# Interdisciplinary Advisors and PhD Training

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August 22, 2025

**Abstract**

Universities increasingly establish interdisciplinary research centers to catalyze cross-field collaboration, yet the implications for doctoral training are unclear. We examine whether advisors' engagement in such centers affects their PhD students' productivity and novelty. Using administrative and publication data from a large research university, we link 1,036 advisors to 3,658 PhD graduates (2007–2023). Our scientist-year panel tracks student output from program start through two years post-graduation. Identification relies on within-advisor comparisons: we contrast students graduating after an advisor engages with a center to earlier students of the same advisor and to students whose advisors never engage, controlling for fine-grained research units. We find a trade-off. Students of interdisciplinary advisors publish fewer papers during the PhD, with no robust gains in research novelty once advisor fixed effects are included. Nevertheless, these students coauthor with collaborators whose expertise is more distant and receive more citations on papers coauthored with their advisors. We find no consistent evidence that students' own work becomes more interdisciplinary by standard measures. By identifying student-level trade-offs, our results extend research on mentorship and collaboration policy and inform the future design and assessment of interdisciplinary initiatives.

# 1 Introduction

Interdisciplinary[1] research centers aimed at promoting cross-field collaboration and scientific creativity have proliferated in contemporary universities (Jacobs and Frickel, 2009; Leahey and Barringer, 2020). While university administrators, funders, and policymakers continue to emphasize support for interdisciplinarity (D'Este and Robinson-Garcia, 2023; Rylance, 2015), prior studies often portray this mode of research as a challenging venture that creates both benefits and costs to individual scientists (Leahey, 2018; Rhoten and Parker, 2004). For example, interdisciplinary work boosts scientists' visibility at the expense of productivity (Leahey, Beckman, and Stanko, 2017), and can enhance the societal relevance of their research while it undermines their reputation among scholars (Fontana, Iori, Sciabolazza, and Souza, 2022). Because interdisciplinary centers chiefly seek to cultivate relationships and interactions that reconfigure collaborations among faculty (Biancani, McFarland, and Dahlander, 2014; Boardman and Corley, 2008), these initiatives may also reshape the environment underpinning academic training, offering a unique set of opportunities and challenges for PhD students.

A growing literature stresses the vital role of the research environment, and especially mentorship provided by doctoral advisors, on successful academic training (Brostrom, 2019; Corsini, Pezzoni, and Visentin, 2022; Wuestman, Wanzenbock, and Frenken, 2023). Advisors transfer essential skills and tacit knowledge to conduct research (Paglis, Green, and Bauer, 2006; Roche, 2022), and provide social capital that affords long-lasting opportunities (Hottenrott and Lawson, 2015; Pezzoni, Sterzi, and Lissoni, 2012), shaping a range of advisees' outcomes. Advisors are key determinants of PhD students' research productivity (Corsini et al., 2022; Shibayama, 2019), post-graduation job placement (Rose and Shekhar, 2023), and creative performance (Ma, Mukherjee, and Uzzi, 2020; Wang and Shibayama, 2022). Furthermore, advisors' mentorship, comprising regular supervision, input on students' questions and methods, and guidance over the submission and publication process, can be pivotal in successfully navigating interdisciplinary research (Lyall and Meagher, 2012; Wang and Shibayama, 2022). However, whether and how advisors who engage in interdisciplinary research influence the research outcomes of their PhD students remains unclear.

On the one hand, exposure to interdisciplinary research can expand doctoral students' access to distinct collaborators. Doctoral students typically lack extensive ties to academic commu-

[1]We follow the commonly-adopted broad definition of interdisciplinary research as the "integration of perspectives, information, data, techniques, tools, concepts, and/or theories from two or more disciplines (Leahey, 2018).

nities, making it difficult for them to initiate collaborations beyond their immediate research group (Wuestman et al., 2023). By lowering the search costs of identifying individuals with complementary expertise and shared interests (Boudreau et al., 2017), advisors who join interdisciplinary centers may help foster the formation of collaborations with scientists with different expertise or background. Consistent with the knowledge recombination perspective, a more diverse set of collaborators can provide access to new information, fresh perspectives, and unique resources (Fleming, Mingo, and Chen, 2007; Uzzi and Spiro, 2005), thereby advancing PhD students' creative performance. Moreover, a more extensive collaboration network can broaden the potential audience for their research, thereby generating more visibility and potentially leading to a citation premium (Leahey et al., 2017; Vakili, Teodoridis, and Bikard, 2021).

On the other hand, for scientific collaborations to make effective use of individuals' distinct expertise, they require adequate communication procedures (Reagans, Miron-Spektor, and Argote, 2016) and a functional division of research tasks (Haeussler and Sauermann, 2020). These processes are time-intensive and cognitively demanding (Bercovitz and Feldman, 2011; Onal-Vural, Dahlander, and George, 2013), and can be especially challenging in interdisciplinary teams, where differences in terminology, methods, and procedures tend to create frictions (Cummings and Kiesler, 2005; Mansilla, le Lamont, Sato, and Lamont, 2016). To the extent that such challenges arise during a critical stage of training, when students are honing their research skills and expertise, engaging in interdisciplinary work may negatively affect PhD students' research productivity.

In this paper, we examine whether advisors who engage in interdisciplinary research centers influence their PhD students' research novelty and productivity. Our research context is the establishment of two interdisciplinary research centers at a large research university, and we use advisors' engagement with these centers as a "footprint" of their commitment to interdisciplinary work during PhD student's training. We combine administrative records on advisors and PhD students with publication data, analyzing a sample of 1,036 advisors and 3,658 PhD graduates from 2007 to 2023. Our analyses are at the scientist-year level and focus on students' research output from PhD start and up to two years after graduation. We leverage panel data models to identify within-advisor effects, contrasting students who graduated after their advisor engaged with a center with students of the same advisor who graduated before that engagement, and also against students whose advisors never engaged. Moreover, as we focus on a single institution and control for fine-grained research units, our approach allows us to hold constant the advisor

mentorship, the broader organizational context, and the specific research environment of the student.

Our findings point to a trade-off in doctoral training under interdisciplinary advisors. Students whose advisors engage in interdisciplinary research produce fewer publications during their PhD, and we find no robust effects on research novelty once advisor fixed effects are accounted for. At the same time, these students benefit in specific ways: they receive more citations when collaborating with their advisors and are exposed to coauthors with more distant expertise. However, we find no consistent evidence that their own research becomes more interdisciplinary according to standard measures.

Our paper makes three contributions. First, we extend research on the conditions that shape PhD student research by examining how a university policy establishing interdisciplinary centers affects doctoral training (Corsini et al., 2022; Graddy-Reed, Lanahan, and D'Agostino, 2021). Second, we bridge prior work on interventions aimed at fostering collaborations among established researchers (Boudreau et al., 2017; Carayol, Henry, and Lanoe, 2023) with research on the individual consequences of interdisciplinary engagement (Biancani, Dahlander, Mcfarland, and Smith, 2018; Leahey et al., 2017), by shifting attention to the implications such policies may have for PhD students. Third, we contribute to science policy debates on whether interdisciplinary initiatives fulfill their promise of fostering interdisciplinary research, a claim that remains contested and warrants further investigation. (e.g., Bishop, Huck, Ownley, Richards, and Skolits, 2014).

# 2 Institutional Context

We merge university records of PhD defenses with administrative funding and personnel files to create a researcher–year panel of 1,036 advisors and 3,658 PhD graduates (2007–2023). Using each researcher's full name and organization affiliation details, we retrieve bibliometric data for these reserachers and their coauthors from the Dimensions database of Digital Science (Herzog, Hook, and Konkiel, 2020; Hook, Porter, Draux, and Herzog, 2021), and construct their publication histories from 2002 through 2024. We also collect metadata for each publication, including citation counts, article-level disciplinary classifications, as well as detailed information on every listed author, including their affiliation as reported in the publication and the curated

organization identifiers.[2]

To identify advisors' membership in the research centers, we combine information on the center websites with affiliation information extracted from publication records. We focus on substantive interdisciplinary engagement, defined as the inclusion of the center in a publication's affiliation, which is encouraged by both the centers and the university. Since the university's renewal policy emphasizes acknowledging center-enabled collaborations, but centers do not replace faculty departmental affiliations, and much faculty research may not be interdisciplinary, we do not expect researchers to mention the center in every publication. Our approach is therefore conservative and provides a lower bound on center engagement. Concretely, we search each publication's affiliation field using string matching and regular expressions to detect center names in English and Dutch, including acronyms and full names.[3] As of 2024, the LBI and LKI together listed 352 senior academic researchers on their websites. Of these, we identify 164 who both served as advisors and acknowledged the center in their publications during the study period, equivalent to 15.5% of all advisors in our dataset. These advisors supervised 544 PhD students (equivalent to 14.8% of graduates) and, on average, referenced the center in about 30% of their publications in a given year.

## Advisors

We begin our descriptive analysis by comparing trends in research output for two groups of advisors: those who at any point joined an interdisciplinary center ("ID advisors") and those who did not ("non-ID advisors"). Figure 6.1 shows binned scatterplots with academic unit fixed effects to isolate within-acdemic unit variation in advisors' outcomes and overlays quadratic fits to trace trends by advisor type (Starr, Goldfarb, Smith, and Mgmt, 2020). Consistent with prior work (Su, 2014), the plots indicate systematic differences across the two groups, especially in research productivity and collaboration.

In Figure 6.1a, ID advisors exceed non-ID advisors in coauthor-weighted publications, although the gap narrows over time: ID productivity appears to decelerate, while non-ID advisors

[2]The Global Research Identifier Database (GRID) ensures that we identify researchers who are affiliated with the KU Leuven. In complementary queries, we also capture all their publication records, irrespective of their KU Leuven affiliation (i.e., publications before or after being employed by the university). Furthermore, we exclude publications with 20 or more authors (equivalent to approx. the top 3% of retrieved records by author count) because the affiliation data are often imprecise, abbreviated, or merged across multiple individuals in these cases.

[3]For example, we test *Leuven Cancer Institute*, *Leuven Kanker Instituut*, and *Kankerinstituut*, as well as *Leuven Brain Institute*, *Leuven Brein Instituut*, and *Breininstituut*. Because we always pair these strings with KU Leuven's organizational identifier (GRID-ID), the risk of false positives is close to zero, which we confirm by manual checks.

follow a steady upward trajectory. Figure 6.1b reports average annual citations per publication; ID advisors are consistently more cited, but the difference is relatively modest and stable.

Figure 6.1c plots collaborations with other center members, which is suggestive of engagement with interdisciplinary research. We observe that up to about 2018, ID and non-ID advisors collaborate at similar rates; in recent years, ID advisors publish more intensively with center-affiliated researchers. Finally, Figure 6.1d shows the number of new coauthors: ID advisors display a clear upward trend that outpaces the increase for non-ID advisors. These trajectories are descriptive and intended to contextualize our analysis of PhD students' research.

### PhD Students

Table 6.1 reports the proportion of students whose advisor at some point engaged in interdisciplinary research across faculties. Medicine shows the highest proportion, with about one-third of students advised by an advisor that engages in interdisciplinary research, followed by Movement and Rehabilitation Sciences (25%) and Psychology and Education (18%). By contrast, Engineering, Pharmaceutical Sciences, and the Natural Sciences have much lower shares, below 5% each. Overall, about 15% of students in the sample are linked to an ID advisor.

In Table 6.2, we report summary statistics of PhD students and their advisors (both ID and non-ID Advisors) at the PhD entry year. Regarding student characteristics, we report the time to graduation (Phd Duration), the presence of a co-advisor,and a binary variable if the student reported any publications prior to starting the PhD. PhD students whose advisors ever joined an interdisciplinary center earned their PhD in a slightly longer time (4.24 vs. 4.09 years), they are more likely to have co-advisors (75% vs. 66% with co-promoters), and they are more likely report publications before PhD entry (22% vs. 17%). We also report key characteristics of advisors at the time of PhD entry, including the number of PhD students they supervise, whether they hold the rank of full professor, their research productivity, the size of their coauthor network, and the breadth of their research portfolio (further details in the following section). Compared to non-ID advisors, ID advisors supervise fewer PhD students on average (1.80 vs. 2.14) and are more likely to be full professors (26% vs. 19%). Finally, consistent with the trends described above, ID advisors are on average more productive, collaborate with more coauthors, and conduct more diversified research.

