Can affirmative action remedy gender inequality in science? Evidence from early career funding

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Abstract

We study the impacts of a large national affirmative action policy designed to reduce gender inequality in the ranks of high-achieving scientists. The policy raised the maximum age of eligibility for a nationally-competitive early career grant in China by five years for women, but not for men. We find that the policy causes a large increase in the number of female recipients of this grant, concentrated in the newly-eligible age range. We find no evidence that this affects grantees' subsequent scientific productivity, but does have a positive impact on their chances of winning subsequent, larger scientific grants. Ultimately, however, the policy does not significantly increase the likelihood of academic promotion for female awardees, suggesting that more coordinated action may be required to remedy the gender inequality that persists among senior STEM faculty and, more broadly, in roles of leadership in science.

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1. Introduction

There are far fewer women than men in most STEM fields, and this inequality is greater in more senior positions (Ceci et al. 2014; Beaudry and Larivière 2016; Antecol, Bedard, and Stearns 2018; Huang et al. 2020). Many factors contribute to this phenomenon, including explicit discrimination in promotion or evaluation (Urry 2015; Van der Lee and Ellemers 2015; Witteman et al. 2019) and unequal recognition for work (Beaudry and Larivière 2016; Sarsons 2017; Wiedman 2020; Sarsons et al. 2021). While evidence suggests that explicit gender discrimination has decreased over time (Bertrand, Goldin, and Katz 2010; Ceci and Williams 2011; Goldin 2014; Blau and Kahn 2017), recent work has shown that intrahousehold choices regarding labor, caregiving, and career paths play a large role in generating ongoing patterns of gender inequality (Ceci and Williams 2011; Ceci et al. 2014; Goldin 2014; Huang et al. 2020).

Synthesizing research on these and related issues, Goldin (2021) describes how couples, particularly those with children, rationally respond to the tradeoff in many white collar jobs between job flexibility and pay by assigning one parent to choose a career path that allows for flexibility in response to sudden caregiving needs, while the other parent takes a less flexible job that has more convex financial and career returns to time spent on the job. These choices often follow historical patterns of gender inequality, with women in heterosexual partnerships disproportionately choosing the more flexible career path, which has less potential for higher pay and upward mobility. Such choices can perpetuate the gender gap in science and other fields with existing gender inequality and convex returns to investments of effort and time.

One policy option to reverse the inequality generated by these household choices is to explicitly compensate women for their time. For example, policy could explicitly offset the gender imbalance in household labor by offering women longer windows of time to seize key career opportunities (Antecol, Bedard, and Stearns 2018; Bedard, Lee, and Royer 2021; Goldin 2021). Such policy follows the spirit of the wide menu of policies, collectively

known as "affirmative action," which provide differential opportunities to historically disadvantaged or marginalized groups (Holzer and Neumark 2000; Fryer Jr and Loury 2005; Crosby, Iyer, and Sincharoen 2006; Sowell 2008).

In this paper we study the short, medium, and longer-term impacts of a large affirmative action policy targeting young female scientists, designed to address gender inequality in the ranks of STEM faculty and leadership. The policy changed the age eligibility criterion for female applicants to a nationally competitive grant for young researchers in China. The grant, called the *National Natural Science Foundation of China* (NSFC) *early career grant* (in Mandarin, *zhongguo ziran kexue jijin weiyuanhui qingnian xuezhe*), offers large, unrestricted funding to early career scientists and is the single most important funding opportunity for early career scientists in China. The policy we study, implemented in 2011, extended the maximum age of eligibility for women applying to this grant by five years, while leaving that for men unchanged. Its explicit goal was to increase the proportion of grant recipients who are female. By providing women additional flexibility in when they applied for this funding, it deliberately counters some of the forces leading to the persistence of gender inequality, particularly in jobs such as academic research (Ceci and Williams 2011; Kuhn and Shen 2012; Ceci et al. 2014; Goldin 2021).

Early career research support is a potentially high-leverage option for addressing gender inequality in STEM fields. Historical allocation of such funding has been highly unequal in several contexts (Boyle et al. 2015; Van der Lee and Ellemers 2015; Witteman et al. 2019), as it is in China over much of the period we study. Inequality in early funding is seen as a core contributor to subsequent gender inequality in the ranks of scientists across a wide range of fields and contexts (Shen 2013; Boyle et al. 2015; Sege, Nykiel-Bub, and Selk 2015; Van der Lee and Ellemers 2015; Beaudry and Larivière 2016). The potential for early career funding to remedy such inequality comes from two sources: one, the compounding interest of early investments; and two, because of the "Matthew Effect", wherein early career successes greatly increase the likelihood of later success (Ley and

Hamilton 2008; Bol, de Vaan, and van de Rijt 2018).

We use a difference-in-differences design to study how this policy affects several outcomes over the life-cycle of female scientists' careers, spanning early receipt of funding via this mechanism, subsequent scientific productivity, receipt of other scientific funding, and, later, academic promotion. To track these outcomes, we generate an important new dataset connecting administrative data to data on scientific productivity. These data link the records of individuals from a wide range of sources, and cover the universe of STEM faculty in a set of elite Chinese universities. They comprise information on scientific productivity, career advancement, and demographics for 26,373 individuals.

We estimate that the policy increased the proportion of early career grant recipients who are female by roughly 30 percent. We show that this effect differs by field: we estimate the largest effects in chemistry, biology, and medicine, and the smallest impact in economics and management. We also find that the affirmative action policy does not lower the average quantity or quality of the scientific outputs – primarily peer-reviewed journal articles – produced by scholars over the course of their early career grant.

We next show that this policy led to greater productivity among female scientists early in their careers. We estimate that receipt of the early career grant, as induced by the policy, has large positive effects on recipient women's subsequent scientific output, measured by their total number of academic publications. We also estimate that it has no negative impact on the total number of citations of their published work. In other words, policy-induced receipt of the grant leads to an increase in the quantity of the work of these scholars with no change in the quality of their work. We also show that women who receive the grant due to the policy are also more likely to secure later funding via the NSFC's general grant, a larger nationally competitive funding mechanism for supporting STEM research.

Finally, we show that these early gains do not reduce gender inequality among those who hold senior academic roles. Specifically, we find no evidence that policy-induced receipt of the early career scientific grant increases the likelihood of female recipients'

eventual academic promotion. We conclude that this policy alone is unlikely to remedy the persistent gender inequality seen at the highest levels of STEM research. This finding underscores the need for coordinated action, including additional complementary policies, to promote later career advancement for female scientists.

Our paper makes three key contributions. First, we quantify a series of important policy impacts of a large national affirmative action policy intended to address gender inequality in science. These findings are relevant for a wide range of contexts – such as the US, Europe, and other countries in East Asia – where national funding of scientific research is an important feature of the scientific process, and where gender inequality in senior roles in science persists. We estimate the short, medium, and long-term impacts of this affirmative action policy, which abruptly increased the funding opportunities available to millions of early career female scientists in China, the world's largest country and its second largest producer of scientific research (Xie, Zhang, and Lai 2014). We show how this policy affects women's scientific productivity, their likelihood of securing later, larger grants, and their career advancement.

Second, our study advances our understanding of the efficacy of policies designed to address gender inequality in the labor market. Prior research has studied sources of this inequality (Correll, Benard, and Paik 2007; Bertrand, Goldin, and Katz 2010; Blau and Kahn 2017; Goldin 2021; Kim and Moser 2021), and other work has studied the impact of policies which target these causes – for example, the provision of extended maternity leave (Ruhm 1998; Olivetti and Petrongolo 2017; Antecol, Bedard, and Stearns 2018). This research finds such policies do not consistently improve women's labor market outcomes. We contribute understanding of the efficacy of a different type of policy to address labor market gender inequality, one which aims to directly promote the career development of early career female scientists by compensating them with greater flexibility in the competition for a crucial early career award.

Finally, we generate causal evidence of how greater opportunity for scientific funding

affects subsequent scientific productivity and career advancement. Previous research has shown how the amount of funding a researcher receives correlates with career development, particularly for women (Beaudry and Larivière, 2016; Ley and Hamilton, 2008; Sege et al., 2015). These studies, however, present primarily correlational evidence. Our analysis provides novel, quasi-experimental evidence of the impact of a well-resourced national funding initiative for early career scientists at elite institutions on their subsequent productivity and promotion.

The rest of our paper proceeds as follows. Section 2 first describes global gender inequality in science, describes this inequality in our empirical setting (China), and then describes the affirmative action policy which we study. Section 3 introduces the main datasets used in our analyses. Section 4 presents our research design. Section 5 presents our empirical results, and the final section concludes.

2. Background

In this section we discuss gender inequality among science faculty, both globally and in the context we study, China. We then describe the national funding landscape for science research in China and describe the affirmative action policy we study.

2.1 Gender inequality in science

Despite tremendous progress towards gender equality in science, the number of men in science faculty positions globally still vastly exceeds that of women (Antecol, Bedard, and Stearns 2018; Huang et al. 2020), and these gaps are particularly pronounced in the ranks of elite researchers. In a study documenting the careers and productivity of scientists across six continents, Huang et al. (2020) show that, among scientists in the top global quintile of research productivity, males produce almost 40 percent more research than females.

Goldin (2021) illustrates that a key source of such gender inequality is the choices made by heterosexual couples in response to the non-linear returns to effort and time in

many white-collar professions, such as academic research. In these fields, jobs with higher pay or greater potential for advancement often require that the employee be available for work at times – nights, weekends – at which there are likely to be conflicting caregiving needs. This leads many potentially high-earning couples to pick one spouse to take such a "greedy" job, as Goldin calls such positions, and the other to take a more flexible job in order to tend to needs that arise in the early years of childrearing which are sudden or inconveniently timed; for example, retrieving a sick child who needs to be brought home from school, or attending the child's afternoon sports match.

In this paper, we study the careers of scientists in the People's Republic of China. In China, the national government has emphasized the equal importance of women and men in the labor market since its founding in 1949, countering cultural practices in place prior to the founding of the PRC which were highly preferential to males (Zheng 2016; Edwards 2020). Nonetheless, gender inequality in Chinese science persists and is particularly acute among the ranks of senior Chinese scientists (Ma et al. 2018). As in the US, females in China are more likely than males to earn BA degrees. Despite this, males comprise nearly 60 percent of Chinese PhD students. As we show later in the paper, this gap is even larger in the rolls of faculty in STEM fields at elite Chinese universities. This increases with academic rank, and females comprise an exceedingly small proportion of the people occupying such roles at the highest levels of these professions. In 2019, for example, female scientists accounted for only six percent of members of the highly prestigious Chinese Academy of Science, and only five percent of members of the Chinese Academy of Engineering. This is similar to patterns found in the US, Spain, and Italy (Ceci et al. 2014; Bagues, Sylos-Labini, and Zinovyeva 2017; Lundberg and Stearns 2019).

