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Dissertation Authors and Their Mentors. Can Gender Diversity in Russian STEM be Achieved?[1]

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Introduction

There is a significant gender gap in STEM disciplines, especially in computer science, physics, and maths (Holman, Stuart-Fox & Hause, 2018). The gap is relatively stable across time and geography (Huang et al., 2020), and one possible reason for this could be the reproduction of gender stereotypes and the perception of STEM as "male" fields; for example, there is a transition of negative stereotypes about women's math abilities to girls by their parents and teachers (Shapiro & Williams, 2012). Moving towards gender parity remains essential because there are social and economic benefits to diversity in STEM disciplines that can help promote scientific progress and economic growth (Intemann, 2009; Hong & Page, 2004).

There are several ways to explore gender disparities in academia, such as through publications (Pilkina & Lovakov, 2022), hiring (Clauset, Arbesman & Larremore, 2015), or dissertations (Schwartz, Liénard & David, 2021). We investigate mentorship between dissertation authors and their mentors in Russia. We consider gender structure at different stages of an academic career through the lens of dissertation writing and mentoring. We are interested in STEM fields separately and in comparison to non-STEM fields.

We detect that the share of women is lower at later stages of the academic career track, and the depth of this decline varies by field; the lowest proportion of women is in STEM fields. Also, STEM fields are not homogeneous, but more importantly, the subfields within some fields are not homogeneous either. Thus, in Russia, several characteristics do not replicate the patterns evident in data from other countries (Schwartz, Liénard & David, 2021; LaBerge et al., 2022). However, the key trends and problems seem universal and persistent regardless of data origin.

Data

We analyze data from the Higher Attestation Commission website (Latin: HAC, Cyrillic: ВАК). The HAC integrates information on Ph.D. dissertations in Russia and the following degree level — doctoral dissertations. In the HAC data, dissertation authors explicitly connect

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with their mentors. We inferred the gender of authors and mentors from the patronym (used in Russian names in addition to the first and second names). Gender inference is available for 97.2% of authors and 87,7% of mentors. We excluded individuals whose patronym with a high probability of association with both genders.

The resulting dataset includes 45,608 dissertations, where 32,972 are Ph.D. (between 2012 and 2016) and 12,636 are doctoral (between 2008 and 2016). It is a multidisciplinary dataset with 18 general research fields that contain 308 subfields. For example, *Medical Sciences* is a general field with subfields such as *Cardiology*, *Immunology*, and 35 other subfields.

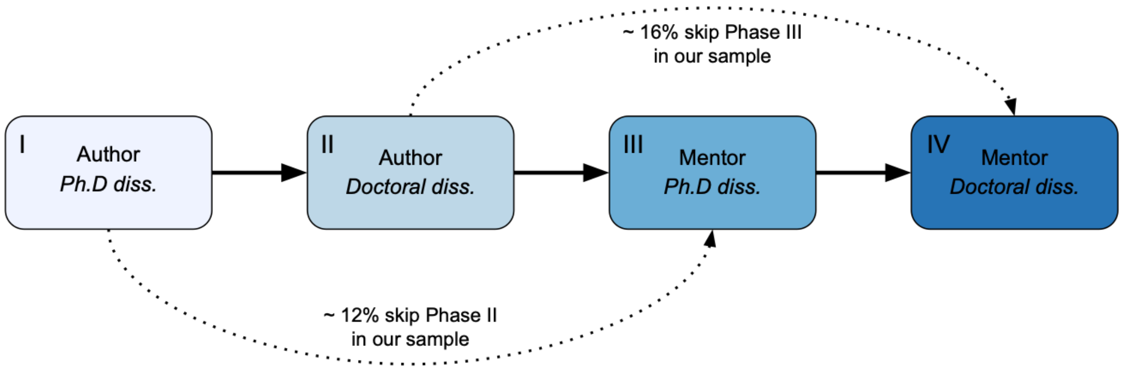
Results

Stages of academic career

There are two types of dissertations in Russian academia: Ph.D. and Doctoral. Ph.D. dissertation generally is defended by most people on the academic track. Doctoral dissertation follows Ph.D. and has a higher status, and fewer people hold it. Dissertation processing is supported by a mentor, who usually combines scientific advising and administrative guidance. As a rule, persons can become dissertation mentors only after they have reached the author stage (Huisman, Smolentseva & Froumin, 2018).

