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Looking Beyond Representation: Gender Inequities in Research Attrition, Output, Leadership, and Collaboration in Chilean Education Researchers' Career Trajectories

Lorena Ortega¹, Carolina Guzmán-Valenzuela², Matías Montero¹,
Diego Palacios^{3, 4, 5}, and Francisca Ortiz Ruiz^{6, 7}

¹ CIAE, Instituto de Estudios Avanzados en Educación, Universidad de Chile

² Facultad de Educación y Humanidades, Universidad de Tarapacá

³ Society and Health Research Center, Universidad Mayor

⁴ Millennium Nucleus for the Evaluation and Analysis of Drug Policies, Santiago, Chile

⁵ Millennium Nucleus on Sociomedicine, Santiago, Chile

⁶ Centro de Economía y Políticas Sociales, Facultad de Ciencias Sociales y Artes, Universidad Mayor

⁷ Millennium Institute for Care Research, Santiago, Chile

Despite a more favorable representation of women in highly feminized academic fields, such as education, gender disparities manifest themselves across different dimensions of faculty work and unfold over the course of research careers. In this study, we focus on the role of gender in shaping the careers of Chilean education researchers. Using survival, Poisson regression, and social network analyses, we examined gendered patterns of attrition, research output, first authorship, and coauthorship across researchers' career trajectories. Bibliometric data were analyzed for the 5,702 authors who published articles in Scopus-indexed education journals between 2011 and 2021 while affiliated with a Chilean institution. Our results show that, despite similar initial representation, being a female researcher increases attrition hazard by 21.5%, with women at the beginning of their research career being particularly at risk of attrition. We also found a significant gender gap in the number of articles published, with Chilean female education researchers publishing, on average, 20.8% fewer articles than male researchers, a disparity that increases in magnitude with years of research experience. However, there were no significant gender differences in research leadership (i.e., first authorships). In relation to collaboration profiles, female researchers showed significantly fewer coauthorships and were more likely to engage in national collaborations when compared to male researchers, who tended to develop more international (both regional and nonregional) collaboration profiles. Furthermore, coauthorship patterns showed significant levels of gender and research experience homophily. Possible explanations pertaining to structural barriers faced by female researchers and policy implications are discussed.

Keywords: gender, academia, research career, survival analysis, exponential random graph models

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Despite the increased participation of women in higher education and academia, gender disparities prevail in research outputs and trajectories (United Nations Educational, Scientific and Cultural Organization, 2021). Gender gaps in research have been largely investigated in the fields of science, technology, engineering, and

mathematics (hereinafter STEM fields), where the underrepresentation of women is more salient (Thébaud & Charles, 2018). In contrast, gender disparities in highly feminized disciplines,¹ such as education, have been relatively understudied. This, despite the fact that the overrepresentation of women in certain fields of study does not necessarily translate into more gender-equal relational dynamics, career development, and organizational cultures in these spaces (Acker, 1990; Muñoz-García et al., 2023).

Indeed, previous studies suggest that female researchers in highly feminized fields also face gender bias and disparities in hiring, peer review, citation, grant funding, and acceptance at scholarly journals,

¹ Throughout the article, we use the terms “feminized fields” and “feminized disciplines” to refer to knowledge areas in which women are typically overrepresented relative to men due to gender-stereotyped study and career choices that result in horizontal segregation. In upper secondary and tertiary education, women tend to lag behind men in participation in STEM fields and are more likely to choose study areas such as education and health. This is a widespread and persistent phenomenon in most Western countries, including Chile (Barone & Assirelli, 2020; Bordón et al., 2020).

Lorena Ortega  <https://orcid.org/0000-0002-6471-0277>

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Correspondence concerning this article should be addressed to Lorena Ortega, CIAE, Instituto de Estudios Avanzados en Educación, Universidad de Chile, Periodista José Carrasco Tapia 75, Santiago, Chile. Email: lorena.ortega@ciae.uchile.cl

which directly affect their academic productivity and career progression (Shen, 2013). Furthermore, available evidence in highly feminized academic fields suggests that structural gender inequities manifest and unfold throughout the research life course (Silander et al., 2013). Such disparities are often associated with the unequal division of academic labor, with women taking on significantly more teaching and tutoring duties (Belluigi et al., 2023) and academic service responsibilities compared to men (Hanasono et al., 2019) and with the unequal involvement of male and female researchers in domestic and care work (Cervia & Biancheri, 2017). This, in turn, can lead to gender gaps in research production, leadership and collaboration, and, consequently, in academic promotion and salaries (Winslow & Davis, 2016). Therefore, it is key to investigate research careers from a gender perspective, incorporating the notion of temporality by using longitudinal approaches (Selva et al., 2011).

In Latin America, the number of social sciences research publications has been growing spectacularly in the last decade, especially in the field of education (Guzmán-Valenzuela et al., 2023), with the case of Chile being notorious in this respect (Nussbaum & González, 2015). Previous studies applying a longitudinal perspective to the analysis of gender gaps in science, conducted in Chile more than a decade ago, found significant gender differences at the beginning of the academic career (Bernasconi, 2010), in its development, and in access to, and participation in, the scientific community (Stefoni, 2010). Other studies in Chile have focused on barriers and facilitators of female participation in academia (e.g., Cerros & Ramos, 2011), on issues pertaining to family–work balance (e.g., Fardella Cisternas & Corvalán Navia, 2020; Ortiz Ruiz et al., 2021), on the unequal distribution of academic work (e.g., Mandiola Cotroneo et al., 2019), and on the gendered experiences and identities of academics (Fardella Cisternas et al., 2021). However, gender disparities in research involvement throughout the career life course have not been studied in the Chilean context, despite their importance for individual academic promotion, institutional performance, and national sustainable and equitable development. Further, with few exceptions (e.g., Queupil & Muñoz-García, 2019), the role of researchers' gender in career development has not received significant attention in the field of education.

This study investigated gendered patterns of attrition, output, leadership, and collaboration throughout the careers of Chilean researchers in the field of education. To this end, bibliometric, longitudinal, and social network approaches were applied. Specifically, we focused on those researchers who published, at least once between 2011 and 2021, in Scopus-indexed education journals in affiliation with a Chilean institution. Thus, in this article, we depict the structure of the Chilean academic community of educational researchers with a focus on the effect of gender throughout the career life course and, in doing so, provide a comprehensive account of gender disparities in interrelated facets of researchers' careers in the field.

Conceptual Framework

The participation and experiences of female researchers are not equal to those of men (Poczatková & Křibíková, 2017). Several studies have shown that female scientists tend to publish fewer articles (Elsevier, 2020; Huang et al., 2020; Larivière et al., 2013;

Winslow & Davis, 2016), are cited less frequently (Bendels et al., 2018; Ross et al., 2022), and are less likely to appear as first authors in collaborative publications (Elsevier, 2020; Larivière et al., 2013), compared to their male peers. These gaps in research output, leadership, and impact, to the detriment of women, are the result of structural barriers and disadvantages, and affect academic prestige and promotion (Gómez Cama et al., 2016).

Two forms of gender segregation in academia have been widely documented and confirmed in diverse contexts (Eslén-Ziya & Yildirim, 2022; Silander et al., 2013). The first one is horizontal segregation, which refers to the unequal distribution of men and women across fields of study: Certain disciplines, such as STEM fields, are traditionally perceived as more male-dominated, while women are overrepresented in caregiving disciplines, such as education, childcare, and social work (Barone & Assirelli, 2020; Thébaud & Charles, 2018). Research on this form of segregation generally aims to understand how certain disciplines or cultural factors create an environment that is more appealing or welcoming to individuals of a particular gender (Larivière et al., 2013). Vertical segregation, in turn, refers to the unequal distribution of individuals across different hierarchical positions within an organization or profession. In the context of academia, vertical segregation refers to the tendency for female academics to occupy lower academic positions compared to their male counterparts. The latter, even in highly feminized fields (Eslén-Ziya & Yildirim, 2022).