2.2 Scientific Funding from the National Natural Science Foundation of China

Our empirical analysis focuses on funding from the Chinese National Natural Science Foundation. The NSFC was established in 1986 to fund and support basic research, and to foster the development of talented scientists. Its support is awarded based on a rigorous

merit-review system. Like its US counterpart, the United States National Science Foundation (NSF), the NSFC is China's largest sponsor of basic science research. In recent years, the NSFC has become the world's largest research funding agency in terms of applications received: in 2019 the NSFC received about 230,000 applications, more than three times that of the two main US national scientific grantmaking institutions, the NSF and the National Institutes of Health (NIH).[2]

The NSFC has eight scientific departments that sponsor funding of different fields. These are the Mathematical and Physical Sciences; Chemical Sciences; Life Sciences; Earth Sciences; Engineering and Material Sciences; Information Sciences; Management Sciences; and Health Sciences. It also has one transdisciplinary research department, established at the end of 2020, which we do not study because its inception occurs after the end of the time frame of our analysis.

The NSFC has two flagship funding mechanisms: the early career grant and the general grant. The early career grant aims to support early career scientists in basic science and has a maximum age of eligibility for application. The general grant is open to all scientists and has no age limit. While a scientist can, at most, receive one early career grant in their career, there is no limit on the number of general grants a scientist may receive. The average amount of funding awarded in a successful general grant is more than double that awarded in the average successful early career grant. This highlights the fact that general grants are designed primarily to continuously support scientists' mid-career development, whereas the early career grant focuses primarily on helping young scientists establish themselves in their careers.

There has been tremendous growth in both the supply of and demand for these grants over time. The NSFC's funding budget grew from about 10 million US dollars in 1986 to roughly $4.5 billion in 2019. The competition for these grants is also consistently fierce: despite this increase in funding, over the past two decades the approval rate for each of the

[2] Sources: http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/35861/37047/, https://nexus.od.nih.gov/all/2019/03/13/nih-annual-snapshot-fy-2018-by-the-numbers/, https://www.nsf.gov/about/how. Accessed December 30, 2021.

two awards has hovered around or below 20 percent. In 2001, for example, the approval rate was 21.1 percent for the early career grant and 18.35 percent for the general grant; in 2019, it was 17.90 percent for the early career grant and 18.98 percent for the general grant.

2.3 The policy we study

In 2010 the Central Committee of the Communist Party of China and the State Council issued a joint document calling for policies designed to help narrow gender inequality in professional workplaces (Ma et al., 2018). Following this, in 2011 the National Natural Science Foundation of China (NSFC) implemented a policy which extended the maximum age of eligibility at the time of applying for the early career grant from 35 to 40 years old for female scientists, while holding the age limit for male scientists constant at 35.[3]

By allowing women more time than men to compete for this award, the policy explicitly compensates for the gender inequality in time spent on caregiving and other household work linked to gender inequality in STEM, and in careers more broadly (Bertrand, Goldin, and Katz 2010; Blau and Kahn 2017; Lindsey 2020; Goldin 2021). Furthermore, by targeting women early in their careers, and providing additional flexibility regarding when they can compete for this important award during years of particularly high demands on women's time due to caregiving, it is one of the few policies we are aware of which explicitly aims to compensate for the root causes of gender inequality in this field (Ceci and Williams 2011; Antecol, Bedard, and Stearns 2018).

[3] The NSFC also increased its funding budget to 2.83 billion US dollars in 2011, almost doubling the amount of the previous year; this increase in the NSFC funding budget, however, was not gender-specific.

Figure 1. Proportion of female awardees in two main NSFC grants

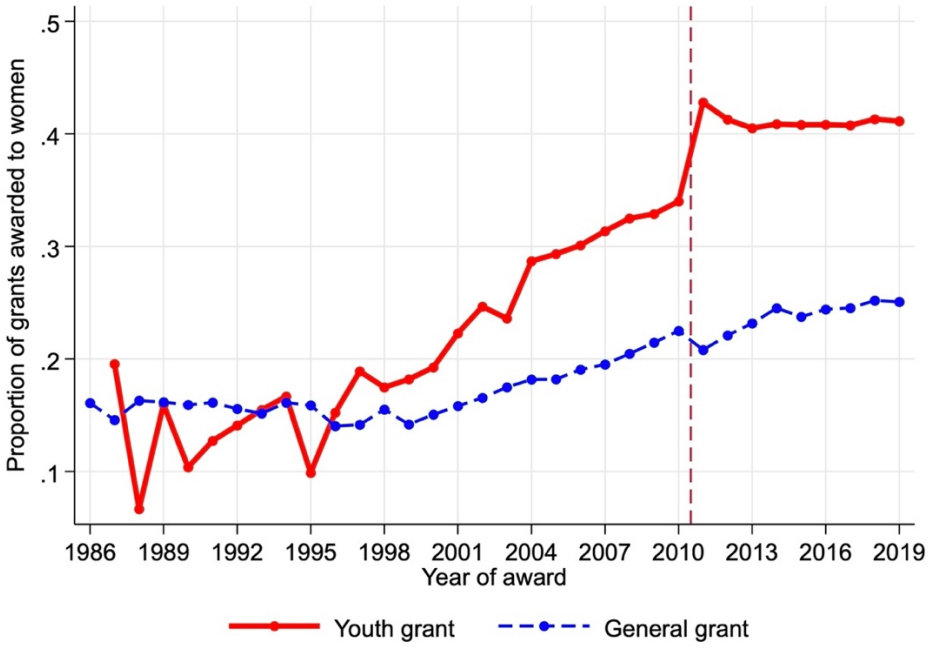


Figure 1 note: the grants data in this figure come from the *Annual Reports of the National Natural Science Foundation of China*. Because the NSFC does not provide gender information on grant awardees between 1986 and 2010, we use a machine learning inference procedure to assign gender to each awardee.

In Figure 1 we show the proportion of NSFC early career and general grants awarded over time, by gender. Prior to 2000, less than 20 percent of early career grants were awarded to females. Since then, this proportion has risen gradually over time, increasing to 32.66 percent by 2010. In 2011, the first year of the affirmative action policy, it rose to 42.80 percent, and has since remained stable around that value. By contrast, the proportion of NSFC general grants awarded to females was also relatively low before 2000 (less than 15 percent), and it rose more gradually between 2000 and 2010, to roughly 22 percent, where it has also been stable over the past decade.[4]

[4] We show these trends for our faculty data in Figure A1. Note that there was a slight, one year dip in 2011 because many female scientists aged 36 to 40 were suddenly eligible for the NSFC early career grant upon announcement of the affirmative action policy.

3. Data sources

We analyze data from three main sources: a novel dataset containing information on the universe of faculty in departments eligible for NSFC funding in a random sample of 20 top Chinese universities; administrative data from the NSFC on all grant recipients; and data on the volume and citations of individual scientists' scientific outputs collected from the website *Scopus.com* (Baas et al. 2020). In this section, we describe these data and their properties.

3.1 Faculty data

A key contribution of our paper is to introduce a new dataset which collects key demographic, career, and productivity data from the universe of faculty in STEM departments at a random sample of 20 top Chinese universities eligible for funding from the NSFC. These data comprise information for tens of thousands of individual scientists. We collect these data because the NSFC does not disclose information on grant applicants at the individual level. Because these data comprise all faculty eligible for NSFC awards at these universities, they allow us to approximate the universe of winners and non-winners at a random sample of institutions whose faculty are active competitors for these grants.[5] Three further reasons make this a particularly appropriate sample to study the impact of the policy: one, the majority of NSFC grants go to university faculty; two, faculty at top universities receive the majority of these awards; and three, almost all faculty at these top universities are expected to apply for these awards. In 2019, 84.15 percent of NSFC grants were awarded to university faculty. Within awards to faculty, roughly two thirds are awarded to faculty at universities belonging to the nationally recognized set of 114 elite institutions from which our sample of 20 universities was drawn (for reference, there are roughly 2,700 eligible post-secondary institutions in China). Finally, because winning NSFC funding is often a necessary condition for a faculty member to apply for academic promotion at these top universities, nearly all young faculty members in the institutions we

[5] In Section 5.5 we discuss the low levels of mobility between institutions at this level over our period.

study are likely to be applicants to this funding mechanism over the period we study.[6]

Our process of data collection began with the selection, using a random number generator, of 20 universities from the 114 elite Chinese universities recognized by the Chinese government's "211" project (Yaisawarng and Ng 2014). The list of these 20 universities appears in Table A1 of the Appendix. For each selected university, we then hand-collected demographic and career information from the webpage of each faculty member in all relevant departments. These data were all collected in 2019. They include the name, gender, year of birth, educational history, academic rank, academic field, and career history of each faculty member listed on the official, institutional website of the department and/or of the individual faculty member. We limit our focus to faculty in fields eligible for NSFC awards: the natural sciences; engineering; and economics and management.[7] This yielded a dataset of 26,373 faculty members.

We assign gender and age to each faculty member using the information available on these official university websites. Gender identification comes from two sources: explicit mention of the person's gender on the website, and visual identification using the photograph posted on the site. Using these methods, we are able to identify the gender of the faculty member for 93.23 percent of the people in our data (24,587 cases). The 6.77 percent of faculty without an immediately classifiable gender identity have no specific gender information listed, and no photo posted on either their department or their individual sites. Age classification is also derived from two sources of information. The first is the person's birth year as listed on their website; we observe this for 40.85 percent of the faculty members we study (10,776 cases). For another 50 percent of the sample, we do not

[6] Many top universities require faculty members to regularly apply for NSFC funding. According to a survey conducted by the NSFC, of Chinese institutions that have been awarded NSFC grants prior 2011, 58 percent require that an assistant professor win a NSFC fund before they apply for promotion to associate professor (National Center for Science and Technology Valuation, 2011). A survey on Xiaomuchong (http://muchong.com/t-6453003-1), the largest online forum for Chinese scientists, shows that roughly three quarters of elite 211-project universities have such requirements.

[7] Within these 20 randomly selected universities, we focus on faculty in the schools of natural science, engineering, and economics & management at each university, as the NSFC does not fund research in other fields (such as the humanities or other social sciences). Among the 261 schools contained in these 20 universities, four (1.53%) do not provide a complete faculty list on the school's website. When a school or professor's personal site provides incomplete information, we supplement the information with data retrieved from Baidu Baike (https://baike.baidu.com/), the Chinese equivalent to Wikipedia and the largest Chinese-language website providing such information.

observe birth year directly but can infer it based on the years in which the person earned their bachelor's degree, master's degree, and PhD.[8] Using these methods, we are able to classify birth year for just over 90 percent of the sample.

