

All-Female Teams Produce More Disruptive Work: Evidence from Scientific Papers

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Extended Abstract

Recent advancement in the science of science provides a novel metric called *disruption* to assess how innovative a scientific work can be [1]. This metric quantifies the extent to which a scientific work consolidates its predecessors' ideas or disrupts the subsequent use of the components on which it was built. Previous research has analyzed the characteristics of scientific teams that produce disruptive papers and patents. For example, smaller scientific teams [10], newer collaborative relationships among team members [11], egalitarian team structure [4], and teams working in proximity [6] have been shown to be disruptive. Despite these findings, the influence of a team's gender composition on disruption remains uninvestigated. Understanding how the interplay between gender majority and minority within teams affects their outcomes and ideation processes will have important consequences for scientific research.

In this study, we evaluate the effects of gender composition on scientific disruption. We analyzed disruptive papers produced by teams of different gender compositions between 1950-2010 using the SciSciNet [7] dataset, which contains over 134 million publications. This analysis included over 20 million papers' metadata, including their disruption index (DI), year of publication, author's gender, and field of study. We employed Funk & Owen-Smith's definition of disruption in which a value of -1 denotes papers that consolidate their predecessors' ideas, and a score of 1 denotes papers that upend their predecessors' ideas [5, 10]. A paper was considered disruptive if its DI lay in the 95th percentile of the papers produced that year. To infer the authors' gender, SciSciNet provides a probability denoting the degree to which a name is associated with a person of the female gender [9]. We assigned researchers as female if their probability score was higher than 50%. We then calculated the team's gender composition of each paper as a percentage of female authors identified, resulting in all-male teams (probability equal to 0%), 50/50 teams (50%), and all-female teams (100%).

Our results show that all-female teams' production of disruptive papers was proportionally higher than teams of other gender compositions over the decades (Fig. 1). Thus, despite an overall smaller output of papers, the proportion of disruptive work produced by all-female teams appeared higher than that of other teams. Moreover, over the years we see teams with female members (team gender composition greater than 0%) increasingly contribute to science. Notably, all-female teams and 50/50 teams have increasingly produced disruptive work. Especially, all-female teams have produced the highest proportion of disruptive work compared to scientific teams with other gender compositions over the past 20 years (Fig 1).

To further explain these results, we compared the ratio of disruptive papers to total publications produced annually among teams of three gender compositions (all-male, 50/50, and all-female) from 1950 to 2010 (Fig. 2a). For all-female teams, the proportion of disruptive work produced increased as the decades progressed. In contrast, all-male and 50/50 teams had a lower and stagnant production rate of the proportion of disruptive work. A *t*-test confirms that the differences between the proportion of disruptive work produced by teams of

different gender compositions were significant ($t=9.7$, $p<0.1$). Thus, while the number of teams with female researchers has increased over the decades, all-female teams have produced higher disruptive work than other teams.

We also analyzed the effect of team size on disruption, as established by previous research [10], with sizes between 2 and 15 considering the role of the team's gender composition (Fig. 2b). Expectedly, DI decreased as team size increased [10], but smaller all-female teams appeared more disruptive for the same team size than all-male or 50/50 teams. Thus, even though small teams are more disruptive than large teams, amongst the small teams, the gender composition of a team affects which types of teams are more disruptive.

To verify if the effects of gender composition on disruption are discipline agnostic, we studied the proportion of disruptive papers produced in different fields by the three gender compositions. We classified papers under STEM and Social Sciences depending on the paper's field that SciSciNet delegated. Despite accounting for overall fewer papers in STEM and in Social Sciences (Fig. 3a, 3c), all-female teams produced a high proportion of disruptive papers over the decades for both fields (Fig. 3b, 3d). All-male and 50/50 teams showed a lower as well as a stagnant rate of the proportion of disruptive paper production. Notably, in all-female teams, the production rate appeared to be higher in STEM than in Social Sciences. This could be attributed to higher productivity in STEM, especially in newer fields like Computer Science, where new methods and results are constantly being introduced compared to the Social Sciences fields. Thus, even across fields of study, gender composition is shown to influence the production of disruptive work.