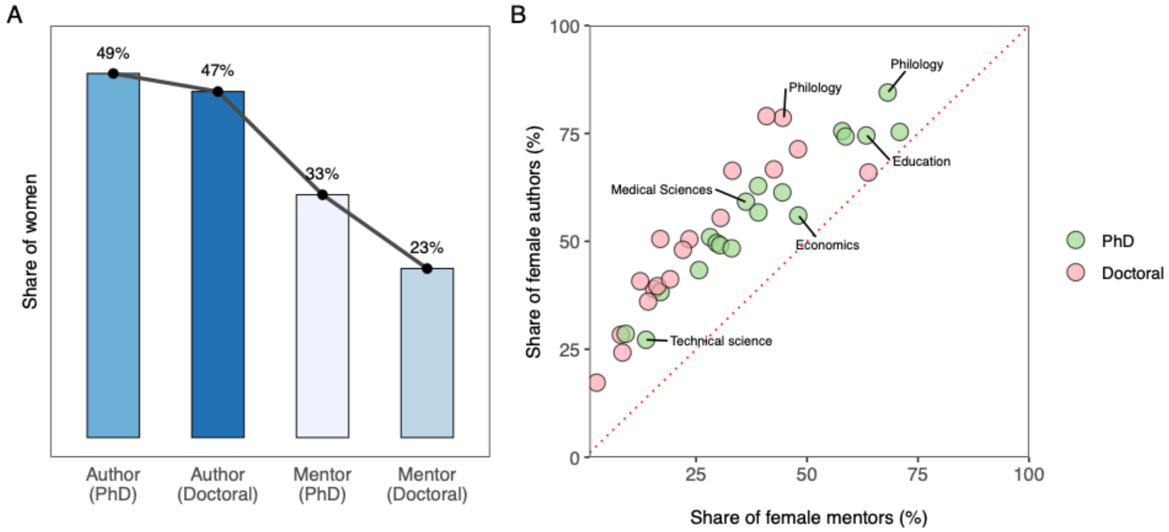
The proportion of women is lower at progressively later stages of the academic career track. This phenomenon is known as a “leaky pipeline.” (Stack, 2004) In the case of the mentoring relationship of dissertation production, four roles can be defined and lined up as a «pipe»: from Ph.D. dissertation author to doctoral dissertation author, then to Ph.D. dissertation mentor, and finally to doctoral dissertation mentor (Fig 1.)

Figure 1: Four roles in the production of dissertations, presented as a pipeline.



Ph.D. authors are distributed by gender evenly — 49% of them are female, and 51% are male (Fig 2A). The proportion of doctoral authors is almost the same — 47% are women. The significant gender gap reveals in the mentor subgroups — only 33% of Ph.D. mentors and 23% of doctoral mentors are women.

