Peers Matter: The Heterogeneous Effects of Female Peers on Scientists' Research Focus*

Paul W. Dai† Hongyuan Xia‡

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Abstract

Scientific research is less likely to focus on women, despite the importance of such studies for women's welfare. This paper studies the impact of increasing female representation in doctoral studies on the research direction of PhD students in the same cohort. We analyze the dissertation and research trajectories of nearly all US healthcare and biology PhD recipients from 1985 to 2015. By exploiting quasi-random year-to-year fluctuations in the female ratio at the PhD program level, we identify the causal impact of female peers on the production of gender-related research, defined as research studying or relating to women, gender, and sex. We find that an increase in female students in a cohort encourages female PhD students to conduct more gender-related research, but discourages male PhD students from engaging in such research. Furthermore, the positive spillover effects on conducting gender-related research observed among female students are primarily attributed to collaborations and informal interactions with female peers. Conversely, the diminished or negative effects seen in male students appear to stem from competitive pressures. Taken together, our findings suggest peer effect is an important factor to resolve the scarcity-substance puzzle of gender-related research production.

Keywords: Gender-Related Research, Gender, Science of Science, Innovation, Higher Education

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†MIT Sloan School of Management, paulwdai@mit.edu.

‡Cornell University Department of Economics, hx276@cornell.edu.

1 Introduction

Scientific research is less likely to focus on women. The shortage of papers and inventions studying or relating to women, gender, and sex, which we define as gender-related research, can have significant implications for the welfare of women. For example, the historical lack of research focus on women's health concerns has been linked to greater rates of misdiagnosis of medical conditions such as heart disease in women. However, given the importance of gender-related research, its scarcity remains a puzzle.

Previous studies investigating the shortage of gender-related research have focused mostly on the underrepresentation of female researchers (Koning, Samila, and Ferguson 2020, 2021; Nielsen et al. 2017; Truffa and Wong 2022). In our paper, we investigate this question considering the *spillover* effects of female researchers and the importance of the gender-diverse environment. In particular, we ask whether a gender-diverse academic environment, characterized by a high proportion of female peers, can inspire researchers, both male and female, to engage more gender-related research in both the short and long term.

Female peers can affect researchers' choices of conducting gender-related research in two competing ways. On one hand, a higher proportion of female peers potentially heightens awareness and interest in female-related issues among researchers, enables formation of teams with a female majority, fosters informal interactions with female peers, and thus boosts the gender-related research production. On the other hand, the academic environment is inherently competitive, with peers competing for scarce research input and racing to publish novel findings. An increased presence of female peers might intensify competition, particularly within the realm of gender-related research. The overall effect is ex-ante ambiguous and may be different across gender.

Identifying the female peers' effects on researchers' propensity to do gender-related research is challenging due to several reasons: First, peers are not randomly assigned, and those who have more female peers may also have an unobserved preference to do gender-related research. For instance, scholars specializing in gender studies might naturally cluster in certain universities, raising concerns about reverse causality and omitted variable bias. Second, the concept of "peers" in academic research is unclear due to the diverse nature of knowledge production, which might refer to a range of associations, from co-authors within one's research network to colleagues in the same department. This diversity complicates the task of precisely determining the peer group impacting the researcher's focus.

To deal with these two challenges, we focus on PhD students and take advantage of the quasi-random year-to-year variation in the cohort female ratio within the same PhD program to estimate the causal impact of female peers on the production of gender-related research. There are several relevant features of our research design. First, PhDs are among the most innovative group of people in the society (Akcigit, Pearce, and Prato 2022), and they continuously push the knowledge frontier. Second, PhDs are at early stage of their academic journey with relatively limited research networks and underdeveloped research agenda, leaving space to be affected by cohort peers. Third, our empirical strategy, the exogenous cohort female ratio within a program, exploits the inherent uncertainty faced by both admissions committees and doctoral candidates regarding each cohort's gender composition. Although a program's admissions committee might aim for a particular gender balance, and incoming students may be aware of historical gender distributions, the exact gender composition of each new cohort remains unpredictable for a given year. This provides a source of plausibly exogenous variation that allows us to identify a causal effect of the female peer ratio on PhDs' propensity to do gender-related research.

We assemble a comprehensive record of the PhD dissertations and research trajectories from two database: First, ProQuest database contains comprehensive metadata of nearly all US PhD dissertations from 1985, including student names, advisors, institutions, thesis titles, abstracts, research subjects, and degree dates (Zolas et al. 2015); Second, the OpenAlex encompasses the publication information of PhD recipients (Priem, Piwowar, and Orr 2022). We link these two datasets based on names and institutions information, and focus on healthcare or biology PhD recipients who graduated between 1985 and 2015 from 62 universities affiliated with the Association of American Universities. To classify whether a particular thesis or publication studies or relates to women, gender, and sex, we employ an off-the-shelf machine learning technique based on the information from abstract and title, as in Truffa and Wong 2022.

Our main empirical results suggest that a 10 percentage points increase in female students in a cohort increases female PhD students' propensity to undertake gender-related research in their dissertations by 0.68 percentage points. By contrast, male PhD students in the same cohort are 0.18 percentage points less likely to write a gender-related research dissertation. Moreover, the peer effects on conducting gender-related research persist for at least 5 years. Such peer effects do not appear before entering the PhD program, which further strengthens our identification assumption. We conduct a series of robustness checks, showing that our findings are not sensitive to our empirical specification. The results are also not driven by the cohort size of the PhD program, or the classifica-

tion rule for PhD gender and for gender-related research, or measurement issue of our key variables. To unpack our finding, we run several heterogeneity tests, which reveals that the peer effects are stronger (a). in applied fields, (b). among PhD students in a large cohort, and (c). who have an advisor working on gender-related research.

We provide some empirical evidence to support our identification assumption. First, our first-order auto-regression of share of female peers on its lag, controlling program and year fixed effects, rejects the path dependency of PhD cohort composition. Second, as in the previous literature, we justify our approach through Monte Carlo simulations, demonstrating that the observed intra-cohort variability in female peer proportions aligns with what one would expect from a random distribution process. Last, we test whether the gender of the student is correlated with the cohort ratio. We show that the cohort-level leave-out mean is not significantly different from zero after controlling for the leave-out mean of program female ratio.

Why do PhD students shift the direction of their research in response to the ratio of female peers? And why do male and female students react to the female ratio differently? In our further mechanism tests, we explore the existence of the two competing mechanisms, diffusion and competition. More specifically, we examine several potential channels: (i) collaboration with female peers, (ii) informal interactions, such as research group interactions, with female peers, and (iii) the intensity of competition to conduct gender-related research within the cohort.

We find an increased number of female peers enhance opportunities for female-to-female collaboration to do gender-related research, yet it does not necessarily lead to a similar increase in mixed-gender collaboration. This can be explained by homophily, the tendency for individuals to collaborate with others who share similar characteristics, including gender. Besides, our results suggest the importance of informal interaction. We explore one setting of informal interactions, the lab, and reveal that the effects of cohort female peers are especially stronger for female PhD students when there is another female peer in the same lab.

We also document that the negative effects of cohort female ratio for male PhD students are much stronger when there are female stars, scientists with 5-year post-graduation citations among the top 10 or top 25 percentile of their field, who are doing gender-related research, while female PhD students are nearly unaffected by the increasing competition visibility. Academic environment is inherently competitive, especially regarding the race to publish novel findings (Hill 2020). Scientists often pivot their research to minimize the negative effects of being "scooped" (Hill and Stein 2019). An increased presence of fe-

male peers might intensify competition, particularly within the realm of gender-related research. Male scientists are more likely to view increasing female peers as competitors, since they may lack an intrinsic understanding of and firsthand experience with gender-related topics, and have a lesser comparative advantage in conducting gender-related research.

In summary, our results indicate a nuanced landscape: the positive spillover effects to do gender-related research observed among female students are primarily attributed to collaborations and informal interactions with female peers. Conversely, the diminished or negative effects seen in male students appear to stem from competitive pressures. This analysis not only confirms the existence of knowledge diffusion and competitive dynamics but also unravels the specific conditions that amplify or mitigate these effects.

Related Literature. First, we join the ongoing debate about how ideas are generated and how scientists choose their research direction, in particular, gender-related research. While existing literature has extensively explored how academic research directions are influenced by factors such as institutional barriers, research funding, political tensions, market competition, and the influence of leading scholars (Acemoglu, Yang, and Zhou 2021; Azoulay, Fons-Rosen, and Graff Zivin 2019; Borjas and Doran 2012; Fry 2023; Myers 2020; Sohn 2021; Truffa and Wong 2022), there remains a gap in understanding the impact of academic environments. A rare exploration in this domain is the work of Truffa and Wong 2022, which examines the shift towards gender-related research in the context of coeducation from the 1960s to the 1990s. Our research diverges and adds a new dimension to this conversation by concentrating on a different facet of the gender-diverse academic environment: the female peers within PhD cohorts. The nature of these peer effects is shaped by the specific cohort dynamics (i.e. diffusion and competition), distinct from the institution-wide shifts accompanying coeducation. Within the micro-environment of a PhD cohort, interactions are more intense and concentrated around specific research activities. This close-knit nature amplifies peer influences on individual research directions, contrasting with the broader, more diffuse impact of increased undergraduate female enrollment.