Gender Disparities in the Risk of Attrition From Academia

Vertical segregation is often viewed as a result of the “leaky pipeline” process, a pattern in which women encounter obstacles and barriers throughout their academic careers that contribute to their earlier departure from academia (Gasser & Shaffer, 2014; Wolfinger et al., 2009). Institutional factors play a key role in pushing women out of academia (Windsor et al., 2021), although there are important differences across disciplines, cohorts, and countries (Kwiek & Szymula, 2024). However, it has been emphasized that individual agency can also contribute to shaping diverse academic pathways (Kizilcec et al., 2023).

The unequal distribution of family and care responsibilities, work–life balance conflicts, and societal expectations about gender roles are among the factors that influence women's decisions to leave academia (Gasser & Shaffer, 2014). In addition, there is strong evidence of the unequal distribution of academic work: In several contexts, it has been found that men tend to be allowed to devote more time to research, while women are expected to carry out more outreach, service, and teaching and tutoring duties, as well as student care work and other forms of affective labor (Hanasono et al., 2019). These roles more often assigned to women are key to standards of institutional and program quality, but they tend to be undervalued in metrics of individual assessment, thus adversely affecting female academics' promotion (Domingo et al., 2022).

Further, Gasser and Shaffer (2014) point out that female academics may leave academia if they are unable to secure a tenure-track position, for example, due to a lack of publications or failure to secure research grants. These authors found that “experiencing a hostile departmental climate, feeling isolated and invisible and encountering little or no transparency in departmental decision-making, increase the likelihood that woman will leak out of

the academic pipeline before, during, and after tenure decisions are made” (Gasser & Shaffer, 2014, p. 332).

As women drop out of (or are excluded from) academic careers at earlier stages than their male colleagues, the overall representation of women in more senior positions, such as professorships and leadership roles, is often low (Howe-Walsh & Turnbull, 2016). Indeed, Larivière et al. (2013) highlighted that the barriers and obstacles faced by previous generations of women in academia have left their mark on the senior ranks of science, creating a persistent gender imbalance. In line with this literature, a comprehensive international longitudinal bibliometric study shows that differences in publishing career lengths and attrition rates explain a large portion of the reported career-wise gender differences in productivity and impact (Huang et al., 2020).

Gender Disparities in Scientific Output

Women may remain in academia and even be promoted but still be less involved in research activities. The gender gap in scientific productivity, with female scientists tending to publish less frequently than their male counterparts, is known as the “productivity puzzle,” a term coined by Cole and Zuckerman (1984). Indeed, within the same discipline, it has been found that scientists’ gender and, to a lesser extent, other characteristics, such as ethnicity, social class, level of education, position in the organization, seniority, and international networks, influence their research output (Prpić, 2002).

Regarding authorship, “globally, women account for less than 30% of fractionalized authorships, while men account for slightly more than 70%” (Larivière et al., 2013, p. 212). Moreover, articles with female lead authors are cited less frequently than articles with male lead authors (Bendels et al., 2018; Ross et al., 2022), which is partly explained by the fact that female scientists publish less. In the field of economics, for example, Koffi (2021) found that “on average, omitted papers are 15%–20% more likely to be female-authored than male-authored ... (an omission that) is more prevalent when there are only males in the citing article” (p. 1). Also, in Chile, a recent study of publications in educational policy (Villalobos & Pereira Mardones, 2022) found that male academics are better represented than female academics in terms of authorship, especially in first authorships (i.e., 57% vs. 43%, respectively).

In examining longitudinal trends of research participation and productivity, it was found, in the United States, that the increase in women’s participation in science over the past 60 years was accompanied by a widening of the gender gap in both research productivity and impact (Huang et al., 2020). Women have also been found to be underrepresented, have lower levels of productivity, and publish fewer articles in highly selective and prestigious journals (Bendels et al., 2018). Moreover, in different contexts, including Latin American (LATAM) countries, these gender gaps grew during the COVID-19 pandemic (Gil et al., 2023).

A key intersecting dimension for understanding gendered research trajectories is that of research experience, or “academic age,” defined as the years since a scholar published their first article (W. Wang et al., 2017). Huang et al. (2020) examined longitudinal gender differences in academic productivity using a comprehensive database of 1.5 million gender-identified authors whose publishing careers ended between 1955 and 2010. This study found that there was a large gender gap in overall career productivity, as determined

by differences in career length (Huang et al., 2020), across the 13 disciplines and 83 countries studied. The authors concluded that “on average, male authors reach an academic age of 11.0 years before ceasing to publish, while the average terminal academic age of female authors is only 9.3 years” (Huang et al., 2020, p. 4613). Similarly, according to Elsevier (2020), a report on the gender gap in research in the United States, Canada, Europe, Japan, Australia, Argentina, Brazil, and Mexico, male authors had, on average, longer publication histories than their female peers.

Gender Disparities in Research Leadership

Gendered patterns of research leadership (usually measured as first or corresponding authorship²) have also been examined in the literature (Vuong et al., 2021), with men dominating these prestigious author positions. Large-scale bibliometric studies, comprising different fields and various national contexts, have found that men are up to twice as likely as women to publish academic articles as first authors (Larivière et al., 2013; West et al., 2013). Furthermore, from a comparative perspective, South American countries show greater gender imbalances in research leadership to the detriment of female researchers (Larivière et al., 2013).

Gender Disparities in Academic Collaboration

Gender can also play a role in patterns of academic collaboration. It has been found that, overall, women tend to build less homophilic relationships, with homophily being defined as the tendency to interact with similar others (for example, male authors collaborating with other male authors; Fell & König, 2016), and more egalitarian research networks than men (Araújo et al., 2017). In Polish universities, for example, it was found that the majority of male scientists collaborate solely with males (Kwiek & Roszka, 2021).

There is also evidence of homophily in Chilean scientific production, with male researchers being particularly likely to favor their same-gender peers (Espinosa et al., 2022). Furthermore, in Chilean education research, women have been found to collaborate more than men and to act as important bridgers among researchers (Queupil & Muñoz-García, 2019). Finally, it has been suggested that, overall, women are less likely to be involved in international research collaborations and more likely to be involved in national coauthorships than their male peers (Elsevier, 2020).

The present study investigated gendered patterns of attrition, output, leadership, and collaboration throughout the careers of Chilean researchers in the discipline of education. As in other contexts, enrollment in bachelor’s and master’s education programs in Chile is highly feminized, with almost three-quarters of students being female, a feature that remained stable between 2011 and 2021 (see Supplemental Figure A1). This aligns with previous studies confirming systematic gender segregation across fields of study in Chile (Bordón et al., 2020). In turn, the participation of women in national doctoral education programs increased over the same period and has been generally larger than that of men, although the proportion of women is clearly lower than the one observed in bachelor’s and master’s education programs.

² First and corresponding authors are usually considered the most important contributors, and these bibliographic attributes tend to coincide (González-Alcaide et al., 2017; Yu & Yin, 2021).

Based on the literature reviewed above, the following hypotheses regarding Chilean education researchers' trajectories were tested:

Hypothesis 1: Research attrition rates will be significantly higher among female researchers when compared to their male peers.

