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Gender disparities in the STEM research enterprise in China

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Gender diversity is essential to the creation of high-quality research and scientific advances. This study provides a large-scale analysis of gender disparities in China's scientific research enterprise, focusing on projects funded by the National Natural Science Foundation of China (NSFC) between 2010 and 2015. We inferred highly accurate researcher genders based on names in Chinese characters and matched them to their Chinese and English-language publications. We reveal a significant underrepresentation of women in both principal investigator (PI) roles and team participation. Women PIs led only 23.3% of NSFC-funded projects between 2010 and 2015 and accounted for 27.1% of authors on these project teams. Gender disparities were prominent across all fields, with the largest gaps in computer and engineering-related fields and the smallest in health and life sciences. Notably, the disparity intensified in more prestigious Key programs and senior scientist ranks, while Young scientist programs exhibited comparatively greater gender balance, suggesting potential benefits of targeted early-career funding policies. Women PIs tend to build a more gender-balanced team than men PIs, although both tend to recruit more men team members than women. Gender-diverse teams produced significantly more publications for both women and men PIs. These findings underscore the need for targeted policy interventions, including increased support for gender-diverse teams, institutional incentives for women leaders, and broader inclusivity initiatives to foster a sustainable and equitable scientific community in China.

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Introduction

Gender diversity in human capital and research teams is critical to creating high-quality research and scientific advances (Nielsen et al. 2018; Y. Yang et al. 2022). However, gender disparities in the scientific workforce have long existed in various aspects. Globally, compared with men, women produce fewer publications (Larivière et al. 2013), receive fewer citations (Larivière et al. 2013; L. Zhang et al. 2021), are disadvantaged in authorship credit allocation (Ni et al. 2021), and are less likely to receive prestigious awards (Meho 2021). Evidence also indicates gender disparities in the scientific workforce of specific countries and regions (Finkel and Olswang 1996; Prpić 2002; Zheng et al. 2022) and disciplinary fields (Pearl-Martinez and Stephens 2016; Caplar et al. 2017; Shannon et al. 2019; Dworkin et al. 2020) regarding productivity (Prpić 2002), citation (Maliniak et al. 2013; Caplar et al. 2017; Dworkin et al. 2020), tenure, and promotion (Finkel and Olswang 1996), and the chance of funding (Ley and Hamilton 2008; Wu et al. 2021). These gender disparities perpetuate in various aspects of science and the scientific workforce and are usually correlated and mutually reinforcing, contributing to the higher attrition rates for women in the scientific workforce (Y. J. Xu 2008). Losing the intellectual power of half of the human population is not a price that is affordable for any nation.

Research on gender disparities in science has been booming in the last few decades (Casad et al. 2021; Llorens et al. 2021). Nevertheless, most large-scale studies expand the scope at the global level (Ni et al. 2021; L. Zhang et al. 2021) or focus on English-speaking countries and regions (Ley and Hamilton 2008; Thelwall 2020; Zheng et al. 2022). As one of the top global scientific research powerhouses (Conroy and Plackett 2022), research regarding gender disparities in the research enterprise of China is largely limited. Findings at the global level or concerning other nations might not entirely depict the issue in the context of China, as gender disparities are rooted in the historical and cultural contexts (Inglehart et al. 2003). Understanding whether the research enterprise in China is built equitably and fairly for different gender groups is critical to constructing a sustainable and dynamic science workforce in China and the expanded lens for a global overview of the issue in science.

Gender inequality has been an entrenched issue in Chinese society. Until the beginning of the 20th century, most Chinese women had been denied or restricted from access to education, with only women from the elite class privileged to have such opportunities. The traditional Confucian values require women to be obedient to their male family members and engage in childcaring and housework (Pan 2001). After 1949, the ruling Communist Party of China enforced disruptive nationwide political movements to challenge Confucianism and mobilized women to participate in the workforce (Wolf 1985). Women had increased opportunities to receive higher education due to the relieving financial burden, the demand for human capital investment, and the outstanding values of gender equality (Pan 2001; X. Shu 2004). However, the political force did not reach the domestic sphere: women still bear heavy family responsibilities and are encouraged to take on double workloads within and outside the family (Y. Li 2013). Furthermore, women are still disadvantaged in the promotion to leadership positions in institutions, enterprises, and bureaucracies (Wolf 1985; Tang and Horta 2021). Due to the widespread male-preference cultural norms, women were more prone to drop out of schools than men, especially in rural and economically disadvantaged areas (M. Zhang and Cai 2000). These factors signal that Chinese women's social status and rights were not protected adequately, which may lay the ground for gender inequality in academia in modern China.

Since China implemented the new economic reform and opening-up policy in 1977, Chinese women have been provided with more and better opportunities in higher education but faced challenges in the job market (Zhong and Guo 2017). Positions in China's rising research enterprise attract many women because they are considered to have relatively high job security and a flexible work schedule that would allow them to balance work and family (M. Zhang and Cai 2000; F. Shu et al. 2020). However, women researchers face systematic barriers to job employment and promotion to higher career ranks (M. Zhang and Cai 2000; Rhoads and Gu 2012). Women account for 51.2% of all full-time faculty (including teaching instructors and research faculty at all ranks), but only 36.9% and 18.2% of master and doctoral advisors and 31.6% of full professors as of 2020, respectively (Ministry of Education 2021)[1]. Given the essential role played by graduate students in the research workforce, women's disadvantage in advising graduate students further affects their research productivity, which is essential in the publication-based academic reward system. Furthermore, among those ever elected to the Chinese Academy of Science (CAS) and the Chinese Academy of Engineering (CAE), the two most elite clubs of scientists in China, only 5.2% and 5.6% of them are women, respectively (Y. Hu 2018). This is likely because women are usually excluded from masculine club culture, need to juggle family and work, and are burdened with more pressure than men to survive in the publication-oriented research evaluation system (Rhoads and Gu 2012; B. Li and Shen 2022). Tang & Horta (2021) concluded that China's research and higher education system maintains patriarchal characteristics, especially in research-intensive universities, which are central to the Chinese research system. Using the data of excellent young scientists of the National Natural Science Foundation of China (NSFC), Wang et al. (2025) found that women scientists have fewer chances and need to wait a longer time for promotion. Nevertheless, except for the share of women among the general university faculty, CAS, and CAE, little is known about gender disparities in the general research enterprise in China.