We further restrict our sample to faculty aged between 28 and 60 years of age at time of observation in 2019. The upper age limit accounts for the fact that in many institutions, professors are required to retire at age 60. The lower age limit accounts for the fact that most scholars receive their PhDs at age 28 or older. This means that the people in our analysis belong to the birth cohorts spanning from 1960 to 1991.

Our final analysis sample of faculty with age and gender data comprises 22,452 faculty members, of which fewer than 30 percent are female. In Panel A of Table 1, we show the proportion of faculty who are female by field. There is a much smaller proportion of female faculty in the fields of math, physics, engineering, material science, and information science, while in the fields of management and economics and health sciences, women comprise more than 40 percent of faculty. In Panel B we show how this proportion varies by academic rank. We see that gender inequality increases with rank; at the highest rank, full professor, less than 20 percent of faculty in our data are female.

3.2 Administrative data from NSFC grants

Our second key source of data is administrative data from the NSFC. The NSFC posts basic information on the recipients of each NSFC grant, including name and institution. We scraped these data from the official NSFC website (http://kd.nsfc.gov.cn/) and matched them to our faculty data using author name and university name. In cases with more than

[8] Specifically, we use the following rules: (1) With information on the year of receipt of a bachelor's degree (YB), we assign birth year to be YB – 22, assuming that people are most likely to earn their bachelor's degree at the age of 22. We classify 10,478 cases using this method. (2) With information on the year of receipt of a master's degree (YM) but no YB, we assign birth year to be YM – 25, because China's master's programs usually last for three years and, normally, are immediately preceded by receipt of a BA. We classify a further 232 cases using this method. (3) With information on the year of receipt of a PhD (YP) but no YB or YM, we assign birth year to be YP – 29, assuming that China's PhD programs usually last for four years, and normally are immediately preceded by receipt of an MA. We classify an additional 2,262 cases using this method.

Table 1. Summary statistics – faculty data

	Proportion female	Number of observations
Panel A: Gender by field		
Math & physics	.268	2,586
Chemistry	.321	2,450
Biology	.344	1,869
Earth science	.298	706
Engineering & material science	.240	7,727
Information science	.275	3,854
Management & economics	.413	2,811
Health science	.396	449
Panel B: Gender by academic rank		
Assistant	.392	4,233
Associate	.335	9,366
Full	.199	8,610
Overall	.293	22,452

Table 1 notes: this table presents the number of observations in our faculty data by rank and field, and the proportion of these observations who are female.

one match (eight percent of the total matches), we manually checked both sources to confirm the validity of the match.

We observe the faculty members in our data in 2019, at which point 38.46 percent had been awarded the early career grant, and 41.15 percent had been awarded the general grant at least once.[9] Split by gender, 39.53 percent of female faculty had received the early career grant, a proportion similar to that of male faculty (38.02 percent). For the general grant, however, only 29.93 percent of female faculty were recipients, compared with 45.80 percent of male faculty.

The NSFC also collects and publicizes information on completed grants. This information includes the scientific output of awardees during the grant, including papers

[9] The 20 universities in our data account for 12.24 percent of all approved NSFC early career grants and 15.66 percent of all approved NSFC general grants between 1986 and 2019.

published in peer-reviewed journals, conference papers, books, awards, and patents. We collect these output data for all early career grants in our sample and match them to the faculty data.

3.3 Data on scientific publications

To collect a full record of each faculty member's publications in scientific journals, we access a major online database cataloging the bibliographic information of scientific papers and their citations, *Scopus.com*. Scopus regularly collects publication information from a curated set of over 34,000 peer-reviewed journals, as well book series and trade journals. It uses an algorithm based on authors' names, affiliations, and email addresses to link these publications to authors.

We successfully link more than 80 percent of the faculty members in our data to publication records in Scopus. Among the faculty we fail to successfully match to a Scopus profile, we inspect a random sample of faculty profiles to determine the likely causes of this failure. We find that the majority of these faculty are not publishing their work in English at all and/or work in fields where faculty are more likely to publish exclusively in Chinese-language journals not covered by Scopus. In practice, these scholars work primarily in the fields of economics and management.

We use the Scopus Application Programming Interface (API) to extract information about both the quantity and quality of publications of the faculty in our data. We collect two main variables to measure the quantity of faculty output: the number of published peer-reviewed journal articles the person published in a given year and, separately, the number of published peer-reviewed journal articles in that year on which the person was first author. To measure the quality of faculty output, we collect the number of citations the person's work has received each year. In Table A2 we describe the productivity of faculty in our data by gender and receipt of the early career grant. Two main patterns emerge: one, faculty who win the early career grant have higher average scientific productivity than those who do not; two, women in our sample publish fewer papers than men, and these papers are less

cited than those of male faculty.

4. Research design

In this section we describe our research design. Our primary method is a difference-in-differences research design, which we use to estimate the impact of the affirmative action policy on a series of outcome variables related to scientific productivity and career advancement. We also employ an instrumental variables strategy to derive a parameter immediately relevant to policy: the impact of the early career grant – receipt of which was caused by the affirmative action policy – on these outcomes.

4.1 Assigning treatment status

We assign treatment status – that is, whether the person benefitted from extra eligibility for the early career grant as a result of the affirmative action policy – using the person's birth year, their gender, and the year of implementation of the policy. The policy first came into effect in 2011. Starting that year, it extended women's maximum age of eligibility for the early career grant application from 35 to 40. As a result, women aged between 36 and 40 – that is, those born between 1971 and 1975 – were suddenly once again eligible for the grant until they turned 41. All women younger than this enjoyed a full five years of additional eligibility. We classify all women in our sample who were born in 1971 or later as treated by the policy. Because our data were collected in 2019, women born after 1979 were still benefitting from the extended eligibility granted by the policy in the years after we observe them.

4.2 Empirical approach

Our main analyses estimate the impact of the affirmative action policy on a set of outcomes related to academic productivity, external funding, and promotion using a difference-in-differences (DiD) approach. Intuitively, this approach calculates the difference in outcomes between those born in cohorts who are eligible for the policy as

compared to those born in earlier cohorts (the first difference) across the difference in outcomes between females and males (the second difference). To do so, we estimate the following equation:

$$y_{icu} = \beta_0 + \beta_1 F_i + \beta_2 F_i * P_c + \mu_c + \gamma_u + \rho_f + \epsilon_{icu} \quad (1)$$

The outcome variable, y_{icu}, is specified for person i, in birth cohort c, at university u. F_i is an indicator for the female gender of person I; P_c is an indicator for whether the person was born in or after 1971. We also include cohort fixed effects, μ_c, to account for secular trends over time in the likelihood of being awarded the NSFC early career grant; university fixed effects, γ_u, to account for unobserved confounding factors at the university level, such as incentive policies to encourage NSFC grant applications which may vary from institution to institution; and fixed effects, ρ_f, for each of the scholarly fields in which the NSFC awards the early career grant, in order to account for any systematic differences in likelihood of being awarded the grant across the different NSFC-eligible scientific disciplines described in Section 2. The main parameter of interest in this equation is β_2, which captures the difference in the outcome variable for women across the pre/post policy periods, as compared to that difference for men, after controlling for these fixed effects.

A key assumption required for this approach to yield causal estimates of the policy on the outcomes we study is the "parallel trends" assumption. Specifically, this requires that female scientists and male scientists have similar trends, by cohort, in the key outcome variable over the period prior to announcement of the affirmative action policy. This is a test of the assumption that, in the counterfactual case without the NSFC affirmative action policy, trends in the outcome variables for the two groups would have had similar slopes. We conduct this test using a series of linear regressions in which the outcome variable is the person's likelihood of winning the early career grant, and, separately, their volume of publications before winning the grant, and the key explanatory variable is the person's gender. In Appendix Table A3 we present this analysis; our estimates yield no evidence that the parallel trends assumption is violated.

We also estimate an event-study version of this equation, regressing the outcome variable on the same set of controls, only with the P_c variable in equation 1 replaced by a series of cohort-specific indicator variables as follows:

$$y_{icu} = \delta_0 + \delta_1 F_i + \sum_{c=1960}^{1991} \delta_{2c} F_i * \mu_c + \mu_c + \gamma_u + \rho_f + \epsilon_{icu} \quad (2)$$

Plotting these δ_{2c} coefficients by cohort provides visual evidence of the persistence of the effect, as well as of patterns in the outcome variable prior to the introduction of the policy.

Where appropriate, we also describe the observational patterns of the outcome variable before and after the policy was introduced among subgroups of interest, e.g., female faculty. To do so, we estimate an ordinary least squares regression of the outcome variable on receipt of the grant, controlling for individual fixed effects to remove time-invariant, person-level factors. This takes the following form:

$$y_{icut} = \alpha_0 + \alpha_1 P_c + \mu_c + \sigma_i + \delta_t + \epsilon_{icu} \quad (3)$$

In this equation, we replace the field and university fixed effects with person-level fixed effects, σ_i, to control for time-invariant differences across scholars, and year-level fixed effects, δ_t, to control for secular time trends in outcomes.

The final aspect of our research design uses an instrumental variables approach to generate a causal estimate of a more policy-relevant parameter: the impact of receipt of the early career grant on subsequent productivity. We use the NSFC's gender affirmative action policy as our main instrument, as it generates a sudden change in eligibility for the early career grant among the women in our data belonging to a small set of birth cohorts, a change which we show is plausibly orthogonal to the outcome variables we study.

4.3 Sample restrictions

In some of our later analyses, we employ one or two sample restrictions. The first restriction, which we call the *short time series* condition, limits the birth cohorts we study to a much shorter range, 1966 to 1975. This includes five birth cohorts on either side of the new eligibility cutoff introduced by the policy. We employ this restriction when we wish

to ensure the productivity standards used to evaluate scholars are more constant across the groups we study than they might be with a wider time range, given the dramatic changes in Chinese academia over this period (Li 2010; Xu, Rose, and Oancea 2021).[10]

The second sample restriction, which we call the *policy* condition, focuses on scholars who would not have won the grant without the policy. This condition restricts our attention to two groups: male scholars who do not win the grant, and female scholars who would not have won the grant without the policy (i.e., women who won the grant after the policy went into place, at age 36 or higher, and who have not previously won the general grant, which would have precluded them from the early career grant). When we use this sample restriction, our comparison is between women who would not have won the grant without the policy, and others who did not win the grant.

5. Results

In this section, we present our empirical estimates. Each subsection presents estimates related to one of the sets of outcomes we study – receipt of the grant, productivity during the grant, productivity after the grant, and career advancement.