Second, our paper adds to an active literature documenting the importance of gender peer effects in academic settings. A number of studies have demonstrated that students, especially females, benefit academically from an increase in the number of female peers in school (Anelli and Peri 2019; Bostwick and Weinberg 2022; Hoxby 2000; Lavy and Schlosser 2011; Mouganie and Wang 2020; Schneeweis and Zweimüller 2012). These studies span various educational levels and outcomes, including major selection and attrition

rates in high schools, colleges, and graduate programs. Some of them use similar empirical strategy, the quasi-random cohort female ratio. We expand the literature by specifically exploring how the gender composition of peers influences the research directions chosen by PhD students, an area less examined in current literature. Furthermore, while much of the existing research emphasizes the positive spillover effects of peer presence, there is a gap in understanding the negative spillover effect, i.e., how competitive dynamics among peers shape academic choices (Chen and Hu 2022). Theoretical frameworks suggest that heightened competition can reduce the propensity to engage collaborative or supportive behaviors (Drago and Garvey 1998). This aspect is particularly salient in PhD programs, where learning from and cooperating with peers are crucial for academic progress and research innovation (Teodoridis 2018; Wuchty, Jones, and Uzzi 2007). Our study introduces a novel dimension to the discourse on gender peer effects by highlighting how competition among PhD students, particularly between females and males, can lead to a reduced inclination towards gender-related research. Moreover, we documents that peer effects can work differently among females and males. In our study, females are affected by peers through collaboration and informal interactions, while males are affected by peers through competition pressure. This unique angle not only diversifies the current understanding of gender peer effects but also underlines the multifaceted nature of peer interactions in shaping academic trajectories.

Third, our research contributes to the literature that are trying to understand the relationship between diversity and innovation. Substantial research also has shown that racial, gender, and ethnic diversity of team members is linked to higher creativity and higher team performance (Hofstra et al. 2020; Yang et al. 2022). A series of studies suggest that the entrance of women in previously male-dominated fields can in influence research priorities and agendas (Koning, Samila, and Ferguson 2020, 2021; Nielsen et al. 2017). These studies focus mainly on the diversity of identity without causally identifying the effect of a diverse environment (Truffa and Wong 2022). Moreover, these studies typically do not examine the early, formative stages of a researcher's career. In contrast, our research situates itself within the realm of doctoral education. We explore how gender diversity within PhD cohorts has an impact the innovative directions of emerging scholars. This perspective is crucial given recent findings that highlight the negative implications of a toxic academic environment on female representation (Dupas et al. 2021; Wu 2020) and, by extension, on innovation. By examining the PhD setting, we shed light on how diversity at this critical juncture of academic career development can shape future research trajectories.

The remainder of this paper is structured as follows. Section 2 presents the data we use in our analysis. Section 3 describes our empirical strategy, with estimation results in Section 4. Section 5 discusses the mechanism. Section 6 concludes.

2 Data and Measurement

In this section, we describe the data and how we construct the key variables for empirical analysis.

2.1 PhD data: ProQuest Dissertations & Theses Global

ProQuest Dissertations & Theses Global Data[1] is the official offsite dissertation repository for the U.S. Library of Congress. It encompasses an extensive collection of U.S. PhD dissertations, spanning from 1985 to 2015. This database provides detailed metadata for each dissertation, including the student's name, advisors, committee members, institution, dissertation title, abstract, research subjects, and the date of degree conferral. These structural and semantic footprints enable us to scrutinize students' research focus at the very onset of their scholarly careers. Besides, the database's near-exhaustive coverage of U.S. PhD graduates enables us to comprehensively gather peer information within each academic program. Details of variable construction will be elaborated later.

For the current analysis, our dataset consists of 93,790 dissertations authored by healthcare or biology PhD recipients who graduated between 1985 and 2015 from 62 universities affiliated with the Association of American Universities. We restrict our sample on healthcare and biology due to the well-defined nature of gender-related research in these fields, a clarity that is less apparent in disciplines like mathematics and physics. Additionally, both healthcare and biology are at the forefront of innovation, making them ideal contexts to examine the impact of female peers on cutting-edge research.

2.2 Publications data: OpenAlex

OpenAlex is a comprehensive repository that contains more than 240 million published papers in various journals and conferences (Priem, Piwowar, and Orr 2022). It is worthwile to mentioning that OpenAlex includes a unique author identifier through a thorough name disambiguiation algorithm. Using key information such as PhD names, dissertation

1. https://www.proquest.com/.

titles, advisor names, affiliations, degree years, and research fields from the ProQuest database, we linked these details with publication records in the OpenAlex database.

2.3 Matching Algorithm

For PhD matching in these two datasets, we relies on the PhD names, dissertation titles, degree year in ProQuest data as well as paper, author, title, publication years information for each paper in OpenAlex. Note that we do not use the institution information to account for the case that PhD students may publish dissertation after graduation in a potentially different institutions.

We divide the matching algorithm into the following steps: First, we conduct a simple name cleaning algorithm to split the first and last name of authors and a simple paper title cleaning in both datasets. Second, for each PhD in ProQuest data, we extract any papers written by author with the exact same last name and at least the same first name initials (to account for nicknames and abbreviations), which we call these entries potential matches. For these potential matches, we restrict their published year no earlier than 5 years and no later than 10 years of PhD graduation. Third, we compute the similarity score between the titles of dissertation and published paper, select the best match conditional on a high threshold. We finally get 35,686 PhDs (about 25.9% of PhD recipients in our ProQuest sample) matched to OpenAlex data.

For finding the publication information for advisors, we rely on the advisor affiliations, exact last name, and initials of first name. We exclude the matches with research fields are different in two datasets.

2.4 Main Variables

In this section, we describe our classification of the gender of PhD students, assigning the field of research, how we group PhD into different cohorts, and construction of gender-related research.

Gender of PhD Recipients. Since the gender of PhD recipients is not provided in the ProQuest database, we classify the gender of the researcher by using PhD recipients' first names and Genderize.io[2], an API that has been employed by academia to identify gender and report its true positive probability of this classification (Huang et al. 2020; Koffi and Marx 2023; Topaz and Sen 2016). For example, the reported true positive probability is

2. https://genderize.io/

0.99 and 0.86 for "Paul" and "Hongyuan" as the first name to be identified as male. In the process, All 93,790 PhD recipients can be assigned to either female or male, and 81,302 PhD recipients (about 86.7%) can be assigned to one gender with a true positive rate no less than 0.9.

Cohort Female Ratio. Our principal independent variable is the cohort female ratio, which we define as the proportion of female students graduating in the same year within a given PhD program. Although the ProQuest database lacks explicit program information, it does include specific class or subject terms for each dissertation. These terms are categorized into 432 subject areas, which further align with 21 broader disciplines. For example, biology (subject number: 0306) and molecular biology (subject number: 0307) are subjects within the biological science disciplines. However, these subject terms, despite their specificity to research topics, may not accurately represent the actual academic programs of the PhD recipients.

To deal with this issue, we undertake a reclassification of these subject terms according to the first four digits of the CIP (Classification of Instructional Programs) code. The CIP framework provides a systematic approach for the effective tracking and reporting of various study fields and program completions[3]. Our reclassification process involves an initial Google search, where we pair each subject term with "CIP code" as keywords. This search aims to preliminarily align the subject terms with their corresponding CIP categories. Following the initial search results, we perform a manual verification to ensure the accuracy and relevance of the Google-derived classifications. This reclassification results in the consolidation of the subject terms into 182 distinct fields. With this refined classification, we define a "program" as a specific combination of a university and a field of study, and a "cohort" as the group of PhD graduates who completed their degrees in the same field and year at a particular university. For example, individuals who received their PhDs from Cornell University in the field of biological engineering in 2015 are classified as belonging to the same cohort.

Gender-Related Research (GRR). Our main outcome variables are whether the dissertation is gender-related research and the ratio of gender-related words of the dissertation. We use a similar keyword approach adopted by Truffa and Wong 2022. By using Datamuse API [4], a word-finding query search engine based on Google Books Ngrams data and other corpus-based datasets. We compile our baseline word list by selecting the top 20 most related words, such as "gender", "female", "women", and "sex", with the

3. https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=55
4. https://www.datamuse.com/api/

full list in Appendix A. We intentionally exclude male-related words because historically men are considered "standard" in research. The gender-related research is labeled as one if at least one of these keywords appears in either the title or the abstract. There are two advantages of this approach: (1) titles and abstracts are available for nearly all PhD recipients, which entitles a consistent measure of the gender-related research; (2) this approach can be applied broadly to all fields instead of only one or two fields in some existing work (Koning, Samila, and Ferguson 2020). Under such definition, a research paper is considered gender-related if the research topic is about women or it highlights analysis pertaining to gender or women. There are 6.4 percent of dissertations can be defined as gender-related. Two examples of gender-related dissertations with the corresponding titles and abstracts are provided in Appendix Figure C.1. Besides, to measure the intensity of gender relatedness for each dissertation, we compute the proportion of gender-related words in title and abstract, which is a continuous variable ranging from 0 to 1. However, we acknowledge potential concerns regarding to this approach. In particular, the non-agnostic nature of the keyword list could introduce bias. To mitigate this issue, we conduct several robustness checks by varying keyword list as in Appendix A.

Similar approach applies to classify published paper in OpenAlex, except we only use the title recorded in OpenAlex due to the large number of papers. For the PhD students and advisors in the matched data, they publish 25,280,890 papers in total. Approximately 2 percent of all papers are classified as gender-related. [5]

Based on that, we create three categories of variables: the first category is an indicator variable variable indicating whether the author does gender-related research, the second category is the share of gender-related research in all papers by the author, and the third category is the number of gender-related research papers. To account for potential delay in publication process and the lumpiness of number of published paper in a year, we construct four variables in wider time windows, that is, 6-10 years and 1 to 5 year before/after graduation.