Many factors contributed to the relatively less explored research on gender disparities in China's research enterprise, among which are the limited availability of data and methods needed for such studies. Large-scale studies on the research workforce typically rely on publication and author records to track the individuals in the workforce. However, most researchers in China publish in English in addition to Chinese due to the various incentives for "internationalizing" science in China (Feng et al. 2013). Therefore, a comprehensive list of authors in China's research enterprise should be based on publications in both Chinese and English languages. Yet, no general platforms comprehensively house publications in both languages (F. Shu et al. 2019). Additionally, most large-scale studies on gender diversities in the scientific workforce rely on gender imputation algorithms to perceive the genders of researchers. However, many of them are known to work better for names of English origin and lack generalizability towards names of Chinese origin, especially when written in *Pinyin*, the standard system of Romanized spelling for transliterating Chinese (Holman et al. 2018; van de Weijer et al., (2020)). We believe these factors are highly related to the lack of comprehensive analysis concerning gender diversity issues in the research enterprise of China.

This study aims to analyze gender diversity in the science, technology, engineering, and mathematics (STEM) research enterprise of China based on highly credible data from the NSFC. We collected the historical records for projects funded by NSFC and the publications in all languages reported by the PIs as the project outcomes. NSFC is a key government research funding

agency supporting natural sciences and engineering. Its funded projects play a crucial role in China's research ecosystem, and the researchers involved constitute a significant segment of the scientific workforce, particularly in STEM fields (W. Yang 2016). NSFC had a budget of 31.3 billion yuan ($4.8 billion) in 2021 (S. Liu 2022), accounting for 6.3% of China's total budget for research expenditures in 2021 (National Bureau of Statistics, Ministry of Science and Technology, Ministry of Finance (2022)).

Our research population is all NSFC-funded PIs and their associates, which is a subset of researchers in the entire STEM scientific workforce in China. While we acknowledge that this population does not include all researchers, NSFC remains the most acknowledged funding source for Chinese research papers indexed in the Web of Science. About 64% of all Web of Science-indexed publications by Chinese researchers acknowledged NSFC support (Xianwen Wang et al. 2012; Y. Liu et al. 2019), underscoring its broad coverage and its central role in shaping China's research landscape. Due to NSFC's outsized contribution, compared with countries such as the US and Japan, China was identified as a "single-funding-agency dominated" country and has an extremely one-sided reliance on NSFC funding (Xianwen Wang et al. 2012). Previous research has demonstrated that selecting NSFC as the main data source for studying China's scientific research activity is justifiable and appropriately representative (Zhi and Meng 2016; K. Li et al. 2024). Given this extensive reach, we argue that our study provides meaningful insights into gender disparities among an influential and well-supported segment of the research workforce.

Furthermore, because the publication information was provided by project PIs and aggregated by the project, our data eliminates the problems of disambiguating and matching authors across data sources of different languages. We also suggest a new approach that allows us to infer binary author genders based on names in Chinese characters or *Pinyin*. Our approach allows us to study the gender disparities in China's research enterprise without omitting individuals who published in one language or another. With these, we compared the gender composition among NSFC PIs and the teams they led and analyzed the relationship between team gender diversity and publication productivity.

Data and Methods

Data source. This study utilizes data on funded projects and their associated research outputs, both retrieved from the NSFC Project Outcome Portal[2]. The portal serves as the official platform where PIs are required to report the progress and outcomes of projects funded by NSFC upon project completion. Therefore, it is considered a highly comprehensive and accurate data source for understanding the landscape of NSFC funding. In August 2021, we collected the metadata for NSFC projects and corresponding outcomes, including the project title, project type, disciplinary field, year, funding amount, PI name, PI institution, and outcomes associated with each project. Project outcomes may include journal and conference publications, patents, reports, and books. This study analyzes journal and conference publications, accounting for 90.6% of the total outcomes.

To assess the quality of self-reported data, we examined the accuracy of English-language publications and author names in our dataset by cross-checking them against our in-house version of Web of Science. We extracted 374,294 English publications with available DOIs from our analytical sample and matched them with Web of Science records, finding that 295,871 (79%) were indexed. It is important to note that Web of Science applies selection criteria and does not index all journals. For the indexed publications, we compared the first, second, third, and last authors' names (in *Pinyin*) between NSFC author bylines and Web of Science records. This comparison covered 1,177,940 author entries, including duplicates across papers. Our analysis showed a 97.7% match rate between the two sources, providing strong evidence that the NSFC database is highly consistent with Web of Science records. These findings validate the dataset's accuracy in author attributions.