5.1 Impact on receipt of the early career grant

In our first set of results, we present our estimates of the impact of the affirmative action policy on the likelihood that women received the early career grant. In Figure 2, we plot the raw likelihood, by birth cohort and gender, of receipt of the early career grant. The area between the two vertical lines demarcates the cohorts who had enjoyed the full benefit of the affirmative action policy at the time we observe them in 2019. Visually, the graph

[10] This restriction has the added benefit of avoiding confounding from the general grant. Early career grantees who are ineligible to apply for the general grant at the time we observe them because they have not completed their early career grants. Because early career grants have a duration of three or more years, and while someone holds an early career grant they are typically ineligible for application of the general grant. Scholars who have won the early career grant in the two previous years prior are usually not permitted (and, when permitted, are strongly discouraged) to apply for the general grant according to the NSFC application regulations. In most cases, therefore, people apply for the general grant only after completing their early career grants. This restriction limits our analysis to those who would have completed their early career grant before 2019 and would have applied for the early career grant before applying for the general grant. Doing so avoids the risk of a downward bias on our estimates from the inclusion of female scholars who are ineligible for general grants when studying receipt of the general grant as an outcome.

shows that in this period of eligibility, the proportion of women who receive the early career grant increases dramatically, and that the gender imbalance in who receives the early career grant reverses.

We present results from estimating Equation 1, using likelihood of receiving the grant as the outcome variable, in Table 2. We estimate that the policy increases women's likelihood of winning the early career grant by 7.6 percentage points, from a baseline likelihood of 40 percent, or an 18 percent increase in the baseline likelihood of receipt. The table shows three columns of results; these demonstrate that the magnitude and significance of our estimates are stable to the exclusion of additional fixed effects at the university and NSFC department (field) level. For parsimony, in all subsequent analyses we include both sets of fixed effects.

Figure 2. Receipt of the NSFC early career grant

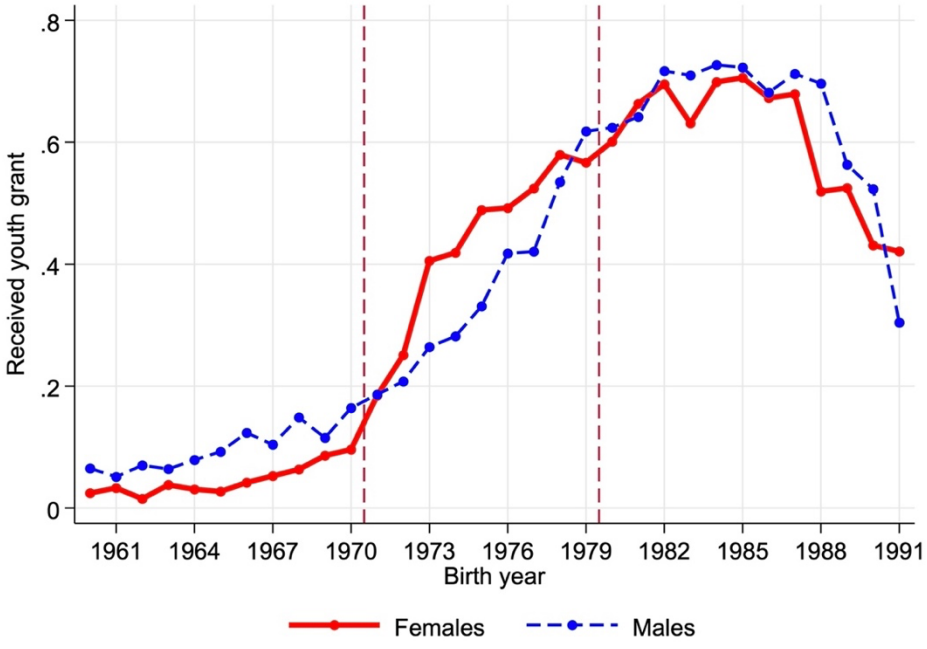


Figure 2 note: This figure shows the likelihood of receipt of the early career grant by birth year and gender for our faculty data. The two vertical dashed lines show the window in which women in our data were eligible for the full benefit of the affirmative action policy we study. Note that at the time of observation (2019), women in all cohorts after 1979 still have remaining eligibility for the grant beyond the window of our study, as do men in all cohorts after 1984.

In Figure 3 we present results from estimating equation 2, generating an event-study style graph for this outcome variable. The figure shows two key patterns. First, we observe no evidence of a difference in outcomes between women and men born in birth cohorts that make them ineligible for the benefits of the policy (i.e., people born before 1971).[11] Second, the figure shows an immediate and statistically significant increase in female receipt of the award, relative to male receipt, among cohorts who are fully eligible for the policy – those born between 1971 and 1979. For cohorts who have not reached the upper age limit (40 years) in 2019 and so are still able to apply for the NSFC early career grant after we observe them in 2019, this effect trends back to zero. The magnitude of the estimates shown in this figure are similar to the visible departure from trend in male and female receipt of the award over the 1971-1979 period presented in Figure 2: women's

Table 2. Impact of the affirmative action policy on receipt of the early career grant

	(1)	(2)	(3)
Estimated effect of the policy	0.076***	0.079***	0.077***
	(0.013)	(0.013)	(0.013)
Female	-0.053***	-0.039***	-0.029***
	(0.011)	(0.011)	(0.011)
Cohort dummies	X	X	X
University dummies		X	X
NSFC department dummies			X
Mean outcome (female)	0.396	0.396	0.396
Observations	22,049	22,049	22,049

Table 2 note: this table presents results from estimating equation 1 using our faculty data, with an indicator variable for having won the early career grant in 2019 as the dependent variable. * p<0.1, ** p<0.05, *** p<0.01.

[11] This also provides additional evidence that the parallel trends assumption is satisfied in our research design.

likelihood of receipt of the award increases by between eight and 20 percent for fully eligible cohorts.

We next investigate the potential for heterogeneity in our estimates across fields, given evidence of heterogeneity in the gender gap in scientific funding across fields in other contexts (Boyle et al. 2015). To implement this, we estimate field-specific impacts of the policy for four sets of scientific fields: (1) math, physics, and earth science, (2) chemistry, biology, and medicine, (3) engineering (including computer science), and (4) economics and management.

Figure 3. Cohort-specific estimates of impact on likelihood of receiving funding

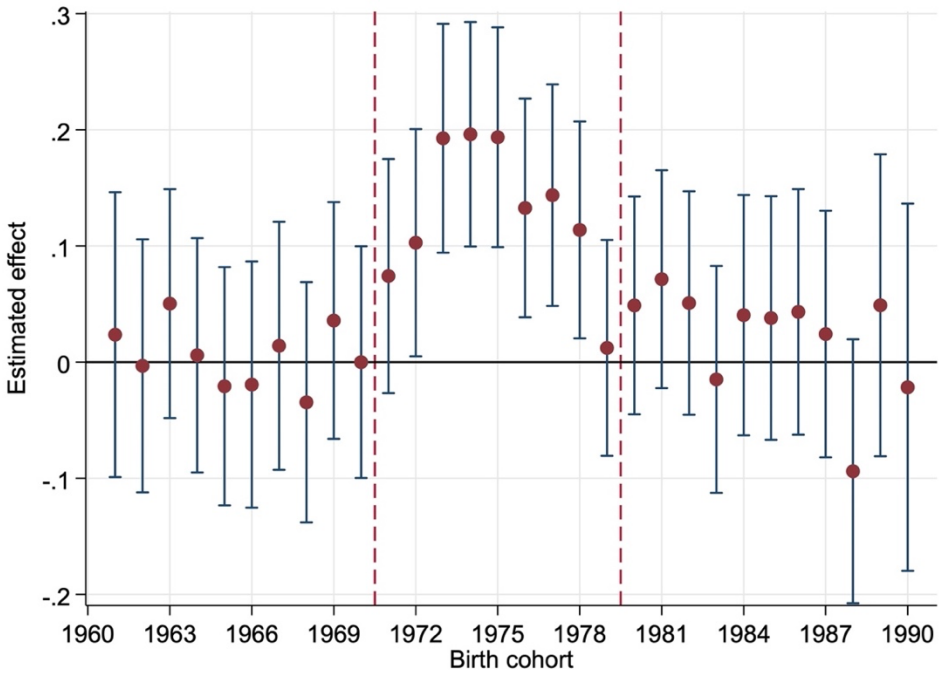


Figure 3 note: this figure shows birth-year estimates of how female receipt of the early career grant increased with the implementation of the affirmative action policy on women's receipt of the NSFC early career grant. The results were generated by estimating equation 2 using our faculty data, with an indicator variable for having won the early career grant in 2019 as the dependent variable. The two vertical dashed lines show the window in which women in these data were eligible for the full benefit of the affirmative action policy we study. Note that at the time of observation (2019), women in all cohorts after 1979 still have remaining eligibility for the grant beyond the window of our study, as do men in all cohorts after 1984.

We present these results in Table 3. We find that the NSFC affirmative action policy has the greatest effect on the likelihood of female faculty winning the early career grant in chemistry and the life sciences, and the smallest effect for scholars in the fields of economics and management. We speculate that one potential reason for this discrepancy is that faculty in economics and management are less likely to face pressure from their departments and institutions to apply for the NSFC early career grant, as such funding may be less important for the conduct of their work and advancement in these fields because the "lab" model of science is less prominent in economics and management than in most other fields funded by the NSFC.

Table 3. Heterogeneity in receipt of early career grant by field

	(1) Math, physics, and earth science	(2) Chemistry, biology, and medicine	(3) Engineering	(4) Economics and management
Effect of the affirmative action policy	0.076*	0.207***	0.053***	0.032
	(0.040)	(0.028)	(0.019)	(0.030)
Female	-0.045	-0.071***	-0.020	-0.019
	(0.034)	(0.024)	(0.016)	(0.024)
Mean outcome (female)	0.458	0.479	0.397	0.232
Observations	3,154	4,706	11,405	2,784

Table 3 note: this table shows how our estimates from Table 2 vary by field of study; here again we use our faculty data to generate these estimates, generated by estimating equation 1 with an indicator variable for having won the early career grant in 2019 as the dependent variable. * p<0.1, ** p<0.05, *** p<0.01.

5.2 Quantity and quality of output associated with the early career grant

We next examine whether the scientific output associated with these grants differs after the introduction of this policy. Ad ante, this policy could have had a range of possible

effects. On the one hand, it could have enabled many equally productive scholars to earn the award who wouldn't otherwise have been able to. On the other hand, it could have given the award to a new, broader set of scholars who, on the margin, were less productive than prior recipients.

