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Women in the Shadow of Big Men: The Case of Canada Excellence Research Chairs

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Abstract

Canada Excellence Research Chairs program—an award worth up to ten million dollars over seven years to attract and support world-renowned researchers and their teams to establish research programs in Government of Canada’s science and technology priority areas at Canadian universities—has been one of the most controversial governmental funding allocations in Canada. One of the main criticisms to this program is the absence of clear selection and recruitment criteria, including promulgation of standards for inclusion and diversity, which have resulted in lack of representation of women among Chairs. The main purpose of this study is to shed light on gender differences in scientific production and impact of publications induced by Canada Excellence Research Chairs program and to examine co-authorship collaboration patterns that are formed as a result of introduction of this program. Findings reveal that when Chairs are listed as main investigators of the scientific work (either last or corresponding authors), female-led papers receive higher rate of citations and are published in journals with higher impact. Although citation impact of papers that include collaborations with women are the highest, more than 78% of researchers of each gender repeat their collaborations, with their male peers on authoring more than one papers. Last but not least, this study concludes that collaborations with women are fragile and are dependent on the presence of central male researchers. Therefore, contributions of women to high impact research is effective as long as they are under the shadow of more central, influential and popular men.

Keywords

Canada Excellence Research Chairs Program; Gender; Bibliometrics; Co-authorship Network Analysis

Conference Topic

Science policy and research assessment

Introduction

Occupational gender segregation—a pervasive phenomenon expressing different distribution of women and men across occupations and sectors—has long been of central concern to science and public policy (Bettio, Verashchagina, Mairhuber, & Kanjuo-Mrčela, 2009; Charles, 2003; Fortin & Huberman, 2002). It is commonly differentiated along two dimensions: horizontal and vertical. Horizontal segregation is the differences in concentration of women and men in certain professions or sectors, whereas vertical segregation refers to representation of men and women at different levels or positions of labour hierarchy in terms of income, prestige, and the like. The vertical dimension has dovetailed with well-known notions of “glass ceiling” (Hymowitz & Schellhardt, 1986) and “sticky floor” (Noble, 1992), where visible or invisible barriers prevent women from advancing into top levels of hierarchy, and intrinsic forces tend to keep women at the lowest levels of the hierarchy (Meulders, Plasman, Rigo, & O’Dorchai, 2010).

Academia is no exemption and is not immune to gender segregation. Women in science also hit the glass ceiling—a hindrance to those trying to progress to senior ranks in academia (Caprile, Addis, Castaño, & others, 2012). However, the “leaky pipeline” metaphor (Berryman, 1983) suggests that women tend to leave science long before they face the glass ceiling, bearing witness to the higher attrition of women from science as they advance through the pipeline of science (the educational/professional system training scientists).

In response to the growing concern on women’s progression and retention in academia, science and technology (S&T) policies have typically centered either on getting more women into science and engineering (S&E) fields, or on affirmative action programs to remedy gender disparities along the science pipeline (Buré, 2007). However, increases in quotas as a stand-alone measure is likely to be futile to fix the leaky pipeline and glass ceiling for women in science, unless reinforced by systematic socio-economic strategies that alleviate inequalities in other arenas of society in ways that support productivity, diversity and inclusion (Alexander & Jacobsen, 1999; Cheldelin & Eliatamby, 2011, p. 239; Etzkowitz, Kemelgor, & Uzzi, 2000). This study tries to articulate these issues into Canadian scientific system, delving into Canada Excellence Research Chairs (CERC) program—an award worth up to ten million dollars over seven years to attract and support world-renowned researchers and their teams to establish research programs in Government of Canada’s S&T priority areas at Canadian universities. These awards are acknowledged to be most generous available globally¹.

The CERC program was launched in 2008, the successor to government of Canada’s economic plan known as “Advantage Canada”, a plan to improve Canada’s global competitiveness as a knowledge-based society by creating pool of talents and effectively translating research into innovation to provide solutions and address concerns primarily in four fields, namely (1) Environmental Sciences (2) Natural Resources (3) Health Sciences (4) Information and Communications Technologies (Science-Metrix, 2015). Advanced manufacturing, social inclusion and innovative society, and other areas to benefit Canada have been added to the government of Canada’s priority areas after the first competition² (Science-Metrix, 2015).