Figure 1 visualizes the number of gender-related dissertation produced by female and male PhD students and the average cohort female ratio over time. Table 1 displays the summary statistics of all variables in our main specification.

5. This magnitude is comparable to applying a keyword approach only to titles in dissertations (i.e. 0.015).

Figure 1: Descriptive Stats: Number of Gender-Related Research and Cohort Female Ratio

(a) Number of Gender-Related Research **(b)** Mean of Cohort Female Ratio



Note: This figure shows the number of gender-related research and the mean of cohort female ratio from 1985 to 2015.

3 Empirical Strategy

In this section, we introduce the empirical specification in Section 3.1, discuss and provide evidence for our identification assumption in Section 3.2.

3.1 Empirical Specification

Our empirical strategy is essentially a difference-in-differences approach, comparing female and male PhD recipients between cohorts with a high fraction of female students and those with relatively low one within a given doctoral program, following

$$\begin{aligned} Y_{i,u,s,t} = f\Big(&\beta_0 + \beta_f \text{Female}_i \times \text{Cohort Female Ratio}_{u,s,t} \\ &+ \beta_m \text{Male}_i \times \text{Cohort Female Ratio}_{u,s,t} \\ &+ \gamma \text{Female}_i + \text{Controls}_{i,u,s,t} + \lambda_{u,s} + \psi_t + \epsilon_{i,u,s,t}\Big), \end{aligned} \tag{1}$$

where $Y_{i,u,s,t}$ is gender-related research related outcome, for example, an indicator equals one when the PhD student i, who graduated in year t with field s from university u, has a dissertation that is gender-related. We include the program fixed effects $\lambda_{u,s}$, where a program is defined as a university-field combination. The inclusion of $\lambda_{u,s}$ ensures that all the comparisons are within the same program. In other words, we do not rely on comparisons across different programs and only compare PhD students who are in the same program (university $\times$ field) but different cohorts. The year fixed effects ψ_t control

Table 1: Summary Statistics

	Female		Male	
Var.	Mean	S.D.	Mean	S.D.
Panel A: All PhDs	N=44830		N=48960	
Gender-Related Dissertation	0.0911	0.288	0.0387	0.193
Gender-Related Intensity	0.0010	0.004	0.0003	0.002
Cohort Female Ratio	0.5493	0.184	0.4119	0.160
Cohort Size	19.1094	15.546	19.8487	15.760
Advisor Gender-Related Research	0.4911	0.500	0.4270	0.495
Total Words (Title + Abstract)	185.8843	111.213	187.0898	110.976
Panel B: PhDs Matched to OpenAlex	N=16981		N=18888	
Gender-Related Dissertation	0.0875	0.283	0.0372	0.189
Gender-Related Intensity	0.0009	0.004	0.0003	0.003
Cohort Female Ratio	0.5513	0.184	0.4136	0.160
Cohort Size	19.7939	16.190	20.7577	16.525
Advisor Gender-Related Research	0.4911	0.500	0.4270	0.495
Total Words (Title + Abstract)	191.7149	115.142	191.3496	114.581
Num. of Papers				
5+ years before graduation	7.4069	76.482	9.9686	85.728
1-5 year before graduation	21.5110	205.614	28.0256	232.794
0-5 years after graduation	59.1056	502.407	76.1186	585.897
6-10 years after graduation	73.8258	625.225	94.3145	709.632
Num. of Gender-Related Papers				
5+ years before graduation	0.0858	1.032	0.0904	1.059
1-5 year before graduation	0.2834	2.870	0.2856	2.796
0-5 years after graduation	0.9793	8.214	0.9242	7.912
6-10 years after graduation	1.3741	11.790	1.2666	10.166

Notes. Each observation is at individual PhD level. Panel A includes all observations in our main estimation, and Panel B only include PhDs that are matched to the OpenAlex database. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Cohort Size* is the number of PhD students graduating in the same year within a given PhD program. *Advisor Gender-Related Research* is a binary variable which switches to one when the PhD's advisor has ever done some female-focused research. *Total Words (Title + Abstract)* is the number of words in the title and abstract of the PhD's dissertation. *Num. of Papers* and *Num. of Gender-Related Papers* is the number of all papers and the number of all female-focused papers, respectively, published in a given period.

for the overall time trend.

The primary variables of interest are the interaction terms of the PhD student i's gender indicator (i.e. Female_i and Male_i) and Cohort Female $\text{Ratio}_{u,s,t}$, which measures the percentage of student i's peers graduated from the same program (university u $\times$ field s) in year t who are female. We test the robustness of our main specification using several alternative measures of cohort female ratio, including the number of female peers in the

cohort, the ratio of women to men in the cohort, and the female ratio in the graduated and neighbor cohorts.

The coefficient β_f measures difference of probabilities of undertaking gender-related research for females in a higher versus lower cohort female ratio settings within the same PhD program. $\beta_f > 0$ implies a higher cohort female ratio results in more gender-related research production among female PhD students, and $\beta_f < 0$ suggests the opposite. Similar interpretation applies to β_m, which measures the effects of cohort female ratio on male PhD students. The signs of these estimates enable us to distinguish different mechanisms of peer effects: on one hand, increasing female representation in a cohort draw more attention and interest in female-related research topics, promote the formation of female-led research team, which stimulates more gender-related research; on the other hand, academic environment is rife with competition, for example, lab resource, research funds, and the attention from advisors, etc. In this way, a higher female share in the cohort may intensify the competition of execute gender-related research, which may even *crowd-out* the production of that.

In terms of our control variables, we add the research focus of PhD students' advisors (i.e. gender-related or not) as control variables to further alleviate the omitted variable bias stemming from faculty characteristics. An advisor's research interests can significantly shape a student's academic trajectory, potentially serving as a primary source of omitted variable bias. This influence is particularly evident when students select their PhD programs, often considering the research areas of potential advisors as a decisive factor. For instance, in many natural science disciplines, the admissions process is fundamentally a mutual selection between advisors and students. These students, in choosing this lab, are not only selecting a program but also aligning their future research with their advisor's expertise. Such scenarios underscore the importance of controlling for advisors' research focus, allowing us to more accurately isolate the effects of cohort gender composition on students' research directions towards gender-related topics. By doing so, we significantly reduce the potential bias introduced during the admission and advisor selection process. Other control variables include the size of the cohort and the number of total words in the title and abstract of each dissertation.

We choose linear probability model as our baseline specification because it enables us to employ program level and year fixed effects to control for the time-invariant characteristics of each program and the overall time trend. The interpretation of the implied marginal effects is also easier in this model. As an additional robustness check, we employ probit models when the outcome variable is a binary variable and conditional fixed effects

Poisson model with QML (quasi-maximum-likelihood) when the outcome variables are non-negative discrete variables (i.e., number of gender-related research).

3.2 Identification Assumption

Our identification strategy relies on the assumption that within a particular doctoral program, year-to-year variation in cohort gender composition is quasi-random and not correlated with other unobserved factors influencing the research focus of the PhD students within that cohort. More specifically, it exploits the inherent uncertainty faced by both admissions committees and prospective doctoral candidates regarding each cohort's gender composition. Although the admission committee of a doctoral program might aim for a particular gender balance, and incoming students may be aware of historical gender distributions, the exact gender composition of each new cohort remains unpredictable.

In this section, we further present several pieces of evidence supporting our identification strategy.

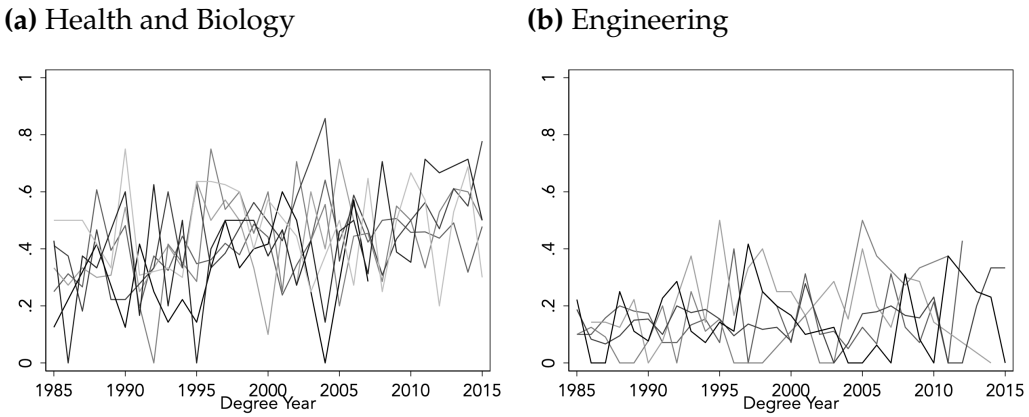
No Within-Program Path Dependency on Cohort Female Ratio. Our first evidence exploits the time series nature of cohort female variation in the program. One potential violation of this assumption could be some omitted variables that affect the gender ratio of a program and the research focus of the PhD students simultaneously. For example, a new female faculty member may attract more female students to the program while fostering students to do gender-related research at the same time.

A telling signal of this type of endogeneity would be any evidence of time trends in the cohort gender composition within programs. We visualize this assumption in Figure 2, where each line represents a trajectory of female ratio in a healthcare or biology PhD program of the Cornell University over time. As we can notice there are no clear upward or downward trends in gender composition in programs in healthcare and biology, especially in a relatively shorter time window.

To further rule out the concern that the year-to-year fluctuation of gender-related research conducted by faculty may drive the cohort female ratio fluctuations, we intentionally pick programs in engineering as a reference in Figure 2, where gender-related research, by its nature, is rare. In this setting, cohort female ratio is unlikely driven by faculty research focus, we can still observe very similar fluctuations for programs in engineering, despite that the unconditional mean of gender-related research is significantly lower than healthcare and biology.