Hypothesis 2: Female researchers will tend to exhibit lower research output levels (i.e., number of articles published) than their male colleagues, a gap that will increase with years of research experience.

Hypothesis 3: Female researchers will exhibit lower levels of research leadership (i.e., first authorships) than male researchers.

Hypothesis 4: Collaboration patterns will differ by researcher gender, with male researchers showing a higher number of coauthorships and more international collaboration profiles than female researchers.

Hypothesis 5: Coauthorship networks will show significant patterns of gender and experience homophily.

Method

Data

Our data correspond to 5,702 authors (50.0% of whom were women) who published at least one regular or review article³ in Scopus-indexed journals classified in the subject categories of Education and/or Developmental and educational psychology (hereinafter, "education journals")⁴ between 2011 and 2021 (inclusive) while affiliated with a Chilean institution. For these authors, we extracted their complete history of article publication in Scopus-indexed education journals (including those articles published before 2011). Thus, the analytical sample included 4,528 articles⁵ and 16,205 authorships.

These data were retrieved using the Scopus Application Programming Interface, operated through the *rscopus* package in R (Muschelli, 2019). Furthermore, to exclude researchers who were not significantly involved in the field of educational research (i.e., occasional authors), we omitted cases that met the following two conditions: (a) authors whose year of first publication in a Scopus-indexed education source was more recent than the year of their first publication in a Scopus-indexed source categorized in other subject areas, and (b) authors who had published only one article in a Scopus-indexed journal in the subject area of education by 2021.

The selection of Scopus as our data source responds to the following four reasons: (a) its frequent use in bibliometric analyses (Mongeon & Paul-Hus, 2016); (b) its broader coverage, compared to other commonly used bibliographic databases, such as Clarivate Analytics WoS (Singh et al., 2021);⁶ (c) the importance of Scopus-indexed publications for Chilean research funding agencies⁷ and for the accreditation of higher education institutions and programs in the country; and (d) the authors' institutional access to the Scopus Application Programming Interface's advanced search and filtering functions.

Data preparation and cleaning included (a) author disambiguation, (b) the extraction of authors' experience or academic age (years since the first Scopus-indexed publication in education), and (c) the

inference of the authors' gender using the *genderizeR* package in R (Wais, 2016).

As shown in Figure 1 (Panel A), the number of both male and female authors affiliated with a Chilean institution and publishing articles in Scopus-indexed education journals increased rapidly between 2011 and 2021 (by 471.7% and 637.8%, respectively). However, the gender composition of the Chilean education research community remained somewhat stable during this time period, with a slightly lower representation of women (i.e., 40.3% in 2011 and 46.6% in 2021; Panel B).

We also explored the gender composition of teams involved in collaborative articles published in Scopus-indexed education journals between 2011 and 2021 and coauthored by at least one researcher affiliated with a Chilean institution.⁸ The large percentage of collaborative articles authored only by men decreased between 2011 and 2021 (32.7% and 21.2%, respectively), while the relatively smaller percentage of articles authored only by women remained somewhat stable during this period (9.9% and 11.5%, respectively), as shown in Supplemental Figure A2. Thus, the proportion of mixed-gender articles increased slightly (from 57.4% to 67.3%), suggesting that gender homophily in coauthorship has decreased over time in this research field. The latter, due to a decrease in the presence of all-male teams, which were, nonetheless, still almost twice as common as all-female teams in 2021.

Furthermore, when describing the gender composition of this research community and distinguishing by years of research

³ We acknowledge that there are several journals, published by higher education institutions or other organizations, that are not Scopus-indexed. Book and book chapters are also important and common scholarly outputs, especially in the social sciences and humanities. However, the difficulties of accessing comparable data from these nonindexed sources remain a challenge for large-scale bibliometric analysis. The coverage of books and book chapters is still low in both the Web of Science (WoS) and Scopus databases. Notably, neither books nor book chapters authored by researchers affiliated with Chilean institutions were indexed in Scopus in education between 2011 and 2021.

⁴ We used the official Scopus field classification of journals. This classification allows for interdisciplinary foci, as a given journal may be classified in more than one field. The Scopus journal classification is often used in research to delineate disciplines and fields of study. A recent study by Thelwall and Pinfield (2024) shows that education journals publish articles that match their Scopus classification.

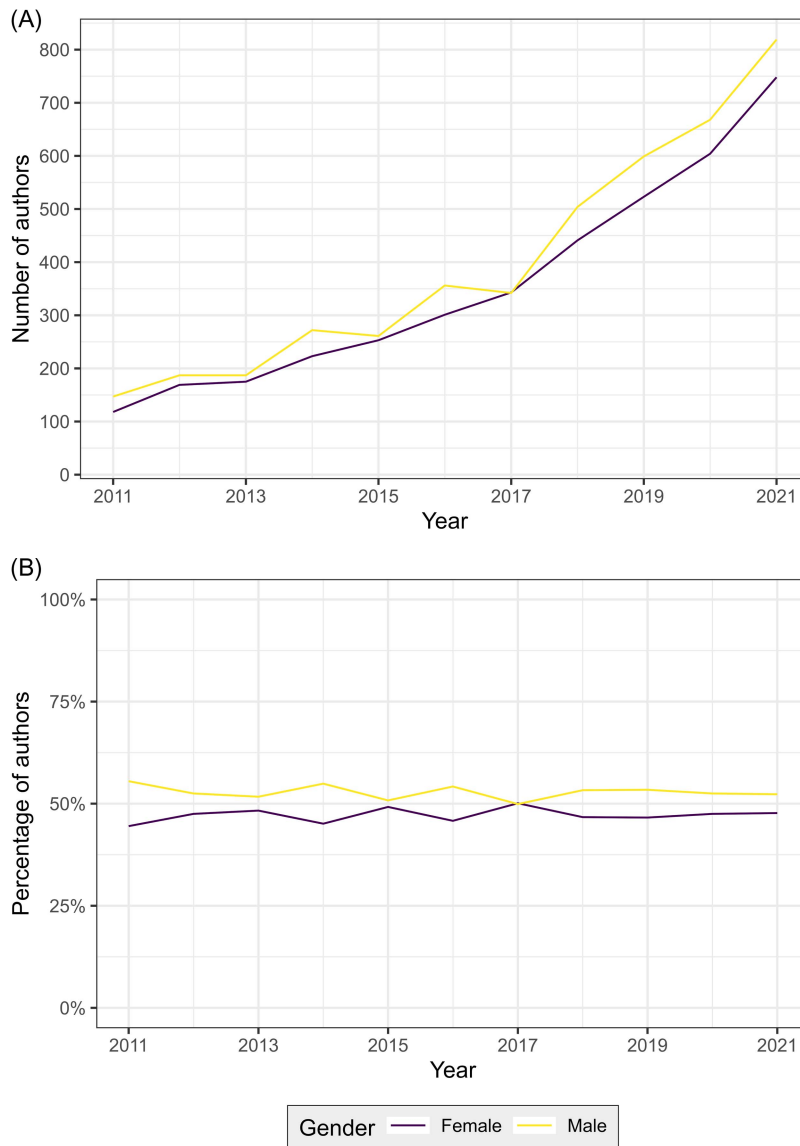
⁵ In total, 83.8% of the articles in our sample were published in journals classified into the subject category Education, 8.3% in the subject category Developmental and educational psychology, and 7.9% in both subject categories.