This program has been one of the most controversial governmental funding allocations in Canada over the past decade. The primary criticisms were twofold: (1) the program’s lack of focus on support and retention of local talents, and (2) the absence of clear selection and recruitment criteria, including promulgation of standards for equal opportunities, inclusion and diversity (Ghoussoub, 2013; The Globe and Mail, 2010, 2014). The attention to the latter concern was raised after selection of Chair holders in the first CERC competition in 2010, among which no women were even shortlisted for nomination³. This issue provided an immediate impetus to review CERC Gender Issues by the Ad Hoc Panel and the lack of representation of women among CERCs was further dubiously explained by underrepresentation of women in top academic positions, low participation of women in Canada’s top four priority areas, and women’s vulnerability to mobility stress and career change (Science-Metrix, 2015). Canada’s effort to allay this concern was limited to a more transparent recruitment process report from universities, and accommodation of rising stars (rather than established researchers) and number of CERC positions open to all areas of research into the CERC program (de la Giroday, 2013; Science-Metrix, 2015). These initiatives resulted in the selection of only one woman out of nine additional Chairs under the second competition concluded in 2015. As of total, only one of twenty seven appointed CERCs is a woman.

The extreme underrepresentation of women in CERC program reflect one of the consequences of the glass ceiling and leaky pipeline phenomena, upon which attainment of equity and

¹ http://www.cerc.gc.ca/about-au_sujet/index-eng.aspx

² http://www.cerc.gc.ca/news_room-salle_de_presse/releases-communiques/2016/nr-co-20161012_faq-questions-eng.aspx?pedisable=true

³ <http://www.cerc.gc.ca/program-programme/equity-equite-eng.aspx>

diversity practices are obviated in Canada's largest investment in research. This study shares the assumption that appointment of more female CERCs alone does not necessarily lead to promote equitable access to the program for qualified researchers of each gender. For this purpose, this study looks into co-authorship collaborations that are initiated by CERC program and tries to answer one main question: What are the gender differences in research output and scientific contributions that are induced by CERC program? Therefore, this study applies bibliometric and social network analysis (SNA) techniques to provide a cross-gender analysis of scientific production and impact, and collaboration patterns of Canada Excellence Research Chairs.

Methodology

Bibliographic publication data is gathered from Web of Science (WoS) database for Canada Excellence Research Chairs, where Chairs are affiliated to the Canadian university awarded in years 2008-2015. Since the focus of CERC programme is on advancement and diversification of Canadian scientific community, collaborators of CERCs are defined as Canadian-affiliated researchers who have authored one or more papers with CERCs.

CERC program is launched in 2008 and full given names of authors are available in the WoS from 2008 onwards. Therefore, gender is assigned to the given names of CERCs and their collaborators, using U.S. Census, WikiName, Wikipedia, France and Quebec lists (More details in (Larivière, Ni, Gingras, Cronin, & Sugimoto, 2013)). Among 27 CERCs, 21 CERCs are identified with at least one paper published with their awarded Canadian university. A total of 712 articles were extracted from the Web of Science database, along with their 750 distinct authors.

The quantitative analyses are grounded on bibliometric indicators of scientific output, using the number of scientific publications as an indicator of productivity of a researcher, the normalized citations as research impact, and normalized Impact Factor (IF) as a journal impact indicator. The normalized citation impact of a paper is calculated as the average yearly number of citations received by a paper divided by the average yearly number of citations to all the papers from the same year, in the same subject area and of the same document type (Glänzel & Schubert, 2005; Moed, De Bruin, & Van Leeuwen, 1995). The normalized journal IF is calculated similar to the citation impact where the IF of the journal associated to each paper is considered instead of number of citations.

The proportion of scientific production of each gender is defined as a fractional count of articles, according to which each author account for $1/x$ count of authorship where x is the number of co-authors of an article affiliated to a Canadian university to which a gender is assigned.

In this paper, orders of authors in the byline is considered as a measure of contribution, due to the fact that fields of research of CERCs follow contribution-based authorship ordering as a common practice, based on which first author position is typically given to younger researchers with lower professional rank and last author position is assigned to the principal investigator with high rank (West, Jacquet, King, Correll, & Bergstrom, 2013). Articles with CERCs listed as a corresponding author are also identified to help analyse the contribution of researchers of each gender where CERCs are responsible for the research project as a whole, including acquisition of funding, oversight of a research process and production of the final manuscript (Yank & Rennie, 1999).