We conduct a formal statistical test to rule out path dependency of female ratio within

Figure 2: Within-Program Female Ratio Fluctuations (Example: Cornell University)



Note: This figure keeps track the female ratio fluctuations within all PhD programs of (a) health and biology and (b) engineering in Cornell University.

the PhD program. First, we show that there is no statistically meaningful correlation of female ratio in adjacent years. Specifically, we estimate the following first-order auto-regression model of cohort female ratio,

$$\text{Cohort Female Ratio}_{u,s,t} = \alpha_0 + \alpha_1 \text{Cohort Female Ratio}_{u,s,t-h} + \lambda_{u,s} + \psi_t + \epsilon_{u,s,t}, \quad (2)$$

where $h = 1$, controlling program and year fixed effects $\lambda_{u,s}$ and ψ_t, respectively, with standard error clustered at university level. Appendix Table B.1 reports that $\widehat{\alpha}_1$ is not statistically distinguishable from 0 with a negligible magnitude, suggesting there is no path dependency in share of female students within a program in adjacent cohorts. Second, it is possible that PhD committee may pursue a balanced gender composition for all of the students enrolled in the program at a given year. If this argument were true, we should expect that the cohort gender ratio for new admitted cohort is very similar with that for graduated cohort, which may challenge our identification strategy. To rule out this concern, we revisit (2) by setting $h = 5$, a time length for a typical US PhD program, and test the null hypothesis that $\alpha_1 = 1$. Results in Appendix Table B.1 reject the null with p-value less than 1%. Lastly, we re-estimate these two regressions for PhD program in engineering. The result is very similar with those in healthcare and biology, ruling out the story that faculty gender-related research is the main cause of cohort female ratio fluctuations.

We also provide more direct evidence showing that the year-to-year fluctuation of gender-related research conducted by faculty doesn't drive the cohort female ratio fluctuations. We construct two variables to proxy the time-variant department research interest: *Department Past GRR* is the ratio of PhD advisors who have done GRR within 10 years be-

fore enrollment in the program, and *Department Future GRR* is proxied by the ratio of PhD advisors who have done GRR during PhD period in the program. Table B.2 shows that the cohort female ratio is not significantly correlated with neither the department past GRR or the department future GRR.

Monte Carlo Simulation. In the second test, we leverage the statistical distribution of cohort female ratio, by using the Monte Carlo simulation exercise as in the previous literature (Bostwick and Weinberg 2022; Lavy and Schlosser 2011; Mouganie and Wang 2020). The goal is to show that the observed within-program variation in gender composition in our data closely resembles the randomly generated variation from a binomial distribution. Specifically, for each doctoral program, we randomly generate the gender of the students in each cohort using a binomial distribution function Binomial(n, p). The parameter n equals the actual cohort size and p equals the average proportion of females in that program across all years. Then, we compute the within-program simulated standard deviation of the proportion of females over all years. We repeat this process over 1,000 iterations to obtain an empirical confidence interval for the standard deviation for each program. Our observed within-program standard deviation lies within the empirical 90% confidence interval for 91% of PhD programs in our sample, which further supports our assumption that the within-program, year-to-year variation in cohort gender composition is as good as random.

Randomization Test Using Linear-in-Mean Model. In the third test, we directly estimate a linear-in-mean model to show that cohort female ratio is as good as random within a program across years. Specifically, we estimate

$$\text{Female}_{i,u,s,t} = \theta_0 + \theta_1 \overline{\text{Female}}_{-i,u,s,t} + \theta_2 \overline{\text{Female}}_{-i,u,s} + \lambda_{u,s} + \psi_t + \epsilon_{i,u,s,t}, \tag{3}$$

where the dependent variable is an indicator for female student for individual i, the $\overline{\text{Female}}_{-i,u,s,t}$ represents the female ratio of all PhD in the same program and year other than individual i herself [6]. We follow the recommendation by Guryan, Kroft, and Notowidigdo 2009 by adding the leave-me-out mean for the entire program pooling the PhD students across all years, i.e. $\overline{\text{Female}}_{-i,u,s}$, to correct the bias for estimating θ_1, especially when the cohort size is relatively small. [7] We expect to see θ_1 is indistinguishable from

6. The previous literature also call it leave-me-out mean satisfying the following accounting identity: $\text{Female}_{i,u,s,t} = N\overline{\text{Female}}_{u,s,t} - (N-1)\overline{\text{Female}}_{-i,u,s,t}$, where N is the cohort size and $\overline{\text{Female}}_{u,s,t}$ is exactly the cohort female ratio.

7. Guryan, Kroft, and Notowidigdo 2009 shows that, without the this correction, even if the grouping or the selection into the same cohort is random, θ_1 is negatively biased and the bias is decreasing in the cohort size.

0, if our identification assumption is valid. Table B.3 reports the estimated θ_1, which is insignificant and does not depend on the inclusion of covariates.

4 Empirical Results

We present the main estimation result in Section 4.1 and discuss the results of robustness checks of that in Section 4.2. We further investigate the driving factor for these female peer effects

4.1 Main Result

Table 2 reports the impact of cohort female ratio on PhDs' research focus in their dissertations following the specification (1). We use two outcome variables: (i) a binary variable indicating whether the PhD's dissertation is gender-related in Columns (1) to (3), and (ii) the ratio of gender-related keywords in title and abstract to measure the gender relatedness of each dissertation in Columns (4) to (6).

Table 2: The Impact of Cohort Female Ratio on Gender-Related Dissertation Production

	Disertation			Intensity		
	(1)	(2)	(3)	(4)	(5)	(6)
Female Ratio	0.01777***			0.00011		
	(0.00632)			(0.00007)		
Female × Female Ratio		0.06075***	0.05845***		0.00066***	0.00065***
		(0.01068)	(0.01048)		(0.00013)	(0.00013)
Male × Female Ratio		-0.01978**	-0.02124***		-0.00038***	-0.00037***
		(0.00783)	(0.00791)		(0.00011)	(0.00010)
Program FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
R^2	.11	.11	.12	.091	.091	.096
Observations	93,790	93,790	93,790	93,790	93,790	93,790

Notes. Each observation is at individual PhD level. *Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. All estimation include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. *, ** and *** indicate statistical significance at 90%, 95% and 99% levels, respectively.

To start with, we observe a positive correlation between cohort female ratio and the propensity of doing gender-related research. More specifically, Columns (1) and (4) sug-

gest that, when the share of female peers increases 10 percentage points, PhD students in the same cohort are 0.17 percentage points (27% of the unconditional mean) more likely to do gender-related research, and the ratio of gender-related words in titles and abstracts increase by 0.0011 percentage point (17% of the unconditional mean). To unpack this effect, in other columns, we include the interaction terms of cohort female ratio with gender indicators. We uncover the differential effects of increasing cohort female ratio on producing gender-related research for female and male PhDs.

Column (2) suggests a 0.61 percentage point increase in probability of having a gender-related dissertation for female PhDs if there is 10% more females in the cohort. By contrast, such effect for male PhD, if anything, is negative, with the magnitude of 0.20 percentage decline. Result in Column (4) agrees with our findings using gender-related research intensity as the outcome. In Columns (3) and (6), we include the advisor's research focus, cohort size, and the number of words in title and abstract as controls variables. Reassuringly, the estimation results are very similar with the specification without these controls, which indirectly suggest that the main source of variation we exploit stems from the within-program cohort female ratio instead of other plausible driving forces.

4.2 Robustness Check

We conduct a series of robustness checks. By and large, these results confirm our main findings.

Classification of Gender. As we mentioned in Section 2, we don't have the gender information for each PhD recipient. We use the Genderize.io to classify the gender using the first name of each PhD recipient. As long as our classfication does not systematically misreport recipients to a specific gender, our estimates are unbiased since the error is random, though the standard errors for these estimates are inflated. Nonetheless, we rely on conduct robustness check utilizing the reported probability or confidence of that name being the assigned gender. We set different probability thresholds and only use the observation above these thresholds as our sample. Appendix Table B.8 reports similar results as Table 2.

Classification of Gender-Related Research. In the baseline result, we classify gender-related research based on any occurrence of gender-related research related keywords in either thesis title and abstract. We re-construct the dependent variable only based on title or abstract separately, and report the estimation results in Appendix Table B.9. Besides, in Appendix Table B.10, by using different keyword lists, we argue that our results are not

driven by deliberate choices of keywords to define the gender-related research. All the tests deliver similar results as those in Table 2.

Alternative Definitions of Female Peers. In our main specification, we define cohort female ratio as the share of student i's peers graduated from the same program in year t who are female. We construct several alternative measures of the cohort gender composition, including the number of female peers in the cohort, the ratio of female peers in the graduate and neighbor cohorts, and the ratio of females to males in the cohort. Table B.11 reports the results using different measures of cohort gender composition. Interestingly, these results show no evidence of a linear effect of the number of female peers in a program on the probability of doing gender-related research for either female or male PhDs. However, this finding is not inconsistent with the main results and merely indicates that the effect of an additional female peer interacts with the cohort size (e.g., one additional female peer has a large effect in a small cohort and little to no effect in a very large cohort). This interaction is better captured by the use of the percent female measure in the main specification. The effects of the ratio of female peers in the graduate and neighbor cohorts and the ratio of females to males in the cohort are similar as our main specification.