Disciplinary fields. NSFC organizes its programs based on disciplinary fields. There are eight departments based on disciplinary fields in NSFC, including Mathematics and Physical Sciences (MPS), Chemical Sciences (Chem), Life Sciences (Life), Earth Sciences (Earth), Engineering & Material Science (EMS), Information Sciences (Info), Management Sciences (MS), and Health Sciences (Health). Additionally, there are over 120 subdepartments focusing on smaller research fields under each disciplinary department in our data. We refer to the disciplinary department by NSFC as fields and subdepartments as subfields. Even though most of these field names are self-evident from the English-language perspective, it is essential to note a few ontological differences embodied in these names. One is the *Information Sciences*, which is dedicated to the areas of "the generation of signals, acquisition, storage, transmission, processing, and utilization of information" (National Natural Science Foundation of China 2021). These areas are strongly situated in the knowledge domain of computer science, despite the field's name in China's research enterprise. Another is *Management Sciences*. This department is centered on "research on improving the understanding of objective law in management and economic activities" (National Natural Science Foundation of China 2021). As a result, this disciplinary field contains many research domains that are regarded as social sciences, such as economics, public administration, sociology, and library and information science. For consistency, the subsequent analysis by disciplinary field will rely on the disciplinary department classification by NSFC.

Project types. Each of the disciplinary departments funds a variety type of projects. This study selected the following four types to focus on: Key Projects (*Key*), General Projects (*General*), Young Scientist Projects (*Young*), and Projects for Less Developed Regions (*Region*). These four project types account for about 95.8% of all projects we collected (see Supplement Table S1). The *Region* program typically funds projects (up to four years) proposed by PIs affiliated with institutions located in economically less developed regions in China, where funding at the province level is relatively limited, and institutions are generally ranked lower than those in more economically developed regions. The *Key, Young*, and *General* projects have a broader set of eligible applicants than the *Region* program, yet are different in many ways, which leads to a somewhat "laddered" structure based on PI seniority. A *Key* project (1.4% of total projects) usually spans five years. It is usually considered the most prestigious among the four, with most of its PIs being established scholars in their fields with prior NSFC project experience. A *General* project usually spans four years and has the broadest set of eligible applicants among the four, where all researchers in universities with permanent PI status are eligible to apply. *General* projects account for about 48.7% of all projects in our sample. The *Young* project (42.6%) typically lasts three years and is open to scholars under the biological age of 35. Therefore, *Key* projects are usually considered more prestigious than others and go to senior PIs more often, while *Young* projects are primarily for junior PIs, with *General* projects in the middle of the hierarchy.

Additionally, this study focused on projects funded by NSFC starting from 2010 (project funding year), given the more comprehensive coverage for projects and outcomes after 2010

in the dataset. We chose 2015 as the ending project funding year, as projects analyzed in this study may take up to 5 years to complete. Using 2015 as the ending year allows us to make sure that we have complete outcome records for all projects by the time we collect the data. The final analytical sample used in this study includes 185,465 projects funded by NSFC between 2010 and 2015 and 2,323,443 corresponding publications (in both Chinese and non-Chinese languages). The projects were awarded to PIs associated with 2,757 universities from all 31 provinces and regions in China.

Gender imputation

Gender imputation of names in Chinese characters. In our study, all PI and author names of Chinese-language publications are in Chinese characters. We identified 880,311 unique names associated with these PIs and authors. We used a Python package, *ngender* (J. Hu 2015), to infer the binary genders associated with names in Chinese characters. *ngender* calculates the Bayesian probability of a gender category for an individual name by considering all characters and their combinations in the given name. It has been proven to be one of the best-performed gender-inference tools available for names in Chinese characters (Zhao and Kamareddine 2018).

In predicting the gender of names in Chinese characters, *ngender* allows for self-defined thresholds for the probability of deciding the gender of a given name. The default probability of deciding a gender by *ngender* is 50%: if the predicted Bayesian probability of a given name belonging to a certain gender is higher than 50%, the gender is assigned to the corresponding name. Yet, the 50% threshold was found to bear some limitations due to gender-neutral names in Chinese culture, where female names are more likely to be gender-neutral than male names (Huang and Wang 2022). For higher reliability of the gender imputation procedure, we tested gender prediction using a range of thresholds in a 10% increment from 50% to 80%. We used the self-reported gender information for 10,000 doctoral recipients in China to evaluate the performance of *ngender* (C. Wang et al. 2021; J. Yang et al. 2022). We chose 60% as the cut-off threshold for our gender prediction based on the evaluation results, by F1 score, and the percentage of PIs with predicted genders (see Supplement Fig. S1).

Gender imputation of names in Pinyin. NSFC-funded projects yield publications in both Chinese (34.2% of total publications) and non-Chinese languages (65.8% of total publications, mostly English). When publishing in languages other than Chinese, it is the normal practice that authors write their names in the format of *Pinyin* in the author byline. To study the gender composition of teams comprehensively, we also need to predict the gender of authors of English publications where author names appear in *Pinyin* format. As a *Pinyin* name could be associated with multiple names in Chinese characters, predicting the gender based on names in Chinese characters should produce more accurate results. To better predict the gender of authors in non-Chinese publications, we matched their names in *Pinyin* back to corresponding Chinese characters within the same team. It is noted that we considered variations of author names when expressed in *Pinyin* format. For example, *Xueran Wang* might be transliterated into *XR Wang* or *Xue-ran Wang* in different publications. Then the latter two forms will also be matched with the Chinese characters associated with *Xueran Wang* in the same NSFC project. We then predicted the gender of authors of non-Chinese publications based on their matched names in Chinese characters.

The above procedure allows us to infer the gender categories of authors who published in non-Chinese languages while also maintaining plausible precision, as the gender imputation was based on Chinese characters. Author name disambiguation was performed at the project level: We consider that authorships associated with the same name (in Chinese characters or *Pinyin*) in a single NSFC team are the same individual, based on the consideration that it should be rare that multiple individuals within the same project share a name. Our project-level disambiguation is important to correctly connect individuals with publications, given the more significant ambiguities among names used in East Asian countries, including China (S. B. Xu and Hu, 2024).