The collaboration patterns of CERCs are mapped using the co-authorship network analysis, in which nodes represent authors and two nodes are connected when two authors co-author a paper. Each link (edge) is categorized into whether it connects two female authors (F-F) link, or one female and one male author (F-M), or two male authors (M-M). Weight of each link represents the extent to which two authors who have already collaborated on a paper, repeat

their collaborations by co-authoring another paper together and is referred to as collaboration repetition rate in this research.

In this study, the listed network measures in Table 1 are deployed to characterize the CERC's co-authorship network, assessing the role of authors of each gender. CERC's network of co-authorship is further visualized using Gephi's (Bastian, Heymann, & Jacomy, 2009) Force-Atlas 2 layout, in which the proximity of two nodes is defined by the weight of the edge that links the two nodes.

Table 1. Network measures and their properties

<i>Parameter</i>	<i>Meaning</i>	<i>Interpretation</i>
Degree Centrality (Freeman, 1979)	A node's total number of connection	How collaborative an author is.
Betweenness Centrality (Anthonisse, 1971; Freeman, 1979)	Number of times a node is on the shortest paths between other nodes	How much control an author has over information in the network.
Eigenvector Centrality (Newman, 2004)	A centrality measure that is proportional to the sum of centralities of those it is connected to	To what extent an author is connected to the most connected authors.
Closeness Centrality (Sabidussi, 1966)	Proximity of a node to the other nodes in the network	How easily an author can reach/spread information in the network
Clustering Coefficient (CC) (range 0 -1) (Holme, Min Park, Kim, & Edling, 2007; Watts & Strogatz, 1998)	Ratio of total number of links that could exist for an actor to the number of real existing links.	How well direct collaborators of one author are connected to one another if the author is removed from the network. The lower the CC, the more important an author is in the network.

Findings

21 Chairs are identified with at least one paper affiliated to their awarded university, noting that other 6 Chairs that are not included in our publication data analysis are selected as CERCs from 2015 onward. Therefore, they had no paper published with a Canadian affiliation in years 2008-2015. Among these 21 Chairs identified, one is female (who is involved in authoring 22 papers) and 20 are male researchers (who are responsible for authoring 690 total articles). 214 female and 515 male authors were involved in CERCs' authorship collaborations, being referred to as CERC collaborators in this research.

Although share of female authorship for CERCs is very limited (4%), women account for 25% of authorship among CERC collaborators (Fig. 1). CERC publications with female collaborators involved, have higher or equal scientific impact as those authored with male collaborators (Fig. 2). When women are lead-authors (first authors), their papers receive lower number of citations although being published in journals with higher impact (Fig. 3). This has been associated to Matilda effect (Rossiter, 1993) in science in several studies (Ghiasi, Larivière, & Sugimoto, 2015; Larivière, 2014), according to which women's contribution to science is played down and attributed to their male peers (which in this case is in terms of the citation rate expected to be received by publishing papers in journals with higher IF than journals in which male first-authored papers are published). However, when women are last authors their papers receive lower citation rate (Fig. 3).

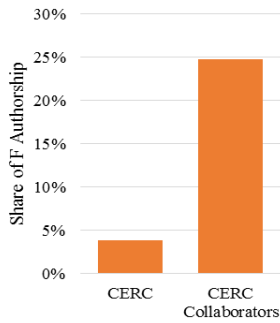


Figure 1. Share of female authorship

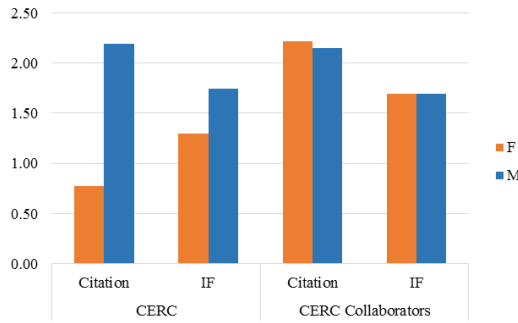


Figure 2. Differences in citation and journal impact of CERCs and their collaborators