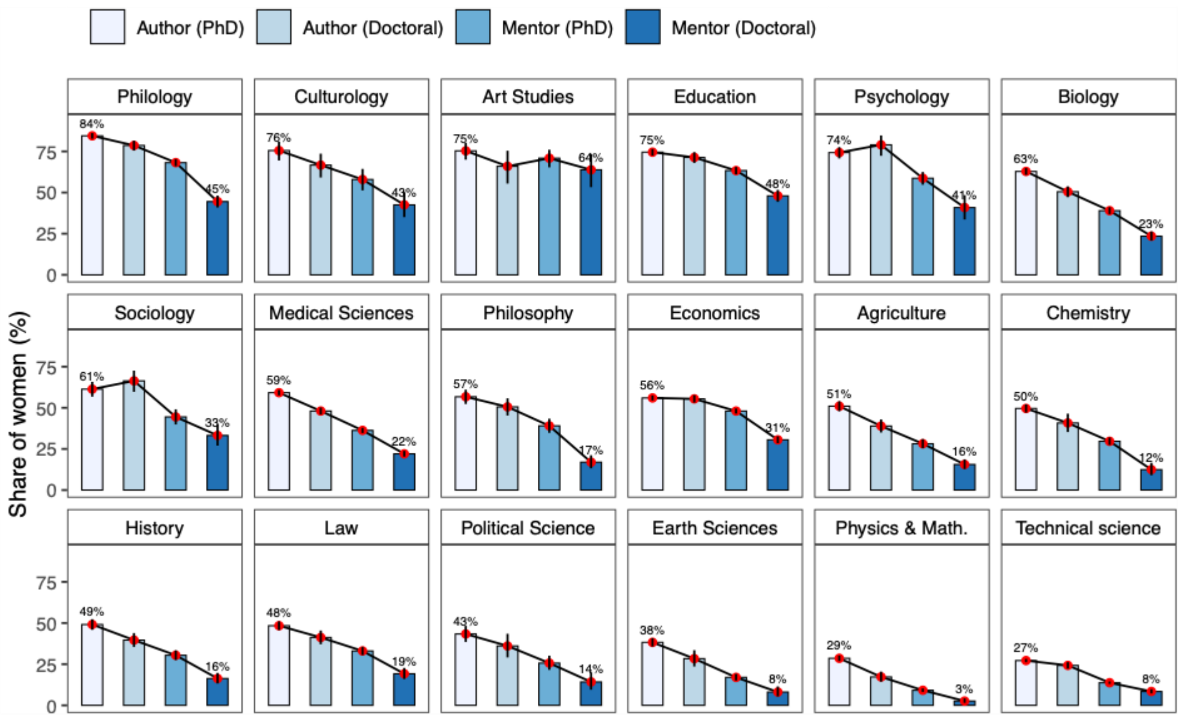
Figure 2: (A) Share of women according to their role in the dissertation production. (B) Share of female mentors less than female authors across all general fields.



Previous investigations show that the general fields are not homogeneous by gender — there are more "male" fields like STEM and more "female" like Education (Holman, Stuart-Fox & Hauser, 2018). Possible explanations vary from academic environment factors (Moss-Racusin et al., 2012) to personal characteristics and gender behavioral patterns (Bleidorn et al., 2016). From our data, we see a similar result — the share of female dissertation authors has varied by general fields — from 17% in Physics (Doctoral) to 84% in Philology (Ph.D.) (Fig 2B.) However, the share of female mentors is always smaller than female authors, even in "female" fields like Education and Philology.

Another point is that the share of women is lower at later stages of the academic career track, and the depth of this decline varies by field (Fig 3). Culturology and Art Studies have wide confidence intervals for each stage. They do not allow us to confidently say that there is a general declining trend in the share of women in these fields. Art Studies, in general, is close to balance — the proportion of women in all stages is more stable than in other general fields. Psychology and Sociology show an increase in the proportion of female doctoral dissertation authors compared to the Ph.D. authors. However, when we look at the confidence interval, we can confirm the proximity of these shares, which is also detected in other fields, such as Economics.