⁶ Recent comparative studies show that Scopus's journal coverage is larger than that of WoS (the other most frequently used database in research requiring to obtain publication metadata and bibliometric indicators; Prancuté, 2021) and that the difference in journal coverage between these two sources has grown over time (Mongeon & Paul-Hus, 2016; Singh et al., 2021). For the majority of disciplines, Scopus includes most of the journals indexed in WoS: About 99% of WoS journals are also indexed in Scopus, 34% of journals indexed in Scopus overlap with WoS, and the remaining 66% of Scopus journals were not indexed in WoS (Singh et al., 2021). Thus, the more selective education journals, typically indexed in WoS, are also indexed in Scopus.

⁷ For example, the Chilean Agency for Research and Development's competitive research funding programs evaluate the productivity of researchers and institutions mainly on the basis of publications indexed in Scopus and WoS.

⁸ These collaborative articles represent 87.4% of the total number of articles published in education journals, between 2011 and 2021, and authored by at least one researcher affiliated to a Chilean institution. The remaining 12.6% corresponds to single-authored articles.

Figure 1
Trends of Number and Percentage of Authors Publishing Articles in Scopus-Indexed Education Journals, in Affiliation With a Chilean Institution, Between 2011 and 2021, by Author Gender



Note. See the online article for the color version of this figure.

experience in education, we found that there is a significant decrease in the relative participation of women as researchers become more senior (up to 13 years of experience), as depicted in Supplemental Figure A3.⁹ This trend suggests a leaky pipeline pattern, which was further investigated using survival analysis.

Also, during most of the 2011–2021 period, the average number of articles published per year differed significantly between male and female Chilean researchers. As shown in Supplemental Figure A4, this gender gap in academic productivity appears to have widened over the last 12 years and was particularly large between 2019 and 2021.¹⁰

Variables

Our analyses were guided by the following research question: How do the effects of gender on research attrition, article publication, leadership, and patterns of collaboration manifest themselves over the career life course of Chilean education

⁹ It is important to note that, in Chile, the normal retirement age is 65 years for men and 60 years for women.

¹⁰ This might be due, in part, to the Chilean massive protests' and the COVID-19 pandemic's disproportionate negative effects on the careers of female researchers, as evidenced in other contexts (Deryugina et al., 2021).

researchers? Below, we list the dependent and outcome variables of our study.

Outcome Variables

The following outcome variables were modeled to study gender effects on researchers' trajectories.

Time Until Attrition From Research. This was defined as 2.8 or more years without publishing in the field of education. To estimate whether an author was an active researcher, we first calculated the average time between two consecutive publications in our sample for authors with two or more published articles, weighted by the number of articles published by the author ($M = 1.8$ years; $SD = 1.5$ years). We, then, considered a researcher to have dropped out of research if the time elapsed between the last article published by the author and the end of the period covered by this study was larger than 1.5 SD s from the average time calculated above; this is, 33 months without publishing an article. Those authors who did not meet the criteria were considered to be active in educational research and were treated as right-censored cases. Finally, in conducting survival analysis, we excluded authors who might have retired or died. This is, from the inactive researchers that were identified, we excluded those who were two or more standard deviations away from the average number of years since the publication of their first article in a Scopus-indexed education journal.

Research Output. Number of articles published in Scopus-indexed educational journals.

Research Leadership. Number of first-authored articles published in Scopus-indexed educational journals. First authorship is a bibliometric attribute commonly used as an indicator of research leadership (González-Alcaide et al., 2017).¹¹ When analyzing gender differences in first authorships, we excluded single-authored and single-gender collaborative articles.

Coauthorships. The number of coauthorships of authors in Scopus-indexed education journals commonly used as an indicator of research collaboration. To conduct network analysis, we constructed bipartite rectangular adjacency matrices for each year, reflecting the participation of authors (rows) in articles (columns). A value of 1 represents the participation of an author in a given article, and 0 represents no participation.

Predictor Variables

The following individual-level variables were included in the models as potential predictors.

Female. A dichotomous variable distinguishing males (0) from females (1) is inferred based on the authors' first name and the country of institutional affiliation (Wais, 2016).¹²

Research Experience. Years since the author published his/her first document in a Scopus-indexed education source. This attribute is also referred to as "academic age" in the literature.¹³ We considered authors with up to 40 years of experience.¹⁴

In addition, we considered the following coauthorship-level variable:

Type of Collaboration. This variable distinguished between the following four categories: (a) single authorship: authorships that involved only a single author affiliated with a Chilean institution (i.e., no collaboration involved); (b) national coauthorship: coauthorships involving two researchers affiliated with a Chilean institutions;

(c) regional coauthorship: coauthorships involving one researcher affiliated with a Chilean institution and one researcher affiliated with an institution in another LATAM country; and (d) international non-LATAM coauthorship: coauthorships involving one researcher affiliated with a Chilean institution and one author affiliated with an institution in a non-LATAM country.

Analysis

Data analyses included the following techniques: (a) survival models to model time to research attrition; (b) models for count data (i.e., Poisson regression) to model the number of authorships, first authorships, and coauthorships; and (c) social network models (i.e., bipartite exponential random graph model) to examine coauthorship patterns and mechanisms. It is important to note that, in our analyses, we used full-article counting (i.e., a publication is fully assigned to each coauthor) instead of fractional counting methods (i.e., a publication is fractionally assigned to each coauthor; Perianes-Rodríguez et al., 2016), as the former is the method used in individual and institutional research evaluation systems in Chile. Thus, all article authorships were counted equally, regardless of the number of coauthors involved.

Survival Models

Survival models have been frequently used to investigate gender differences in faculty's time to departure/attrition, as well as time to promotion (e.g., Kwiek & Szymula, 2024; Wolfinger et al., 2008). In this study, the Kaplan–Meier estimator was used to identify gender differences in the number of months between the date of the authors' first and last publication, up to the final data point (i.e., December 30, 2021). Cox proportional hazard models were also estimated to describe the probability of not dropping out from research (i.e., survival) as a function of gender. These models were fitted using the R-package *survival* (Therneau, 2024).

Poisson Regression

Given the nonparametric count distribution of the variables number of authorships, first authorships, and coauthorships, similar progressions of Poisson regression models were fitted to study gendered patterns of research output, leadership, and collaboration. As shown in Equation (1), the expected number of authorships/first authorships/coauthorships (y_i) by researcher i was specified as a log-linear model and as a function of gender:

$$\ln(y_i) = \beta_1 + \beta_2 \text{Female}_{2i}. \quad (1)$$

¹¹ In the literature, corresponding authorship is also used as an indicator of research leadership. Further, in the vast majority of articles in the social sciences, the corresponding author is also the first author (Yu & Yin, 2021).

¹² As software that infers gender on the basis of first names categorizes researchers as either men or women, we had to limit our analyses to a binary conceptualization of gender. However, we adhere to the use of the term gender rather than of sex to emphasize that differences between male and female researchers are not biologically based.

¹³ It is important to note that "academic age" is not the same as biological age, as researchers start publishing at different ages (although one could expect them to be positively correlated).

¹⁴ This excluded only six authors from the original sample.