# 3 Empirical Strategy

We aim to determine whether having an interdisciplinary advisor is associated with PhD students' research productivity and novelty, and the average direction of that association (if any). Our unit of analysis is defined at the PhD student-year level, and we examine their outcomes from their year of entry to two years after graduation.[4] We combine panel fixed effects models with an entropy balancing procedure akin to matching (Hainmueller, 2011; Hainmueller and Xu, 2013), which we further describe below. Concretely, we estimate the following relationships:

$$Y_{ijt} = \beta d_{ij} + \theta A_{ij} + \gamma S_{it} + \mu_{(i)c} + \mu_{(i)k} + \lambda_t + e_{ijt} \tag{3.1}$$

$$Y_{ijt} = \beta d_{ij} + \alpha_j + \gamma S_{it} + \mu_{(i)c} + \mu_{(i)k} + \lambda_t + e_{ijt} \tag{3.2}$$

Our key variable of interest is $d_{ij}$, a binary variable equal to one if advisor $j$ demonstrates engagement in interdisciplinary research within a five-year window around the start of student $i$'s PhD (from five years before to five years after PhD entry). By using a five-year window before and after PhD entry, we factor in that advisors' interdisciplinary engagement can influence students both through research conducted before the student starts her PhD and also through research in progress. Furthermore, the definition ties interdisciplinary exposure directly to the student's training period, aligning the measure with the developmental stage when mentorship and research environment should matter most.[5]

The crucial difference between the two equations is that, while in equation (1) we include advisor's $j$ attributes measured at the time student $i$ starts the PhD ($A_{ij}$), in equation (2) we replace it by advisor fixed effects ($\alpha_j$), thus absorbing time-invariant advisor characteristics. In other words, $\beta$ in equation (2) captures the average difference in research outcomes ($Y$) between students of the same advisor, holding student attributes and other research environment characteristics constant, thereby allowing us to interpret the remaining variation more directly as reflecting differences in mentoring.

[4]These additional years after graduation account for the time lag between research execution and publication (Bjork and Solomon, 2013). For example, a recent systematic review suggests that the average editorial handling times vary from a few months to two years across biomedical journals (Andersen, Fonnes, and Rosenberg, 2021). Our results are robust to using just one year of lag (results not reported).

[5]In supplementary analyses, we also construct an intensity-based measure of advisors' interdisciplinary engagement, captured by the number of an advisor's publications that mention the center, and we experiment with alternative window lengths to test the sensitivity of our results. These analyses confirm the robustness of our findings when using the intensity-based measure, but show that extending the window beyond five years dilutes statistical significance. These results are reported in the Appendix A.1.2.

Specifically, we control for students' attributes ($S_{it}$), including characteristics at PhD entry (pre-doctoral publications and the presence of a co-advisor), and the scientific field(s) in which the student is active each year. We also include several sets of fixed effects: PhD entry cohort ($\mu_{(i)c}$) since students who start together may face similar training conditions; academic unit fixed effects ($\mu_{(i)k}$) to absorb persistent features of the research environment such as infrastructure, culture, and organization; and year fixed effects ($\lambda_t$). Together, these variables capture the socialization process of PhD students (Gardner, 2010), encompassing both formal and informal interactions with colleagues and faculty (e.g., through coursework or social activities) as well as the broader environment in which training occurs. Academic units and departments typically follow a disciplinary logic, transmitting shared scientific norms and practices to graduate students (Jacobs, 2013).

In addition, we control for several advisor attributes ($A_{ij}$) that may influence student outcomes and confound the effects of interdisciplinary exposure, including a proxy of their research ability, career stage, and collaboration network. Because our descriptive analyses reveal systematic differences between PhD students whose advisors engage in interdisciplinary work and those who do not, in all specifications, we use weights for the control group observations using entropy balancing. In doing so, we correct for the first three moments (mean, variance, skewness) so that the distribution of covariates (i.e., $S_{it}$ and $A_{ij}$) is as similar as possible across students with and without an ID advisor.

Entropy balancing offers two key advantages over conventional matching methods and has therefore gained popularity in observational studies (for example, Kaellberg and Waernbaum, 2023; Trunschke, Peters, Czarnitzki, and Rammer, 2024). First, unlike other techniques that require a common support and typically lead to excluding substantial portions of the data, entropy balancing techniques use all the observations in the sample to achieve comparable groups. Second, entropy balancing does not impose parametric assumptions about the determinants of treatment assignment; in our context, the (observable) student attributes that are associated with potential selection into ID advisors. We report all summary statistics at the student,year-level in Table 6.3, and the balance achieved across groups in Table 6.4 and Table 6.5.[6]

[6]Pairwise correlations are reported in the Appendix C, Table A.8.

### Outcome Variables

***Novelty.*** Our focus on novelty connects to theories of knowledge recombination, which view creativity as arising from bridging otherwise disconnected ideas and accessing new perspectives and information (Fleming et al., 2007; Simonton, 1999). Interdisciplinary research may facilitate such recombination by fostering atypical combinations of knowledge domains, thereby increasing the likelihood of scientific discoveries (Fontana, Iori, Montobbio, and Sinatra, 2020; Uzzi, Mukherjee, Stringer, and Jones, 2013).

We measure scientific novelty at the time of publication using the text-based measures developed by Arts, Melluso, and Veugelers (2025). These measures identify terminology first introduced in a focal publication and observed at least twice in the scientific corpus (as recorded in the OpenAlex repository), capturing the scientific contribution of publications irrespective of citation dynamics.[7]

We aggregate these measures to the researcher–year level and construct four variables: (i) a binary indicator equal to one if any publication in that year introduces at least one new word, (ii) a binary indicator for at least one new phrase, (iii) the average number of new words across all publications in that year, and (iv) the average number of new phrases across all publications in that year.

***Productivity.*** Our focus on productivity is motivated by prior research highlighting the trade-offs of interdisciplinary research. While interdisciplinary work can yield novel insights and increase visibility, it often comes at the cost of reduced research output (Leahey, 2018; Leahey et al., 2017). More broadly, the literature on the organization of scientific work emphasizes that collaboration choices frequently involve trade-offs between individual productivity and the potential for disproportionate credit or recognition (Bikard, Murray, and Gans, 2015). In particular, participation in complex, interdisciplinary collaborations can depress short-term productivity due to heightened coordination and communication costs. Nonetheless, scientists may still pursue such collaborations either because they anticipate a "credit premium" if the project succeeds or because they are motivated by the opportunity to advance ambitious scientific goals (Bikard et al., 2015; Vakili et al., 2021).

We capture student productivity using five complementary measures: (i) total publication

[7]We link our publication corpus to the open repository made available by Arts et al. (2025) using publication DOIs. The repository is available here, and it covers publications up until 2023.

count; (ii) coauthor-weighted publication count, which divides each paper by the number of coauthors to account for team size; (iii) publications coauthored with the advisor, reflecting the intensity of mentoring during PhD training; (iv) average yearly citations per publication across the student's research output; and (v) average yearly citations per publication for the subset coauthored with the advisor. For (iv) and (v), we calculate, for each publication in year $t$, the cumulative citations accrued to date, divide by the number of years since $t$, and then average across the relevant set of publications.

### Control Variables

We measure the following attributes of PhD students:

***Pre-doctoral publications.*** Binary variable that equals one if the student has any publications prior to the PhD start. The presence of students' research skills and/or experience before their formal training may be an imperfect but useful signal of ability (Corsini et al., 2022; Roche, 2022).

***Co-Advisors.*** Binary variable that equals one if the student has a co-advisor involved in his PhD. The co-promotors may share responsibilities in training, expand the sources of ideas and expertise that the student may draw on, and can also provide additional, access to other collaborators.

***Scientific Field.*** We use a set of binary variables to capture the disciplines in which the researcher publishes in each year. We rely on the publication-level disciplinary classification obtained from Dimensions, which follows the Australian and New Zealand Standard Research Classification.[8] For parsimony, we use a compact version of the division-level fields of research, including Biological Sciences; Biomedical and Clinical Sciences; Chemical Sciences; Health Sciences; Engineering; Information and Computing Sciences; Psychology; and include a residual category for Other fields.

In addition, we measure the following characteristics of advisors:

***Nr Advisees.*** We measure the number of students who begin their PhD under the same advisor in a given year, as a larger number of students may dilute the time and attention the advisor can devote to each student (e.g., Paglis et al., 2006).

***Advisor Productivity*** and ***Advisor Coauthors***. Because more productive and better-

[8]More details on the ANZRC system can be found here.

connected advisors can provide richer training opportunities and resources (e.g., Corsini et al., 2022), We measure the citation-weighted number of publications by the student's advisor within five years prior to PhD start; and the number of unique coauthors within five years prior to PhD start.

***Full Professor.*** Binary variable that equals one if the advisor is a full professor at the university by the PhD start year, and zero otherwise. This allows us to capture career-specific factors that may affect the engagement in interdisciplinary work and influence research outcomes. For instance, unlike junior colleagues, full professors face little career risk even if a research project fails (Franzoni and Rossi-Lamastra, 2017).

***Advisor Research Breadth*** We measure the knowledge breadth based on the distribution of the publication portfolio of the advisor across scientific fields (Nagle and Teodoridis, 2020; Teodoridis, Bikard, and Vakili, 2019). Put differently, we capture the extent to which an advisor's expertise is concentrated in a few domains or spread across multiple areas. Formally, using the 171 group-level field categories of the ANZRC system ($f$), we define the breadth of a researcher $i$ in year $t$ in the following way:

$$ResearchBreadth_{it} = 1 - \sqrt{\sum_{f=1}^{171} \left( \frac{PublicationCount_{itf}}{PublicationCount_{it}} \right)^2} \tag{3.3}$$

The index lies within the range $[0, 1)$, as it never reaches one and is equal to 0 when all publications of a given researcher in a year belong to the same field of research. Given that a single publication may be categorized in up to four group-level fields of research, we take a fractional approach so that a single publication that mentions two categories scores 0.5 in each category. The interpretation of the research breadth is intuitive: the greater the breadth of knowledge (i.e., more diversified research expertise), the closer to 1 the value of the index.

# 4 Results

## 4.1 Novelty

We present results on PhD students' research novelty in Table 6.6. For each of the outcome variables, we estimate equations (1) and (2) presented in the section **??**, alternating between the specification that includes advisor attributes at PhD entry and the specification with advi-

sor fixed effects. All estimated models include year, cohort, scientific field, and academic unit fixed effects. While equation (1) captures cross-sectional correlations between advisor characteristics and student outcomes conditional on a comprehensive set of student-, advisor-, and research environment- controls, equation (2) improves our estimates by capturing within-advisor effects of engagement with interdisciplinary research. We implement the procedure developed by Guimaraes and Portugal (2010), which absorbs high-dimensional fixed effects to address redundancy or multicollinearity, and iteratively drops singleton observations.[9] Moreover, in all models we use the entropy balancing weights and we cluster standard errors at the advisor level to account for intra-cluster (within-advisor) correlation. Unless stated otherwise, we log-transform our dependent variables for ease of interpretation and comparability of estimated coefficients across models.

A central contrast in our novelty results lies between the introduction of *new words* and *new phrases*. Focusing on the primary coefficient of interest, advisors' engagement with an interdisciplinary center ($d_{ij}$), we find no robust evidence of an association with the introduction of *new words*. Concretely, in Table 6.6, Columns (1)–(2) and (5)–(6) show that $d_{ij}$ is not significantly related to either the likelihood of introducing a new word or the average number of *new words*. By contrast, Columns (3)–(4) indicate a positive association between $d_{ij}$ and the likelihood of introducing a new phrase, although this effect becomes only weakly significant once advisor fixed effects are included. Moreover, in Columns (7)–(8), we find a positive and statistically significant relationship between $d_{ij}$ and the average number of *new phrases*, with the association becoming even stronger when accounting for advisor fixed effects. This pattern is consistent with the baseline frequencies reported by Arts et al. (2025), who show that only 7% of publications in their corpus introduce a new word, compared to 25% introducing a new phrase. In our sample, at the student-year level, the introduction of *new phrases* is also more than three times as common as the introduction of *new words*. Taken together, these results suggest that while the introduction of *new words* represents a rarer and arguably more fundamental form of novelty, and we find no effect, the introduction of *new phrases* is more prevalent and shows a positive relationship with advisors' interdisciplinary engagement.

[9]This explains the discrepancy in the number of observations reported across model estimates, even when the outcome variable is the same.

## 4.2 Productivity

Turning to research productivity, we follow the same structure discussed above and present our results in Table 6.7. Table 6.7, Columns (1)–(4), shows a positive correlation between $d_{ij}$ and research productivity (as measured by publications count, and less so when coauthor-weighted) in the baseline model. However, once we include advisor fixed effects, the coefficient becomes negative and statistically significant. This suggests that, while students of ID advisors appear slightly more productive in the cross-section, within-advisor estimates indicate that students are significantly less productive when their advisors engage in interdisciplinary research. In Columns (5)-(6), we find no statistically significant relationship for the number of publications coauthored with the advisor, suggesting the effect is not driven by mentorship intensity as proxied by advisor-student coauthorships. Turning to citations, Columns (7)–(8) show no statistically significant relationship for students' average yearly citations when considering their full output. However, Column (10) reveals a positive and statistically significant within-advisor association between interdisciplinary engagement and students' average citations when we restrict to advisor–student publications. This citation premium suggests that, although interdisciplinary work may come at the cost of lower research productivity, the projects on which students collaborate with their advisors can reach broader audiences and attract greater visibility, consistent with the idea of a trade-off between productivity and prominence Leahey et al. (2017).[10]

Taken together, these findings suggest a potential trade-off in doctoral training under interdisciplinary advisors. On the one hand, we find some evidence that students of interdisciplinary advisors are more likely to introduce *new phrases* and that their joint work with advisors tends to receive a citation premium, pointing to gains in more incremental forms of scientific novelty and visibility. On the other hand, we observe a productivity penalty, with students publishing less overall when their advisors are engaged in interdisciplinary work.