To study this question, we use information on scientific output associated with each completed NSFC early career grant, as officially recorded by the NSFC. As with major funding agencies in the US and Europe (NSF, NIH, and the European Research Council), the NSFC requires awardees to report output as part of the terms of the award and it reports these output data. These output data include information on articles published in peer-reviewed journals, conference papers, books, awards, and patents. Because peer-reviewed journal articles account for the majority of most scholars' grant-related scientific output, we measure grant quality using the following three indicators: the number of total outputs as recorded by the NSFC, the number of peer-reviewed journal articles, and the number of other outputs. For this analysis, we limit our analysis to early career grants awarded between 2006 and 2015, that is, in a ten year window around the start of the policy which ensures that all productivity associated with the grant is measured at time of observation in 2019.

We present our results in Table 4; we find no evidence that the quantity of scientific outputs associated with early career grants decreased as a result of the policy. Indeed, while our coefficient estimates are statistically indistinguishable from zero, the signs on our point estimates are uniformly positive.

5.3 Scientific productivity after receipt of the award

Our results thus far have shown that the NSFC affirmative action policy significantly increased female scientists' likelihood of being awarded this early career funding without any demonstrable negative impact on the quality of research produced under the grants awarded to these newly-eligible female faculty. We next analyze the impact of this policy on its intended goal: early career advancement of awardees, as measured by subsequent

Table 4. The impact of the NSFC affirmative action policy on grant quality

	(1) Number of all outputs	(2) Number of journal papers	(3) Number of other outputs
Effect of the affirmative action policy	0.037 (0.123)	0.010 (0.097)	0.027 (0.060)
Female	-0.854*** (0.109)	-0.662*** (0.085)	-0.192*** (0.052)
Mean outcome (female)	8.060	6.243	1.817
Observations	95,660	95,660	95,660

Table 4 note: in this table we show estimates of how the scientific output associated with grants awarded to females after the implementation of the affirmative action policy vary, as compared with awards in that period to men. Estimates generated using equation 1, with the dependent variable described in the column title and in the text; in all cases, it is measured at the grant level. * p<0.1, ** p<0.05, *** p<0.01.

academic performance.

The data we analyze in this section are at the person-by-year level, comprising records of individual scientific outputs collected from Scopus and matched to our faculty data. We study two key outcome variables: one, the number of published papers, as a proxy for the quantity of research the person produces in that year; and two, the number of citations of the individual in that year, a proxy for the quality of the research the individual has produced up to that point.[12]

In Table 5 we present our estimates of the impact of the policy, and of receipt of the grant, on scientific productivity. In column 1 we show the OLS results of a regression of receipt of the outcome on receiving the grant. In column 2, we present results from estimating equation 1, using the outcome variable named in the panel title (in IV terms,

[12] We define the quality measure as the number of a professor's citations in a certain year divided by the distance between that year and 2020 (Borjas and Doran 2015).

Table 5. The impact of the early career grant on women's scientific productivity

	(1) OLS	(2) Reduced-form	(3) IV
Panel A. Number of papers			
Received the early career grant	1.002***		0.156
	(0.099)		(0.229)
Effect of the affirmative action policy		0.058	
		(0.091)	
Female	-0.467***	-0.314***	-0.314***
	(0.050)	(0.064)	(0.064)
Mean outcome (female)	2.94	2.94	2.94
F-statistic of the first stage			89.96
Observations	28,669	28,669	28,669
Panel B. Number of citations			
Received the early career grant	3.348***		0.499
	(0.610)		(1.266)
Effect of the affirmative action policy		0.193	
		(0.567)	
Female	-1.938***	-1.406***	-1.405***
	(0.309)	(0.398)	(0.383)
Mean outcome (female)	6.83	6.83	6.83
F-statistic of the first stage			91.26
Observations	27,632	27,632	27,632

Table 5 note: in this table, we present our estimates of how receipt of the early career grant, as caused by the NSFC affirmative action policy, affects women's scientific productivity. We employ both the *short time series* and *policy* sample restrictions in this analysis. The F-statistic of the first-stage regression for column 3 is around 90, which is slightly smaller the threshold value of 104.7 suggested by Lee et al. (2021), but is an order of magnitude larger than the rule-of-thumb value suggested by Stock, Wright, and Yogo (2002). * p<0.1, ** p<0.05, *** p<0.01.

these are our "reduced-form" results). In column 3, we present our IV estimates. In Panel A we show estimates for the total number of papers the person has published in a peer-reviewed journal, as of 2019, as the outcome variable; in Panel B, we show estimates for the number of citations the person has received at that time.

The OLS results in column 1 show that receiving the early career grant is associated with more published papers and more citations for female scientists, suggesting that the early career scientific grant may promote female scientists' productivity. The reduced-form estimates in column 2 show a positive coefficient that is not statistically significant, and the IV estimates, while larger, are still small and statistically insignificant.

Other work finds a positive productivity impact of receiving scientific funding (Benavente et al. 2012; Jacob and Lefgren 2011a). Because non-recipients may shift to other funding sources (Jacob and Lefgren 2011b), our estimates of the productivity effect of research funding likely underestimate the true value of the parameter. In the second panel, we again find no statistically significant evidence that the early career grant improved the quality of academic papers of female scientists, as measured by citations, though the point estimate is also positive.

In sum, our empirical results from this section show that the early career scientific grant has large positive effects on the quantity of the publications of female faculty, and we find no evidence of an attendant decrease in the quality of their research. These results suggest that the NSFC affirmative action policy achieved its intended goal of helping to promote early career female scientists' productivity.

5.3 Impact on receipt of subsequent funding

In this section, we examine how women's receipt of early career scientific funding affects their receipt of subsequent scientific funding. Our outcome variable is receipt of the NSFC's general grant, a larger competitive grant which scientists may win multiple times in their career (described in further detail in Section 2). The general grant is particularly important for these scientists' later career development for two reasons. First, the average

amount awarded in a general grant is more than double that given by the early career grant. Second, the general grant can be won multiple times by the same scientist, providing a renewable source for research support, whereas the early career grant can be won at most once by any individual.

We first plot the proportion of faculty in our data who have won the general grant at least once, by gender and birth cohort. We show this in Figure 4; the figure indicates no evidence that the affirmative action policy is associated with a reduction in the gender gap in female scientists' likelihood of receiving the general grant.

We present our main empirical results in Table 7, which follows the same format as in Table 6. The OLS results in column 1 suggest that recipients of the early career grant are 22 percent more likely than non-recipients to be awarded the general grant, but the difference-in-difference estimates in column 2 indicate that the policy has a small and statistically insignificant effect on the likelihood of being awarded the general grant. Our IV estimates in column 3, are consistent with the reduced-form regression results in column 2, showing no evidence of a positive impact of the policy.[13]

We next probe the possibility that the above results mask heterogeneity in effect size among scientists at different stages of their career, or in different fields. In Panel B of Table 7, we employ both the *short time series* and *policy* criteria. We find a large, positive, and statistically significant effect of the early career grant on the likelihood of getting larger grants in the future among these faculty. We estimate that, in this sample, the causal impact of receiving the early career grant is a statistically significant 26.8 percent increase in the subsequent likelihood of receipt of the general grant.

[13] The F-statistic of the first-stage regression in Panel A is 14.52, larger than the rule-of-thumb threshold value of 10 from Stock, Wright, and Yogo (2002), but smaller than that of 104.7 from Lee et al. (2021).

Figure 4. Receipt of the NSFC general grant

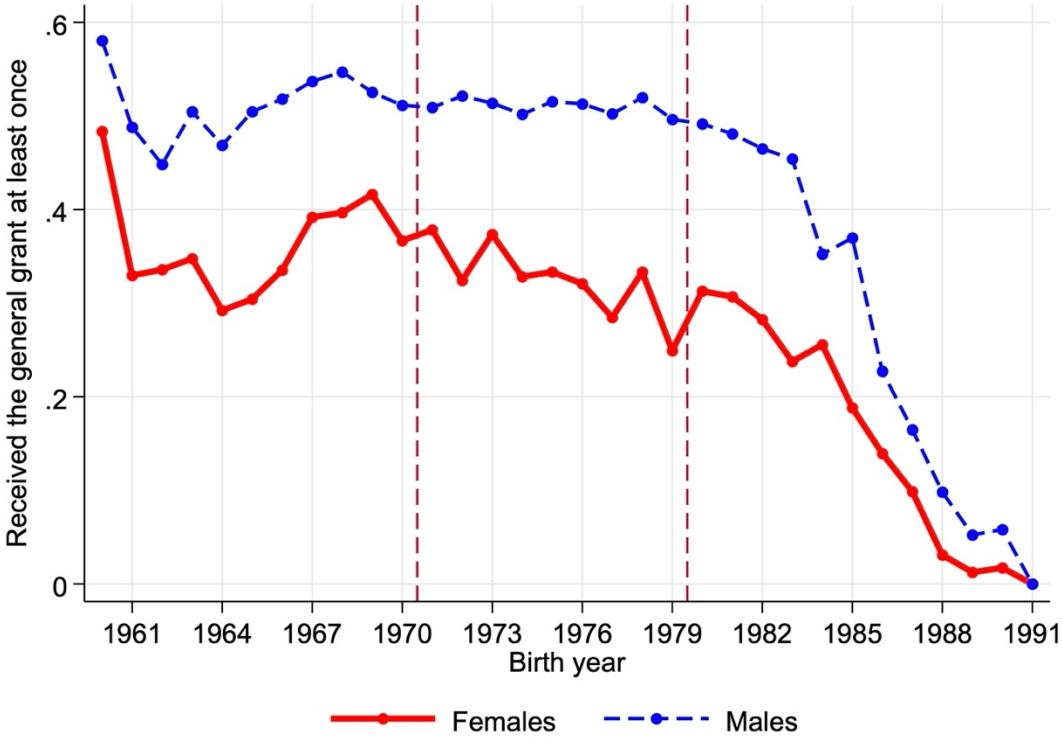


Figure 4 note: in this figure, we show the proportion of women and men in our faculty data who have received the NSFC general grant at least once, by birth cohort.

Our analyses in this section show that the early career scientific grant has a positive effect on recipients' likelihood of subsequently being awarded an important, larger grant, conditional on their eligibility. This suggests that, at least at the early stages of scientists' careers, the affirmative action policy we study has important knock-on effects that are likely to further assist in career advancement (Lerchenmueller and Sorenson 2018).