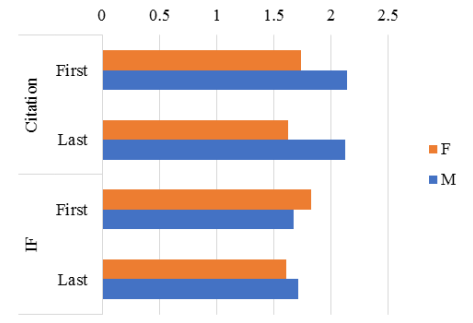


Figure 3. Citation and journal impact by authorship order

When Chairs are listed as last authors (which is often held by principal investigator or supervisor of the research project) (Table 2), female first-authored papers receive higher citation impact and are published in journals with higher IF (Fig. 4). These differences are even more conspicuous when Chairs are corresponding authors (main investigators of the research project) (Table 2; Fig. 5).

Table 2. Number of first-authored papers and share of authorship of each gender when CERCs are last authors or corresponding authors

	CERCs as last authors		CERCs as corresponding authors	
	First-authored papers (#)	Authorship (%)	First-authored papers (#)	Authorship (%)
Female	48	25%	7	45%
Male	156	75%	11	55%

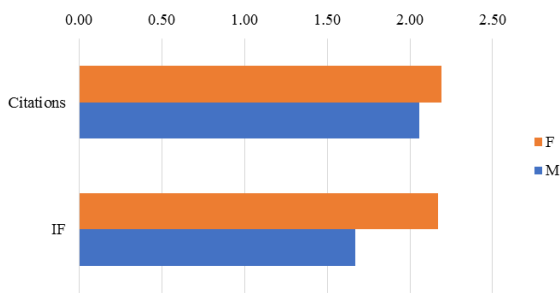


Figure 4. Citation and journal impact of papers first-authored by CERC collaborators when CERCs are last authors

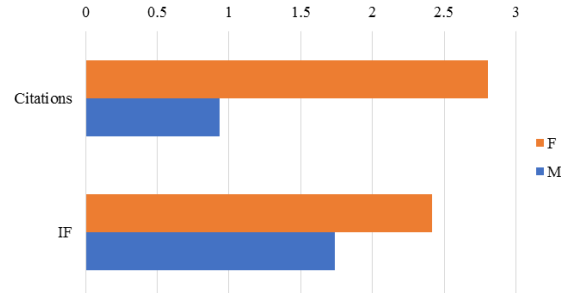


Figure 5. Citation and journal impact of papers first-authored by CERC collaborators when CERCs are corresponding authors

Co-authorship Network Analysis

Details on CERC co-authorship collaboration network can be found in Table 3. Degree centrality is higher for women, which shows that female researchers are more collaborative than male researchers involved in CERCs' co-authorship collaborations. However, men are more productive and average clustering coefficient is lower for men in the network. This confirms that direct collaborators of a female author are better connected if she is removed from the network, highlighting important position of male researchers within the network.

Table 3. Network properties of CERCs' co-authorship collaborations (2008-2015)

		<i>Female</i>	<i>Male</i>
<i>Nodes</i>	<i>CERC</i>	1	20
	<i>CERC Collaborator</i>	214	515
	<i>Total</i>	215	535
<i>Productivity</i>	<i>CERC</i>	22.00	34.50
	<i>CERC Collaborator</i>	2.02	2.36
	<i>Total</i>	2.11	3.56
<i>Degree</i>	<i>CERC</i>	28.00	35.50
	<i>CERC Collaborator</i>	10.79	9.35
	<i>Total</i>	10.87	10.33
Clustering Coefficient	<i>CERC</i>	0.27	0.21
	<i>CERC Collaborator</i>	0.90	0.86
	<i>Total</i>	0.89	0.83

Share of F-F collaborations are the lowest in CERC authorship collaboration network and majority of collaborations are between two male researchers (Fig. 6), which is expected due to the low share of women involved. Moreover, M-M collaborations are shown to be the strongest ties among other collaboration types (Fig. 7). At individual level, the female CERC have repeated her collaborations with other female authors at a higher rate than her male authors. However, among 20 male CERCs, this trend is only observed for three Chairs.

The findings also reveal that only 17% of female researchers and 22% of male researchers involved in more than one paper with CERCs, repeat their collaborations more with their female colleagues. Hence, it can be concluded that for both genders, repeating an authorship collaboration with a male researcher is preferred.