## 4.3 Exploring Mechanisms

In what follows, we examine two potential mechanisms that may underlie this trade-off: (1) whether interdisciplinary advisors enable distinct research collaboration patterns, and (2) whether students' research becomes more interdisciplinary.

[10]In the Appendix, we report estimates from Poisson fixed-effects regressions using raw counts as the dependent variable. Our results on publication productivity remain robust.

### 4.3.1 Research Collaboration

As argued above, one way an advisor's engagement with an interdisciplinary research center can affect PhD students is by to facilitate the formation of new collaborations, and possibly collaborations with researchers whose expertise is more distant (Boudreau et al., 2017). To understand if PhD students whose advisors engage in interdisciplinary work are associated with distinct patterns of research collaborations, we revisit our main specifications using a different set of outcome variables. Namely, we test the relationship between $d_{ij}$ and four research collaboration variables: (i) a binary indicator that equals one if the student collaborates with another member of an interdisciplinary center in a given year, capturing the extent to which students connect with members of center; (ii) the number of new coauthors by year, reflecting students' ability to expand their collaboration networks; (iii) the average distance in collaborators' expertise, which captures the extent to which students engage with cognitively distant researchers, consistent with the knowledge recombination process; and (iv) the standard deviation of collaborator distance. The value of (iii) and (iv) lies in unpacking between students who, on average, work with more distant collaborators, from those who participate in more heterogeneous teams that combine both nearby and far expertise.

To measure distance in collaborators' expertise, we compute, for each pair of researchers who collaborate in a given publication year, the Jaccard distance between their sets of active research fields over the five preceding years.[11] This measure captures differences in their research knowledge bases. The distance ranges from 0, indicating identical prior field expertise, to 1, indicating no overlap. We then aggregate these distances to the student by year level by taking the mean and the standard deviation across each student's collaborations.

We present results on PhD students' research collaboration patterns in Table 6.8, following the same analytical approach as in our main results. Columns (1)–(2) show that students with ID advisors are more likely to collaborate with ID center members, though this relationship disappears once advisor fixed effects are included. Turning to Columns (3)–(4), we find that students of ID advisors appear to form more new coauthor relationships in cross-sectional analysis, but the within-advisor estimates reveal a negative and statistically significant effect. One possible interpretation is that once advisors join an interdisciplinary center, they can become "spread too thinly" across collaborations, leaving them less able to facilitate new collaborative ties for their advisees than before. Regarding collaborator expertise, Column (6) demonstrates

[11] This leads to the exclusion of collaborators with no research activity in that window.

a positive and significant association between ID advisors and the average expertise distance of students' collaborators in the fixed-effects specification, indicating that advisees of ID advisors engage with more diverse expertise. By contrast, we do not find evidence that these students join more heterogeneous teams, as the standard deviation of collaborator distance is unaffected. Taken together, these within-advisor results suggest that while interdisciplinary advisors may open doors to more diverse expertise, they may also constrain the formation of new coauthor relationships, possibly reflecting a reallocation of research efforts when advisors take on interdisciplinary commitments.

### 4.3.2 Interdisciplinarity

We now turn to explore whether advisors' engagement with interdisciplinary centers can mitigate collaboration costs. Prior work on interdisciplinarity disentangles three components (Stirling, 2007; Wang, Thijs, and Glänzel, 2015): *variety*, *disparity*, and *balance*. *Variety* is defined as the number of distinct disciplines represented in a publication; *Balance* is how evenly different disciplines are referenced in a publication. *Disparity* captures how far apart those disciplines are from each other based on cognitive distance (e.g., how frequently disciplines cite each other in the past).[12] To understand the relationship between advisors' engagement and students research interdisciplinarity, we follow Leahey et al. (2017) and aggregate the publication-level interdisciplinary measures to the researcher,year-level by taking the average across each researcher set of publications in a given year.

Because the centers in our study are organized around specific research themes, we expect that advisors engaged with the centers promote work anchored in those topics. Rather than pushing students' researchers into more fields, we expect them to conduct research through a wider range of approaches and/or methods. Accordingly, we anticipate that students' research may display greater *disparity*, though not necessarily greater *variety*. By the same logic, we also anticipate higher *balance*, as centers broaden the knowledge base by fostering cross-fertilization and the integration of insights from different traditions focused on similar topics.

We present results on PhD students' research interdisciplinarity in Table 6.9. In Columns (1)–(2), we find a negative association between students' research *variety* and advisors' engagement with interdisciplinary work, which becomes statistically significant only in the within-advisor models. For *disparity* and *balance*, we do not uncover statistically significant relation-

[12]We provide technical details on the construction of these variables in the Appendix A.2

ships. Put differently, we find little evidence that students of ID advisors are better positioned to produce more interdisciplinary research; if anything, their work appears somewhat more specialized. Taken together, these results suggest that while students may gain access to new collaborators through their advisors' involvement in the center, this does not necessarily translate into a broader interdisciplinarity of their own research.

# 5 Discussion

We study whether and how advisors who engage in interdisciplinary research influence the research outcomes of their PhD students, a question that remains underexplored. This question is important because prior literature highlights the central role of advisors and the broader research environment in shaping successful academic training, while interdisciplinary centers are specifically designed to foster new collaborations among faculty across academic units.

Specifically, we study an initiative to establish research centers within a large European university, which allows us to hold constant the research environment attributes while focusing on the role of mentorship in shaping how the opportunities and challenges of interdisciplinary work translate to students. We exploit detailed longitudinal data on PhD students and their advisors, linked to administrative and publication records, and use variation in advisors' engagement with interdisciplinary centers to identify how such engagement affects students' productivity and novelty.

In terms of contributions, we add to the literature on the conditions shaping the productivity of PhD students, who represent the future scientific workforce and face distinctive challenges in establishing academic careers, especially in the biomedical domain (Corsini et al., 2022; Daniels, 2015). We extend this work by studying a university policy aimed at fostering interdisciplinary research —namely, the establishment of interdisciplinary centers— and its implications for doctoral training. Consistent with prior work on interdisciplinary research (e.g., Leahey et al., 2017), our findings underscore a trade-off: students of interdisciplinary advisors may gain in terms of novelty or visibility, particularly through collaborations that span more distant areas of expertise, but they also incur a productivity penalty, publishing fewer papers during their PhD. Importantly, our evidence weighs more heavily on the latter, documenting a clearer and more consistent productivity penalty than corresponding benefits along other margins.

We also bridge two related strands of research. The first examines how policies or micro-level

interventions (Boudreau et al., 2017; Carayol et al., 2023) shape the formation of collaborations among established researchers. The second investigates the role of interdisciplinary centers (Biancani et al., 2018), again primarily focusing on established researchers. Our study sits at the intersection of these literatures by documenting how advisors' engagement in interdisciplinary centers can influence their PhD students' research. Finally, we contribute to the broader science policy debate, which has called for more evidence on whether interdisciplinary initiatives deliver on their promise of fostering interdisciplinarity (Bishop et al., 2014; Bolger, 2021). On this point, our results suggest that while interdisciplinary centers may expand collaboration opportunities, the benefits for doctoral students come with clear trade-offs, and do not seem to generate more interdisciplinary research, as measured by the indicators widely used in prior literature (e.g., Wang et al., 2015).

Our study is not without limitations. The specificity of our institutional setting may restrict the generalizability of the findings to other similarly sized, research-intensive European universities. Future work could examine how particular design features of interdisciplinary centers —such as their internal organization or the roles that researchers assume within them— shape the trade-offs associated with interdisciplinary work. Finally, further research might extend the analysis to post-graduation outcomes, investigating whether students of interdisciplinary advisors experience different career trajectories, levels of satisfaction with their training, or long-run scientific impact.

# References


Andersen, M. Z., Fonnes, S., and Rosenberg, J. (2021). Time from submission to publication varied widely for biomedical journals: a systematic review. *Current Medical Research and Opinion*, *37*, 985-993. doi: 10.1080/03007995.2021.1905622

Arts, S., Melluso, N., and Veugelers, R. (2025, 1). Beyond citations: Measuring novel scientific ideas and their impact in publication text. *Review of Economics and Statistics*, 1-33. Retrieved from `https://dx.doi.org/10.1162/rest_a_01561` doi: 10.1162/REST_A_01561/127741

Bercovitz, J., and Feldman, M. (2011, 2). The mechanisms of collaboration in inventive teams: Composition, social networks, and geography. *Research Policy*, *40*, 81-93. doi: 10.1016/J.RESPOL.2010.09.008

Biancani, S., Dahlander, L., Mcfarland, D. A., and Smith, S. (2018). Superstars in the making? the broad effects of interdisciplinary centers. *Research Policy*, *47*, 543-557. Retrieved from `https://doi.org/10.1016/j.respol.2018.01.014` doi: 10.1016/j.respol.2018.01.014

Biancani, S., McFarland, D. A., and Dahlander, L. (2014). The semiformal organization. *Organization Science*, *25*, 1306-1324. doi: 10.1287/orsc.2013.0882

Bikard, M., Murray, F., and Gans, J. S. (2015, 7). Exploring trade-offs in the organization of scientific work: Collaboration and scientific reward. *Management Science*, *61*, 1473-1495. doi: 10.1287/mnsc.2014.2052

Bishop, P. R., Huck, S. W., Ownley, B. H., Richards, J. K., and Skolits, G. J. (2014). Impacts of an interdisciplinary research center on participant publication and collaboration patterns: A case study of the national institute for mathematical and biological synthesis. *Research Evaluation*, *23*, 327-340. doi: 10.1093/reseval/rvu019

Bjork, B. C., and Solomon, D. (2013, 10). The publishing delay in scholarly peer-reviewed journals. *Journal of Informetrics*, *7*, 914-923. Retrieved from `https://www.sciencedirect.com/science/article/pii/S1751157713000734` doi: 10.1016/J.JOI.2013.09.001

Boardman, C., and Corley, E. (2008). University research centers and the composition

of research collaborations. *Research Policy*, *37*, 900-913. doi: 10.1016/j.respol.2008.01.012

Bolger, P. (2021, 12). Delivering on the promise: how are sustainability research institutes enabling interdisciplinary research? *International Journal of Sustainability in Higher Education*, *22*, 167-189. doi: 10.1108/IJSHE-10-2020-0415

Boudreau, K. J., Brady, T., Ganguli, I., Gaule, P., Guinan, E., Hollenberg, A., and Lakhani, K. R. (2017). A field experiment on search costs and the formation of scientific collaborations. *The Review of Economics and Statistics*, *XCIX*, 565-576. Retrieved from `http://direct.mit.edu/rest/article-pdf/99/4/565/1918493/rest_a_00676.pdf` doi: 10.1162/REST_a_00676

Brostrom, A. (2019, 9). Academic breeding grounds: Home department conditions and early career performance of academic researchers. *Research Policy*, *48*, 1647-1665. Retrieved from `https://www.sciencedirect.com/science/article/pii/S0048733319300721?via%3Dihub` doi: 10.1016/J.RESPOL.2019.03.009

Carayol, N., Henry, E., and Lanoe, M. (2023). Stimulating collaborations: Evidence from a research cluster policy. *Review of Economics and Statistics*. doi: 10.1162/rest_a_01376/2163780/

Corsini, A., Pezzoni, M., and Visentin, F. (2022, 12). What makes a productive ph.d. student? *Research Policy*, *51*. doi: 10.1016/j.respol.2022.104561

Cummings, J. N., and Kiesler, S. (2005). *Collaborative research across disciplinary and organizational boundaries* (Vol. 35). doi: 10.1177/0306312705055535

Daniels, R. J. (2015, 1). A generation at risk: Young investigators and the future of the biomedical workforce. *Proceedings of the National Academy of Sciences of the United States of America*, *112*, 313-318. doi: 10.1073/PNAS.1418761112/SUPPL_FILE/PNAS.1418761112.SD02.XLSX

D'Este, P., and Robinson-Garcia, N. (2023, 3). Interdisciplinary research and the societal visibility of science: The advantages of spanning multiple and distant scientific fields. *Research Policy*, *52*, 104609. Retrieved from `https://www-sciencedirect-com.kuleuven.e-bronnen.be/science/article/pii/S0048733322001329` doi: 10.1016/J.RESPOL.2022.104609

Fleming, L., Mingo, S., and Chen, D. (2007). Collaborative brokerage, generative creativity, and creative success. *Administrative Science Quarterly*, *52*, 443-475. doi: 10.2189/ASQU.52.3.443

Fontana, M., Iori, M., Montobbio, F., and Sinatra, R. (2020, 9). New and atypical combinations: An assessment of novelty and interdisciplinarity. *Research Policy*, *49*. doi: 10.1016/J.RESPOL.2020.104063

Fontana, M., Iori, M., Sciabolazza, V. L., and Souza, D. (2022, 9). The interdisciplinarity dilemma: Public versus private interests. *Research Policy*, *51*, 104553. Retrieved from `https://www.sciencedirect.com/science/article/pii/S0048733322000774` doi: 10.1016/J.RESPOL.2022.104553

Franzoni, C., and Rossi-Lamastra, C. (2017, 10). Academic tenure, risk-taking and the diversification of scientific research. *Industry and Innovation*, *24*, 691-712. Retrieved from `https://www.tandfonline.com/action/journalInformation?journalCode=ciai20` doi: 10.1080/13662716.2016.1264067

Gardner, S. K. (2010, 1). Contrasting the socialization experiences of doctoral students in high- and low-completing departments: A qualitative analysis of disciplinary contexts at one institution. *The Journal of Higher Education*, *81*, 61-81. Retrieved from `/doi/pdf/10.1080/00221546.2010.11778970?download=true` doi: 10.1080/00221546.2010.11778970

Graddy-Reed, A., Lanahan, L., and D'Agostino, J. (2021, 6). Training across the academy: The impact of r&d funding on graduate students. *Research Policy*, *50*, 104224. doi: 10.1016/J.RESPOL.2021.104224

Guimaraes, P., and Portugal, P. (2010). A simple feasible procedure to fit models with high-dimensional fixed effects. *The Stata Journal*, *10*, 628-649.