Table 6. The impact of the early career grant on winning the general grant

	(1) OLS	(2) Reduced-form	(3) IV
	Panel A: Full sample		
Received the early career grant	0.223***		-0.214
	(0.007)		(0.227)
Effect of the affirmative action policy		-0.017	
		(0.015)	
Female	-0.131***	-0.115***	-0.121***
	(0.007)	(0.012)	(0.010)
Mean outcome (female)	0.301	0.301	0.301
F-statistic of the first stage			14.52
Observations	22,049	22,049	22,049
	Panel B: Restricted sample		
Received the early career grant	0.256***		0.268***
	(0.031)		(0.102)
Effect of the policy		0.059**	
		(0.025)	
Female	-0.075***	-0.074***	-0.077***
	(0.013)	(0.018)	(0.024)
Mean outcome (female)	0.184	0.184	0.184
F-statistic of the first stage			129.50
Observations	4,340	4,340	4,340

Table 6 note: in this table, we present our estimates of how receipt of the early career grant, as caused by the NSFC affirmative action policy, affects women's likelihood of receiving the NSFC's general grant. In Panel A we use the *short time series* restricted sample. In Panel B, we use the *short time series* and *policy* restricted sample. * p<0.1, ** p<0.05, *** p<0.01.

5.4 Career advancement – promotion to full professor

Finally, we estimate how the affirmative action policy affects the likelihood of female scientists' academic promotion. A key motivation for policies such as this is the large gender gap in senior roles and positions of leadership in many STEM fields (Ceci et al. 2014; Lerchenmueller and Sorenson 2018; Lundberg and Stearns 2019; Van Miegroet et al. 2019; Eagly 2021). In this section, we estimate the impact of the affirmative action policy on one key measure of female advancement: the likelihood of female faculty to be promoted to full professor.

Here again we limit our sample with the *short time series* and *policy* restrictions. Because of the age limit on application for the early career grant, the majority of applicants are assistant or associate professors and very few of them are full professors.[14] We therefore focus on the impact of receiving the NSFC early career grant on women's likelihood of being promoted to the rank of full professor.

We present our results in Table 7, following the same order of presentation as in Tables 6 and 7. The OLS estimation results in column 1 show that winning the early career grant is correlated with a greater likelihood of being promoted to full professor. The results in columns 2 and 3 show no evidence that the policy had any impact on women's likelihood of being promoted to full professor, and the reduced form results in column 2 can exclude anything greater than a six percent increase in this likelihood.

In Table 8, we repeat this analysis, only replacing the outcome variable with the likelihood of the person being promoted to either associate or full professor. Here again, we find no evidence of any positive impact of the policy.[15] In short, our findings in this

[14] We present the proportion of early career grantees in each year, by academic rank, in Appendix Figure A2. According to official NSFC statistics spanning the period from 2001 to 2019, the proportion of assistant professors among early career grant awardees increases over time, and is stable at about 80 percent in the final five years of our data, with the proportion of associate professors winning the grant forming its mirror image, decreasing early in the period and remaining stable at an average of 18 percent over the last five years of our data. The proportion of awardees who are full professors is less than 3 percent and this proportion is stable over the entire period of study.

[15] One potential concern to our study of the impact of the policy on academic promotion is that the NSFC affirmative action policy may attract older female scientists with higher academic rank to apply for the NSFC early career grant. As we show in Figure A2, however, the proportion of full professors applying for the grant is exceedingly small and constant over our study period, and we only observe a temporary drop in the proportion of assistant professors and a temporary increase in the proportion of associate professors in 2011, which immediately reverts to trend

Table 7. The early career grant and women's promotion to full professor

	(1) OLS	(2) Reduced-form	(3) IV
Received the early career grant	0.207***		0.037
	(0.035)		(0.126)
Effect of the affirmative action policy		0.008	
		(0.029)	
Female	-0.158***	-0.136***	-0.136***
	(0.015)	(0.021)	(0.023)
Mean outcome (female)	0.254	0.254	0.254
F-statistic of the first stage			129.05
Observations	4,276	4,276	4,276

Table 7 note: this table shows our estimates of how the affirmative action policy affects women's likelihood of being promoted to full professor, as compared with men who are not affected by the policy. We apply the *short time series* and *policy* sample restrictions to the data to generate these analyses. * p<0.1, ** p<0.05, *** p<0.01. We present an analog to this table, with the *policy* sample restriction relaxed, in Table A.5.

section suggest that the policy is unlikely to have meaningfully increased female scientists' likelihood of promotion in academic rank.

Given our findings, documented in previous sections, that receiving the early career grant increases female scientists' productivity and their possibility of getting the general grant, it is surprising to see no evidence that the policy increased female scientists' likelihood of academic promotion. One possible explanation may be related to gender discrimination in female scientists' promotion (Huang et al. 2020). Our results suggest that while an affirmative action policy such as the one we study may help increase women's productivity and their early career prospects, more concerted action may be required to promote the mid- and late-career development of female scientists.

Table 8. The early career grant and women's promotion to associate or full professor

	(1) OLS	(2) Reduced-form	(3) IV
Received early career grant	0.219***		-0.120
	(0.028)		(0.137)
Effect of the affirmative action policy		-0.027	
		(0.023)	
Female	-0.051***	-0.009	-0.008
	(0.012)	(0.017)	(0.024)
Mean outcome (female)	0.799	0.799	0.799
F-statistic of the first stage			129.05
Observations	4,276	4,276	4,276

Table 8 note: this table shows our estimates of how the NSFC affirmative action policy affects women's likelihood of being promoted to associate or full professor, as compared with men who are not affected by the policy. We apply the *short time series* and *policy* sample restrictions to the data to generate these analyses. * p<0.1, ** p<0.05, *** p<0.01. We present an analog to this table, with the *policy* sample restriction relaxed, in Table A.6.

5.5 Robustness

In this section we discuss and evaluate the empirical importance of potential sources of bias for the estimates we generate. A common potential source of confounding in estimates generated by research designs such as ours is the existence of some omitted factor coincident in time with the policy we study. For example, if other gender- and cohort-specific policies were implemented concurrently, their impact would also be contained in our main estimates. Two policies, one implemented the year before, and one implemented gradually from 2011 onward, warrant separate discussion. One is a policy stipulating that in grant competitions where two candidates – male and female – present applications of similar quality, that priority be given to females. The second is a policy which gradually increased the proportion of panel experts judging grant competitions, starting in 2011. The

former policy was implemented one year before the maximum age extension, while the latter was gradually implemented. Unlike the policy we study, neither target recipients by age, which means that the first difference of our difference-in-differences strategy (comparing between women who do and who do not enjoy new, age-specific eligibility for the early career grant) should remove the effect of these policies on later performance. As we show in the event study, the effects we measure are at the cohort-level and occur entirely coincident with the period of the NSFC gender affirmative action policy's implementation on cohorts of women who are eligible for the grant. They are not present among those who are ineligible, and are not present among female scholars who are still eligible to apply after we observe them, as we might expect if the effects we observe were driven primarily by this global female preference.

We also perform a series of analyses to test the robustness of our results to alternative specifications and threats to identification. First, because our faculty data do not contain people who left the institution before the data was collected in 2019, there is a risk of bias from attrition if faculty departed the institution, differentially by gender, in response to the affirmative action policy. For instance, because female faculty members are more likely to win the NSFC early career grant after the policy, it is possible that, as a result, they may be more likely to be promoted and less likely to leave the school. Unlike in the US, many top Chinese universities did not have tenure-track systems until recently. The risk of bias from differential attrition in response to the policy is greater among universities which introduced the tenure-track system immediately before or at the same time as the NSFC affirmative action policy. Seven out of 20 sampled universities introduced the tenure-track system in either 2010, 2011, or 2012.[16] Our main results are robust to restricting our sample to the 13 universities whose tenure system did not change over this time, shown in Table A4. This suggests that our main results are not driven by attrition related to the tightening of requirements for faculty persistence at the institution.

[16] At the time of writing, only a small number of elite Chinese universities use the tenure-track system.

Another concern is measurement error in the "running variable," that is, the person's year of birth. Our birth year variable is constructed using the year of award of bachelor's or other degrees, instead of the person's stated birth year, in 55 percent of cases. Any measurement error in this variable which is correlated with gender and the outcome variables we use could bias our estimates. Our results are robust to restricting our sample to only faculty with age assigned by stated year of birth or year of BA receipt, which is likely to have less error than age as assigned by year of receipt of either a master's or PhD degree.

Finally, because many professors of economics and management in China only publish academic papers only in Chinese-language journals – and for whom there is therefore greater likelihood of missing data in the scientific productivity data from *Scopus.com* – we re-run our core analyses excluding faculty in the fields of economics and management.[17] Our results are also robust to this alternative specification.

6. Conclusion

Over the last 50 years, even as gender norms have changed, gender inequality in many important parts of society has persisted. Recent research has identified a key driver of this pattern: jobs with convex returns to effort and time require couples raising children to specialize, even within the same industry, with one partner taking a "greedier" job and the other taking a more flexible one in order to be able to respond to caregiving needs. These patterns of within-couple specialization have the effect of reinforcing and retrenching existing societal gender inequality, particularly at the highest professional ranks.

In this paper, we evaluate the impacts of an affirmative action policy which aims to address gender inequality in academic science research. By increasing the maximum age of female eligibility for applying to China's major early career research funding award, the policy directly compensates women for their outsize role in caregiving, providing them

[17] The economics and management faculty members in our data study publish an average of 0.11 English-language papers per year. Faculty in other fields publish 1.25 English-language papers per year.

greater flexibility in terms of when to compete for the funding and recognition provided by the award.

We show that the policy was successful at increasing the proportion of early career scientific grants awarded to women. This effect differs across STEM fields, with the largest impact in chemistry, biology and medicine and the smallest impact in management and economics. We also find that the gender-specific affirmative action policy does not lower the quality of research completed during the period of these grants.

We show evidence that the increased research funding opportunities provided by the policy helps women advance early on in their careers, but not beyond that. We find that receiving the early career grant has large positive effects on the quantity of women's scientific output and no negative effect on the quality of this output. We also estimate that female recipients of the early career grant are more likely to acquire future larger grants later on in their careers. Ultimately, however, we find that the early career scientific grant does not significantly affect inequality in the gender composition of senior STEM faculty, as measured by the likelihood of promotion to associate or full professor.

Our findings generate two key lessons for policy targeting gender inequality in science. Prior efforts to address this inequality, such as greater periods of parental leave for scientists or reservation quotas for females among committees allocating funding for scientific research can have unintended, negative consequences (Antecol et al., 2018) or have little or limited impact on the targeted outcome (European Commission 2009; Bagues, Sylos-Labini, and Zinovyeva 2017).[18] By contrast, the affirmative action policy we study succeeds in increasing female scientists' early productivity as well as their chances of acquiring larger grants later on in their careers.