Then, as shown in Equation 2, we controlled for researchers' experience:

$$\ln(y_i) = \beta_1 + \beta_2 \text{Female}_{2i} + \beta_3 \text{Research_experience}_{3i}. \quad (2)$$

We also included the quadratic term of *research experience* to test for nonlinear effects, as depicted in Equation 3.

$$\ln(y_i) = \beta_1 + \beta_2 \text{Female}_{2i} + \beta_3 \text{Research_experience}_{3i} + \beta_4 \text{Research_experience}_{4i}^2. \quad (3)$$

Finally, in Equation 4, we examined the statistical interactions between the variables *female* and *research experience* and between *female* and *research experience*²:

$$\ln(y_i) = \beta_1 + \beta_2 \text{Female}_{2i} + \beta_3 \text{Research_experience}_{3i} + \beta_4 \text{Research_experience}_{4i}^2 + \beta_5 \text{Female}_{2i} \times \text{Research_experience}_{3i} + \beta_6 \text{Female}_{2i} \times \text{Research_experience}_{4i}^2. \quad (4)$$

Also, to further investigate gender differences in coauthorships, additional Poisson models were fitted. We used the specifications shown in Equation (1) to Equation (3) and then tested the main effects of *type of collaboration* categories, included as a set of dummy variables, as Equation (5) shows.

$$\ln(y_i) = \beta_1 + \beta_2 \text{Female}_{2i} + \beta_3 \text{Research_experience}_{3i} + \beta_4 \text{Research_experience}_{4i}^2 + \beta_5 \text{Regional}_{5i} + \beta_6 \text{International}_{6i}. \quad (5)$$

To detect different patterns of collaboration by gender, the statistical interaction between the variables *female* and *type of collaboration* categories was included while controlling for the interaction terms for *female* and *research experience*, as well as for *female* and *experience*². Finally, the interaction effects between *research experience* and *type of collaboration*, as well as between *research experience*² and *type of collaboration* categories, were also modeled.

Bipartite Exponential Random Graph Models

Exponential random graph models are a family of statistical models for the analysis of cross-sectional social network data to examine local processes such as reciprocity, transitivity, and homophily (Robins et al., 2007). In this study, we used an extension for bipartite networks (P. Wang et al., 2009) to model academic collaborations (i.e., coauthorships). A bipartite network has two distinct sets of nodes (here, researchers and articles), where ties are only defined between nodes from different sets (i.e., researchers linked to articles). Using this approach, we estimated the probability of having a research collaboration based on actor attributes (i.e., *female* and *research experience*) and dyadic attributes (i.e., *same gender* and *similar research experience*), as homophily is a common feature of scientific networks. We estimated separate models for each year (2011–2021, 11 models) using the R-package *ergm* (Hunter, Handcock, et al., 2008) and later combined the results using the Viechtbauer's (2010) meta-analysis method implemented in the

R-package *metafor*.¹⁵ Only articles with 2–10 authors were included in these analyses.¹⁶

Regarding model specification (the same for each year), we aimed for a parsimonious model that addressed the hypotheses (P. Wang et al., 2009) and presented a reasonable visual goodness-of-fit (Hunter, Goodreau, et al., 2008). Thus, we included the following effects in the model: (a) *edges* to describe the tendency of actors to establish relationships; (b) *nodefactor* and *nodecov* effects, which represent the likelihood of authors with specific characteristics to participate in articles compared to the reference category for categorical and continuous variables, respectively (e.g., *nodefactor female* indicates whether women were more likely to participate in collaborative articles compared to men); and (c) *nodematch* effects to represent the tendency to have coauthorships with researchers with similar attributes. Additionally, to represent the variation in the degree distribution in actors and articles (centralization) and to improve the goodness of fitness of the model, we included the effects of *gwb1degree* and *gwb2degree*, respectively, as well as an effect representing the tendency of researchers to have only one coauthorship, *bldegree(1)*.

Results

Gendered Patterns of Research Attrition

In this section, we present the results of the survival analysis modeling time to research attrition as a function of researcher gender. As shown in Table 1, there is a significant effect of gender on survival probability, to the detriment of women ($p < .001$), with a hazard ratio (β) of 1.215, indicating a moderate relationship between the researcher gender and the risk of research attrition: Being a female researcher increases the attrition hazard by 21.5%, compared to that of male researchers. The predicted survival proportions at different months of research experience for male and female researchers are shown in Figure 2. The depicted survival functions show that female researchers are significantly more likely than men to drop out after publishing their first Scopus-indexed education articles, thus creating an initial gender gap in survival probability that is not reverted in subsequent years. In fact, after an initial critical period, the risk of attrition/exclusion from the field evolves similarly for men and women. Moreover, after 5 years (60 months) since the first published article, both male and female researchers have a very low risk of attrition from education research.

Gender Gaps in Research Output and Leadership Across the Career Life Course

The results of the Poisson models predicting research output, in Table 2, show a significant effect of gender on the number of articles published (Model 1, incidence rate ratio [IRR] = 0.792, $p < .001$), which means that, overall, Chilean female education researchers publish 20.8% fewer articles than male researchers. On average, one additional year of experience increases the predicted number of articles by 38.6% (Model 2, IRR = 1.386, $p < .001$) for both men and women. However, the effect of experience is nonlinear:

¹⁵ This approach estimates and tests the mean as well as the standard deviation of each effect included in the model, using an iterated weighted least squares method and without assuming a normal distribution.

¹⁶ This corresponds to 86.1% of the total number of articles in our sample.

Table 1
Cox Proportional Hazards Estimates of Research Attrition

Effect	Model 1	Model 2	Model 3
Female	1.215*** (0.603)	1.189*** (0.052)	
Number of first authorships		0.603*** (0.027)	0.610*** (0.037)
Female × Number of First Authorships			0.975 (0.053)
Fit indexes			
AIC	30458.2	29870.8	29872.3
BIC	30463.8	29882.0	29889.0

Note. $n = 4,463$ authors. Standard errors are reported in parentheses. Number of events: 1,866. Hazard ratios are shown. AIC = Akaike information criterion; BIC = Bayesian information criterion.

*** $p < .001$.

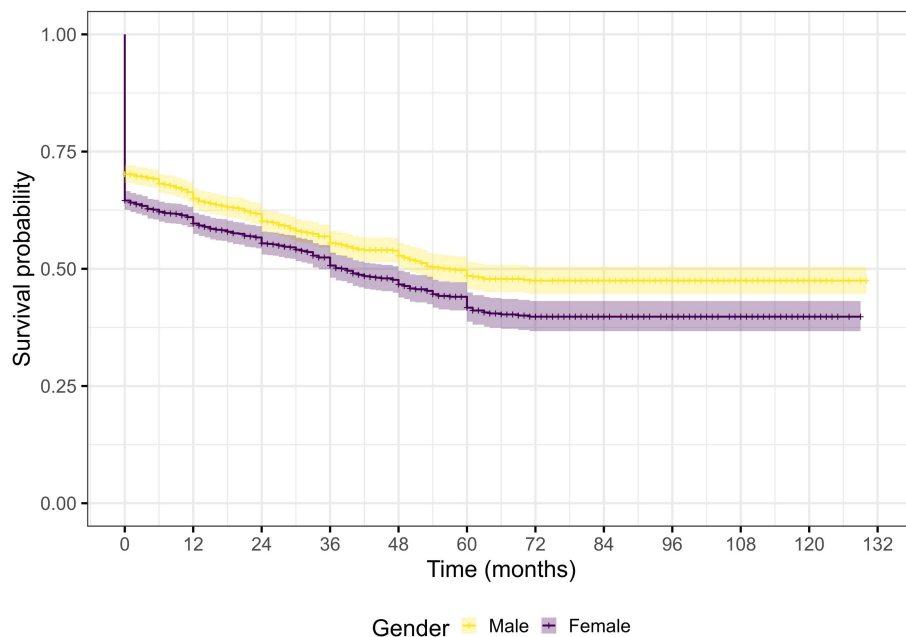
The growth rate in the number of published articles slows down significantly as experience increases, suggesting an inverted U-shape (Model 3, IRR = 0.910, $p < .001$). Furthermore, there is a significant interaction between gender and experience, as shown in the results of Model 4. This is, the positive effect of experience on research output is slightly weaker for female researchers (suggesting a widening of the gender gap as experience increases), and there is a more linear trend for women (suggesting a slower but more sustained growth in research output), compared to male researchers.