Haeussler, C., and Sauermann, H. (2020, 7). Division of labor in collaborative knowledge production: The role of team size and interdisciplinarity. *Research Policy*, *49*. doi: 10.1016/j.respol.2020.103987

Hainmueller, J. (2011). Entropy balancing for causal effects: A multivariate reweighting method to produce balanced samples in observational studies. *Political Analysis*,

*16*, 25-46. doi: 10.1093/pan/mpr025

Hainmueller, J., and Xu, Y. (2013, 9). ebalance: A stata package for entropy balancing. *Journal of Statistical Software*, *54*, 1-18. Retrieved from `https://www.jstatsoft.org/index.php/jss/article/view/v054i07` doi: 10.18637/JSS.V054.I07

Herzog, C., Hook, D., and Konkiel, S. (2020, 2). Dimensions: Bringing down barriers between scientometricians and data. *Quantitative Science Studies*, *1*, 387-395. Retrieved from `https://direct.mit.edu/qss/article/1/1/387/15568/Dimensions-Bringing-down-barriers-between` doi: 10.1162/QSS_A_00020

Hook, D. W., Porter, S. J., Draux, H., and Herzog, C. T. (2021). Real-time bibliometrics: Dimensions as a resource for analyzing aspects of covid-19. *Frontiers in Research Metrics and Analytics*. Retrieved from `www.frontiersin.org` doi: 10.3389/frma.2020.595299

Hottenrott, H., and Lawson, C. (2015). Flying the nest: how the home department shapes researchers' career paths. *Studies in Higher Education*, *42*, 1091-1109. Retrieved from `https://www.tandfonline.com/action/journalInformation?journalCode=cshe20` doi: 10.1080/03075079.2015.1076782

Jacobs, J. A. (2013). *In defense of disciplines : interdisciplinarity and specialization in the research university* (Vol. 1). The University of Chicago Press.

Jacobs, J. A., and Frickel, S. (2009). Interdisciplinarity: A critical assessment. *Annual Review of Sociology*, *35*, 43-65. doi: 10.1146/annurev-soc-070308-l

Kaellberg, D., and Waernbaum, I. (2023, 11). Large sample properties of entropy balancing estimators of average causal effects. *Econometrics and Statistics*. doi: 10.1016/J.ECOSTA.2023.11.004

Leahey, E. (2018, 10). The perks and perils of interdisciplinary research. *European Review*, *26*, S55-S67. doi: 10.1017/S1062798718000261

Leahey, E., and Barringer, S. N. (2020, 3). Universities' commitment to interdisciplinary research: To what end? *Research Policy*, *49*. doi: 10.1016/j.respol.2019.103910

Leahey, E., Beckman, C. M., and Stanko, T. L. (2017, 3). Prominent but less productive: The impact of interdisciplinarity on scientists' research. *Administrative Science*

*Quarterly*, *62*, 105-139. doi: 10.1177/0001839216665364

Lyall, C., and Meagher, L. R. (2012, 8). A masterclass in interdisciplinarity: Research into practice in training the next generation of interdisciplinary researchers. *Futures*, *44*, 608-617. Retrieved from https://www-sciencedirect-com.kuleuven.e-bronnen.be/science/article/pii/S0016328712000535 doi: 10.1016/J.FUTURES.2012.03.011

Ma, Y., Mukherjee, S., and Uzzi, B. (2020, 6). Mentorship and protégé success in stem fields. *PNAS*, *117*, 14077-14083. Retrieved from www.pnas.org/cgi/doi/10.1073/pnas.1915516117 doi: 10.1073/pnas.1915516117/-/DCSupplemental

Mansilla, V. B., le Lamont, M., Sato, K., and Lamont, M. (2016). Shared cognitive-emotional-interactional platforms: Markers and conditions for successful interdisciplinary collaborations. *Technology, & Human Values*, *41*, 571-612. doi: 10.1177/0162243915614103

Nagle, F., and Teodoridis, F. (2020, 1). Jack of all trades and master of knowledge: The role of diversification in new distant knowledge integration. *Strategic Management Journal*, *41*, 55-85. doi: 10.1002/smj.3091

Onal-Vural, M., Dahlander, L., and George, G. (2013). Collaborative benefits and coordination costs: Learning and capability development in science. *Strategic Entrepreneurship Journal*, *7*, 122-137. Retrieved from https://onlinelibrary.wiley.com/doi/10.1002/sej.1154 doi: 10.1002/sej.1154

Paglis, L. L., Green, S. G., and Bauer, T. N. (2006, 6). Does adviser mentoring add value? a longitudinal study of mentoring and doctoral student outcomes. *Research in Higher Education*, *47*. doi: 10.1007/s11162-005-9003-2

Pezzoni, M., Sterzi, V., and Lissoni, F. (2012, 5). Career progress in centralized academic systems: Social capital and institutions in france and italy. *Research Policy*, *41*, 704-719. doi: 10.1016/J.RESPOL.2011.12.009

Reagans, R., Miron-Spektor, E., and Argote, L. (2016). Knowledge utilization, coordination, and team performance. *Organization Science*, 1108-1124. Retrieved from http://pubsonline.informs.orghttp://www.informs.org doi: 10.1287/orsc.2016.1078

Rhoten, D., and Parker, A. (2004). Risks and rewards of an interdisciplinary research path. *Science*, *306*. Retrieved from https://www.science.org/doi/10.1126/science.1103628 doi: 10.1126/science.1103628

Roche, M. P. (2022, 10). Academic entrepreneurship: Entrepreneurial advisors and their advisees' outcomes. *Organization Science*. doi: 10.1287/orsc.2022.1633

Rose, M. E., and Shekhar, S. (2023, 10). Adviser connectedness and placement outcomes in the economics job market. *Labour Economics*, *84*, 102397. Retrieved from https://www.sciencedirect.com/science/article/pii/S0927537123000726 doi: 10.1016/J.LABECO.2023.102397

Rylance, R. (2015). Global funders to focus on interdisciplinarity. *Nature*, *525*. Retrieved from http://go.nature.com/uyfxlp

Shibayama, S. (2019, 4). Sustainable development of science and scientists: Academic training in life science labs. *Research Policy*, *48*, 676-692. doi: 10.1016/J.RESPOL.2018.10.030

Simonton, D. K. (1999). *Origins of genius: Darwinian perspectives on creativity.* Oxford University Press.

Starr, E., Goldfarb, B., Smith, R. H., and Mgmt, S. (2020). Binned scatterplots: A simple tool to make research easier and better. *Strategic Management Journal*, *41*, 2261-2274. Retrieved from https://sms.onlinelibrary.wiley.com/doi/10.1002/smj.3199 doi: 10.1002/smj.3199

Stirling, A. (2007). A general framework for analysing diversity in science, technology and society. *Journal of The Royal Society Interface*, *4*, 707-716. doi: 10.1098/rsif.2007.0213

Su, X. (2014). Academic scientists' affiliation with university research centers: Selection dynamics. *Research Policy*, *43*, 382-390. Retrieved from http://dx.doi.org/10.1016/j.respol.2013.11.001 doi: 10.1016/j.respol.2013.11.001

Teodoridis, F., Bikard, M. L., and Vakili, K. (2019). Creativity at the knowledge frontier: The impact of specialization in fast-and slow-paced domains*. *Administrative Science Quarterly*, *64*, 894-927. doi: 10.1177/0001839218793384

Trunschke, M., Peters, B., Czarnitzki, D., and Rammer, C. (2024, 9). Pandemic effects:

Do innovation activities of firms suffer from long covid? *Research Policy*, *53*, 105024. doi: 10.1016/J.RESPOL.2024.105024

Uzzi, B., Mukherjee, S., Stringer, M., and Jones, B. (2013, 10). Atypical combinations and scientific impact. *Science*, *342*, 468-472. doi: 10.1126/science.1240474

Uzzi, B., and Spiro, J. (2005, 9). Collaboration and creativity: The small world problem. *American Journal of Sociology*, *111*, 447-504. doi: 10.1086/432782

Vakili, K., Teodoridis, F., and Bikard, M. (2021, 10). Detrimental collaborations in creative work: Evidence from economics. *Organization Science*. doi: 10.1287/orsc.2021.1501

Wang, J., and Shibayama, S. (2022, 4). Mentorship and creativity: Effects of mentor creativity and mentoring style. *Research Policy*, *51*. doi: 10.1016/j.respol.2021.104451

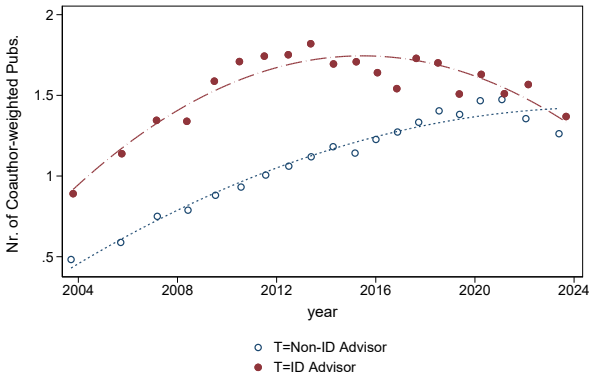
Wang, J., Thijs, B., and Glänzel, W. (2015, 5). Interdisciplinarity and impact: Distinct effects of variety, balance, and disparity. *PLoS ONE*, *10*. doi: 10.1371/journal.pone.0127298

Wuestman, M., Wanzenbock, I., and Frenken, K. (2023, 10). Local peer communities and future academic success of ph.d. candidates. *Research Policy*, *52*, 104844. Retrieved from `https://www.sciencedirect.com/science/article/pii/S0048733323001282` doi: 10.1016/J.RESPOL.2023.104844

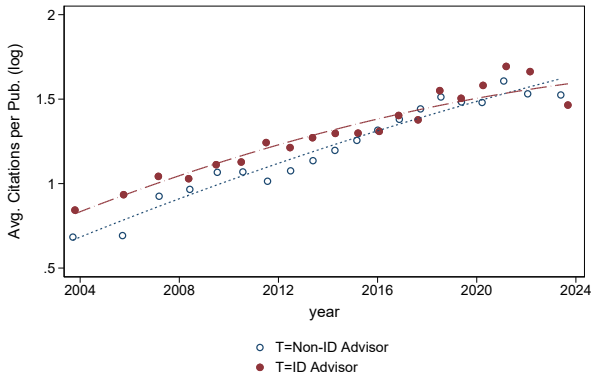
# 6 Tables and Figures

Figure 6.1: Advisor's Research Output by Year with Academic Unit FE

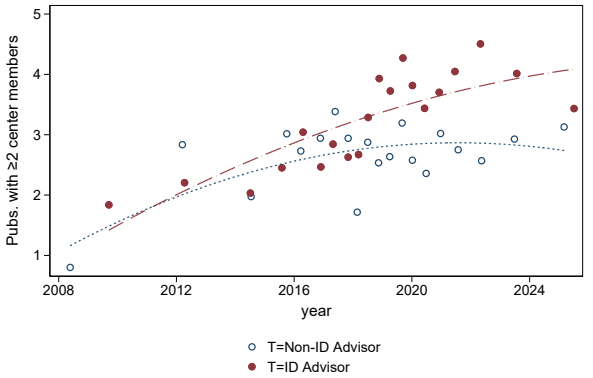
(a) Coauthor-weighted publications




(b) Avg. citations per pub.