Based on the procedures described above, our final analytical sample includes 2,049,337 (91.4% of the total) publications associated with 180,534 (98.1%) projects that have at least one author whose gender category was successfully predicted. It is worth mentioning that our process removes 17.9% of all non-Chinese publications. Overall, we were able to match 46.01% of author instances (authorships) in *Pinyin* to their corresponding Chinese characters. To ensure the accuracy of gender assignment, our method excludes authors who are neither PIs nor authors in any Chinese-language publications, which we admit is a limitation of our study. For author names in Pinyin, we analyzed the relationship between an author's position in the byline and the likelihood of their name matching an existing name in Chinese characters. Within publications with the same number of authors, this relationship exhibits a U-shape, with the first and last authors showing the highest match percentages (see Supplementary Fig. S2). This pattern highlights our analysis involving more leading authors (first and last authors), who are generally the major contributors to research (Ni et al. 2021). Supplement Table S2 shows the details of the final analytical sample used in this study.

Results

Gender disparities among NSFC PIs. Our results show that men dominate the research enterprise in China (see Fig. 1a), a trend consistent with findings about many other regions and nations (Paul-Hus et al. 2015; Santos et al. 2019; Zheng et al. 2022). Among projects funded by NSFC between 2010 and 2015, 76.7% were led by men, and 23.3% by women, with slight fluctuation across years: men's share of PIs slightly decreased from 79.6% in 2010 to 75.5% in 2015, while women's share increased from 20.4% to 24.5%. This suggests a mild increase in the projects led by women PIs during this period. Further results show that women's extended share of PIs across the period could be attributed to the increase in projects funded through the *Young* and *Region* programs (from 36.2% in 2010 to 46.4% in 2015), where women account for the largest share of PIs among all the project types (30.6% and 24.1%, respectively).

Further examination shows that the gender gap among NSFC PIs exists across all project types, yet the extent varies (see Fig. 1b and Supplement Fig. S3). The *Key* Program has the highest percentage of men PIs: more than 91.7% of projects awarded as *Key* projects by NSFC were led by men. The *Young* project is the most gender-balanced program among the four, yet the women's PI share is only 30.6%. Given the "laddered" nature of NSFC project types (see *Methods*), it is suggested that gender disparities are severe overall but more prominent in the more senior group of scientists in the research enterprise of China.

Aggregating by disciplinary fields, men's overrepresentation in China's science workforce is prominent across all eight fields (see Fig. 1c). Specifically, *Information Sciences* (82.4%) has the highest share of men PIs, followed by *Engineering & Materials Sciences* (81.9%) and *Math & Physical Sciences* (81.9%). *Health Sciences* is the most "gender-balanced" field among the eight, where women