Figure 3 depicts the mean number of authorships, as predicted by Model 4 (i.e., the best-fitting model), and confirms that the significant gender differences in article production, to the detriment of women, vary, in magnitude, by career stage.

Next, we focus on findings regarding research leadership, obtained by comparing the participation of women and men as first authors of collaborative articles (i.e., those with two or more authors) authored by mixed-gender teams.

As shown in Supplemental Table A1, the results of our Poisson models suggest that researcher gender does not predict the number of articles published as first author. Overall, an additional year of experience does increase the number of first authorships by 9.2% (Model 2, IRR = 1.092, $p < .001$) for both women and men. However, similar to the growth shape for research output depicted above, the advantage of an additional year of experience on the number of first authorships decreases over time. Finally, we did not find a statistically significant moderating effect of gender on the

Figure 2
Time to Research Attrition for Authors Who Published at Least One Article in Scopus-Indexed Education Journals Between 2011 and 2022, Affiliated With a Chilean Institution, by Researcher Gender



Note. Research attrition was defined as not publishing articles after 33 months in Scopus-indexed education journals. 95% CIs are shown. CI = confidence interval. See the online article for the color version of this figure.

Table 2
Results From Poisson Models Predicting Authors' Research Output

Effect	Model 1	Model 2	Model 3	Model 4
Intercept	2.589*** (0.034)	2.290*** (0.031)	2.242*** (0.032)	2.240*** (0.034)
Female	0.792*** (0.016)	0.855*** (0.017)	0.883*** (0.017)	0.881*** (0.019)
Experience		1.386*** (0.006)	2.170*** (0.028)	2.219*** (0.038)
Experience ²			0.910*** (0.003)	0.904*** (0.004)
Female × Experience				0.949* (0.024)
Female × Experience ²				1.016* (0.007)
Fit indexes				
AIC	20319.9	17297.3	15604.4	15602.9
BIC	20332.7	17316.6	15630.1	15641.4

Note. Research output is defined as number of articles published in Scopus-indexed education journals. $n = 5,702$ authors. Standard errors are reported in parentheses. Incidence rate ratios are shown. AIC = Akaike information criterion; BIC = Bayesian information criterion.

* $p < .05$. *** $p < .001$.

effect of research experience. The predicted patterns, based on the best-fitting model (Model 3) are depicted in Supplemental Figure A8.

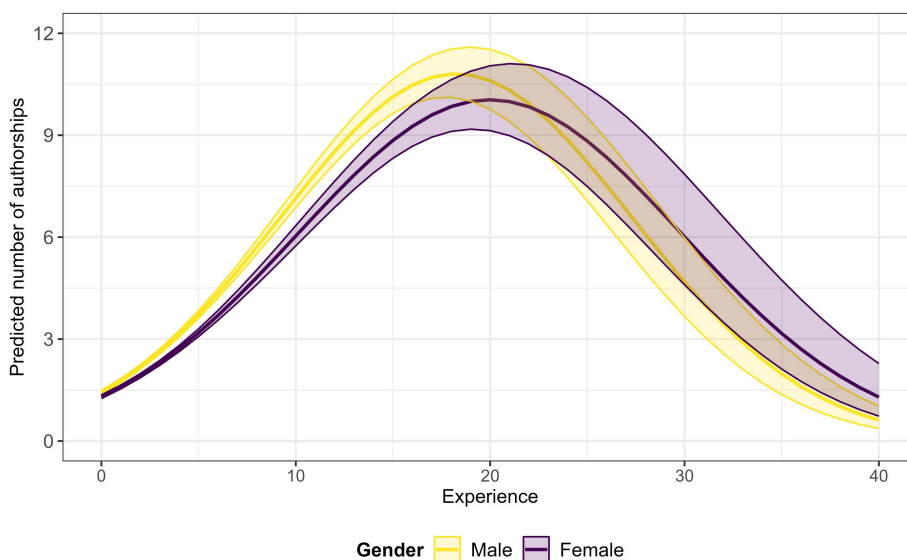
Gender Differences in Research Collaboration Across the Career Life Course

Now, we focus on gendered patterns of collaboration in publications in Scopus-indexed education journals. The results of models predicting the number of coauthorships are presented in Table 3. First, in line with the findings for models predicting research output, presented above, the results of Model 2 show that, at the initial stage of their research careers, the number of predicted coauthorships already differs significantly by gender,

with an average of 29.5% fewer collaborative articles for women with zero years of research experience ($p < .001$).

Further, while the number of coauthorships increases significantly with research experience, this association is significantly weaker for female researchers ($p < .001$), indicating a widening of the coauthorship gender gap (Model 5). Finally, as depicted by the significant interaction effects between gender and type of collaboration in Model 6, for male researchers, international LATAM and non-LATAM coauthorships were significantly more frequent than national collaborations. In turn, for female researchers, the higher incidence of international non-LATAM coauthorships over national collaborations was smaller, and the incidence of national coauthorships surpassed that of international LATAM collaborations. Thus, in addition to having significantly fewer coauthorships, female

Figure 3
Predicted Number of Articles for Researchers Who Published Articles in Scopus-Indexed Education Journals Affiliated With a Chilean Institution, Between 2011 and 2021, by Author Experience and Gender



Note. Predicted counts from Model 4 and 95% CI are shown. CI = confidence interval. See the online article for the color version of this figure.

Table 3
Results From Poisson Models Predicting Research Collaboration

Effect	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Intercept	20.774*** (0.028)	18.968*** (0.027)	19.160*** (0.028)	16.936*** (0.033)	16.590*** (0.037)	16.013*** (0.038)
Female	0.683*** (0.002)	0.705*** (0.002)	0.743*** (0.002)	0.746*** (0.002)	0.787*** (0.003)	0.786*** (0.003)
Experience		1.383*** (0.001)	2.007*** (0.003)	2.026*** (0.003)	2.033*** (0.004)	1.961*** (0.005)
Experience ²			0.909*** (0.000)	0.909*** (0.000)	0.908*** (0.000)	0.929*** (0.001)
Regional				1.020*** (0.004)	1.063*** (0.006)	1.108*** (0.006)
International				1.296*** (0.003)	1.340*** (0.004)	1.433*** (0.004)
Female × Experience					0.989*** (0.003)	0.986*** (0.003)
Female × Experience ²					1.002* (0.001)	1.003*** (0.001)
Female × Regional					0.877*** (0.008)	0.859*** (0.008)
Female × International					0.913*** (0.004)	0.920*** (0.004)
Experience × Regional						1.060*** (0.007)
Experience ² × Regional						0.973*** (0.002)
Experience × International						1.071*** (0.003)
Experience ² × International						0.951*** (0.001)
Fit indexes						
AIC	1154101.6	964568.6	883805.9	869412.0	868894.9	863470.3
BIC	1154119.1	964594.9	883841.0	869464.6	868982.5	863593.0

Note. Research collaboration is defined as number of coauthorships of articles published in Scopus-indexed education journals. $n = 3,598$ authors. Standard errors are reported in parentheses. Only articles with 2 and up to 10 authors were considered. AIC = Akaike information criterion; BIC = Bayesian information criterion.

* $p < .05$. *** $p < .001$.

researchers were also more likely to engage in national collaborations when compared to male researchers, who tended to develop more international (both regional and nonregional) collaborative profiles.