(c) Publications with center members




(d) New Coauthors

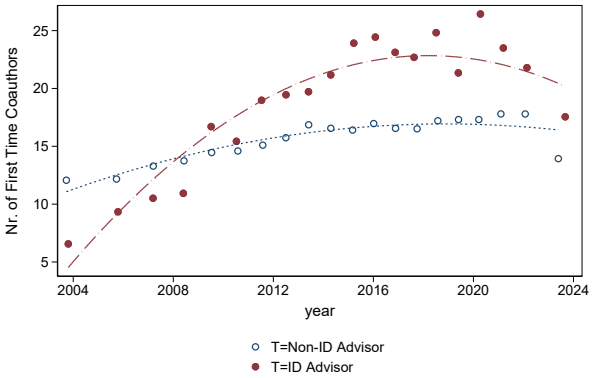


Table 6.1: Share of Students with ID Advisor by Faculty (student-level)

| | ID Advisor | | |
|---|---|---|---|
| Faculty | mean | (sd) | N |
| Engineering Science | 0.03 | (0.17) | 799 |
| Medicine | 0.34 | (0.47) | 1,149 |
| Movement and Rehabilitation Sci. | 0.25 | (0.43) | 134 |
| Pharmaceutical Sci. | 0.05 | (0.21) | 120 |
| Psychology and Education | 0.18 | (0.38) | 331 |
| Natural Sciences | 0.04 | (0.19) | 587 |
| Total | 0.15 | (0.35) | 3,658 |

Table 6.2: Descriptive statistics by Advisor Type (student-level)

| | ID Advisor $N = 542$ | | non-ID Advisor $N = 3,116$ | | |
|---|---|---|---|---|---|
| Variable | mean | (sd) | mean | (sd) | t-val |
| *Student* | | | | | |
| PhD Duration | 4.24 | (0.81) | 4.09 | (0.50) | 5.88 |
| Co-Advisor (0/1) | 0.75 | (0.43) | 0.66 | (0.47) | 4.27 |
| Pre-doc. Pubs. (0/1) | 0.22 | (0.42) | 0.17 | (0.37) | 3.03 |
| *Advisor* | | | | | |
| Nr. Advisees | 1.80 | (1.07) | 2.14 | (1.50) | -5.05 |
| Full prof. (0/1) | 0.26 | (0.44) | 0.19 | (0.39) | 4.28 |
| Advisor Productivity | 62.6 | (46.2) | 47.6 | (43.5) | 7.36 |
| Advisor Coauthors | 30.5 | (28.3) | 15.5 | (14.9) | 18.4 |
| Advisor Research Breadth | 0.40 | (0.12) | 0.32 | (0.16) | 11.0 |

Table 6.3: Summary statistics, (student,year-level)

Panel A: Independent Variables

| Variable | Mean | SD | Min | Max | N |
|---|---|---|---|---|---|
| $d_{ij}$ (0/1) | 0.10 | 0.31 | 0.00 | 1.00 | 19,750 |
| Pre-doctoral Pubs (0/1) | 0.21 | 0.40 | 0.00 | 1.00 | 19,750 |
| Co-Advisor (0/1) | 0.69 | 0.46 | 0.00 | 1.00 | 19,750 |
| Nr. Advisees (log) | 0.67 | 0.52 | 0.18 | 2.42 | 19,750 |
| Advisor Productivity (log) | 3.38 | 1.50 | -1.61 | 6.33 | 19,750 |
| Advisor Coauthors (log) | 2.33 | 1.32 | -1.61 | 5.11 | 19,750 |
| Full Prof. (0/1) | 0.22 | 0.41 | 0.00 | 1.00 | 19,750 |
| Advisor Research Breadth | 0.32 | 0.16 | 0.00 | 0.66 | 19,750 |
| PhD Cohort | 2014 | 4.26 | 2004 | 2019 | 19,750 |
| Year | 2018 | 4.20 | 2004 | 2024 | 19,750 |
| Biology Sci. | 0.19 | 0.40 | 0.00 | 1.00 | 19,750 |
| Biomedical Sci. | 0.40 | 0.49 | 0.00 | 1.00 | 19,750 |
| Chemical Sci. | 0.12 | 0.32 | 0.00 | 1.00 | 19,750 |
| Health Sci. | 0.27 | 0.45 | 0.00 | 1.00 | 19,750 |
| Engineering | 0.13 | 0.34 | 0.00 | 1.00 | 19,750 |
| Computing Sci. | 0.10 | 0.30 | 0.00 | 1.00 | 19,750 |
| Pshychology | 0.10 | 0.31 | 0.00 | 1.00 | 19,750 |
| Other fields | 0.34 | 0.47 | 0.00 | 1.00 | 19,750 |

Panel B: Outcome Variables

| Variable | Mean | SD | Min | Max | N |
|---|---|---|---|---|---|
| Publications count | 2.78 | 2.39 | 1 | 15 | 19,750 |
| Coauthor-wt. Pubs. | 0.53 | 0.50 | 0.01 | 6 | 19,750 |
| Pubs. w. Advisor | 1.57 | 1.71 | 0 | 15 | 19,750 |
| Avg. Citations per Pub. | 5.76 | 11.67 | 0 | 731 | 19,750 |
| Avg. Citations per Pub. w. Adivsor | 5.53 | 11.25 | 0 | 583 | 14,373 |
| New Words (0/1) | 0.14 | 0.35 | 0 | 1 | 11,231 |
| New Phrases (0/1) | 0.45 | 0.50 | 0 | 1 | 11,231 |
| Avg. New Words | 0.08 | 0.26 | 0 | 6 | 11,231 |
| Avg. New Phrases | 0.36 | 0.58 | 0 | 14 | 11,231 |

Table 6.4: Covariate Balance Before Weighting

| | $d_{ij} = 1$ | | | $d_{ij} = 0$ | | |
|---|---|---|---|---|---|---|
| Variable | Mean | Variance | Skewness | Mean | Variance | Skewness |
| Pre-doctoral Pubs (0/1) | 0.29 | 0.20 | 0.95 | 0.21 | 0.16 | 1.45 |
| Co-Advisor (0/1) | 0.76 | 0.18 | -1.22 | 0.67 | 0.22 | -0.74 |
| Nr. Advisees (log) | 0.58 | 0.21 | 0.67 | 0.69 | 0.28 | 0.66 |
| Advisor Productivity (log) | 3.88 | 0.33 | -1.63 | 3.33 | 2.24 | -2.25 |
| Advisor Coauthors (log) | 3.13 | 1.22 | -1.10 | 2.26 | 1.69 | -1.25 |
| Full Prof. (0/1) | 0.23 | 0.18 | 1.26 | 0.20 | 0.16 | 1.52 |
| Advisor Research Breadth | 0.39 | 0.01 | -0.56 | 0.32 | 0.03 | -0.45 |
| Year | 2019 | 13.80 | -1.23 | 2018 | 18.62 | -0.88 |
| PhD Entry Year | 2016 | 11.70 | -1.56 | 2015 | 17.12 | -1.00 |
| Biology Sci. | 0.24 | 0.18 | 1.24 | 0.18 | 0.15 | 1.65 |
| Biomedical Sci. | 0.82 | 0.15 | -1.65 | 0.33 | 0.22 | 0.71 |
| Chemical Sci | 0.03 | 0.03 | 5.82 | 0.13 | 0.11 | 2.20 |
| Health Sci. | 0.06 | 0.05 | 3.82 | 0.30 | 0.21 | 0.86 |
| Engineering | 0.16 | 0.14 | 1.82 | 0.11 | 0.10 | 2.45 |
| Computing Sci. | 0.05 | 0.04 | 4.28 | 0.11 | 0.09 | 2.57 |
| Pshychology | 0.24 | 0.18 | 1.20 | 0.08 | 0.08 | 3.01 |
| Other fields | 0.10 | 0.09 | 2.68 | 0.35 | 0.23 | 0.61 |

Table 6.5: Covariate Balance After Weighting

| | $d_{ij} = 1$ | | | $d_{ij} = 0$ (Weighted) | | |
|---|---|---|---|---|---|---|
| Variable | Mean | Variance | Skewness | Mean | Variance | Skewness |
| Pre-doctoral Pubs (0/1) | 0.29 | 0.20 | 0.95 | 0.29 | 0.20 | 0.95 |
| Co-Advisor (0/1) | 0.76 | 0.18 | -1.22 | 0.76 | 0.18 | -1.22 |
| Nr. Advisees (log) | 0.58 | 0.21 | 0.67 | 0.58 | 0.21 | 0.67 |
| Advisor Productivity (log) | 3.88 | 0.33 | -1.63 | 3.88 | 0.33 | -1.65 |
| Advisor Coauthors (log) | 3.13 | 1.22 | -1.10 | 3.13 | 1.22 | -1.10 |
| Full Prof. (0/1) | 0.23 | 0.18 | 1.26 | 0.23 | 0.18 | 1.26 |
| Advisor Research Breadth | 0.39 | 0.01 | -0.56 | 0.39 | 0.01 | -0.56 |
| Year | 2019 | 13.80 | -1.23 | 2019 | 13.77 | -1.08 |
| PhD Entry Year | 2016 | 11.70 | -1.56 | 2016 | 11.66 | -1.40 |
| Biology Sci. | 0.24 | 0.18 | 1.24 | 0.24 | 0.18 | 1.24 |
| Biomedical Sci. | 0.82 | 0.15 | -1.65 | 0.82 | 0.15 | -1.65 |
| Chemical Sci | 0.03 | 0.03 | 5.82 | 0.03 | 0.03 | 5.82 |
| Health Sci. | 0.06 | 0.05 | 3.82 | 0.06 | 0.05 | 3.82 |
| Engineering | 0.16 | 0.14 | 1.82 | 0.16 | 0.14 | 1.81 |
| Computing Sci. | 0.05 | 0.04 | 4.28 | 0.05 | 0.04 | 4.28 |
| Pshychology | 0.24 | 0.18 | 1.20 | 0.24 | 0.18 | 1.20 |
| Other fields | 0.10 | 0.09 | 2.68 | 0.10 | 0.09 | 2.68 |

Table 6.6: PhD Students' Research Novelty

| | Binary | | | | Average | | | |
|---|---|---|---|---|---|---|---|---|
| | New Words | | New Phrases | | New Words | | New Phrases | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $d_{ij}$ (0/1) | 0.026 | 0.024 | 0.098*** | 0.118* | -0.008 | 0.062 | 0.100** | 0.444*** |
| | [0.023] | [0.084] | [0.032] | [0.072] | [0.024] | [0.095] | [0.045] | [0.162] |
| Pre-doc. Pub. (0/1) | 0.026 | 0.001 | 0.035 | 0.015 | -0.011 | -0.020 | -0.008 | -0.023 |
| | [0.016] | [0.017] | [0.025] | [0.037] | [0.019] | [0.022] | [0.037] | [0.056] |
| Co-Advisor (0/1) | -0.009 | -0.013 | 0.037 | 0.023 | -0.011 | -0.019 | 0.054 | 0.037 |
| | [0.020] | [0.022] | [0.030] | [0.030] | [0.027] | [0.034] | [0.045] | [0.050] |
| Nr. Advisees (log) | -0.027 | | -0.023 | | -0.040* | | -0.029 | |
| | [0.016] | | [0.024] | | [0.021] | | [0.039] | |
| Advisor Productivity (log) | 0.010 | | -0.054** | | 0.019 | | -0.058* | |
| | [0.018] | | [0.023] | | [0.023] | | [0.035] | |
| Advisor Coauthors (log) | -0.005 | | -0.015 | | -0.005 | | -0.041** | |
| | [0.009] | | [0.012] | | [0.011] | | [0.018] | |
| Full Prof. (0/1) | 0.025 | | 0.030 | | 0.016 | | 0.035 | |
| | [0.024] | | [0.026] | | [0.027] | | [0.040] | |
| Advisor Research Breadth | -0.103 | | -0.103 | | -0.053 | | -0.018 | |
| | [0.079] | | [0.100] | | [0.090] | | [0.152] | |
| Constant | 0.082 | 0.080* | 0.455*** | 0.167*** | -1.491*** | -1.496*** | -0.851*** | -1.376*** |
| | [0.083] | [0.049] | [0.113] | [0.051] | [0.105] | [0.060] | [0.168] | [0.101] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y |
| $N$ | 9304 | 9237 | 9304 | 9237 | 9304 | 9237 | 9304 | 9237 |
| adj. $R^2$ | 0.120 | 0.160 | 0.125 | 0.179 | 0.084 | 0.103 | 0.102 | 0.144 |

*Notes:* Fixed effect regressions using entropy weights. Robust standard errors clustered at the advisor level.
$d_{ij}$=1 if advisor demonstrates engagement in interdisciplinary research within a 5-year window around PhD entry
Cols.(5)-(8) dep.vars.in logs$((x + 0.2))$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