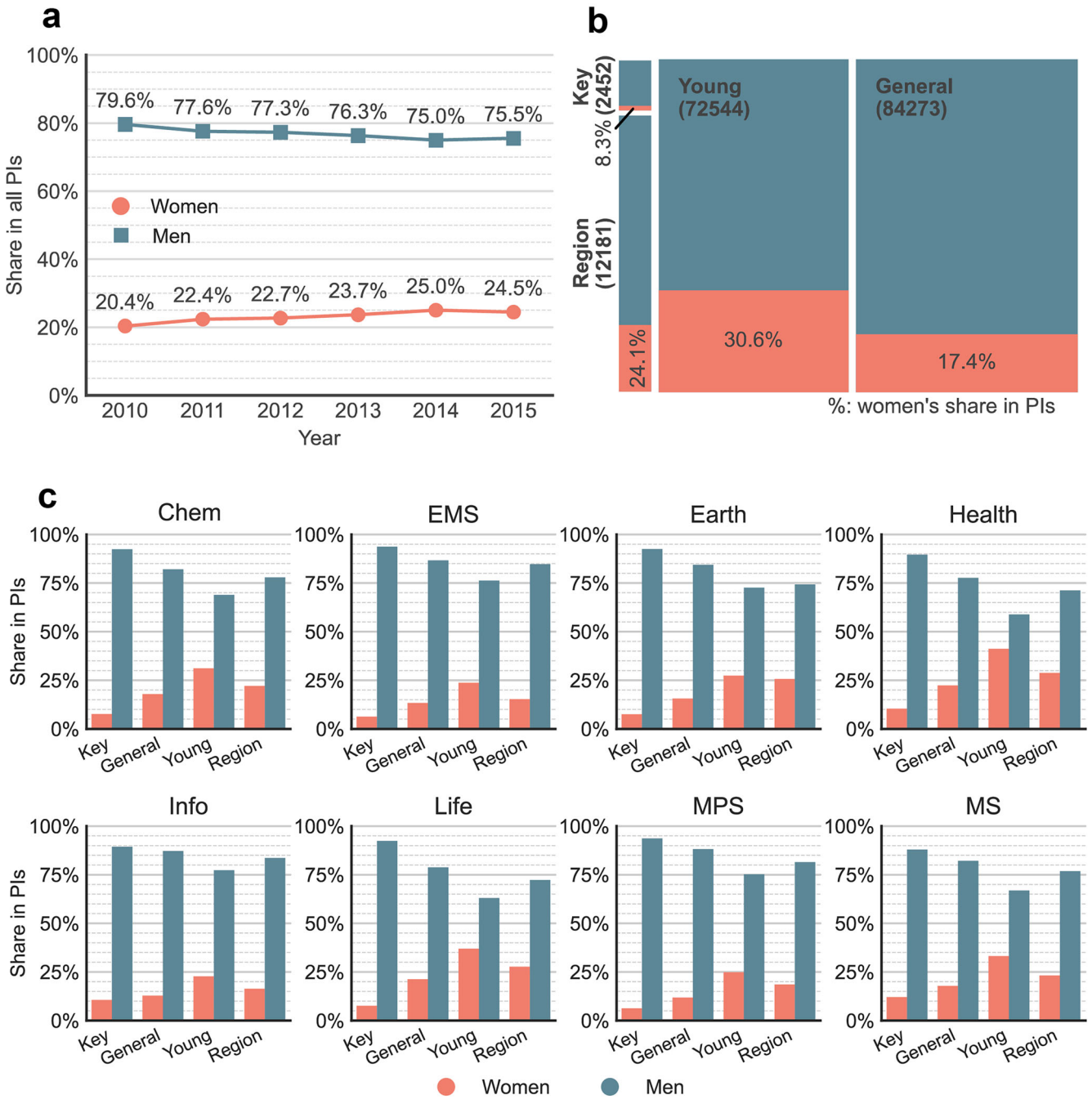

Fig. 1 The gender composition of NSFC PIs. a The gender composition of NSFC PIs by time. **b** The share of women PIs by NSFC project type, sorted by PI numbers. **c** The gender composition of PIs by disciplinary fields.

PIs account for about 30.0% of the total. Further aggregating by project type, the share of men PIs outweighs that of women PIs in every disciplinary field and project type. Men are more overrepresented among *Key* program PIs across all disciplinary fields. The *Young* program in *Health Sciences* has the most balanced gender composition among all, where women PIs account for about 41.0% of the total. All disciplinary fields have very similar percentages of *Key* program projects but differ in the percentages of the *Young* program projects. These may indicate subtle differences in gender diversities in different knowledge domains.

Gender disparities among NSFC project teams. We further investigated the gender composition among teams funded by NSFC, which we operationalized using the authors in the bylines of publications reported as the outcome of NSFC projects. Our results show that NSFC project teams are also dominated by men (see Table 1): women account for about 28.1% of all authors (23.0% of authorships), 30.5% of first authors (25.6% of authorships), and 25.6% of last authors (18.5% of authorships). In the meantime, the percentage of women on NSFC project teams remained stable (see Supplement Fig. S4) during the investigated period.

Examining the spectrum of disciplinary fields, the gender gap in NSFC teams exists across all eight fields, regardless of their orders in the author bylines (see Fig. 2a and Table 1). However, the level of gender disparities varies by field. The *Engineering & Material Sciences* field has the lowest share of women among the

eight fields, accounting for about 19.0% of all authors (regardless of author order), 21.3% of all first authors, and 18.7% of all last authors. *Health Sciences* has the highest share of women authors regardless of authors' positions in bylines, indicating its relatively lower gender disparities in teams among the eight fields.

Aggregating by project type, we found the gender composition in teams follows a similar pattern to what we observed among project PIs: women account for about 23.3% of all authors, 26.5% of the first authors, and 22.6% of the last authors among teams funded through the NSFC *Key* program, making it the project type with the lowest share of women team members among all program types(see Fig. 2b). The smallest gender gap appears in teams funded through the *Region* program, where women account for about 31.5%, 35.4%, and 30.2% of all, first, and last authors.

We found a mild difference in the gender composition of authors between publications in Chinese and English (see Supplement Table S3). Among publications in Chinese, women account for 27.4% of all authors, 31.0% of first authors, and 26.2% of the last authors. The number is 24.8%, 26.8%, and 23.1% for all, first, and last authors of publications in English, respectively. The percentages of men are about 3% to 4% higher in English publications than in Chinese publications. This may indicate that men's publication profiles might be more international while women more domestic.

Table 1 Women's share of authorship and author by disciplinary field.

	Women authorship			Women author		
	All	**First**	**Last**	**All**	**First**	**Last**
By field						
Chem	25.4%	31.6%	18.3%	30.7%	35.8%	27.3%
Earth	21.4%	23.8%	19.7%	24.5%	28.6%	24.8%
EMS	16.9%	18.5%	15.1%	19.0%	21.3%	18.7%
Health	33.0%	38.3%	24.5%	35.8%	40.9%	32.7%
Info	17.7%	20.1%	15.5%	21.6%	24.4%	21.6%
Life	30.4%	35.6%	22.6%	33.7%	39.4%	30.9%
MPS	16.9%	20.5%	14.0%	21.6%	26.1%	21.7%
MS	26.9%	26.4%	25.5%	32.2%	31.6%	33.1%
By project type						
Key	17.3%	20.6%	12.2%	23.3%	26.5%	22.6%
General	22.3%	24.6%	17.3%	26.8%	30.1%	25.3%
Young	23.9%	26.6%	21.2%	26.5%	30.1%	25.1%
Region	28.4%	30.7%	23.2%	31.5%	35.4%	30.2%
Total						
Total	23.0%	25.6%	18.5%	27.1%	30.5%	25.6%

PI gender and team gender diversity. We investigated if the gender of project PIs is related to the gender composition of their teams. Our results show that a large proportion of key authors are project PIs, as expected. PIs participate in 87.2% of all publications in our analytical sample and form 33.1% of all authorships. More importantly, among collaborative publications, PIs are the first or last authors in 37.7% and 49.1% of all publications, respectively. PIs contributed 219,726 single-author publications, accounting for about 29.2% of the total. As a comparison, we found that 98.3% of all PIs serve as an author in at least one publication from the project. About 70.1% served as the first author in at least one of the publications, and 76.6% as the last. If we remove all PIs from authors, the composition of authors vis-à-vis the gender of PIs is summarized (see Table 2). The percentages of authors from both genders decreased after the PI for each team was excluded in calculating the same-gender author shares. This is expected, given PIs are usually involved in most project outcomes.