Empirical Specification and Model. In Appendix Table B.12, we report our results using alternative empirical specification. In Column (1), we further include field $\times$ year and university $\times$ year fixed effects to remove any potential university- or field-specific time trends. In Column (2), we replace the baseline fixed effects with program-specific linear time trend, which allows that different PhD programs can have different general trajectory of female ratio. The estimates of these two model specifications share the same economic and statistical significance as our baseline estimation. Moreover, we also estimate a probit model for the short-term effects when using binary variable as dependent variable. We acknowledge that adding strong fixed effects can result in biased estimates in the probit model. Reassuringly, the results in Column (3) is consistent with our main results. To mitigate the effect of adding too many binary variables in the probit model, we resort to replace the fixed effects with program-specific linear trend in Column (4). This modification yields similar results as Column (3). By and large, our main results are not driven by the empirical specification and model we utilize.

4.3 Heterogeneity

What determines the strength of these female peer effects towards female and male PhD within the same cohort? To investigate this question, we further divide our sample into

different groups based on several characteristics of advisors, fields and cohorts.

First, we divide the sample by whether the advisor of PhD student engages gender-related research or not. Our results in Table B.4 indicate that the female peer effects on PhDs' propensity to do gender-related research and gender relatedness of dissertations are stronger for those with advisors who are also doing gender-related research. This may suggest a certain degree of sorting effects, those PhD students with a gender-related research interest are more likely to choose advisors who have investigated these topics. When a PhD comes to decide which program to choose, they should take the research of their potential advisors into consideration. In fact, in many natural science fields, admission is mainly a process of advisors and students choosing each other. As a result, controlling the research focus of PhD students' advisors can help us to circumvent much omitted variable bias caused by the selection process during admission. This test justifies the inclusion of the advisor's research focus as a control variable.

Moreover, we further separate the doctoral studies into basic research and applied research based on the CIP code.[8] Applied research is more downstream and close to commercialization. These demand side factors can facilitate additional *pulling* effects on the production of gender-related research. In fact, Table B.5 uncovers stronger cohort effects between female peers for applied healthcare programs.

Lastly, we group our sample by the cohort size of the program. The female peer effects might be undermined in a larger cohort. For instance, PhD students are ranked in the cohort for scholarship, prizes and grants, which often have certain quotas; or the attention and support from department always focus on the top students. In this way, a larger cohort size implies more peer pressure, and thus discourage the dissipation of gender-related research. By mitigating this concern, Table B.6 compares the estimation of our main specification for larger and smaller cohorts. The estimates are similar across different cohort size, and, the effects of cohort female ratio are slightly stronger for larger cohorts.

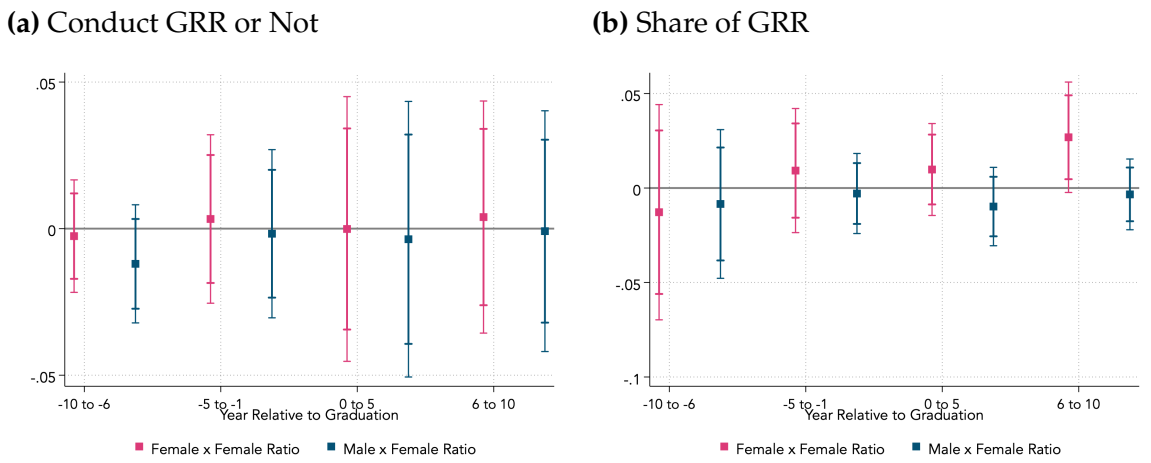
4.4 Long-Run Effects

Do the female peer effects during PhD have a long run impact on the direction of scientific research even after PhD graduation for these early-career scientists?

8. We classify programs as a basic research program if the program is a biology program with CIP code starting from 26 and an applied research program if the program is a healthcare program with CIP code starting from 51.

To investigate this question, we construct the variables for we estimate our main specification by replacing the dependent variables by (i) whether the individual conduct GRR or not to capture the extensive margin, (ii) proportion of GRR papers among all papers to highlight intensive margins. We construct these variables in different time horizons, from 10 years before to 10 years after PhD graduation using a 5-year time window. Estimated coefficients of $\widehat{\beta}_2$ and $\widehat{\beta}_3$ are shown in Figure 3.

Figure 3: Long Run Impact



Note: This figure shows long run impact of cohort female peer effects on the production of GRR, measured by a binary variable of conducting GRR or not (Panel A), and by the proportion of GRR relative to all papers (Panel B), for each time periods relative to graduation years: from -10 to -6, from -5 to -1, from 0 to 5, and from 6 to 10. Marker and bars represent our baseline point estimates and 95% and 99% confidence intervals. Pink and navy colors indicate coefficients for Female $\times$ Female Ratio ($\widehat{\beta}_2$) and Male $\times$ Female Ratio ($\widehat{\beta}_3$), respectively.

To begin with, the coefficients are neither economically and statistically significant six years before PhD graduation. These null results can serve as a placebo test for our main identification assumption, that is peer effects cannot take place before the start of PhD programs. In terms of long run result, we find that, female peer effects within cohort do not affect the choice of research focus, but on the intensive margin on the extensive margin, it does increase the share of GRR. A 10% increase of female ratio within the same PhD cohorts translates into 2.4% increase in share of GRR relative to all papers for female PhD students, even after 6 years of graduation. We do not see such impacts on male PhD students over all time horizons.

We further rule out that such selection into GRR for female students is not compensated by a lower quality of research (Hill and Stein 2019). To do so, we re-estimate this specification by changing the dependent variable as average number of paper citations for both GRR and non GRR. Appendix Figure C.2 shows that there are no significant changes

for average citation for both research types induced by cohort female ratio for PhD students regardless their gender. In Appendix Figure C.2, we show that our results are robust under several attrition by removing potential outliers and using different matching metrics and threshold to merge OpenAlex and ProQuest.

5 Mechanism

Why women are more likely to do gender-related research when they have more female peers, while men are less or negatively affected by more female peers? On one hand, the positive effects may stem from enhanced learning opportunities and knowledge diffusion. However, the effects of female peers can have negative effects that arise from increased competition.

Motivated by these two competing forces, in this section, we outline several mechanisms: (i) formal interactions, such as collaboration between PhDs and their female peers; (ii) informal interactions within the PhD cohorts; (iii) changing competition visibility among peers in doing gender-related research. Our goal for this analysis is two-fold: (i) confirm the existence of these spillover effects, and (ii) elucidate the specific conditions under which one effect may predominate over the other.

5.1 Collaboration with Female Peers

Increasing female peers within the cohort potentially expands the pool of prospective female collaborators for PhD students. This may possibly foster the formation of female-dominant research teams due to homophily, the concept of "birds of a feather flocking together", defined as the tendency for individuals to gravitate towards and collaborate with others who share similar characteristics, including gender. [9] Meanwhile, increasing representation of women could crowd out the formation of mixed gender team, which may explain the observed differences in spillover effects between male and female PhD students within the same cohort. We report the empirical results for this collaboration channel in Table 3.

To test this hypothesis, we categorize a paper based on whether it is produced by a female-dominant team, where there are more women than men. We compute the number

9. Gender homophily has also been noted in investment and other sectors (Greenberg and Mollick 2017; Stolper and Walter 2019; Zeltzer 2020; Zhou, Chai, and Freeman 2024), suggesting that women may prefer to collaborate with other women, while men may be less inclined to partner with female peers.

Table 3: Mechanism - Collaboration

	GRR		Non GRR	
	(1) F-Dom Team	(2) M-Dom Team	(3) F-Dom Team	(4) M-Dom Team
Female × Female Ratio	0.03603**	-0.03073***	-0.08078***	-0.03462
	(0.01463)	(0.01162)	(0.02200)	(0.02610)
Male × Female Ratio	-0.03904***	0.02926**	0.09170***	0.00283
	(0.01166)	(0.01351)	(0.02049)	(0.01676)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	.28	.37	.61	.55
Observations	35,686	35,686	35,686	35,686

Notes. Each observation is at individual PhD level. *GRR* and *Non GRR* indicates gender-related papers and non gender related paper. Column (1) and (3) use number of GRR in female-dominant and male-dominant teams as dependent variables, while Column (2) and (4) use number of non GRR in these teams. *Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. All estimation include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. *, ** and *** indicate statistical significance at 90%, 95% and 99% levels, respectively.

of GRR and non GRR produced in female- and male-dominant teams within 5 years after PhD graduations and use them as dependent variables to re-estimate our main empirical specifications 1. Results are reported in Table 3.

Column (1) suggests that, for every 10 percentage points increase in the female ratio within a cohort, for female students, there is a corresponding 0.36 percentage points rise in the probability to have at least one gender-related paper published in female-dominant teams but a 0.39 percentage points decrease in that for male student. As a stark contrast, we find the opposite result in male-dominant team, that is, stronger female peer effects discourages female but encourages male to create GRR in male dominant teams. Turning into non GRR, we find the impact of homophily for women vanishes.