## Table 6.7: PhD Students' Research Productivity

| | Publications | | | | | | Avg. Citations per Pub. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Simple count | | Coauthor weighted | | with Advisor | | All pubs | | with Advisor | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $d_{ij}$ (0/1) | 0.114** | -0.285*** | 0.076* | -0.182*** | 0.130 | -0.042 | 0.014 | 0.073 | -0.054 | 0.587*** |
| | [0.056] | [0.054] | [0.040] | [0.050] | [0.099] | [0.109] | [0.055] | [0.193] | [0.072] | [0.222] |
| Pre-doc. Pub. (0/1) | 0.208*** | 0.101*** | 0.176*** | 0.079*** | -0.035 | -0.091* | -0.022 | -0.029 | -0.042 | -0.089 |
| | [0.031] | [0.026] | [0.027] | [0.023] | [0.066] | [0.055] | [0.054] | [0.060] | [0.061] | [0.068] |
| Co-Advisor (0/1) | 0.052 | -0.003 | -0.015 | -0.049* | 0.121** | 0.144** | -0.036 | 0.028 | -0.086 | -0.041 |
| | [0.032] | [0.029] | [0.024] | [0.026] | [0.060] | [0.062] | [0.053] | [0.063] | [0.061] | [0.069] |
| Nr. Advisees (log) | -0.003 | | -0.024 | | -0.042 | | 0.010 | | 0.025 | |
| | [0.027] | | [0.021] | | [0.069] | | [0.044] | | [0.051] | |
| Advisor Productivity (log) | -0.097*** | | -0.073*** | | -0.155*** | | 0.154*** | | 0.207*** | |
| | [0.027] | | [0.021] | | [0.053] | | [0.044] | | [0.060] | |
| Advisor Coauthors (log) | 0.053*** | | 0.010 | | 0.102*** | | 0.011 | | -0.023 | |
| | [0.015] | | [0.011] | | [0.036] | | [0.024] | | [0.033] | |
| Full Prof. (0/1) | 0.007 | | -0.014 | | -0.065 | | 0.093 | | 0.054 | |
| | [0.039] | | [0.030] | | [0.073] | | [0.060] | | [0.070] | |
| Advisor Research Breadth | -0.516*** | | -0.367*** | | -0.324 | | -0.234 | | -0.073 | |
| | [0.123] | | [0.112] | | [0.227] | | [0.213] | | [0.251] | |
| Constant | 0.528*** | 0.396*** | -0.635*** | -0.857*** | -0.061 | -0.471*** | 0.661*** | 1.147*** | 0.612** | 1.054*** |
| | [0.121] | [0.039] | [0.096] | [0.037] | [0.260] | [0.087] | [0.210] | [0.130] | [0.258] | [0.135] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y | | Y |
| $N$ | 15748 | 15740 | 15748 | 15740 | 15748 | 15740 | 15748 | 15740 | 12111 | 12073 |
| adj. $R^2$ | 0.393 | 0.504 | 0.348 | 0.448 | 0.205 | 0.358 | 0.186 | 0.246 | 0.170 | 0.245 |

*Notes:* $d_{ij}$=1 if advisor demonstrates engagement in interdisciplinary research within a 5-year window around PhD entry

Fixed-effect regressions using entropy weights. Robust standard errors clustered at the advisor level in brackets. Dependent vars. in $\log(x + 0.2)$.

*:p¡0.10, **:p¡0.05, ***:p¡0.01

Table 6.8: PhD Students' Research Collaboration

| | Collaborations | | | | Collaborators' Expertise | | | |
|---|---|---|---|---|---|---|---|---|
| | w. ID members | | New Coauthors | | Avg. Distance | | SD. Distance | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $d_{ij}$ (0/1) | 0.142*** | -0.027 | 0.107 | -0.847*** | 0.005 | 0.059*** | -0.038*** | 0.036 |
| | [0.024] | [0.034] | [0.072] | [0.200] | [0.013] | [0.019] | [0.011] | [0.026] |
| Pre-doc. Pub. (0/1) | -0.009 | -0.004 | -0.084* | -0.175*** | -0.041*** | -0.024*** | 0.009 | 0.007 |
| | [0.016] | [0.019] | [0.047] | [0.050] | [0.010] | [0.009] | [0.010] | [0.012] |
| Co-Advisor (0/1) | 0.033* | 0.023 | 0.147*** | 0.112** | -0.004 | 0.000 | -0.036*** | -0.044*** |
| | [0.018] | [0.015] | [0.053] | [0.057] | [0.011] | [0.014] | [0.012] | [0.013] |
| Nr. Advisees (log) | 0.015 | | 0.117** | | -0.002 | | 0.013 | |
| | [0.024] | | [0.049] | | [0.010] | | [0.010] | |
| Advisor Productivity (log) | -0.006 | | 0.005 | | -0.003 | | 0.007 | |
| | [0.020] | | [0.036] | | [0.008] | | [0.007] | |
| Advisor Coauthors (log) | -0.008 | | 0.117*** | | 0.009** | | -0.007 | |
| | [0.010] | | [0.026] | | [0.004] | | [0.004] | |
| Full Prof. (0/1) | 0.020 | | 0.010 | | 0.006 | | -0.013 | |
| | [0.022] | | [0.065] | | [0.011] | | [0.011] | |
| Advisor Research Breadth | -0.053 | | -0.475** | | 0.082* | | -0.053 | |
| | [0.076] | | [0.205] | | [0.045] | | [0.043] | |
| Constant | 0.060 | 0.099*** | 0.299* | 1.049*** | -0.270*** | -0.266*** | -0.697*** | -0.726*** |
| | [0.085] | [0.027] | [0.170] | [0.115] | [0.033] | [0.017] | [0.032] | [0.017] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y |
| $N$ | 15748 | 15740 | 15236 | 15226 | 14665 | 14651 | 13856 | 13834 |
| adj. $R^2$ | 0.348 | 0.464 | 0.214 | 0.274 | 0.096 | 0.172 | 0.101 | 0.210 |

*Notes:* Fixed effect regressions using entropy weights. Robust std. errors clustered at the advisor level. Cols.(3)-(8) dep.vars. in $\log(x + 0.2)$.
$d_{ij}$=1 if advisor demonstrates engagement in interdisciplinary research within a 5-year window around PhD entry
Avg. Distance: Jaccard between each collaborator's prior expertise; SD: Std deviation of Jaccard distances across the student's collaborators
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6.9: PhD Students' Interdisciplinarity

| | Variety | | Disparity | | Balance | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| $d_{ij}$ (0/1) | -0.048 | -0.072** | -0.025** | 0.015 | -0.017 | -0.043* |
| | [0.032] | [0.033] | [0.012] | [0.010] | [0.015] | [0.023] |
| Pre-doc. Pub. (0/1) | -0.098*** | -0.073*** | -0.026*** | -0.016** | -0.040*** | -0.036*** |
| | [0.021] | [0.021] | [0.007] | [0.006] | [0.010] | [0.011] |
| Co-Advisor (0/1) | -0.032 | 0.016 | -0.006 | 0.002 | -0.007 | -0.001 |
| | [0.021] | [0.022] | [0.005] | [0.007] | [0.010] | [0.012] |
| Nr. Advisees (log) | 0.070*** | | 0.014** | | 0.027*** | |
| | [0.019] | | [0.006] | | [0.010] | |
| Advisor Productivity (log) | 0.083*** | | 0.011** | | 0.020** | |
| | [0.017] | | [0.006] | | [0.008] | |
| Advisor Coauthors (log) | 0.001 | | -0.004 | | -0.000 | |
| | [0.010] | | [0.003] | | [0.005] | |
| Full Prof. (0/1) | -0.015 | | 0.001 | | -0.001 | |
| | [0.023] | | [0.007] | | [0.011] | |
| Advisor Research Breadth | 0.413*** | | 0.133*** | | 0.133*** | |
| | [0.095] | | [0.034] | | [0.048] | |
| Constant | 1.292*** | 1.783*** | -0.521*** | -0.463*** | -0.514*** | -0.359*** |
| | [0.086] | [0.027] | [0.028] | [0.008] | [0.038] | [0.016] |
| Year FE | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y |
| $N$ | 14053 | 14038 | 14053 | 14038 | 14053 | 14038 |
| adj. $R^2$ | 0.369 | 0.513 | 0.187 | 0.323 | 0.153 | 0.276 |

*Notes:* Fixed effect regressions using entropy weights. Robust std. errors clustered at the advisor level.

$d_{ij} = 1$ if advisor demonstrates engagement in ID research within a 5-year window around PhD entry.

Cols.(1)-(4) dep.vars. in $\log(x + 0.2)$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

*Variety* measures the number of distinct fields of research.

*Disparity* measures the cognitive distance across those fields.

*Balance* measures how evenly are different disciplines referenced.

# A Appendix

## A.1 Supplementary Analyses

### A.1.1 Advisors' ID Engagement

We reestimate our main models of PhD students' productivity and novelty, replacing the binary treatment $d_{ij}$ with a continuous measure defined as the number of publications by the advisor that mention the center in the five years before the student's PhD start. In the tables below, we name this variable *Advisor ID Engagement*.

Table A.1: PhD Students' Productivity (*Advisor ID Engagement* instead of $d_{ij}$)

| | Publications | | | | | | Avg. Citations per Pub. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Simple count | | Coauthor weighted | | with Advisor | | All pubs | | with Advisor | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Advisor ID Engagement | 0.005 | -0.041*** | -0.004 | -0.025** | -0.003 | -0.044* | -0.004 | -0.016 | -0.051* | -0.059* |
| | [0.020] | [0.011] | [0.012] | [0.011] | [0.028] | [0.024] | [0.023] | [0.020] | [0.030] | [0.035] |
| Pre-doctoral Pubs (0/1) | 0.262*** | 0.181*** | 0.222*** | 0.147*** | 0.003 | -0.056 | 0.011 | -0.010 | -0.011 | -0.050 |
| | [0.030] | [0.033] | [0.028] | [0.031] | [0.060] | [0.053] | [0.043] | [0.048] | [0.047] | [0.055] |
| Co-Advisor (0/1) | 0.065** | -0.000 | 0.009 | -0.027 | 0.058 | 0.068 | -0.005 | 0.027 | -0.030 | -0.030 |
| | [0.026] | [0.026] | [0.022] | [0.025] | [0.055] | [0.057] | [0.047] | [0.055] | [0.054] | [0.058] |
| Nr. Advisees (log) | -0.003 | | -0.015 | | -0.013 | | 0.011 | | 0.052 | |
| | [0.027] | | [0.022] | | [0.055] | | [0.040] | | [0.044] | |
| Advisor Productivity (log) | -0.085*** | | -0.060*** | | -0.175*** | | 0.148*** | | 0.156*** | |
| | [0.024] | | [0.020] | | [0.044] | | [0.039] | | [0.049] | |
| Advisor Coauthors (log) | 0.060*** | | 0.015 | | 0.096*** | | -0.007 | | -0.050* | |
| | [0.013] | | [0.011] | | [0.029] | | [0.020] | | [0.027] | |
| Full prof. (0/1) | 0.047 | | 0.042 | | -0.061 | | 0.045 | | 0.050 | |
| | [0.031] | | [0.026] | | [0.055] | | [0.053] | | [0.057] | |
| Advisor Research Breadth | -0.576*** | | -0.470*** | | -0.489** | | -0.119 | | 0.011 | |
| | [0.118] | | [0.108] | | [0.199] | | [0.177] | | [0.210] | |
| Constant | 0.521*** | 0.233*** | -0.643*** | -0.960*** | 0.178 | -0.464*** | 0.600*** | 1.101*** | 0.640*** | 1.200*** |
| | [0.105] | [0.030] | [0.099] | [0.027] | [0.232] | [0.066] | [0.184] | [0.069] | [0.209] | [0.082] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y | | Y |
| $N$ | 16799 | 16792 | 16799 | 16792 | 16799 | 16792 | 16799 | 16792 | 12910 | 12875 |
| adj. $R^2$ | 0.396 | 0.506 | 0.346 | 0.457 | 0.195 | 0.340 | 0.170 | 0.226 | 0.152 | 0.218 |

*Notes:* $d_{ij} = 1$ if the student's advisor became a member of an interdisciplinary center before graduation; 0 otherwise.