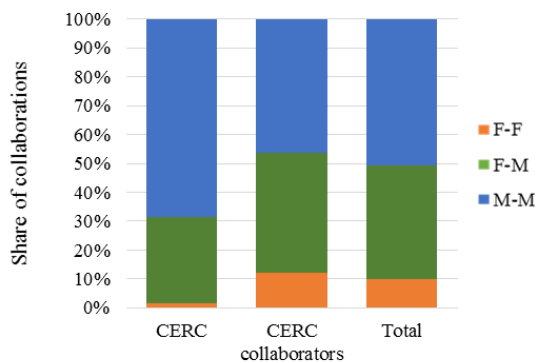


Figure 6. Share of different collaboration type

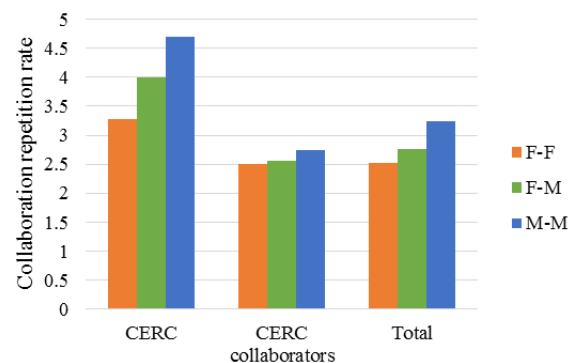


Figure 7. Collaboration repetition rate (edge weight) per collaboration types

Along these lines, average citation impact of papers forming F-F collaborations are the highest compared to those creating F-M and M-M collaboration (Fig. 8)⁴. Therefore, in the CERC co-authorship collaboration network, female authors are collaborating with other female authors on highly cited papers.

⁴ This is not associated to the data size, 86 distinct papers are identified for F-F collaborations, 192 papers for F-M collaborations and 303 papers for M-M collaborations.

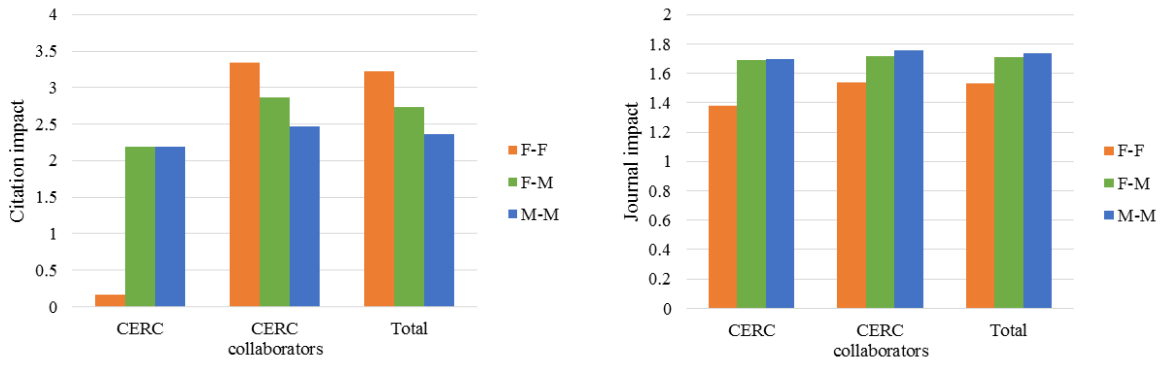


Figure 8. Average citation and journal impact of papers forming different types of collaborations

Since other centrality measures such as betweenness, eigenvector and closeness cannot be applied to disconnected networks, these measures are compared for researchers of each gender in each CERC cluster (CERCs and their connections to their collaborators). Female collaborators of the female CERC are associated to higher betweenness, eigenvector and closeness centrality compared to male collaborators of the CERC. Only 6 of male CERCs are involved in clusters where women have higher eigenvector centrality and 5 male CERCs are located in clusters where women have higher closeness centrality and 2 in cluster with higher female betweenness centrality, noting that these overlap. These measures show the important position of men in the network in majority of CERC clusters, denoting vulnerability of F-F connections and their strong reliance on a male researchers.

Visualization of CERC's collaboration network is shown in Fig. 9. In this network node size is based on degree centrality of an authors and node colours represent different roles of authors. Edges are differentiated based on the collaboration type. The visualization also highlights a presence of male collaborators with high degree centrality where higher shares of female authors and F-F collaborations (orange links) are present, highlighting the fragility of F-F links and their reliance on collaborations with men.