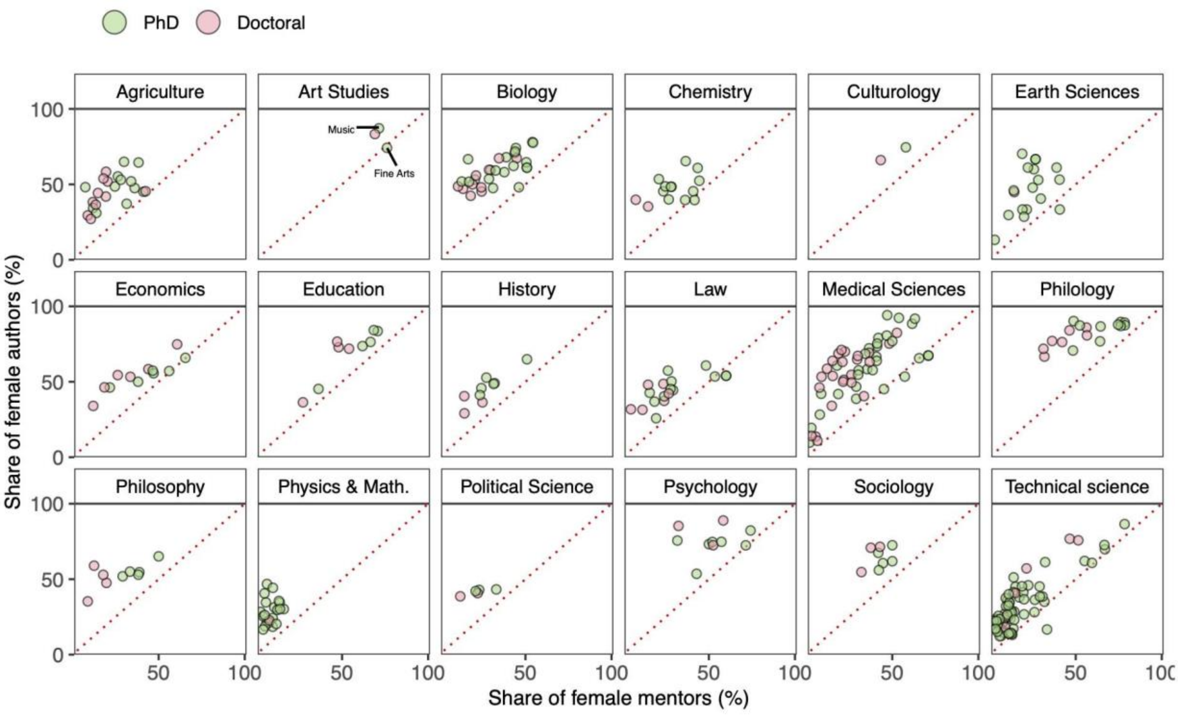
Figure 3: Share of women according to their role in the dissertation production: by general fields.



The gender structure of the fields varies slightly from year to year. The proportion of women among Ph.D. dissertation authors in all STEM fields has not increased or decreased significantly over 20 years. (Fig. S1) We notice a slight increase only in some non-STEM fields, such as Agricultural (from 46% to 54%; $p < 0.001$, chi-sq.test) and Political Sciences (from 43% to 50%; $p < 0.001$, chi-sq.test). Among doctoral dissertation authors, the trend is more favorable for moving toward gender parity. The share of women among doctoral authors increased significantly in some STEM fields such as Technical Sciences (from 16% to 24%; $p < 0.001$, chi-sq.test) and Physics & Math (from 12% to 17%; $p < 0.01$, chi-sq.test). Biology recorded a non-significant decline (from 48% to 45%; $p = 0.62$, chi-sq.test), as well as non-significant growth in Earth Sciences (from 22% to 25%; $p = 0.3$, chi-sq.test) and Chemistry (from 30% to 44%; $p = 0.87$, chi-sq.test).

As we have shown, the general fields are not homogeneous by gender, but either the general fields themselves are not homogeneous by their subfields (Fig 4). For example, for the general field of Art Studies, we get two subfields for Ph.D. and one for doctoral. At the subfields level, the tendency persists that the share of female mentors is smaller than the share of female authors. We detect the different spread of subfields into particular general fields. Physics & Math subfields are tightly concentrated in one area, while Medicine Sciences subfields are extended along the axes. Fig 4 demonstrate the importance of considering gender structure in general fields in light of their internal structure and subfield characteristics (Holman & Morandin, 2019).