5.2 Informal Interactions with Female Peers

Beyond formal collaboration, female peers may have an impact on a student's research direction via informal interactions. In the context of a PhD program, students are immersed in class discussions, out-of-class activities, and casual conversations. The literature on knowledge transfer and idea generation increasingly recognizes the vital role of these informal interactions. Studies have shown that informal interactions, often facilitated by

physical proximity, are key drivers in the dissemination of ideas and knowledge within localized academic or professional communities (Atkin, Chen, and Popov 2022; Chai and Freeman 2019; Hasan and Koning 2019; Roche, Oettl, and Catalini 2023).

While it is challenging to catalog and directly test the impact of all these diverse forms of informal interaction, our study aims to provide suggestive evidence of this mechanism. One of the special features for biology and healthcare doctoral programs is that students are divided into labs to conduct experiments. For those working in the same lab, interactions occur daily or weekly, which are more likely to facilitate knowledge diffusion and thus provide support in pursuing gender-related ideas. Motivated by this feature, we group students sharing the same advisor as in the same lab. Specifically, we estimate the empirical specification 1 by adding further interacting the interaction terms with a binary variable indicating whether there are other female students in the same lab.

Table 4 reveals that female peer effects are especially stronger for female PhD students when other female peers are present in the same lab (coefficient $= 0.028$, p-value < 0.10). Besides, for male PhD students, the coefficient of this triple interaction is positive in terms of producing gender-related research but not significant. By examining the moderating effects of the presence of female peers in the same lab, we provide evidence on the role of informal interactions within the lab in shaping research trajectories.

5.3 Competition Visibility

The academic environment is inherently competitive, particularly in the race to publish novel papers (Hill and Stein 2019). Influenced by a relatively larger number of female peers in the cohort, PhD students, for instance, begin to focus on female reproductive health, thereby intensifying the perceived competition for innovative findings and prestigious publication slots. Male researchers, who might be less familiar with or adept at producing research in gender-related topics, could perceive this heightened competition as a significant barrier. As we mentioned above, we assume that female has comparative advantage in doing gender-related research. When a promising female academic steps into the domain of such research, male PhDs may find it challenging to compete directly with their female counterparts.

To test this channel, we use the presence of *star* researchers as a proxy for the severity of competition. While we don't have the academic records data for each PhD student, we use the linked data to measure whether a PhD student is strong in terms of the ability to do academic research. For each linked PhD student, we calculate their average number

Table 4: Mechanism - Informal Interactions

	(1) Dissertation	(2) Intensity
Female × Female Ratio	0.05138***	0.00054***
	(0.01022)	(0.00013)
Female × Female Ratio × Female Peer w. Same Advisor	0.02778*	0.00047*
	(0.01562)	(0.00025)
Male × Female Ratio	-0.02347***	-0.00043***
	(0.00817)	(0.00010)
Male × Female Ratio × Female Peer w. Same Advisor	0.01576	0.00037
	(0.01757)	(0.00025)
Program FE	Yes	Yes
Year FE	Yes	Yes
R^2	.12	.097
Observations	93,790	93,790

Notes. Each observation is at the individual PhD level. *Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Female Peer w. Same Advisor* is a binary variable indicating to whether PhD shares the same advisor with another female peer in the same cohort. All estimation include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. *, ** and *** indicate statistical significance at 90%, 95% and 99% levels, respectively.

of forward citations for papers published within five years after graduation. Those who are not linked in OpenAlex are unlikely to publish paper during PhDs. We assume those PhDs have average citations among top 10 percent or top 25 percent in their field are stars. Then, we construct a binary variable indicating whether there are female stars carrying out gender-related research for each cohort. We interact this binary variable with the existing interaction terms and re-estimate our specification 1. As shown in Table 5, the negative effects of cohort female ratio for male PhD students are much stronger when there are female stars who are doing gender-related research (coefficient $= -0.107$, p-value < 0.05). In contrast, there is no discernible effect for female PhD students induced by this increasing competition visibility. Collectively, this result indicates that male PhD students shy away from pursuing gender-related research in the presence of fiercer competition of doing that.

Table 5: Mechanism - Competition

	Dissertation		Intensity	
	(1) Top 10%	(2) Top 25%	(3) Top 10%	(4) Top 25%
Female × Female Ratio	0.04376***	0.04257***	0.00051***	0.00051***
	(0.01027)	(0.01023)	(0.00013)	(0.00013)
Female × Female Ratio × Cohort Female Star	0.03395	0.03515	0.00032	0.00029
	(0.03098)	(0.02713)	(0.00042)	(0.00038)
Male × Female Ratio	-0.01270*	-0.01147	-0.00029***	-0.00026***
	(0.00728)	(0.00718)	(0.00009)	(0.00009)
Male × Female Ratio × Cohort Female Star	-0.10718***	-0.08515**	-0.00106**	-0.00097**
	(0.03758)	(0.03321)	(0.00047)	(0.00041)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	.12	.12	.097	.097
Observations	93,790	93,790	93,790	93,790

Notes. Each observation is at individual PhD level. *Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Cohort Female Star* is a binary variable indicating whether star female student presents in the same cohort. Female star is defined as individuals with citation in the top k-% of the field and is doing GRR in her dissertation, Note that $k = 10$ for Columns (1) and (3), and $k = 25$ for Columns (2) and (4). All estimation include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. *, ** and *** indicate statistical significance at 90%, 95% and 99% levels, respectively.

6 Conclusion

In this paper, by exploiting year-to-year quasi-random variation of cohort female, we estimate the causal effects of cohort female ratio on PhD students' choices of research topics, i.e., gender-related research. We find that a higher share of female peers in the cohort fosters female PhD students undertake gender-related researct, but backfires male PhD students to do that. Such cohort female peer effects have a long-lasting impact up to five years after PhD graduation. We shed light on the channel accounting for the differential effects across gender: the positive spillover effects among female students are primarily attributed to collaborations and informal interactions with female peers; conversely, the diminished or negative effects observed in male students appear to stem from competitive pressures. Not only do these channels confirm the existence of knowledge diffusion and competitive dynamics, but they also unravel the specific conditions that amplify or mitigate these effects.

Our study delivers important implications for policies that aim to address the *"Missing Marie Curies"*, that is, the underrepresentation of women and minority group in higher education. Despite our paper is not intended to provide detailed policy recommendation, our results advocates policies to create a more collaborative and less competitive atmosphere, and to encourage scholars of all genders to contribute to research in gender-related issues.

Some caveats for future research are in order. First, our paper mainly focuses on the supply side of gender-related research in the university, and the peer effects can be an amplifier for this supply channel. However, demand side factors, such as public funding, opportunities of commercialization, and social awareness, can also serves as the panacea for the scarcity of gender-related research, which we fall short to address in this paper; second, our paper is silent in the macroeconomic effect of increasing female representation and related female peer effects through directing research to gender-related topics (Brouillette 2021) and reducing the misallocation of talents (Hsieh et al. 2019). In particular, the welfare improvement might be uneven since gender-related research might benefit women population more. Lastly, future researchers might find value in incorporating survey-based data sources, not necessarily restricted to Survey of Earned Doctorates, in order to enhance our understanding of underlying mechanism of divergent female peer effects within PhD cohorts.

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A Data Appendix

A.1 Keywords List

- Baseline List: woman, female, lady, feminism, feminine, femininity, girl, pregnancy, pregnant, gender, sex , wife, daughter, mother;
- Short List: woman, female, sex, gender;
- Extended List: woman, female, lady, feminism, feminine, femininity, girl, pregnancy, pregnant, gender, sex , wife, daughter, mother, gynecological, gynecology, menopause, menstruation, menstrual, urinary tract, vaginosis, vaginitis, uterine fibroids, pregnant, pregnancy, preterm, endometriosis, ovary, ovarian, cervical, turner syndrome, rett syndrome.

B Table Appendix

Table B.1: Robustness Test - First Order Auto-Regression

	(1)	(2)	(3)	(4)
	Cohort Female Ratio			
	Health & Bio	Engineering	Health & Bio	Engineering
Cohort Female Ratio (1-Year Lag)	0.00171	0.00314		
	(0.00783)	(0.01270)		
Cohort Female Ratio (5-Year Lag)			-0.01266	-0.01824
			(0.01121)	(0.01374)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
p-value: H_0			<0.01	<0.01
Adj. R^2	0.39	0.22	0.37	0.21
Obs.	9,954	8,088	8,627	6,909

Notes. This table shows the estimation results of first-order auto-regression 2, where $h = 1$ for Column (1) and (2), and $h = 5$ for Column (3) and (4). Standard errors in parentheses are clustered at the university level. The last two columns report the p-value for null-hypothesis of autocorelation coeffcient $\beta = 1$.

Table B.2: Randomization Test - Department GRR Experience and Funding

	(1)
	Female Ratio
Department Past GRR	0.01321
	(0.01789)
Department Future GRR	-0.00269
	(0.01833)
Program FE	Yes
Year FE	Yes
Adjusted R-squared	0.426
Observations	9431

Notes. Each observation is at cohort level. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Department Past GRR* is the ratio of PhD advisors who have done GRR within 10 years before enrollment in the program. *Department Future GRR* is proxied by the ratio of PhD advisors who have done GRR during PhD period in the program. Standard errors in parentheses are clustered at the program level.