Excluding PIs from authors, our analysis shows that teams led by women PIs are generally more gender-balanced than those by their men counterparts (see Table 2). Among teams with men PIs, about 77.0%, 75.0%, and 79.2% of all, first, and last authors are also men. While among teams with women PIs, about 41.4%, 49.7%, and 43.4% of all, first, and last authors are women. This suggests that men PIs are more likely than their women counterparts to build teams that favor men members, echoing findings in selected disciplines and geographies (Salerno et al. 2019).

Table 2 Same-gender author and authorship share by PI gender.

	% same-gender authorship			% same-gender author		
	All	**First**	**Last**	**All**	**First**	**Last**
PI gender = man						
Including PI	84.3%	83.5%	91.6%	77.0%	75.0%	79.2%
Excluding PI	81.8%	80.3%	86.8%	73.6%	70.0%	74.5%
PI gender = woman						
Including PI	52.4%	61.1%	62.3%	41.4%	49.7%	43.4%
Excluding PI	46.3%	52.3%	48.4%	31.7%	36.2%	29.9%

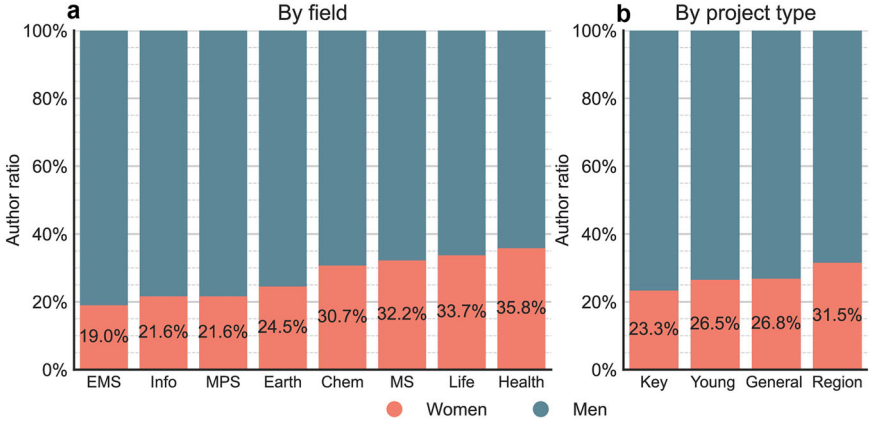

Fig. 2 The gender composition of NSFC project teams. a The gender composition of NSFC teams by disciplinary field. **b** The gender composition of NSFC teams by project type.

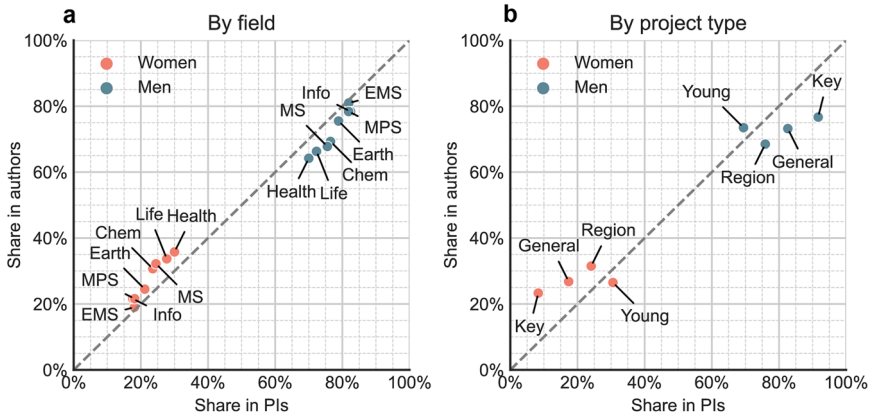

Fig. 3 Women and men's share of PIs and team members. a By disciplinary field. **b** By project type.

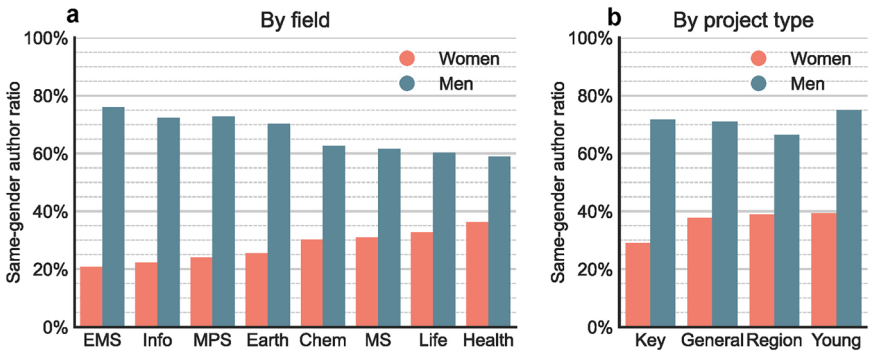

Fig. 4 The same-gender author ratio by PI gender. a By disciplinary field. **b** By project type.

We further compared the share of authors (and the share of PIs) for each gender based on disciplinary fields and project types (see Fig. 3). In each disciplinary field, we found that women take a larger share among authors than they do among PIs, which is the opposite for men. This indicates a better gender balance in the general research workforce than at the PI level, which holds across disciplinary fields. In each project type, our results show that women take a larger share among authors than among PIs among all project types except the *Young* program. This indicates that among *Key*, *General*, and *Region* project teams, the gender composition is more balanced in the general research workforce (as represented by authors) than among the PIs.

Aggregating by PI gender, our results further show that women PIs tend to build a more gender-balanced team than men PIs do, although both tend to recruit more males than females on their teams (see Fig. 4). Among teams led by men PIs, about 77.0% of authors in their teams are also men. The number is 41.4% for teams led by women PIs. Taking disciplinary fields into account, we show that *Engineering & Material Sciences* (75.9%) has the highest share of same-gender authors among teams led by men PIs, followed by *Math & Physical Sciences* (72.7%) and *Information Sciences* (72.3%). In teams led by women PIs, *Health Sciences* (36.3%) has the highest share of same-gender authors, followed by *Life Sciences* (32.7%) and *Management Sciences* (31.0%).