Figure 4: Share of female mentors less than female authors across most subfields.



Gender and mentorship

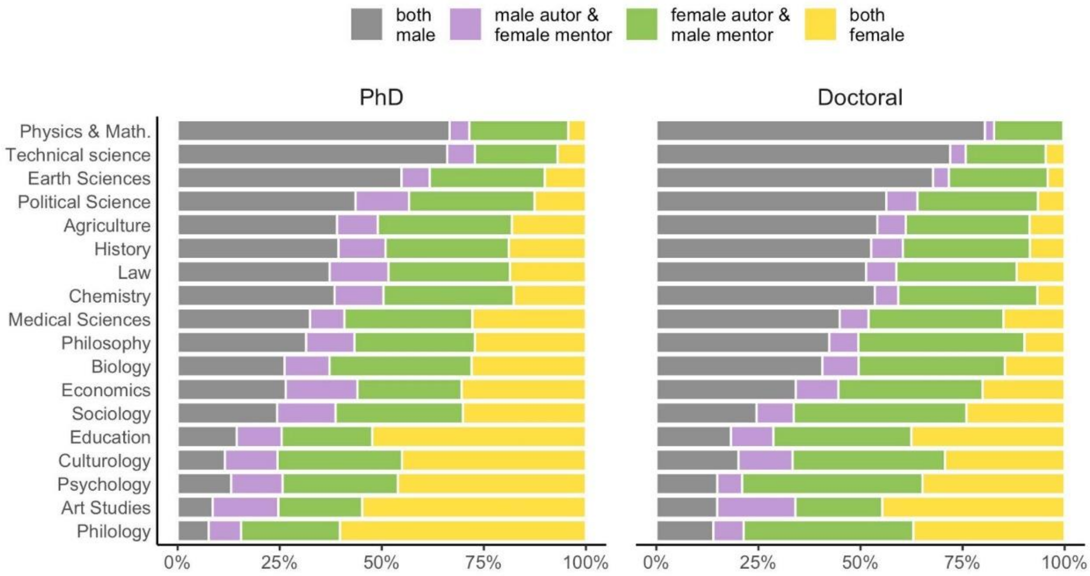
Beyond the gender structure, there is a specific focus on whom women and men prefer to work with in the dissertation production process. A summary of the types of collaborations presents in Table 1. The smallest share among the collaboration types belongs to the «male author & female mentor» type: for Ph.D. dissertations is 10%, for doctoral — 7.3%. The most common type of collaboration is the «both male» type — 40.8% for Ph.D. and 45.9% for doctoral dissertations. In addition, we see that total female mentors primarily supervise female authors (20.8% of all collaborations for both types of dissertations).

Table 1. Dissertations by gender of mentor and author.

Collaboration type	Ph.D. (N=32972)	Doctoral (N=12636)	Overall (N=45608)
both male	13458 (40.8%)	5804 (45.9%)	19262 (42.2%)
male author & female mentor	3302 (10.0%)	927 (7.3%)	4229 (9.3%)
female author & male mentor	8702 (26.4%)	3948 (31.2%)	12650 (27.7%)
both female	7510 (22.8%)	1957 (15.5%)	9467 (20.8%)