Fixed-effect regressions using entropy weights. Robust standard errors clustered at the advisor level in brackets. Dependent vars. in logs$((x + 0.2))$.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.2: Novelty during PhD training (*Advisor ID Engagement* instead of $d_{ij}$)

| | Binary | | | | Average | | | |
|---|---|---|---|---|---|---|---|---|
| | New Words | | New Phrases | | New Words | | New Phrases | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Advisor ID Engagement | 0.037** | 0.019 | -0.005 | -0.028* | 0.044*** | 0.034** | 0.006 | -0.021 |
| | [0.015] | [0.014] | [0.017] | [0.016] | [0.014] | [0.015] | [0.025] | [0.024] |
| Pre-doctoral Pubs (0/1) | 0.037** | 0.026 | 0.066*** | 0.026 | -0.012 | -0.006 | 0.029 | -0.002 |
| | [0.015] | [0.016] | [0.022] | [0.028] | [0.018] | [0.020] | [0.033] | [0.046] |
| Co-Advisor (0/1) | -0.019 | -0.030* | 0.015 | -0.030 | -0.035 | -0.051* | 0.034 | -0.032 |
| | [0.017] | [0.018] | [0.024] | [0.026] | [0.024] | [0.027] | [0.037] | [0.043] |
| Nr. Advisees (log) | -0.026 | | -0.014 | | -0.031 | | 0.000 | |
| | [0.016] | | [0.019] | | [0.021] | | [0.032] | |
| Advisor Productivity (log) | 0.002 | | -0.035** | | 0.010 | | -0.037 | |
| | [0.013] | | [0.015] | | [0.017] | | [0.023] | |
| Advisor Coauthors (log) | 0.005 | | 0.003 | | 0.000 | | -0.008 | |
| | [0.008] | | [0.009] | | [0.009] | | [0.014] | |
| Full prof. (0/1) | 0.026 | | 0.028 | | 0.018 | | 0.023 | |
| | [0.018] | | [0.021] | | [0.022] | | [0.032] | |
| Advisor Research Breadth | -0.087 | | -0.103 | | -0.001 | | 0.053 | |
| | [0.067] | | [0.088] | | [0.079] | | [0.133] | |
| Constant | 0.084 | 0.093*** | 0.425*** | 0.313*** | -1.480*** | -1.437*** | -0.944*** | -1.023*** |
| | [0.061] | [0.024] | [0.079] | [0.033] | [0.079] | [0.033] | [0.120] | [0.059] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y |
| $N$ | 10213 | 10148 | 10213 | 10148 | 10213 | 10148 | 10213 | 10148 |
| adj. $R^2$ | 0.100 | 0.124 | 0.124 | 0.165 | 0.069 | 0.078 | 0.120 | 0.144 |

*Notes:* Fixed effect regressions using entropy weights. Robust standard errors clustered at the advisor level.
Cols.(5)-(8) dep.vars.in logs$((x + 0.2))$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

### A.1.2 Alternative $d_{ij}$

We re-estimate our main models of PhD students' productivity and novelty, redefining the advisor-engagement window. We consider two variants. First, instead of five years before and five years after PhD start, we remove any recency window prior to the student's graduation: any publication that lists the center before the student graduates qualifies the advisor as center-engaged, even if the most recent mention predates entry by more than five years ($d_{ij}(v1)$). Second, we use five years before and two years after ($d_{ij}(v2)$). This captures engagement leading into training while minimizing overlap with publications likely influenced by the student. In both variations, we find consistent evidence of our main results.

Table A.3: PhD Students' Productivity (alternative $d_{ij}(v1)$)

| | Publications | | | | | | Avg. Citations per Pub. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Simple count | | Coauthor weighted | | with Advisor | | All pubs | | with Advisor | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $d_{ij}(v1)$ | 0.107* | -0.274*** | 0.060 | -0.166*** | 0.119 | -0.027 | 0.031 | 0.041 | -0.046 | 0.525** |
| | [0.057] | [0.048] | [0.043] | [0.044] | [0.101] | [0.119] | [0.063] | [0.189] | [0.074] | [0.210] |
| Pre-doctoral Pubs (0/1) | 0.220*** | 0.100*** | 0.184*** | 0.078*** | -0.023 | -0.086 | 0.004 | -0.032 | -0.020 | -0.098 |
| | [0.031] | [0.026] | [0.027] | [0.023] | [0.065] | [0.058] | [0.054] | [0.062] | [0.061] | [0.069] |
| Co-Advisor (0/1) | 0.067** | -0.013 | -0.003 | -0.058** | 0.134** | 0.131** | -0.038 | 0.014 | -0.071 | -0.031 |
| | [0.033] | [0.030] | [0.027] | [0.028] | [0.063] | [0.066] | [0.056] | [0.062] | [0.064] | [0.067] |
| Nr. Advisees (lg) | 0.003 | | -0.011 | | -0.035 | | 0.017 | | 0.057 | |
| | [0.027] | | [0.022] | | [0.069] | | [0.045] | | [0.050] | |
| Advisor Productivity (log) | -0.092*** | | -0.066*** | | -0.151*** | | 0.168*** | | 0.220*** | |
| | [0.025] | | [0.020] | | [0.051] | | [0.041] | | [0.058] | |
| Advisor Coauthors (log) | 0.052*** | | 0.008 | | 0.106*** | | 0.003 | | -0.026 | |
| | [0.016] | | [0.012] | | [0.039] | | [0.024] | | [0.032] | |
| Full. Prof. (0/1) | -0.017 | | -0.031 | | -0.074 | | 0.033 | | 0.036 | |
| | [0.039] | | [0.030] | | [0.072] | | [0.068] | | [0.073] | |
| Advisor Research Breadth | -0.562*** | | -0.433*** | | -0.430* | | -0.092 | | -0.051 | |
| | [0.132] | | [0.122] | | [0.246] | | [0.220] | | [0.265] | |
| Constant | 0.525*** | 0.398*** | -0.638*** | -0.860*** | -0.112 | -0.521*** | 0.591*** | 1.160*** | 0.532** | 1.045*** |
| | [0.118] | [0.037] | [0.095] | [0.037] | [0.255] | [0.100] | [0.202] | [0.134] | [0.250] | [0.133] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y | | Y |
| $N$ | 15683 | 15674 | 15683 | 15674 | 15683 | 15674 | 15683 | 15674 | 12042 | 12007 |
| adj. $R^2$ | 0.403 | 0.502 | 0.359 | 0.450 | 0.206 | 0.347 | 0.186 | 0.240 | 0.173 | 0.251 |

*Notes:* $d_{ij}(v1) = 1$ if the student's advisor became a member of an interdisciplinary center before graduation; 0 otherwise.

Fixed-effect regressions using entropy weights. Robust standard errors clustered at the advisor level in brackets. Dependent vars. in $\log((x + 0.2))$.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.4: Novelty during PhD training (alternative $d_{ij}(v1)$)

| | Binary | | | | Average | | | |
|---|---|---|---|---|---|---|---|---|
| | New Words | | New Phrases | | New Words | | New Phrases | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $d_{ij}(v1)$ | 0.032 | 0.029 | 0.114*** | 0.075 | -0.010 | 0.073 | 0.120*** | 0.386** |
| | [0.027] | [0.103] | [0.033] | [0.082] | [0.029] | [0.117] | [0.045] | [0.180] |
| Pre-doctoral Pubs (0/1) | 0.029 | -0.002 | 0.044* | 0.018 | -0.008 | -0.024 | 0.006 | -0.021 |
| | [0.018] | [0.017] | [0.026] | [0.036] | [0.021] | [0.023] | [0.038] | [0.055] |
| Co-Advisor (0/1) | -0.004 | -0.017 | 0.035 | 0.006 | -0.008 | -0.024 | 0.058 | 0.018 |
| | [0.021] | [0.024] | [0.030] | [0.032] | [0.029] | [0.037] | [0.045] | [0.054] |
| Nr. Advisees (lg) | -0.028 | | -0.016 | | -0.040 | | -0.013 | |
| | [0.019] | | [0.026] | | [0.025] | | [0.042] | |
| Advisor Productivity | 0.003 | | -0.053** | | 0.009 | | -0.065** | |
| | [0.018] | | [0.021] | | [0.023] | | [0.032] | |
| Advisor Coauthors (log) | -0.003 | | -0.018 | | -0.001 | | -0.046** | |
| | [0.010] | | [0.013] | | [0.012] | | [0.019] | |
| Full. Prof. (0/1) | 0.020 | | 0.017 | | 0.016 | | 0.023 | |
| | [0.025] | | [0.030] | | [0.029] | | [0.045] | |
| Advisor Research Breadth | -0.082 | | -0.037 | | -0.051 | | 0.049 | |
| | [0.096] | | [0.114] | | [0.108] | | [0.176] | |
| Constant | 0.092 | 0.080 | 0.435*** | 0.200*** | -1.470*** | -1.494*** | -0.834*** | -1.325*** |
| | [0.082] | [0.057] | [0.103] | [0.055] | [0.106] | [0.070] | [0.160] | [0.108] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y |
| $N$ | 9264 | 9195 | 9264 | 9195 | 9264 | 9195 | 9264 | 9195 |
| adj. $R^2$ | 0.115 | 0.149 | 0.127 | 0.168 | 0.084 | 0.095 | 0.104 | 0.132 |

*Notes:* Fixed effect regressions using entropy weights. Robust standard errors clustered at the advisor level.
$d_{ij}(v1) = 1$ if the student's advisor became a member of an interdisciplinary center before graduation; 0 otherwise.
Cols.(5)-(8) dep.vars.in logs$((x + 0.2))$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.5: PhD Students' Productivity (alternative $d_{ij}(v2)$)

| | Publications | | | | | | Avg. Citations per Pub. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Simple count | | Coauthor weighted | | with Advisor | | All pubs | | with Advisor | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| $d_{ij}(v2)$ | 0.090 | -0.297*** | 0.013 | -0.200*** | 0.114 | -0.059 | 0.044 | 0.209* | -0.105 | 0.814*** |
| | [0.066] | [0.066] | [0.048] | [0.057] | [0.111] | [0.138] | [0.069] | [0.121] | [0.096] | [0.196] |
| Pre-doctoral Pubs (0/1) | 0.213*** | 0.099*** | 0.185*** | 0.090*** | 0.042 | -0.043 | 0.024 | -0.029 | 0.010 | -0.111 |
| | [0.031] | [0.029] | [0.028] | [0.026] | [0.067] | [0.062] | [0.064] | [0.070] | [0.078] | [0.089] |
| Co-Advisor (0/1) | 0.060* | -0.040 | -0.001 | -0.071** | 0.149** | 0.115 | -0.004 | 0.039 | -0.062 | -0.103 |
| | [0.036] | [0.038] | [0.029] | [0.032] | [0.067] | [0.072] | [0.060] | [0.076] | [0.073] | [0.080] |
| Nr. Advisees (lg) | 0.006 | | -0.000 | | -0.016 | | 0.020 | | 0.082 | |
| | [0.031] | | [0.024] | | [0.082] | | [0.053] | | [0.064] | |
| Advisor Productivity | -0.183*** | | -0.135*** | | -0.254*** | | 0.284*** | | 0.356*** | |
| | [0.037] | | [0.034] | | [0.085] | | [0.063] | | [0.088] | |
| Advisor Coauthors (log) | 0.069*** | | 0.022* | | 0.137*** | | -0.014 | | -0.049 | |
| | [0.016] | | [0.012] | | [0.041] | | [0.028] | | [0.036] | |
| Full. Prof. (0/1) | -0.019 | | -0.023 | | -0.117 | | 0.070 | | 0.060 | |
| | [0.046] | | [0.035] | | [0.082] | | [0.077] | | [0.089] | |
| Advisor Research Breadth | -0.736*** | | -0.551*** | | -0.654** | | 0.089 | | 0.119 | |
| | [0.155] | | [0.150] | | [0.306] | | [0.262] | | [0.357] | |
| Constant | 0.933*** | 0.442*** | -0.335** | -0.828*** | 0.286 | -0.494*** | 0.119 | 1.122*** | 0.038 | 1.012*** |
| | [0.174] | [0.044] | [0.164] | [0.043] | [0.392] | [0.095] | [0.311] | [0.127] | [0.380] | [0.134] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y | | Y |
| $N$ | 15128 | 15121 | 15128 | 15121 | 15128 | 15121 | 15128 | 15121 | 11631 | 11599 |
| adj. $R^2$ | 0.424 | 0.506 | 0.361 | 0.438 | 0.237 | 0.362 | 0.198 | 0.239 | 0.186 | 0.257 |