These gendered patterns of collaboration are depicted in Figure 4, which shows the number of coauthorships predicted by Model 6 (i.e., the best-fitting model).

Gendered Research Collaboration Networks

After describing the gendered patterns of research collaboration, this section focuses on the results of the bipartite exponential random graph models' meta-analysis, which jointly models the effect of network structure and node-level attributes over time. This additional analysis is relevant as research collaboration is a relational phenomenon that can be influenced by network and dyadic effects.

Overall, as shown in Table 4, there is a tendency toward scarcity of coauthorships, considering all the possible ones given the number of researchers in the sample (*edges*, $p < .001$). There is also a tendency of degrees' dispersion at both the researcher and article levels (*gw1degree* and *gw2degree*, respectively, $p < .001$), indicating that the number of collaborations is dispersed around researchers and the number of authors is dispersed around articles. We also found a tendency for researchers to have one collaboration per year, *bldegree(1)*, $p < .001$. In line with the results presented above, there are significant gender effects in coauthorships, with women having fewer coauthorships than men (*nodefactor female*, $p < .001$) and coauthorships being based on the same gender (*nodematch female*, $p < .001$). We also found that more experienced researchers were more likely to participate in coauthorships (*nodecov research experience*, $p < .001$), which may reflect the relevance of expertise and prestige in forming collaborative networks in academia. In addition, we found that coauthorships were more likely among researchers with similar *research experience* (*nodematch research experience*, $p < .001$). The results of these effects are also depicted in forest plots (Supplemental Figures A6–A9).

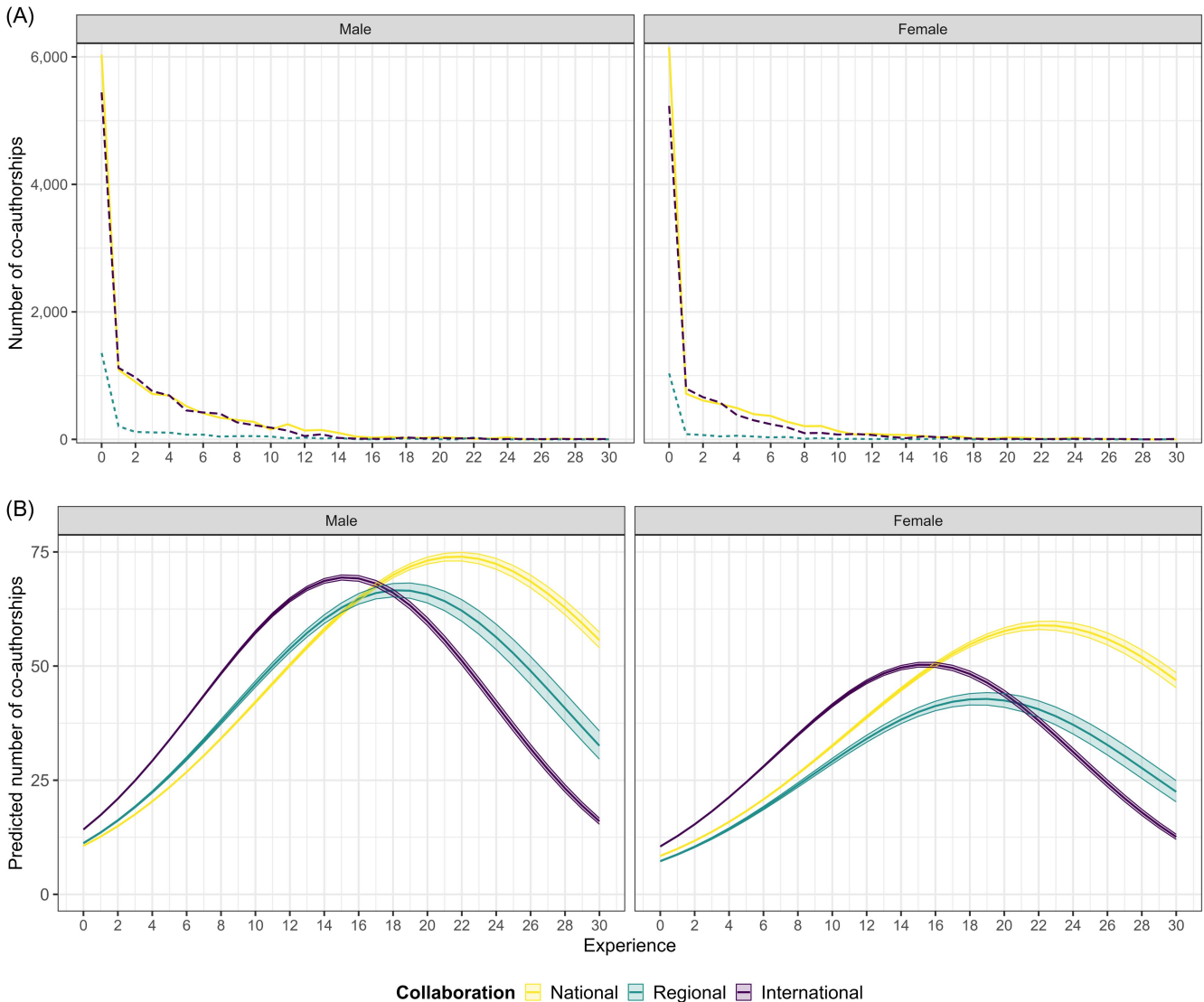
Discussion

This study examined five hypotheses regarding gendered patterns of research attrition, output, leadership, and collaboration throughout the careers of Chilean researchers in the field of education. Our findings can be summarized as follows. First, confirming Hypothesis 1, Chilean female scientists in education have a 21.5% higher research attrition risk than their male counterparts. This gender gap in survival probability appears immediately after researchers publish their first Scopus-indexed article in education and does not reverse in subsequent years. Thus, in line with previous studies (Gasser & Shaffer, 2014; Larivière et al., 2013; Light, 2013), women tend to stop publishing earlier in their careers, creating a research “leaky pipeline”. Further research is needed to investigate whether female researchers leave academia altogether or are disproportionately assigned other academic tasks, to the detriment of their research productivity. Moreover, it is key to identify and address the barriers that exclude female researchers at an early stage in their careers.

Second, Chilean female researchers in education were found to publish, on average, 20.8% fewer articles than male researchers, confirming the patterns observed in other contexts and fields (Huang et al., 2020; Larivière et al., 2013; Winslow & Davis, 2016). This lower research output has several consequences. For example, the number of publications is considered when applying for competitive research grants, broadly and especially in Chile, which reduces women's probability to obtain research funding. Additionally, fewer publications produce fewer citations and research impact, which in turn harms the visibility of female researchers. Fewer publications may also lead to difficulties in obtaining tenure and promotion to more senior academic positions, which, in turn, impacts salaries and academic prestige. While research output tends to increase with experience, for both male and female researchers, we found that the gender gap increases with years of research experience and that the pace of productivity over time differs by gender. Indeed, men show a steeper increase in productivity that peaks faster and then declines,

Figure 4

Number and Predicted Coauthorships in Education Journals Between 2011 and 2021, With at Least one Author Affiliated With a Chilean Institution, by Type of Collaboration (National Coauthorship, Regional Coauthorship, or International Coauthorship) and Author Gender



Note. Only articles with two and up to 10 authors were considered. Predicted counts from Model 6 and 95% CI are shown in Panel B. CI = confidence interval. See the online article for the color version of this figure.

while women show a somewhat slower and more steady growth in productivity as they gain more research experience. The pace of productivity over time may have important consequences for the ability to obtain research grants, be cited, and achieve a higher research status earlier in the academic career. In sum, these findings confirm Hypothesis 2.