The policy we study targets the most important source of research funding for all early career female scientists in STEM fields in China, and has a very specific goal of increasing

[18] Antecol et al. (2018) show that the implementation of gender-neutral tenure clock stopping policies in U.S. universities does not help women eventually earn tenure. Bagues et al. (2017) and European Commission (2009) show some evidence of small effects from increasing quotas for the number of females on key funding committees and from providing extra research funding exclusively to (a small number of) female scientists.

women's representation in the ranks of elite science researchers. Its success in achieving its immediate goals suggests that affirmative action policy with similar features may hold promise for addressing inequality at these levels of STEM research in other contexts (Ceci and Williams 2011; Fershtman and Pavan 2021).

Ultimately, however, we find that the policy is not a panacea for addressing the underrepresentation of women in science. The absence of measurable impact on female scientists' later academic promotion shows that the larger problem of underrepresentation of women in senior STEM roles requires a more concerted approach, combining multiple, potentially complementary strategies.

References

Antecol, Heather, Kelly Bedard, and Jenna Stearns. 2018. "Equal but Inequitable: Who Benefits from Gender-Neutral Tenure Clock Stopping Policies?" *American Economic Review* 108 (9): 2420–41.

Baas, Jeroen, Michiel Schotten, Andrew Plume, Grégoire Côté, and Reza Karimi. 2020. "Scopus as a Curated, High-Quality Bibliometric Data Source for Academic Research in Quantitative Science Studies." *Quantitative Science Studies* 1 (1): 377–86.

Bagues, Manuel, Mauro Sylos-Labini, and Natalia Zinovyeva. 2017. "Does the Gender Composition of Scientific Committees Matter?" *American Economic Review* 107 (4): 1207–38.

Beaudry, Catherine, and Vincent Larivière. 2016. "Which Gender Gap? Factors Affecting Researchers' Scientific Impact in Science and Medicine." *Research Policy* 45 (9): 1790–1817.

Bedard, Kelly, Maxine Lee, and Heather Royer. 2021. "Using Longitudinal Data to Explore the Gender Gap for Academic Economists." In *AEA Papers and Proceedings*, 111:69–73.

Benavente, José Miguel, Gustavo Crespi, Lucas Figal Garone, and Alessandro Maffioli. 2012. "The Impact of National Research Funds: A Regression Discontinuity Approach to the Chilean FONDECYT." *Research Policy* 41 (8): 1461–75.

Bertrand, Marianne, Claudia Goldin, and Lawrence F. Katz. 2010. "Dynamics of the Gender Gap for Young Professionals in the Financial and Corporate Sectors." *American Economic Journal: Applied Economics* 2 (3): 228–55.

Blau, Francine D., and Lawrence M. Kahn. 2017. "The Gender Wage Gap: Extent, Trends, and Explanations." *Journal of Economic Literature* 55 (3): 789–865.

Bol, Thijs, Mathijs de Vaan, and Arnout van de Rijt. 2018. "The Matthew Effect in Science Funding." *Proceedings of the National Academy of Sciences* 115 (19): 4887–90.

Borjas, George J., and Kirk B. Doran. 2015. "Prizes and Productivity How Winning the Fields Medal Affects Scientific Output." *Journal of Human Resources* 50 (3): 728–58.

Boyle, Paul J., Lucy K. Smith, Nicola J. Cooper, Kate S. Williams, and Henrietta O'Connor. 2015. "Gender Balance: Women Are Funded More Fairly in Social Science." *Nature News* 525 (7568): 181.

Ceci, Stephen J., Donna K. Ginther, Shulamit Kahn, and Wendy M. Williams. 2014. "Women in Academic Science: A Changing Landscape." *Psychological Science in the Public Interest* 15 (3): 75–141.

Ceci, Stephen J., and Wendy M. Williams. 2011. "Understanding Current Causes of Women's Underrepresentation in Science." *Proceedings of the National Academy of Sciences* 108 (8): 3157–62. https://doi.org/10.1073/pnas.1014871108.

Correll, Shelley J., Stephen Benard, and In Paik. 2007. "Getting a Job: Is There a

Motherhood Penalty?" *American Journal of Sociology* 112 (5): 1297–1338.
Crosby, Faye J., Aarti Iyer, and Sirinda Sincharoen. 2006. "Understanding Affirmative Action." *Annu. Rev. Psychol.* 57: 585–611.
Eagly, Alice H. 2021. "Hidden in Plain Sight: The Inconsistent Gender Gaps in STEM and Leadership." *Psychological Inquiry* 32 (2): 89–95. https://doi.org/10.1080/1047840X.2021.1930764.
Edwards, Louise. 2020. "Women in the People's Republic of China: New Challenges to the Grand Gender Narrative." In *Women in Asia*, 59–84. Routledge.
European Commission. 2009. "The Gender Challenge in Research Funding. Assessing the European National Scenes." Text. GenPORT. https://www.genderportal.eu/resources/gender-challenge-research-funding-assessing-european-national-scenes.
Fershtman, Daniel, and Alessandro Pavan. 2021. "' Soft' Affirmative Action and Minority Recruitment." *American Economic Review: Insights* 3 (1): 1–18.
Fryer Jr, Roland G., and Glenn C. Loury. 2005. "Affirmative Action and Its Mythology." *Journal of Economic Perspectives* 19 (3): 147–62.
Goldin, Claudia. 2014. "A Grand Gender Convergence: Its Last Chapter." *American Economic Review* 104 (4): 1091–1119.
———. 2021. *Career and Family: Women's Century-Long Journey toward Equity*. Princeton University Press.
Holzer, Harry, and David Neumark. 2000. "Assessing Affirmative Action." *Journal of Economic Literature* 38 (3): 483–568.
Huang, Junming, Alexander J. Gates, Roberta Sinatra, and Albert-László Barabási. 2020. "Historical Comparison of Gender Inequality in Scientific Careers across Countries and Disciplines." *Proceedings of the National Academy of Sciences* 117 (9): 4609–16. https://doi.org/10.1073/pnas.1914221117.
Jacob, Brian A., and Lars Lefgren. 2011a. "The Impact of NIH Postdoctoral Training Grants on Scientific Productivity." *Research Policy* 40 (6): 864–74.
———. 2011b. "The Impact of Research Grant Funding on Scientific Productivity." *Journal of Public Economics* 95 (9–10): 1168–77.
Kim, Scott Daewon, and Petra Moser. 2021. "Women in Science. Lessons from the Baby Boom." National Bureau of Economic Research.
Kuhn, Peter, and Kailing Shen. 2012. "Gender Discrimination in Job Ads: Evidence from China." *The Quarterly Journal of Economics* 128 (1): 287–336.
Lee, David S., Justin McCrary, Marcelo J. Moreira, and Jack R. Porter. 2021. "Valid T-Ratio Inference for IV." National Bureau of Economic Research.
Lerchenmueller, Marc J., and Olav Sorenson. 2018. "The Gender Gap in Early Career Transitions in the Life Sciences." *Research Policy* 47 (6): 1007–17. https://doi.org/10.1016/j.respol.2018.02.009.
Ley, Timothy J., and Barton H. Hamilton. 2008. "The Gender Gap in NIH Grant Applications." *Science* 322 (5907): 1472–74.

Li, Yuan. 2010. "Quality Assurance in Chinese Higher Education." *Research in Comparative and International Education* 5 (1): 58–76. https://doi.org/10.2304/rcie.2010.5.1.58.

Lindsey, Linda L. 2020. *Gender: Sociological Perspectives*. Routledge.

Lundberg, Shelly, and Jenna Stearns. 2019. "Women in Economics: Stalled Progress." *Journal of Economic Perspectives* 33 (1): 3–22.

Ma, Ying, Yandong Zhao, Xu Gong, Li Sun, and Yonghe Zheng. 2018. *Close the Gender Gap in Chinese Science*. Nature Publishing Group.

Olivetti, Claudia, and Barbara Petrongolo. 2017. "The Economic Consequences of Family Policies: Lessons from a Century of Legislation in High-Income Countries." *Journal of Economic Perspectives* 31 (1): 205–30.

Ruhm, Christopher J. 1998. "The Economic Consequences of Parental Leave Mandates: Lessons from Europe." *The Quarterly Journal of Economics* 113 (1): 285–317.

Sarsons, Heather. 2017. "Recognition for Group Work: Gender Differences in Academia." *American Economic Review* 107 (5): 141–45.

Sarsons, Heather, Klarita Gërxhani, Ernesto Reuben, and Arthur Schram. 2021. "Gender Differences in Recognition for Group Work." *Journal of Political Economy* 129 (1): 101–47.

Sege, Robert, Linley Nykiel-Bub, and Sabrina Selk. 2015. "Sex Differences in Institutional Support for Junior Biomedical Researchers." *JAMA* 314 (11): 1175–77. https://doi.org/10.1001/jama.2015.8517.

Shen, Helen. 2013. "Inequality Quantified: Mind the Gender Gap." *Nature News* 495 (7439): 22. https://doi.org/10.1038/495022a.

Sowell, Thomas. 2008. *Affirmative Action around the World*. Yale University Press.

Stock, James H., Jonathan H. Wright, and Motohiro Yogo. 2002. "A Survey of Weak Instruments and Weak Identification in Generalized Method of Moments." *Journal of Business & Economic Statistics* 20 (4): 518–29.

Urry, Meg. 2015. "Science and Gender: Scientists Must Work Harder on Equality." *Nature* 528 (7583): 471–73. https://doi.org/10.1038/528471a.

Van der Lee, Romy, and Naomi Ellemers. 2015. "Gender Contributes to Personal Research Funding Success in The Netherlands." *Proceedings of the National Academy of Sciences* 112 (40): 12349–53.

Van Miegroet, Helga, Christy Glass, Ronda Roberts Callister, and Kimberly Sullivan. 2019. "Unclogging the Pipeline: Advancement to Full Professor in Academic STEM." *Equality, Diversity and Inclusion: An International Journal* 38 (2): 246–64. https://doi.org/10.1108/EDI-09-2017-0180.

Vera-Baceta, Miguel-Angel, Michael Thelwall, and Kayvan Kousha. 2019. "Web of Science and Scopus Language Coverage." *Scientometrics* 121 (3): 1803–13.

Wiedman, Christine. 2020. "Rewarding Collaborative Research: Role Congruity Bias and the Gender Pay Gap in Academe." *Journal of Business Ethics* 167 (4): 793–807. https://doi.org/10.1007/s10551-019-04165-0.

Witteman, Holly O., Michael Hendricks, Sharon Straus, and Cara Tannenbaum. 2019. “Are Gender Gaps Due to Evaluations of the Applicant or the Science? A Natural Experiment at a National Funding Agency.” *The Lancet* 393 (10171): 531–40.