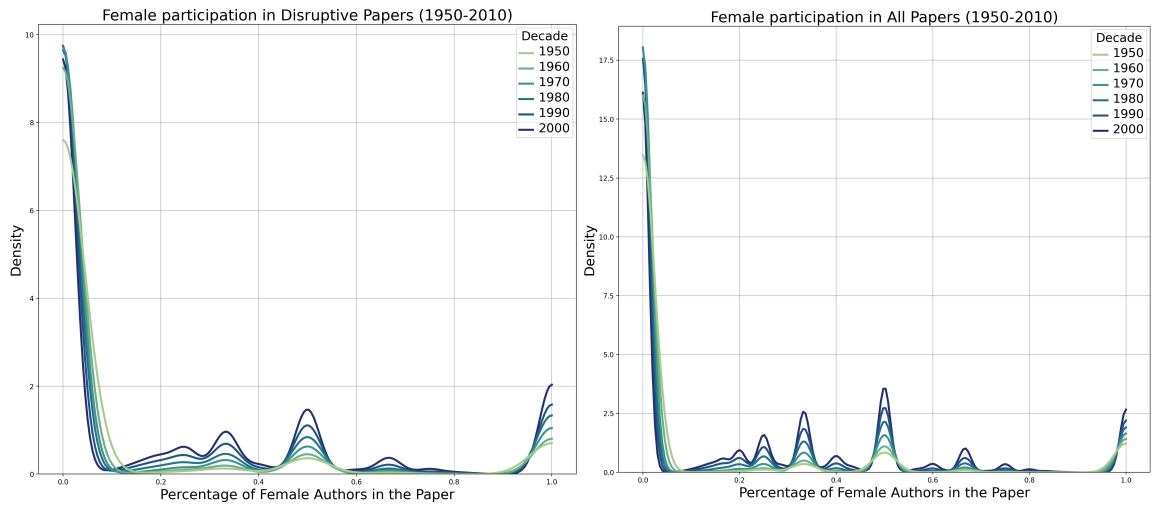
Taken together, these results suggest a significant relationship between team gender composition and disruption. To explore potential explanations for these findings, previous research shows that when the minority status of women and men is changed, it affects them differently, with women in the minority experiencing disadvantages across various dimensions [2, 3, 8]. In contrast, men in the minority have opposite outcomes. For instance, when teams have a female majority, women tend to participate more in team discussions [3] and brainstorming ideas [2] and have a higher sense of belongingness to the team and belief in the team's capabilities [8]. Thus, an all-female team's environment seems to provide its members with increased confidence, engagement, and performance, influencing their ability to fully participate in creating disruptive research.

We plan to investigate if these trends are also portrayed in patent teams and present these results in the future. We hope our results will help inform diversity, equity, and inclusion (DEI) initiatives to allow for greater equity and opportunities for female researchers.

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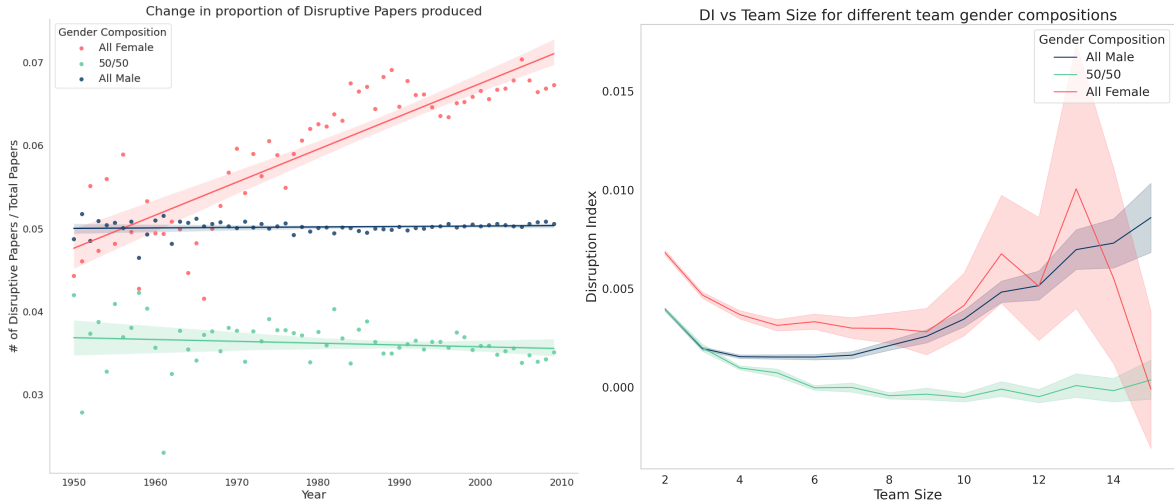
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(a)

(b)

Figure 1. (a) Disruptive papers produced between 1950-2010. The x-axis shows the percentage of female co-authors, and the y-axis shows the density of disruptive papers (DI in the 95th percentile) given that gender composition. (b) Papers produced by teams of different gender compositions between 1950-2010. The x-axis shows the percentage of female co-authors, and the y-axis shows the density of papers given a gender composition.



(a)

(b)

Figure 2. (a) The proportion of disruptive work produced annually by all-male, 50/50, and all-female teams from 1950-2010. The x-axis displays the publication year, and the y-axis shows the ratio of disruptive papers to the total papers published per group in that year. (b) Relationship between DI and team size for all-male, 50/50, and all-female teams. The x-axis shows the size of the team, and the y-axis displays the average DI.