Third, regarding research leadership, we found no significant gender gaps at any of the different levels of research experience when comparing the participation of women and men as first authors of collaborative articles authored by mixed-gender teams. Thus, while female researchers in the field of education publish a significantly lower number of articles, as discussed above, when

they do publish collaboratively, they do not do so in a more subordinate position, as they are just as likely as men to be first authors. This finding is not consistent with Hypothesis 3, which is derived from previous studies reporting that male researchers are generally more likely than female researchers to occupy the prestigious positions of first and corresponding authors (Elsevier, 2020; Larivière et al., 2013; Vuong et al., 2021; West et al., 2013).

Regarding research collaboration (i.e., article coauthorships), we found support for Hypothesis 4: in Chile, female education researchers present significantly fewer numbers of coauthorships, a gap that increases with research experience. Interestingly, the patterns of collaboration also differed by gender: Women were more

Table 4
Meta-Analysis Results From Bipartite ERGMs on the Probability of Coauthoring an Article

Effect	Estimate	β	SE	σ	Q
<i>edges</i>	-8.709***	0.001	0.16	0.155	26.594**
<i>gwdegree</i> (researchers)	4.152***	63.561	0.331	0.375	18.659*
<i>gwdegree</i> (articles)	4.142***	62.929	0.197	0.011	10.232
<i>bldegree</i> (1)	2.655***	14.225	0.072	0.000	5.498
<i>nodefactor</i> LATAM	0.547***	1.728	0.136	0.106	24.992**
<i>nodefactor non-</i> LATAM	0.234*	1.264	0.102	0.087	35.952***
<i>nodefactor gender</i> (women)	-0.333***	0.717	0.04	0.004	9.710
<i>nodecov</i> academic age	0.146***	1.157	0.011	0.001	39.591***
<i>nodematch</i> region	1.961***	7.106	0.114	0.098	34.220***
<i>nodematch</i> gender	0.149*	1.161	0.064	0.010	12.666
<i>nodematch</i> academic age	1.019***	2.770	0.097	0.078	54.908***

Note. β shows the odds ratios on the probability of coauthoring an article. ERGM = exponential random graph models; SE = standard error; LATAM = Latin American.

* $p < .05$. ** $p < .01$. *** $p < .001$.

likely to engage in national coauthorships than men, who tended to develop more international (both regional and nonregional) collaboration profiles. These disparities are likely to affect research visibility and impact and are aligned with previous findings from Elsevier's (2020), which shows that male academics tend to collaborate internationally more than female researchers across different countries and academic disciplines.

Further, as proposed in Hypothesis 5, again based on previous studies (Espinosa et al., 2022; Kwiek & Roszka, 2021), coauthorship patterns showed significant levels of gender and research experience homophily. This is, education researchers in Chile are significantly more likely to collaborate with colleagues of the same gender and of similar research experience. This finding has important implications, as it limits the diversity of research teams and may impede the diffusion of knowledge and innovation across different generations of Chilean education researchers.

Conclusion

In line with previous studies (Silander et al., 2013), we confirmed that, within the Chilean education research community, gender and experience are strong predictors of research attrition, output, and collaboration. We identified several theoretical and methodological contributions of the present study. First, we confirmed that, even in highly feminized academic fields, such as education, women are overall more likely to be excluded from research and disadvantaged in terms of research output and collaboration. Second, by using a quantitative multimethod approach with state-of-the-art inferential techniques, we studied gender effects on different dimensions of research trajectories. By disentangling the complex facets of gender imbalances in research trajectories from a career course and gender perspective, we provide more nuanced insights than previous studies focusing on one of these dimensions. Particularly, by looking beyond cross-sectional gender representation data and descriptive trend analyses, a longitudinal panel approach allowed us to explore

how research trajectories are shaped by cumulative gender disadvantages, and our social network analysis showed how academia is embedded and structured around social mechanisms related to gender, experience, and geopolitical effects and their intersections.

This study is not without limitations. First, we focused on Scopus-indexed education journals. Although Scopus is a comprehensive database, it certainly does not cover all scholarly publications. Thus, we excluded other types of documents that are also important and common scholarly outputs, particularly in the social sciences and humanities, such as not Scopus-indexed journals, books, and book chapters. However, the difficulties of accessing comparable data from these nonindexed documents remain a challenge in large-scale bibliometric analysis, and the coverage of books and book chapters in the Scopus databases is still low. Also, the education focus of the Scopus-indexed journals was determined by the official Scopus journal field classification. While this is a widely used and accurate classification that allows for interdisciplinary foci, we acknowledge that there may be relevant education-related articles that are not published in Scopus-indexed education journals.

Second, previous research suggests that female researchers are less likely to publish in the most prestigious and high-impact social science journals (Light, 2013; Mayer & Rathmann, 2018). Despite the wide coverage of Scopus bibliometric data, gender gaps could be even more pronounced in elite academic sources and selective indexing databases, such as WoS-indexed journals. Thus, gender disparities may be underestimated in this study.

Third, this study did not explore the intersectionalities between gender and contextual/institutional inequalities. Future research would benefit from examining how gender interacts with the type of higher education institution where researchers work (e.g., private vs. public, research-intensive vs. teaching-oriented universities, and regional/local vs. metropolitan universities). These intersectionalities may be particularly salient in the highly stratified Chilean higher education system (Kuzmanic et al., 2023). Third, while we approached gendered research disparities from a longitudinal perspective and used panel data analysis to study individual research trajectories, historical effects are confounded with the effect of research experience in our data. Future research should aim to disentangle cohort differences from academic age effects.

Our findings have important policy implications. First, we highlight the relevance of implementing affirmative action policies that promote the retention of junior female researchers, as well as the research productivity and international collaboration opportunities for women in education research. Second, research funding agencies and institutions should promote and explicitly favor gender- and experience-diverse research teams to ensure knowledge diffusion, innovation, and equitable development opportunities across different generations of Chilean education researchers. Finally, it is key for higher education institutions to monitor the distribution of academic work and promote a more gender-equal engagement in research, teaching, and service duties. These initiatives will not only benefit female researchers but advance the field by promoting research productivity as well as diversity and equity in knowledge production.

Our findings are consistent with studies from other national contexts, such as Spain (Borrego et al., 2010), Italy (Abramo et al., 2021; Ruggieri et al., 2021), and Ecuador (Dávila et al., 2022),

where there is also documented evidence of broader gender disparities in academia. Thus, the results of our study can be significant with regard to the further use of bibliographic information to assess the gendered research participation of scholars beyond the field of education and Chile.

Studies in developing countries coincide in reporting structural barriers for female researchers and traditional gender roles in academia. For example, research in countries such as Colombia and Vietnam has documented similar challenges for women in academia, such as greater domestic and care responsibilities, gender discrimination, and fewer opportunities for funding and promotion (Gil et al., 2023; Vuong et al., 2021). Sugimoto et al. (2015) also showed that countries with a lower human development index and gender inequality index have lower female participation in research output. Thus, gender should be included as a key social category in future studies, especially when looking at researchers' output in emerging countries (Mayer & Rathmann, 2018).

Finally, it is important to recognize that cultural components play an important role in the differences observed in gender equity across countries. Future research should examine findings in different cultural contexts to validate and extend our conclusions. Comparative studies in different national contexts and regions could provide a broader understanding of the factors that contribute to gender disparities in research and how to effectively address them.

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