Team gender diversity and productivity. Gender-diverse teams appear to have advantages in scientific publishing (Y. Yang et al. 2022). We then further analyzed the relationship between team productivity and team gender diversity in the context of China. Team productivity was operationalized as the number of publications produced by the team, and gender diversity was calculated using Simpson's diversity index among all authors of the team assigned with a gender (Simpson 1949). Simpson's diversity index gives a score between 0 (no diversity; single-gender team) and 0.5 (perfectly gender-balanced as 50%-50%). Due to the nature of the count data of publications, we estimated a fixed-effect Poisson regression model by the PI's gender, controlling for the fine-grained project subfield, project type, project years, and funding amount. The regression results show that for both women and men PIs, the productivity of teams increases as the gender diversity among team members increases (Woman PI: coefficient = 0.73, $p = 0.000$, 95% CI [0.69, 0.77]; man PI: coefficient = 0.70, $p = 0.000$, 95%CI [0.67, 0.72]; **see** Table 3). The results suggest that the more balanced the gender diversity in a team, the higher the team's productivity.

Table 3 Fixed-effect Poisson regression results of team gender diversity on team productivity by PI's gender.

	Woman PI teams	Man PI teams
Gender diversity index	0.733*** (0.021)	0.696*** (0.011)
Funding amount	0.004*** (0.001)	0.003*** (0.000)
Fixed effects		
Subfield	Yes	Yes
Project year	Yes	Yes
Project type	Yes	Yes
Pseudo R^2	0.276	0.303
Observations	38,763	128,289

Note. Standard errors are shown in parentheses. ***$p < 0.001$.

Discussion and conclusions

This study is the first large-scale analysis of the gender composition of the research enterprise in China. It bridges an important

gap in our knowledge of the gender inequality issues in the research system of China. The gap was likely related to the limited access to publication data in both languages Chinese researchers frequently publish in, and the methodological limitations for gender imputation based on names in Chinese characters and *Pinyin*. Our results suggest remarkable gender disparities in the research enterprise of China: women PIs led 23.3% of NSFC projects during 2010 and 2015, and women account for 27.1% of all authors in NSFC project teams. The women-to-men (W-M) ratio among team members is lower than the W-M authorship ratio reported by Larivière et al. (2013) and Sugimoto et al. (2015), which was based on authorships instead of individual authors. The share of women authors in this study is also much lower than that (45.4%) reported by Holman et al. (2018), where they admitted that the number might be inaccurate due to the low percentage of authors with assigned genders, a known issue in inferring gender from *Pinyin* names. Therefore, our results suggest that the gender gap in the research enterprise system of China might be more significant than previously known, and the gap has been persistent during the funding window examined in this study.

The gender gap in the research system of China is wider in the more elite clubs of scientists. Our results show that only 8.1% of projects funded under the *Key* class, the most prestigious NSFC project class and usually awarded to established PIs in their fields, were led by women. In comparison, 30.6% of projects funded under the *Young* project, the NSFC project class designated for junior PIs under the biological age of 35, were led by women. This seems to align with previous findings that gender disparity is worse among the senior groups of scientists in regions and nations (Aguinis et al. 2018; Chan and Torgler 2020). The higher representation of women in the *Young* project class contributes an important case for understanding how funding structures and policies may influence gender disparities in research. Several factors could contribute to this trend, including eligibility criteria, career stage effects, and funding policies designed to support early-career researchers. One potential explanation is the program's focus on younger researchers (biological age 35 or below for males and 38 for females), which may intersect with professional and personal factors differently for women. Early-career funding opportunities may be particularly attractive to female researchers who, at this stage, may face fewer institutional barriers than at more senior levels (Lerchenmueller and Sorenson 2018). Additionally, career stage effects could play a role, as young women researchers may have distinct career trajectories and priorities compared to their male counterparts, making them more likely to apply for grants specifically designed for early-career scientists. Another key factor to consider is the age eligibility criteria, which differ between men and women in some funding programs. In the NSFC *Young* project, the different age limitations for the two genders' extended eligibility window have contributed to a higher number of female applicants, which in turn has influenced their overall representation in the program. Furthermore, while historical data indicate a 4–10% gender gap in the acceptance rates of NSFC *Young* project proposals from 2009 to 2018, with male applicants being more likely to receive funding, recent trends suggest that female scientists under the age of 30 have a higher success rate than their male counterparts in this category (Yu et al. 2020). This suggests that targeted policies, such as extended eligibility criteria for women, may help address gender imbalances in research funding. It should be noted that although the *Young* project has fostered greater female participation, gender disparities persist across other NSFC funding schemes. However, a more in-depth investigation into the drivers of this trend and its potential applicability to other programs would require additional data and methodological approaches.

Our results also suggest that the gender gap in China's research enterprise is more significant in computer and engineering-related fields than in others. This echoes previous research regarding the bigger gender disparities among STEM fields in many countries around the world (Holman et al. 2018), suggesting similar discipline-based gender disparities in the context of China's research enterprise. We also found that health and life sciences are more gender-balanced than other fields, which is consistent with findings based on other countries and regions (Larivière et al. 2013). These results suggest that the gender gap variations by disciplinary fields in China reflect the realities in many other countries and regions, indicating that women in China's research enterprise face similar disadvantages as the global women scientists do.