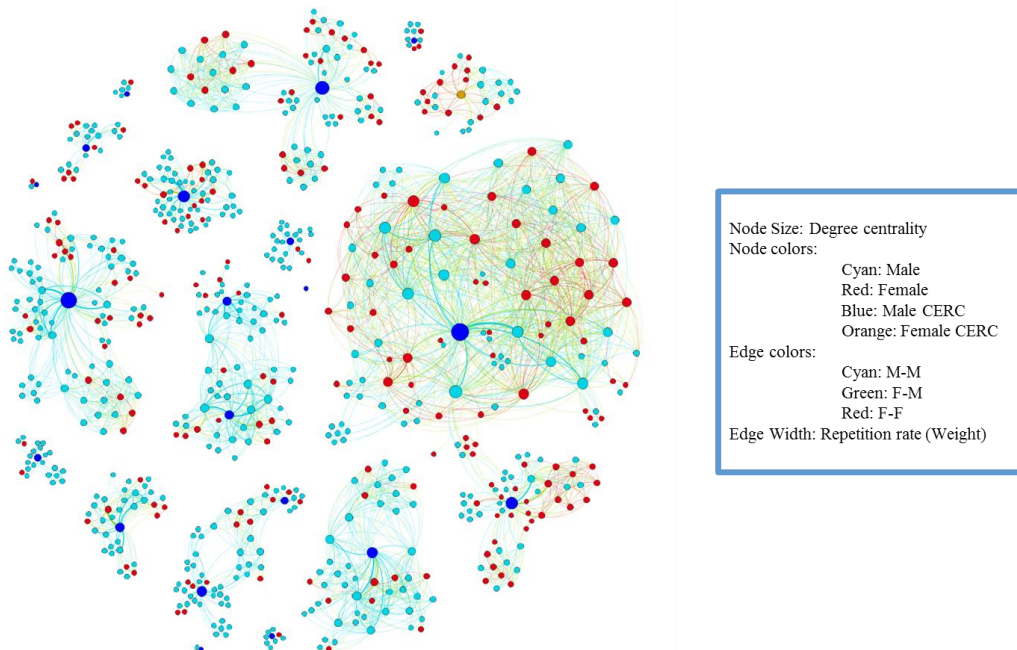


Figure 9. Visualization of co-authorship collaboration network of CERCs

Conclusions

The main purpose of this study is to shed light on gender differences in scientific production and impact of publications induced by Canada Excellence Research Chairs program and to examine co-authorship collaboration patterns that are formed as a result of the introduction of this program. This program is highly male dominated: women account for only 13% of total authorship engendered by CERC program. However, share of female authorship is higher (25%) among CERC collaborators. Although only one woman has been selected as CERC since 2010, female collaborators of CERCs have shown to be as influential as their male collaborators by being involved in papers with higher or equal scientific impact as those of their male peers. Matilda effect (Rossiter, 1993) might be present at the level of citations, based on which when women are lead authors, their scientific work receive lower recognition (citation rate) than the rate that is expected to be received from the journals their papers are published in (Ghiasi et al., 2015; Larivière, 2014). When Chairs are listed as main investigators of the scientific work (either last or corresponding authors), female-led papers receive higher rate of citations and are published in journals with higher impact. This finding reveals that women make the largest contribution to high-impact publications of Chair-supervised projects.

Although average citation impact of papers that are forming collaborations with women (which include F-F or F-M collaborations) are the highest, more than 78% of researchers of each gender repeat their collaborations, with their male peers on authoring more than one paper. Last but not least, based on the network visualization and the centrality measures, this study concludes that F-F collaborations are fragile and might be strongly dependent on the presence of central male researchers. Therefore, this can be said that contribution of women to high impact research is effective as long as they are under the shadow of more central, influential and popular men. The results of this study might benefit Canada's limited S&T gender-related policies, with a specific focus on development and implementation of systematic strategies to increase participation of women in Chair programs as students, colleagues and professionals. The results of this study underpin the importance of collaboration with female researchers, which is often overlooked in retention and inclusion policies of women in S&T, and can provide a baseline to develop gender-responsive policies facilitating forming collaborations with women and favouring the participation of female researchers in CERC.

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