1+Grant spending)
Sample	Postdocs	Postdocs	Grad. stud.	Grad. stud.
A: Maximum of 15 postdocs/graduate students per faculty member				
Treated post death	-0.081**	-1.160**	-0.0079	-0.681
	(0.0365)	(0.582)	(0.0335)	(0.436)
Obs.	1,449	1,449	3,338	3,338
Graduate students/Postdocs	207	207	477	477
B: Maximum of 10 postdocs/graduate students per faculty member				
Treated post death	-0.0751*	-1.012*	-0.0107	-0.676
	(0.0386)	(0.590)	(0.0330)	(0.460)
Obs.	1,323	1,323	2,904	2,904
Graduate students/Postdocs	189	189	415	415
C: Maximum of 5 postdocs/graduate students per faculty member				
Treated post death	-0.097**	-1.336**	-0.0356	-0.759
	(0.0445)	(0.632)	(0.0380)	(0.511)
Obs.	1,043	1,043	2,009	2,009
Graduate students/Postdocs	149	149	287	287
Graduate student/Postdoc FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Yrs since first award empl. FE	Y	Y	Y	Y
Faculty	58	58	84	84

Notes: Panel A, B and C shows estimates for the effect of losing a connected faculty member on grant employment and expenditures when limiting the maximal number of postdocs or graduate students (counted separately) per faculty member at 15, 10 or 5 respectively. Specifically we select postdocs/graduate students up to the set cap for each faculty member and exclude the remaining ones. See notes to Table 2.