Table B.3: Randomization Test (Guryan, Kroft, and Notowidigdo 2009)

	(1)	(2)
	Female	
$\overline{\text{Female}}_{-i,u,s,t}$	0.00651	0.00572
	(0.01210)	(0.01205)
$\overline{\text{Female}}_{-i,u,s}$	-13.40353***	-13.39283***
	(1.15045)	(1.15023)
Program FE	Yes	Yes
Year FE	Yes	Yes
Controls		Yes
Adj. R^2	.17	.17
Obs.	93,539	93,539

Notes. Each observation is at individual PhD level. *Female* is an indicator variable for female PhD. $\overline{\text{Female}}_{-i,u,s,t}$ and $\overline{\text{Female}}_{-i,u,s}$ are the leave-me-out mean of females at the cohort and program level. Column (2) add controls as the baseline specification 1. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.4: Heterogeneity Test - Advisors' Research Focus

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation		Gender-Related Intensity	
	Advisor - Gender-Related	Advisor - Not Gender-Related	Advisor - Gender-Related	Advisor - Not Gender-Related
Female × Cohort Female Ratio	0.06999***	0.03061***	0.00076***	0.00033**
	(0.01598)	(0.01073)	(0.00020)	(0.00016)
Male × Cohort Female Ratio	-0.04500***	0.01147	-0.00075***	0.00010
	(0.01314)	(0.00739)	(0.00017)	(0.00011)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Mean of D.V.	0.10603	0.02815	0.00107	0.00027
Adjusted R-squared	0.127	0.099	0.096	0.104
Observations	42882	50838	42882	50838

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Advisor - Gender-Related* indicates the PhD's advisor has done gender-related research and *Advisor - Not Gender-Related* indicates the PhD's advisor hasn't done any gender-related research. All models include controls for the gender dummy, cohort size, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.5: Heterogeneity Test - Field Difference

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation		Gender-Related Intensity	
	Basic Research	Applied research	Basic Research	Applied research
Female × Cohort Female Ratio	0.00628	0.07469***	-0.00000	0.00064**
	(0.00849)	(0.02282)	(0.00009)	(0.00028)
Male × Cohort Female Ratio	0.00421	-0.02316	0.00004	-0.00070**
	(0.00656)	(0.02090)	(0.00007)	(0.00028)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Mean of D.V.	0.03441	0.15786	0.00027	0.00181
Adjusted R-squared	0.055	0.115	0.040	0.080
Observations	71466	22322	71466	22322

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Basic Research* indicates the PhD graduates from a biology program with CIP code 26 and *Applied* indicates the PhD graduates from a healthcare program with CIP code 51. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.6: Heterogeneity Test - Cohort Size

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation		Gender-Related Intensity	
	Cohort Size < 15	Cohort Size ≥ 15	Cohort Size < 15	Cohort Size ≥ 15
Female $\times$ Cohort Female Ratio	0.04827***	0.07370***	0.00045***	0.00103***
	(0.01215)	(0.02193)	(0.00015)	(0.00029)
Male $\times$ Cohort Female Ratio	-0.01201	-0.05410***	-0.00027**	-0.00075***
	(0.00846)	(0.01590)	(0.00011)	(0.00021)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Mean of D.V.	0.07726	0.04852	0.00078	0.00048
Adjusted R-squared	0.128	0.116	0.101	0.093
Observations	49846	43941	49846	43941

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. All models include controls for the gender dummy, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.7: Robustness Test - OpenAlex Matched Sample

	(1) Gender-Related Dissertation	(2) Gender-Related Intensity
Female × Cohort Female Ratio	0.04354***	0.00035*
	(0.01522)	(0.00019)
Male × Cohort Female Ratio	0.00805	-0.00012
	(0.01230)	(0.00018)
Program FE	Yes	Yes
Year FE	Yes	Yes
Gender Dummy	Yes	Yes
Controls	Yes	Yes
Mean of D.V.	0.04603	0.00043
Adjusted R-squared	0.134	0.148
Observations	24330	24330

Notes. Each observation is at individual PhD level and we only include observations of PhDs that are matched to OpenAlex database. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year).Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.8: Robustness Test - Female Classification

	(1)	(2)	(3)	(4)	(5)	(6)
	Gender-Related Dissertation			Gender-Related Intensity		
	Prob $\geq$ 0.85	Prob $\geq$ 0.90	Prob $\geq$ 0.95	Prob $\geq$ 0.85	Prob $\geq$ 0.90	Prob $\geq$ 0.95
Female $\times$ Cohort Female Ratio	0.06070***	0.06260***	0.06363***	0.00069***	0.00069***	0.00071***
	(0.01119)	(0.01147)	(0.01202)	(0.00014)	(0.00014)	(0.00015)
Male $\times$ Cohort Female Ratio	-0.02425***	-0.02468***	-0.02779***	-0.00040***	-0.00039***	-0.00044***
	(0.00832)	(0.00849)	(0.00880)	(0.00011)	(0.00012)	(0.00013)
Program FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean of D.V.	0.06592	0.06623	0.06575	0.00066	0.00066	0.00066
Adjusted R-squared	0.124	0.125	0.125	0.098	0.098	0.099
Observations	84313	81302	76389	84313	81302	76389

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Prob* is the probability that the gender classification is reliable. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.9: Robustness Test - Gender-Related Research Definition (Title or Abstract)

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation		Gender-Related Intensity	
	Only Title	Only Abstract	Only Title	Only Abstract
Female × Cohort Female Ratio	0.02120***	0.05563***	0.00163***	0.00052***
	(0.00475)	(0.01026)	(0.00042)	(0.00012)
Male × Cohort Female Ratio	-0.01188***	-0.02213***	-0.00105***	-0.00037***
	(0.00348)	(0.00769)	(0.00028)	(0.00010)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Mean of D.V.	0.01542	0.06126	0.00119	0.00056
Adjusted R-squared	0.059	0.118	0.053	0.096
Observations	93790	93790	93790	93790

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in either title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Prob* is the probability that the gender classification is reliable. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.10: Robustness Test - Gender-Related Research Definition (Word List)

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation		Gender-Related Intensity	
	Short List	Extended List	Short List	Extended List
Female × Cohort Female Ratio	0.05512***	0.06303***	0.00060***	0.00077***
	(0.00989)	(0.00571)	(0.00011)	(0.00007)
Male × Cohort Female Ratio	-0.01918***	-0.01771**	-0.00031***	-0.00045***
	(0.00723)	(0.00436)	(0.00009)	(0.00005)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Mean of D.V.	0.05346	0.07181	0.00050	0.00083
Adjusted R-squared	0.123	0.044	0.089	0.039
Observations	93790	93790	93790	93790

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our alternative keyword lists in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Prob* is the probability that the gender classification is reliable. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.11: Robustness Test - Cohort Female Ratio

	(1)	(2)	(3)	(4)	(5)	(6)
	Gender-Related Dissertation			Gender-Related Intensity		
Female × Num. of Female Peers	0.00025			0.00000		
	(0.00044)			(0.00001)		
Male × Num. of Female Peers	0.00038			0.00000		
	(0.00035)			(0.00000)		
Female × Cohort Female Ratio (Neighbor included)		0.07188***			0.00100***	
		(0.01657)			(0.00022)	
Male × Cohort Female Ratio (Neighbor included)		-0.05891***			-0.00079***	
		(0.01359)			(0.00019)	
Female × Female-to-Male Ratio			0.00484***			0.00004*
			(0.00152)			(0.00002)
Male × Female-to-Male Ratio			-0.00791***			-0.00014***
			(0.00190)			(0.00002)
Program FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Gender Dummy	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Mean of D.V.	0.06379	0.06379	0.06379	0.00064	0.00064	0.00064
Adjusted R-squared	0.122	0.123	0.118	0.096	0.097	0.094
Observations	93790	93790	92565	93790	93790	92565

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Num. of Female Peers* is the number of female peers in the cohort, *Cohort Female Ratio (Neighbor included)* is the ratio of female peers in the graduated and neighbor cohorts, and *Female-to-Male Ratio* is the ratio of females to males in the cohort. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract), and fixed effects (program and year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

Table B.12: Robustness Test - Alternative Models

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation			
Female × Cohort Female Ratio	0.05511***	0.05934***	0.01667***	0.01746***
	(0.01025)	(0.01051)	(0.00522)	(0.00522)
Male × Cohort Female Ratio	-0.02608***	-0.02068***	0.00324	0.00353
	(0.00877)	(0.00788)	(0.00585)	(0.00587)
Model	OLS	OLS	Probit	Probit
Program FE	Yes		Yes	
Year FE			Yes	
University× Year FE	Yes			
Field× Year FE	Yes			
Program Linear Trend		Yes		Yes
Adj. R^2	0.12	0.11		
Obs.	93,749	93,790	88,695	88,697

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Gender-Related Intensity* is the ratio of gender-related words in title and abstract of each dissertation. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract). Column(1) and (2) are estimated using OLS, while Column (3) and (3) are estimated using Probit. Column (1) and (4) control for program-specific linear trend (indicator of program interacted with year). Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