We further examined the gender composition among teams led by PIs of different genders and found that men PIs are more likely than their women counterparts to build less gender-balanced teams. We found that among teams led by men, about 73.6% of its members are men, while among teams led by women, only about 31.7% of its members are women. This is consistent with previous findings that male PIs in ecology and zoology collaborate and publish much more with men co-authors (Salerno et al. 2019). The same-gender author ratios for both women and men teams vary by disciplinary fields and project types. Yet, gender diversity matters for teams led by both women and men. Our results show that more balanced teams are more productive and aligned with existing evidence (Bear and Woolley 2011; Y. Yang et al. 2022).

The findings of this study highlight critical areas where policies and interventions can help mitigate gender disparities in China's research enterprise. Given the lower representation of women as PIs, particularly in the most prestigious funding categories, and their underrepresentation in STEM fields such as computer science and engineering, targeted policies are needed to improve gender inclusivity in funding allocations and leadership roles in these categories. Initiatives such as mentorship programs, funding incentives for gender-diverse teams, and institutional support for early-career women scientists can help sustain their participation and advancement. Additionally, our results show that teams led by men tend to be less gender-balanced, despite evidence that gender diversity enhances research productivity. Encouraging institutions and funding agencies to promote gender-balanced research teams through policy mandates or funding criteria could foster more equitable collaboration dynamics. Given that women faculty's attrition rate is higher as they move through the academic system in China (Ministry of Education 2021), policies and practices that will help women in the junior group maintain or increase their participation in science, such as implementing family-friendly policies, tenure flexibility, and career advancement support, will be crucial in ensuring long-term gender equity in China's scientific workforce. Increasing the share of women PIs not only helps reduce gender disparities but also provides visible role models, fostering a more inclusive and equitable research culture for future generations of women scientists (Campbell et al. 2013).

China's research funding system follows a merit-based peer review process, but there is a lack of an official description of the review criteria (X. Liu et al. 2022). As with other funding agencies worldwide, such as the National Institute of Health in the US, implicit biases may influence funding decisions (Ginther et al. 2011; D. Li and Agha 2015; Hoppe et al. 2019). Previous studies have identified selection biases based on gender, race, institutional prestige, and disciplinary priorities (Gillies 2014), which can shape funding outcomes and career trajectories. Evidence from the NSFC *Young* project shows that from 2009 to 2018, female applicants were 4–10% less likely to receive funding than their male counterparts (Yu et al. 2020), suggesting that gender bias

may exist within the funding process. While our study does not directly assess selection bias, it is important to acknowledge that such biases could contribute to the gender disparities we observe. However, our analysis extends beyond PIs to examine the entire research teams they lead, which are primarily composed of graduate students. Given that 51.6% of graduate students in China are female (National Bureau of Statistics of China 2024), the gender composition of research teams may reflect both PI-level selection biases and broader trends in STEM training pipelines. If funding decisions systematically favor male PIs, this could affect downstream opportunities for women in STEM, reinforcing disparities at multiple career stages. Understanding these complexities is essential for designing policies that promote gender equity in funding allocations and research participation, and future research should further explore how funding structures shape career advancement for women in China's research system.

We acknowledge that our research is not without limitations. First, our gender imputation technique, driven by the availability of existing gender assignment algorithms, only allows for binary gender outcomes (man/woman), which cannot represent results for non-binary gender authors. Further advancements in gender classification techniques are needed to improve the inclusiveness of our study. Second, our data is limited by its coverage in terms of time, discipline, research output types, and the research workforce. Because the NSFC outcome portal is relatively new, the comprehensive coverage of projects and outcomes does not start until 2010. The pattern prior to 2010 would also be interesting to analyze to reveal the temporal trends, which we were unable to explore due to data constraints. NSFC also primarily focuses on science and engineering fields, albeit including some social science fields, making our analysis inevitably omit other areas of research. Other types of research outputs, such as patents, were not included. Future research may explore the questions within other fields (especially social sciences and humanities) and merge the funding data with other databases. Fourth, our analysis focuses on NSFC-funded research, which is relatively prestigious. Therefore, this study tends to capture the gender disparities among research teams in the relatively prestigious group of scientists in China. Examining other funding agencies and disciplines could provide further insights. Fifth, the intersectional effect between gender and factors such as ethnicity, socioeconomic background, and geographic location may play a role in shaping gender disparities. Finally, even though the gender imputation method based on Chinese characters we used can bring greater accuracy, the fact that we can only match a fraction of author names in the *Pinyin* form filters out many authors from our analysis. We are hoping that developments in technologies and data infrastructure in the future can help to address these limitations. Specifically, incorporating the original names of Chinese researchers (and those from other countries) in existing research infrastructure will greatly contribute to the name disambiguation and gender imputation issues that we are facing. A mixed-methods approach that incorporates qualitative data is also beneficial for a deeper understanding of the underlying causes of gender disparities and the lived experience of women researchers.

Data availability

All code and original data are available on GitHub (https://github.com/MetascienceLab/GenderChina).

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Notes

1 The colleges and universities in China have a slightly different hierarchical system for faculty compared with western tenure system. In China, most faculty follow the rank system of lecturer (middle rank), associate professor (sub-senior rank), and full professor (senior rank), all of which were prominent positions until the recent decades – there is a trend to adopt the western tenure-track system by elite universities in China since 2000s (F. Shu et al. 2020). On top of the rank tier, faculty will also be evaluated separately for their eligibility to advise master (master advisors) or doctoral (doctoral advisors) students, who are usually a large portion of the research workforce. Most master and doctoral advisors are associate and full professors, accounting for 90.1% in 2020 (Ministry of Education 2021).

2 https://kd.nsfc.gov.cn/

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Author contributions

KL, XZ, CN designed research, collected and processed data, performed analysis, and wrote the paper.

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