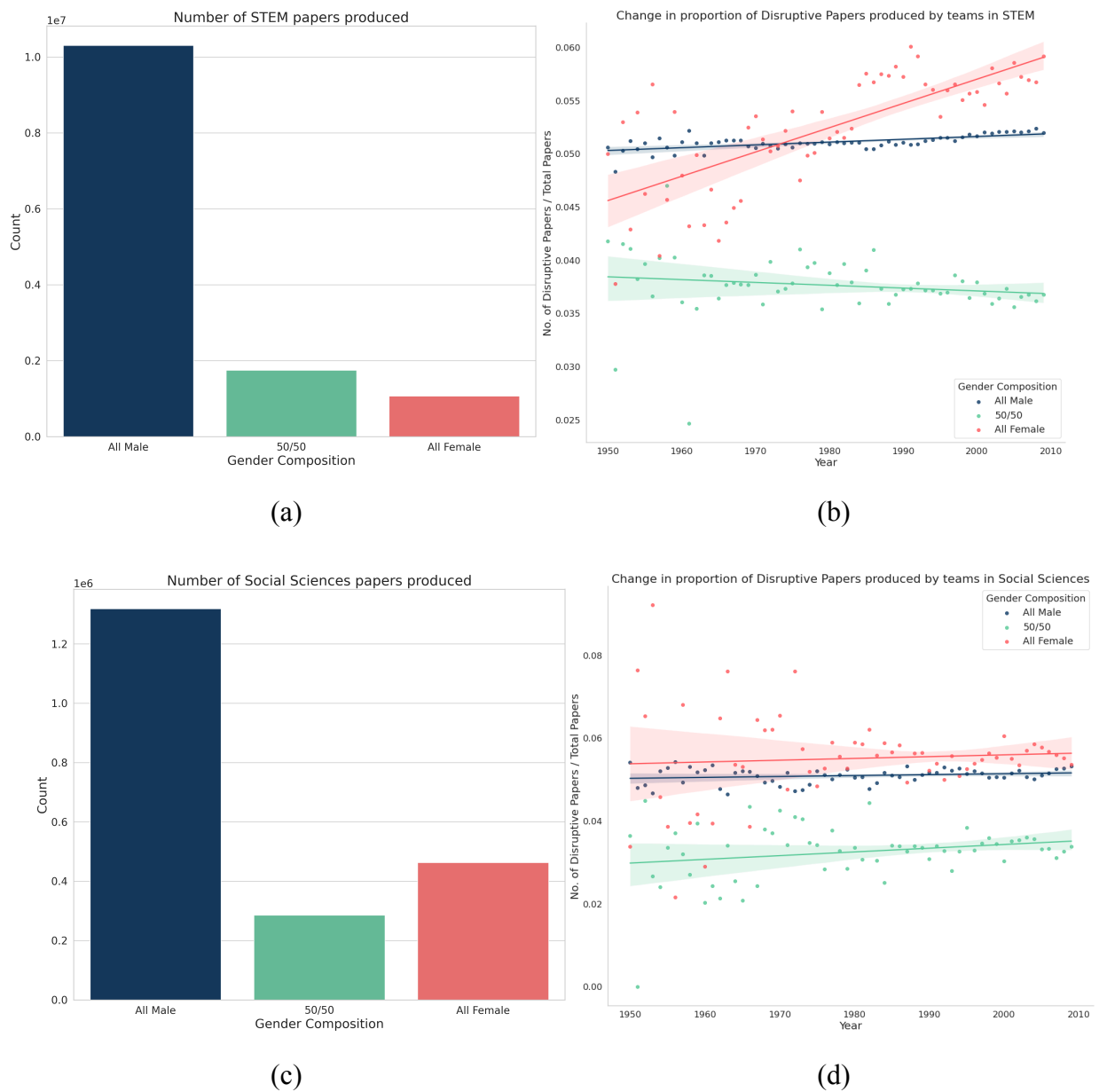


Figure 3. (a) The number of papers produced by all-male, 50/50, and all-female teams in STEM between 1950-2010. (b) The proportion of disruptive work produced annually by all-male, 50/50, and all-female teams in STEM from 1950-2010. The x-axis displays the publication year, and the y-axis shows the ratio of disruptive papers to the total papers published per group in STEM that year. (c) The number of papers produced by all-male, 50/50, and all-female teams in Social Sciences between 1950-2010. (d) The proportion of disruptive work produced annually by all-male, 50/50, and all-female teams in Social Sciences from 1950-2010. The x-axis displays the publication year, and the y-axis shows the ratio of disruptive papers to the total papers published per group in Social Sciences that year.