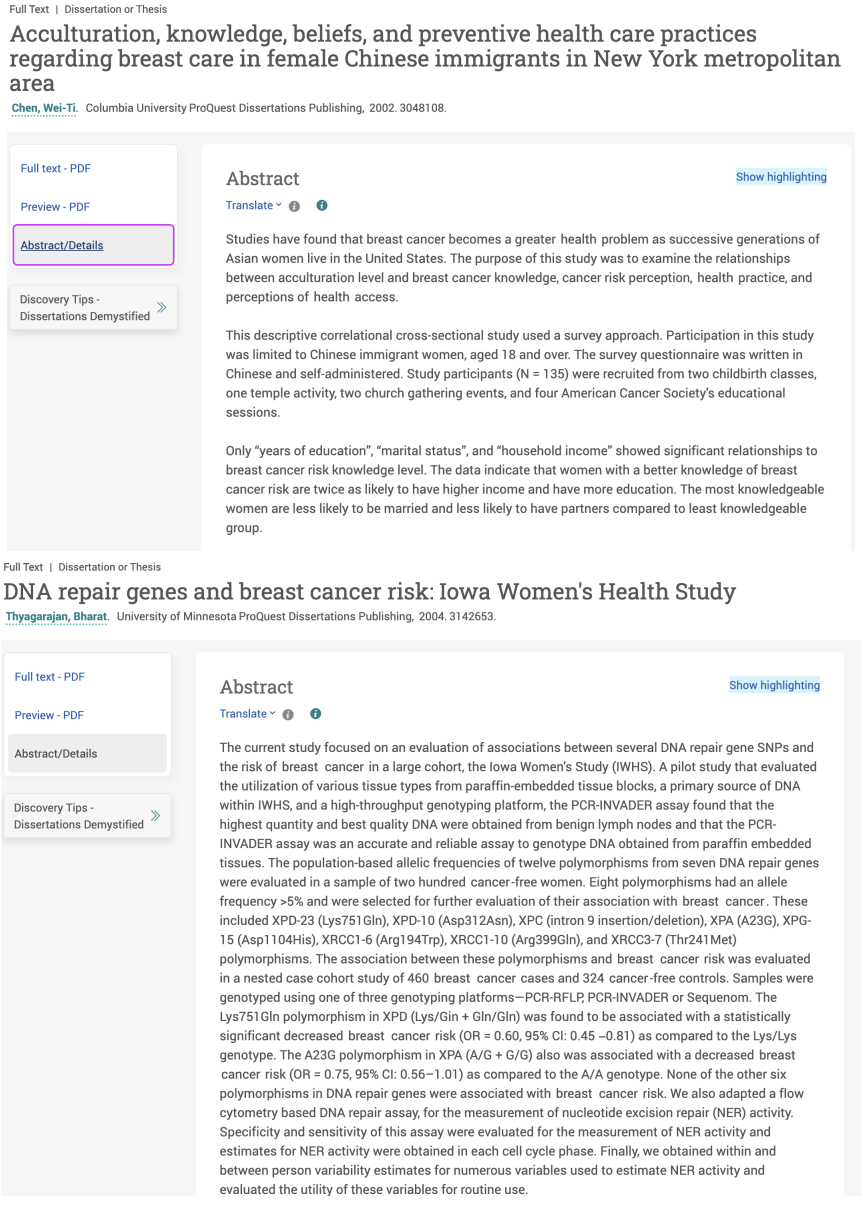
Table B.13: Robustness Test - Effects of Advisors or Peers?

	(1)	(2)	(3)	(4)
	Gender-Related Dissertation			
Female × Cohort Female Ratio	0.05903***	0.06614***	0.04476***	0.06132***
	(0.01052)	(0.01322)	(0.01004)	(0.01294)
Male × Cohort Female Ratio	-0.02048***	-0.02693***	-0.00700	-0.00969
	(0.00772)	(0.01008)	(0.00781)	(0.00978)
Advisor's Past GRR				
Advisor Past GRR	0.02748***	-0.00350	0.02341**	0.01332
	(0.00361)	(0.00612)	(0.00917)	(0.01184)
Female × Cohort Female Ratio × Past GRR			0.02193	-0.03033
			(0.01858)	(0.02438)
Male × Cohort Female Ratio × Past GRR			-0.01368	-0.03829
			(0.02161)	(0.02761)
Advisor's Future GRR				
Advisor Future GRR	0.05262***	0.01748***	0.05360***	0.01933
	(0.00411)	(0.00585)	(0.00963)	(0.01317)
Female × Cohort Female Ratio × Future GRR			0.02964	0.02704
			(0.02003)	(0.02732)
Male × Cohort Female Ratio × Future GRR			-0.04877**	-0.04718
			(0.02139)	(0.03114)
Program FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Advisor FE	No	Yes	No	Yes
Adjusted R-squared	0.131	0.440	0.132	0.440
Observations	93790	63086	93790	63086

Notes. Each observation is at individual PhD level. *Gender-Related Dissertation* is an indicator variable which equals to one if the dissertation contains any gender-related words as defined in our keyword list in title or abstract. *Cohort Female Ratio* is the proportion of female students graduating in the same year within a given PhD program. *Advisor GRR Experience* is whether the PhD advisor has done GRR within 10 years before the PhD's enrollment in the program. *Advisor GRR Funding* is proxied by whether the PhD advisor has done GRR during the PhD period in the program. All models include controls for the gender dummy, cohort size, advisor's research focus, total number of words in title and abstract). All models are estimated using OLS. Standard errors in parentheses are clustered at the program level. $*p < 0.10$; $**p < 0.05$; $***p < 0.01$.

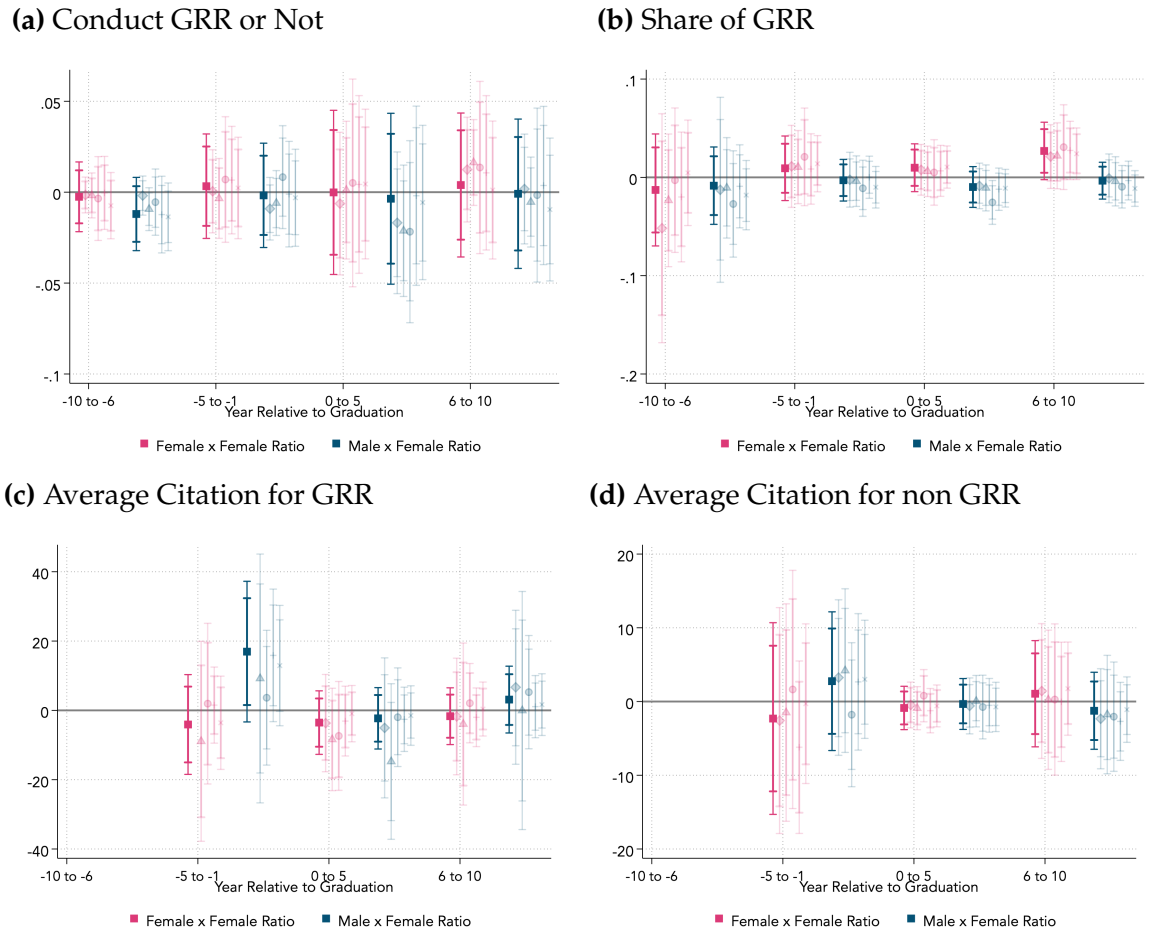
C Figure Appendix

Figure C.1: Example of Gender-Related Dissertation



Notes. The figures shows titles and abstracts of two gender-related dissertations in the ProQuest Database.

Figure C.2: Robustness Check: Long Run Impact



Note: This figure shows the robustness check for the long run impact. For each panel, the solid, non-transparency marker and bars represent our baseline point estimates and 95% and 99% confidence intervals, for each time periods relative to graduation years: from -10 to -6, from -5 to -1, from 0 to 5, and from 6 to 10. Pink and navy colors indicate coefficients for Female $\times$ Cohort Female Ratio and Male $\times$ Cohort Female Ratio, respectively. For other transparency markers with difference shapes and related bars display the results for robustness checks, from left to right: (i) diamond for remove unreliable observations that have publication records long before start of PhD, (ii) triangle for restricting on the sample with individuals publish no more than 10 papers per year, (iii) circle restrict the sample for individuals graduated before 2010 to allow more accurate count for 6 to 10 years publications (iv) plus sign for using Jaccard distance as alternative metric when matching ProQuest and Openalex (v) cross sign for changing the threshold for matching from 0.8 to 0.9. Regression results with less than 400 observations are excluded due to small sample bias and large and meaningless confidence intervals.