Fixed-effect regressions using entropy weights. Robust standard errors clustered at the advisor level in brackets. Dependent vars. in logs$((x + 0.2))$.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Novelty during PhD training (alternative $d_{ij}(v2)$)

| | Binary | | | | Average | | | |
|---|---|---|---|---|---|---|---|---|
| | New Words | | New Phrases | | New Words | | New Phrases | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $d_{ij}(v2)$ | 0.038 | 0.121** | 0.121*** | 0.143* | -0.006 | 0.165** | 0.143** | 0.547*** |
| | [0.037] | [0.060] | [0.046] | [0.080] | [0.038] | [0.074] | [0.062] | [0.127] |
| Pre-doc. Pubs (0/1) | 0.018 | -0.009 | 0.079*** | 0.046 | -0.030 | -0.035 | 0.056 | 0.023 |
| | [0.021] | [0.020] | [0.029] | [0.038] | [0.025] | [0.028] | [0.043] | [0.058] |
| Co-Advisor (0/1) | -0.010 | -0.024 | 0.013 | -0.009 | -0.014 | -0.021 | 0.030 | -0.011 |
| | [0.026] | [0.030] | [0.036] | [0.037] | [0.036] | [0.048] | [0.054] | [0.062] |
| Nr. Advisees (0/1) | -0.033 | | -0.030 | | -0.069** | | -0.038 | |
| | [0.023] | | [0.032] | | [0.029] | | [0.051] | |
| Advisor Productivity | 0.006 | | -0.057 | | 0.003 | | -0.061 | |
| | [0.031] | | [0.035] | | [0.041] | | [0.049] | |
| Advisor Coauthors | 0.006 | | -0.008 | | 0.009 | | -0.036* | |
| | [0.010] | | [0.014] | | [0.013] | | [0.019] | |
| Full prof (0/1) | 0.027 | | 0.039 | | 0.028 | | 0.057 | |
| | [0.030] | | [0.032] | | [0.034] | | [0.048] | |
| Advisor Research Breadth | -0.146 | | -0.109 | | -0.117 | | 0.002 | |
| | [0.113] | | [0.130] | | [0.125] | | [0.203] | |
| Constant | 0.089 | 0.048 | 0.481*** | 0.195*** | -1.414*** | -1.521*** | -0.819*** | -1.359*** |
| | [0.138] | [0.040] | [0.165] | [0.052] | [0.177] | [0.060] | [0.241] | [0.085] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y |
| $N$ | 15128 | 15121 | 15128 | 15121 | 15128 | 15121 | 15128 | 15121 |
| 11631 | 11599 | | | | | | | |
| adj. $R^2$ | 0.424 | 0.506 | 0.361 | 0.438 | 0.237 | 0.362 | 0.198 | 0.239 |
| 0.186 | 0.257 | | | | | | | |

*Notes:* Fixed effect regressions using entropy weights. Robust standard errors clustered at the advisor level.
Cols.(5)-(8) dep.vars.in logs$((x + 0.2))$. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.7: PhD Students' Research Productivity: Poisson

| | Publications | | | | | | Avg. Citations per Pub. | |
|---|---|---|---|---|---|---|---|---|
| | Simple count | | Coauthor weighted | | with Advisor | | All pubs | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| $d_{ij}$ | 0.157** | -0.249*** | 0.160** | -0.289*** | 0.122 | -0.054 | -0.019 | -0.311 |
| | [0.077] | [0.083] | [0.068] | [0.098] | [0.099] | [0.118] | [0.182] | [0.195] |
| Pre-doctoral Pubs (0/1) | 0.246*** | 0.119*** | 0.295*** | 0.135*** | 0.064 | -0.011 | -0.114 | -0.138* |
| | [0.040] | [0.034] | [0.045] | [0.042] | [0.059] | [0.047] | [0.084] | [0.080] |
| Co-Advisor (0/1) | 0.037 | -0.049 | -0.055 | -0.123** | 0.078 | 0.093 | -0.030 | -0.183** |
| | [0.048] | [0.038] | [0.048] | [0.052] | [0.067] | [0.073] | [0.086] | [0.093] |
| Nr. Advisees (lg) | 0.013 | | -0.017 | | 0.017 | | -0.142* | |
| | [0.043] | | [0.044] | | [0.060] | | [0.080] | |
| Advisor Productivity | -0.161*** | | -0.139*** | | -0.173*** | | 0.488*** | |
| | [0.034] | | [0.035] | | [0.044] | | [0.141] | |
| Advisor Coauthors (log) | 0.066*** | | 0.018 | | 0.112*** | | -0.112* | |
| | [0.023] | | [0.018] | | [0.031] | | [0.061] | |
| Full. Prof. (0/1) | -0.008 | | -0.018 | | -0.093 | | -0.166 | |
| | [0.049] | | [0.055] | | [0.064] | | [0.130] | |
| Advisor Research Breadth | -0.523*** | | -0.550*** | | -0.304 | | 0.999 | |
| | [0.166] | | [0.190] | | [0.205] | | [0.674] | |
| Constant | 0.839*** | 0.641*** | -0.756*** | -1.046*** | 0.342* | 0.063 | 0.355 | 2.812*** |
| | [0.155] | [0.058] | [0.155] | [0.072] | [0.199] | [0.093] | [0.684] | [0.174] |
| Year FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Cohort FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Science Field FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Academic Unit FE | Y | Y | Y | Y | Y | Y | Y | Y |
| Advisor FE | | Y | | Y | | Y | | Y |
| $N$ | 11539 | 11510 | 11539 | 11510 | 11527 | 11318 | 9042 | 8995 |
| pseudo $R^2$ | 0.165 | 0.227 | 0.077 | 0.109 | 0.129 | 0.214 | 0.230 | 0.386 |

*Notes:* $d_{ij}$=1 if advisor demonstrates engagement in interdisciplinary research within a 5-year window around PhD entry.
Poisson FE regressions using entropy weights. Robust standard errors clustered at the advisor level in brackets.
*:p¡0.10, **:p¡0.05, ***:p¡0.01

## A.2 Interdisciplinary Indicators

Following Stirling et al.(2007) and Wang et al.(2015), interdisciplinarity can be characterized by three complementary components: *variety*, *balance*, and *disparity*. In terms of notation, a publication's references can be expressed in terms of $n_c$ distinct ASJC (All Science Journal Classifications) disciplines. For each discipline $i$ where $(i = 1, \ldots, n_c)$, $x_i$ denotes the number of references to discipline $i$, and disciplines are sorted in *ascending* order of $x_i$. Moreover, the distance between any two distinct disciplines $i$ and $j$ can be denoted by $d_{ij}$ $(i \neq j)$. With this notation in mind, we define the following indicators:

- Variety $(V)$: Variety captures how many distinct disciplines are referenced:
$$V = n_c. \tag{A.1}$$

- Balance $(B)$: Balance reflects how evenly references are distributed across disciplines. We compute the Gini coefficient $G$, and a balance index $B = 1 - G$, so that higher values indicate greater balance, indicating evenness in the distribution of disciplines. $B = 1$ denotes maximum evenness and $B = 0$ denotes extreme imbalance.
$$G = \frac{\sum_{i=1}^{n_c}(2i - n_c - 1)\, x_i}{n_c \sum_{k=1}^{n_c} x_k}, \qquad B = 1 - G \in [0, 1], \tag{A.2}$$

- Disparity $(D)$: Disparity measures the average pairwise distance among the disciplines cited:
$$D = \frac{\sum_{i \neq j} d_{ij}}{n_c(n_c - 1)}. \tag{A.3}$$

  Following Zhang et al.(2016), distance is defined as one minus a cosine similarity derived from cross-citations. Using all Scopus-indexed papers published in 2020, we construct an ASJC cross-citation matrix and compute:

$$d_{ij} = 1 - \frac{R_{ij} + R_{ji}}{\sqrt{\big(TC_i + TR_i\big)\big(TC_j + TR_j\big)}}, \tag{A.4}$$

  where:

  $R_{ij}$ is the number of references from set $i$ (publications in discipline $i$) to set $j$. $TC_k$ is the total citations received by set $k$ *from other disciplines*. $TR_k$ is the total references made by set $k$ *to other disciplines*.

## A.3 Pairwise Correlations

Table A.8: Pairwise Correlations

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) | (22) | (23) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) $d_{ij}$ | 1 | | | | | | | | | | | | | | | | | | | | | | |
| (2) Pre-doc. Pubs | 0.0728* | 1 | | | | | | | | | | | | | | | | | | | | | |
| (3) Co-Advisor | 0.0560* | 0.0377* | 1 | | | | | | | | | | | | | | | | | | | | |
| (4) Nr. Advisee | -0.0689* | -0.0181* | -0.0995* | 1 | | | | | | | | | | | | | | | | | | | |
| (5) Advisor Productivity | 0.1170* | 0.0222* | 0.0367* | 0.0606* | 1 | | | | | | | | | | | | | | | | | | |
| (6) Advisor Coauthors | 0.2079* | 0.0982* | 0.0922* | 0.1982* | 0.2951* | 1 | | | | | | | | | | | | | | | | | |
| (7) Full Prof. | 0.0321* | 0.0096 | 0.001 | 0.0825* | 0.0514* | 0.1149* | 1 | | | | | | | | | | | | | | | | |
| (8) Advisor Research Breadth | 0.1545* | 0.0217* | 0.0213* | 0.2048* | 0.4738* | 0.2923* | 0.0658* | 1 | | | | | | | | | | | | | | | |
| (9) PhD Cohort | 0.1055* | 0.0838* | -0.0829* | 0.0860* | 0.0833* | 0.1198* | -0.1755* | 0.2633* | 1 | | | | | | | | | | | | | | |
| (10) Year | 0.0724* | 0.0122 | -0.0591* | 0.0702* | 0.0777* | 0.0871* | -0.1197* | 0.2117* | 0.7984* | 1 | | | | | | | | | | | | | |
| (11) Other Fields | -0.1625* | -0.0578* | -0.1143* | 0.0104 | -0.1084* | -0.1856* | -0.0327* | -0.0625* | 0.0181* | 0.0452* | 1 | | | | | | | | | | | | |
| (12) Biology | 0.0317* | -0.0491* | -0.0142 | -0.0005 | 0.0541* | 0.0944* | 0.0438* | 0.0065 | -0.0594* | -0.0311* | -0.0708* | 1 | | | | | | | | | | | |
| (13) Biomedical | 0.2973* | 0.1557* | 0.1978* | -0.1736* | 0.1055* | 0.2501* | 0.0913* | 0.0249* | -0.1248* | -0.0844* | -0.3385* | 0.0535* | 1 | | | | | | | | | | |
| (14) Chemical | -0.0957* | -0.0024 | -0.0669* | 0.1368* | 0.0441* | 0.0917* | 0.0220* | 0.0499* | 0.0564* | 0.0603* | -0.0374* | 0.0280* | -0.1716* | 1 | | | | | | | | | |
| (15) Health | -0.1690* | -0.0215* | -0.0685* | 0.1972* | -0.0605* | -0.0404* | -0.0301* | 0.0408* | 0.0851* | 0.0791* | 0.0598* | -0.1727* | -0.3373* | 0.2006* | 1 | | | | | | | | |
| (16) Engineering | 0.0390* | 0.0889* | 0.1120* | -0.0808* | 0.0056 | -0.0001 | 0.0087 | 0.0139 | -0.0626* | -0.0144 | -0.1040* | -0.1109* | 0.2301* | -0.1160* | -0.1279* | 1 | | | | | | | |
| (17) Computing | -0.0553* | -0.0022 | -0.0572* | 0.0593* | -0.0864* | -0.1155* | -0.0210* | 0.0130 | 0.0331* | 0.0408* | 0.0076 | -0.1209* | -0.1645* | -0.0801* | 0.1365* | -0.0240* | 1 | | | | | | |
| (18) Psychology | 0.1545* | -0.0455* | 0.0527* | -0.0823* | 0.0648* | -0.0632* | -0.0003 | 0.0582* | -0.0715* | -0.0306* | -0.0737* | -0.1101* | 0.0638* | -0.1195* | -0.1901* | 0.1013* | -0.0495* | 1 | | | | | |
| (19) Publications | 0.0502* | 0.1634* | 0.0721* | -0.0378* | -0.0073 | 0.0961* | 0.0644* | -0.0400* | -0.1633* | -0.0279* | 0.1039* | 0.0455* | 0.2685* | 0.0575* | 0.0849* | 0.1931* | 0.0572* | 0.0299* | 1 | | | | |
| (20) Coauthor-wt. Pubs. | -0.0334* | 0.1081* | -0.0160 | -0.0284* | -0.0687* | -0.0862* | 0.0436* | -0.0971* | -0.1866* | -0.0694* | 0.1981* | -0.0313* | 0.0849* | 0.0054 | 0.1124* | 0.1536* | 0.1494* | 0.0501* | 0.7969* | 1 | | | |
| (21) Citations Avg. | 0.0431* | -0.0274* | -0.0242* | 0.0257* | 0.0591* | 0.0564* | 0.0018 | 0.0307* | 0.0683* | 0.0707* | -0.0489* | 0.0907* | -0.0110 | 0.0363* | -0.0084 | -0.0335* | -0.0133 | -0.0081 | -0.0215* | -0.0542* | 1 | | |
| (22) New Words | 0.0429* | 0.0473* | 0.0280* | -0.0304* | -0.0051 | 0.0517* | 0.0296* | -0.0199 | -0.1408* | -0.1178* | -0.0176 | 0.0785* | 0.1537* | 0.0135 | -0.0311* | 0.0302* | -0.0087 | -0.0350* | 0.2712* | 0.1764* | 0.0232 | | |
| (23) New Phrases | 0.0237 | 0.0284* | 0.0299* | -0.0144 | -0.0051 | 0.0538* | 0.0291* | -0.0392* | -0.2098* | -0.1810* | 0.0049 | 0.1042* | 0.1502* | 0.0496* | 0.0439* | 0.0244* | 0.0076 | -0.0615* | 0.3303* | 0.2242* | 0.0454* | 1 | |

*Notes:* Significance levels: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.