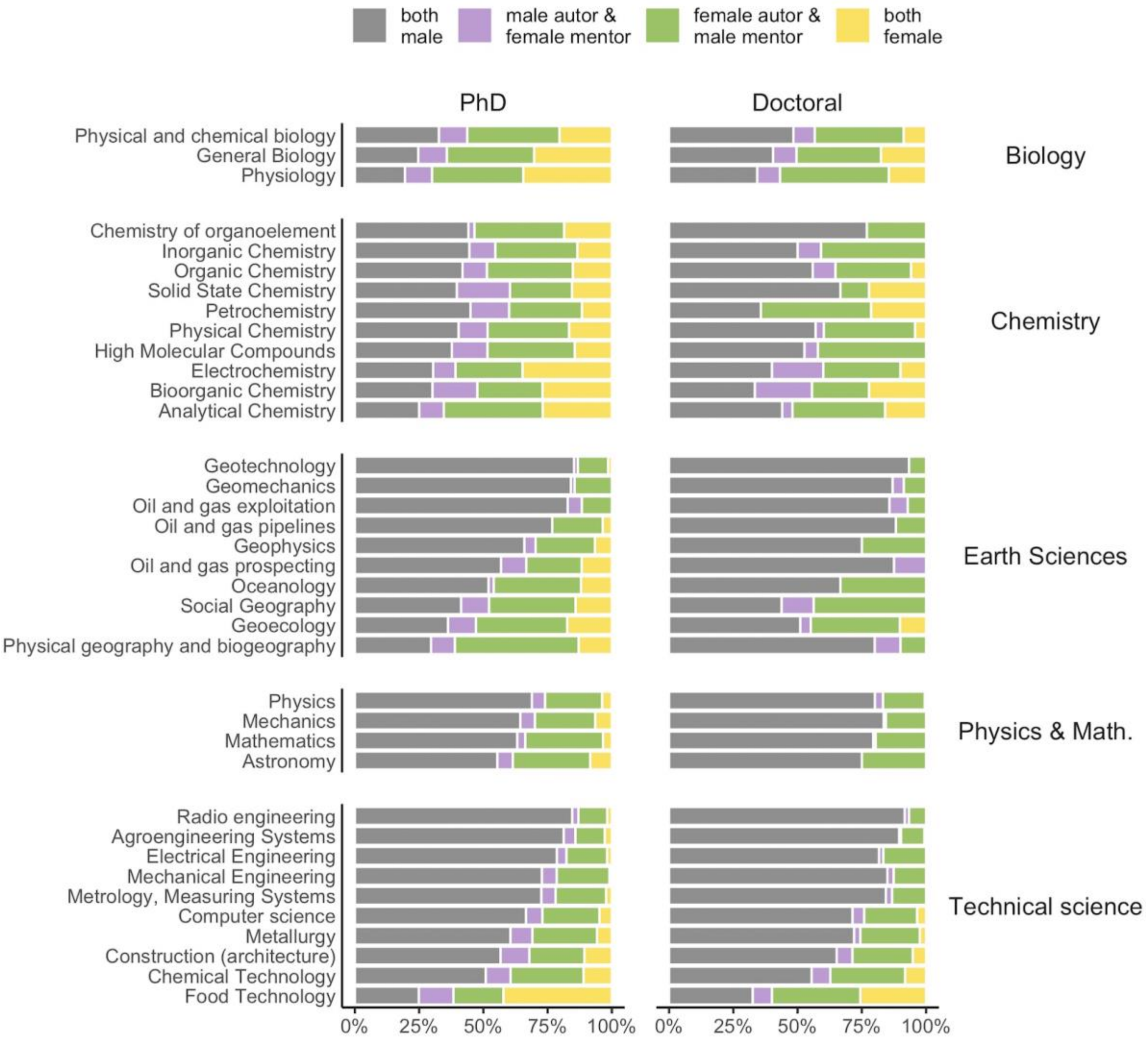
The share of collaboration types varies across general fields, but «male author & female mentor» is always the rarest type (Figure 5). For Ph.D. dissertations, the top three STEM fields have the highest proportion of «both-male» type collaborations (Physics, 67%; Technical Science, 66%; and Earth Sciences, 55%). The highest proportion of «both-women» collaborations is in Philology (60%), Art Studies (55%), and Education (52%). The share of «both women» collaboration for doctoral dissertations has declined in all fields compared to Ph.D. (including Physics, where this type is not present). Among STEM fields, there are more ender-balanced (Biology and Chemistry) and relatively less balanced (Physics, Technical Sciences, Earth Sciences).

Figure 5: Share of collaboration types in general fields.



The gender and collaboration structure of subfields inside STEM fields vary (Fig. 6). A notable example is Technical Sciences, where there is Radio Engineering (less than 4% female mentors for Ph.D.) and Food Technology (56% female mentors for Ph.D.). There are subfields in Earth Sciences where women are widely represented, such as Social Geography, Geoecology, and Oceanology. There are also almost entirely male subfields - Geotechnology, Geomechanics, and Oil and Gas Exploitation. Within Physics & Math, Biology, and Chemistry, the share of collaboration types by subfields varies slightly. Meanwhile, in the Earth Sciences and Technical sciences, we catch more variability, which means that if we aggregate at the level of general fields, we can omit the relatively more female subfields in male-domain STEM fields.

Figure 6: Share of collaboration types in STEM subfields.



Note: Chemistry, Technical, and Earth Sciences are presented by 10 top subfields.

Conclusion

In Russia, women are underrepresented in STEM, as in many other countries. We looked at authors and mentors of two kinds of dissertations. It allows us to show the gender structure of scientific fields and how it is changing over academic career levels. In all fields, the share of women at the higher level of their academic careers (Ph.D./Doctoral mentor) is lower than at the earlier stages (Ph.D./Doctoral author) — it is typical of both female-domain and male-domain fields.

Three of the five STEM fields belong to the most male-dominated scientific fields - Physics, Technical Science, and Earth Sciences. Chemistry and Biology are closer to gender parity. However, if we look at the dynamics over the years, we notice that the gender structure of Ph.D. authors did not practically change for 20 years (Fig S1). Within the more male-dominated fields, such as Technical Sciences and Earth Sciences, there are a small number of relatively more feminine subfields. For example, Food Technology (in TS) or Geoecology (in ES).

Our data allow us to look at the types of author-mentor collaboration. The rarest combination for all fields is «male author & female mentor.» In the case of doctoral dissertations, the proportion of this collaboration type decreases even more. Also, there are vanishingly few «both female» type collaborations in some STEM subfields for doctoral dissertations. It seems essential since one of the possible approaches towards gender parity is encouraging homophily in mentorship (tendency to same-gender collaboration). Despite male mentorship leading relatively more publishable trainees (Gaule & Piacentini 2018), same-gender mentorship reduces the «leaking» of young women from the academy (Shaw & Stanton 2012; Schwartz, Liénard & David, 2021), which leads to achieving a potentially more critical component of gender parity (AlShebli, Makovi & Rahwan, 2020). One possible explanation why same-gender mentorship reduces the «leaking» is that a female mentor can be a role model and benchmark that allows young women to move on the academic track and not drop their academic careers (Cech & Blair-Loy, 2019) or successfully combine motherhood without shifting to teaching (Misra, Lundquist, & Templer, 2012)

Thus, gender parity in STEM in Russia looks distant, but this goal may have become even more unattainable. According to various estimates, between 70,000 and 200,000, Tech workers left Russia after Russia invaded Ukraine on February 24, 2022 (Prince, 2022). Officials have attempted to stop the exodus and compensate for human capital losses and announced on March 2, 2022: "*a military deferment will be provided for those students who will choose STEM programs at universities and work for Russian Tech companies.*" Thus, the state promotes the policy of motivating young men to choose STEM degrees. It is a subject of a particular study whether such policy is adequate to the goals of the government to stop the outflow of Tech specialists in a time of war and sanctions. However, with a high probability, we can expect that this policy will lead to reinforcing gender stereotypes and an even more increase in the gender gap in the STEM fields, which is already profoundly male-domain.

Supplementary Materials

Additional materials are available at the link.

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