Xie, Yu, Chunni Zhang, and Qing Lai. 2014. “China’s Rise as a Major Contributor to Science and Technology.” *Proceedings of the National Academy of Sciences* 111 (26): 9437–42.

Xu, Xin, Heath Rose, and Alis Oancea. 2021. “Incentivising International Publications: Institutional Policymaking in Chinese Higher Education.” *Studies in Higher Education* 46 (6): 1132–45. https://doi.org/10.1080/03075079.2019.1672646.

Yaisawarng, Suthathip, and Ying Chu Ng. 2014. “The Impact of Higher Education Reform on Research Performance of Chinese Universities.” *China Economic Review* 31 (December): 94–105. https://doi.org/10.1016/j.chieco.2014.08.006.

Zheng, Wang. 2016. “Communism and Gender in China.” In *The Wiley Blackwell Encyclopedia of Gender and Sexuality Studies*, 1–8. John Wiley & Sons, Ltd. https://doi.org/10.1002/9781118663219.wbegss761.

Appendix

Figure A1. Proportion of female awardees among NSFC youth and general grants within the faculty sample

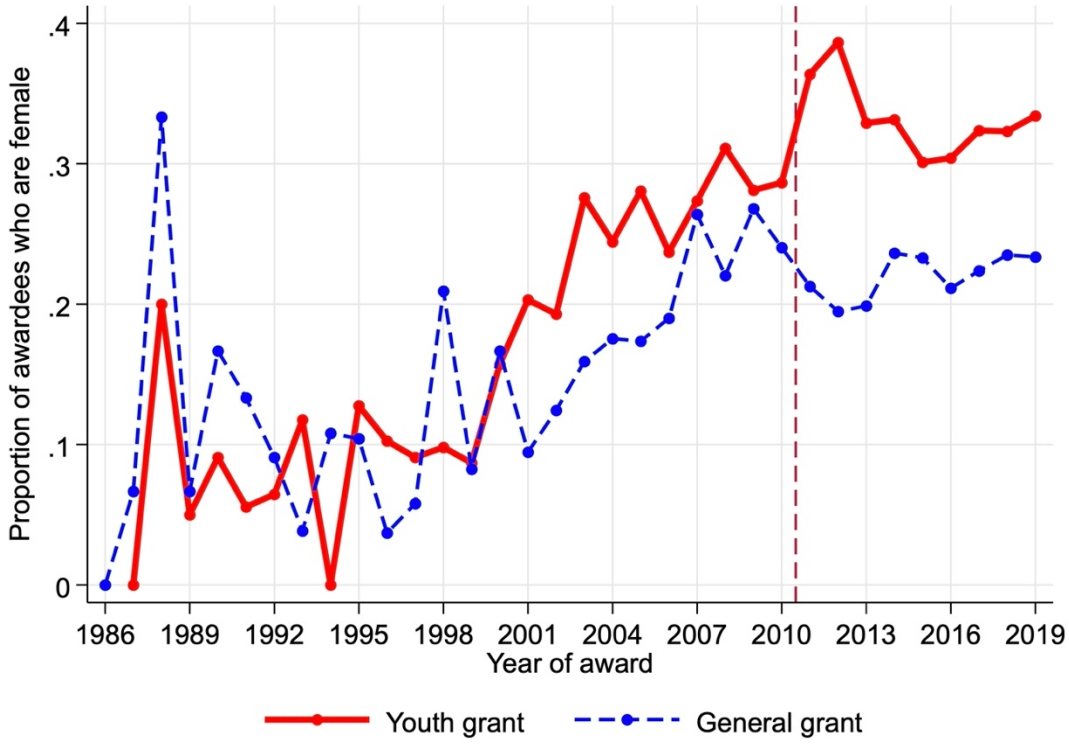


Figure A.1 note: in this figure we show the proportion of early career grants and general grants that went to female recipients between 1986 and 2019 among the people in our faculty data, an analog to what we show in Figure 1 for the NSFC data.

Figure A2. Distribution of early career grant winners by academic rank, over time

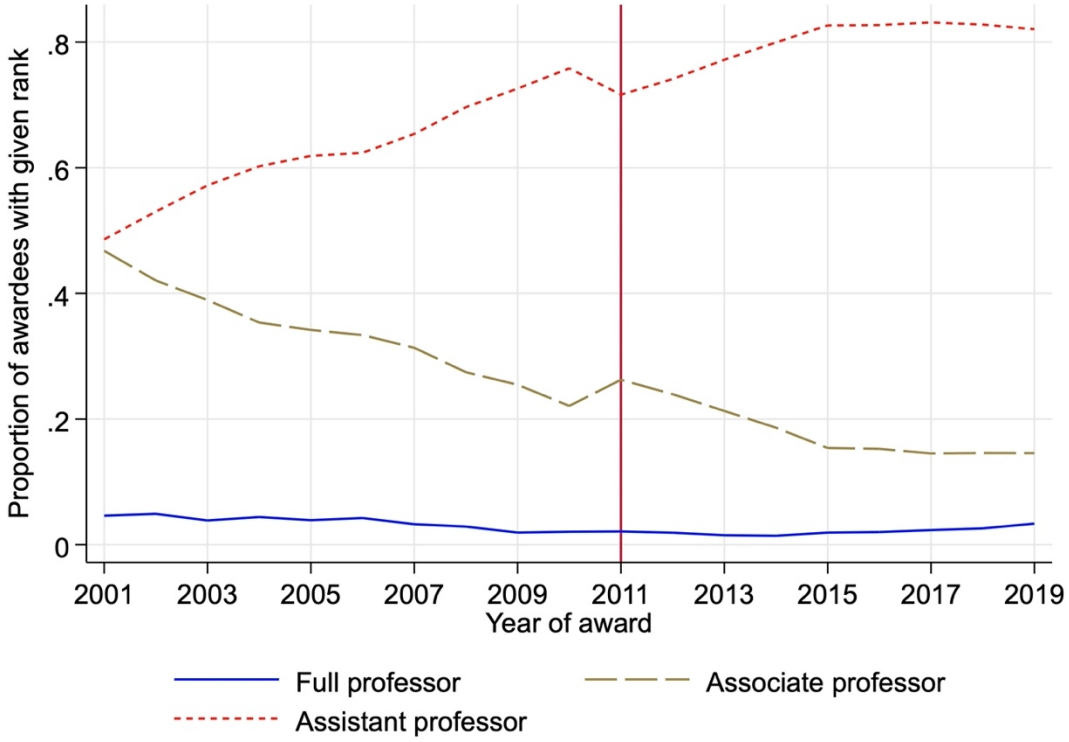


Figure A.2. notes: This shows the proportion of winners of the early career grant who are assistant, associate, and full professors at the time of receipt of award. The data for this figure come from the *NSFC Annual Reports* from 2001-2019.

Table A1. List of the sampled 20 universities

University	University Status	Number of observations
Beihang University	985	1,492
Beijing University of Posts and Telecommunications	211	758
Central China Normal University	211	691
Chongqing University	985	1,990
East China University of Science and Technology	211	1,234
Hohai University	211	1,355
Huazhong University of Science and Technology	985	2,294
Nanjing Normal University	211	881
Nankai University	985	1,264
Northeast Agricultural University	211	576
Northeastern University	985	1,360
Ocean University of China	985	934
Shandong University	985	1,663
Shanghai Jiao Tong University	985	1,748
Shanghai University	211	1,134
Sichuan University	985	2,097
South China Normal University	211	830
Taiyuan University of Technology	211	945
Tsinghua University	985	2,046
University of Science and Technology Beijing	211	1,081
Full sample		26,373

Table A.1 notes: This table shows the twenty randomly selected universities we used to construct our faculty data. The first column lists the name of the institution, the second column lists whether the institution was part of the 985 project or 211 project – nationally recognized university investment programs coordinated by the central government and described in the text – and the third column lists the number of faculty members in our data from the institution.

Table A2. Scientific publications of faculty in our data, by gender

	Number of journal papers	Number of citations
Panel A: Female faculty		
Total	0.228	2.713
Grant awardee	0.373	4.799
Non-awardee	0.132	1.343
Panel B: Male faculty		
Total	0.322	4.057
Grant awardee	0.543	6.640
Non-awardee	0.186	2.460

Table A2 notes: this table shows the annual productivity of faculty members in our faculty data, by gender and receipt of the early career grant.

Table A3. Pre-grant productivity

	Outcome variable in years prior to receipt of the grant	
	Number of papers	**Number of citations**
Female*(>=1971 cohort)	0.089	-0.206
	(0.106)	(0.351)
Female	0.111	0.133
	(0.096)	(0.319)
Mean outcome (female)	0.715	1.146
Observations	12,973	12,973

Table A3 note: this table shows results from estimating equation 1 using the publication data for people in our faculty data, restricting the outcome variable to the years prior to the person's receipt of the grant. * p<0.1, ** p<0.05, *** p<0.01.

Table A4. Impact of the policy on receipt of early career grant, restricting sample to universities whose tenure system did not change over the study period

	(1)	(2)	(3)
Female*(>=1971 cohort)	0.054***	0.069***	0.115***
	(0.016)	(0.014)	(0.015)
Female	-0.020	-0.030***	-0.034***
	(0.014)	(0.011)	(0.013)
Mean outcome (female)	0.396	0.396	0.396
Observations	13,809	19,752	19,499

Table A4 note: this table shows our estimates of how the affirmative action policy affects the likelihood of women winning the NSFC early career grant, as compared with men who are not affected by the policy. * p<0.1, ** p<0.05, *** p<0.01.

Table A.5. The early career grant and women's promotion to full professor, alternative sample

	(1) OLS	(2) Reduced-form	(3) IV
Received the early career grant	0.265***		-0.275
	(0.015)		(0.172)
Effect of the affirmative action policy		-0.042*	
		(0.025)	
Female	-0.191***	-0.152***	-0.159***
	(0.012)	(0.019)	(0.017)
Mean outcome (female)	0.362	0.362	0.362
F-stat of the first stage			30.76
Observations	6,745	6,745	6,745

Table A.5 note: this table shows our estimates of how the affirmative action policy affects women's likelihood of being promoted to full professor, as compared with men who are not affected by the policy. We apply the *short time series* sample restrictions to the data to generate these analyses. * p<0.1, ** p<0.05, *** p<0.01. This table is an analog to Table 7, but with the *policy* sample restriction relaxed.

Table A.6. The early career grant and women's promotion to associate or full professor, alternative sample

	(1) OLS	(2) Reduced-form	(3) IV
Received early career grant	0.136***		-0.311***
	(0.010)		(0.120)
Effect of the affirmative action policy		-0.048***	
		(0.016)	
Female	-0.047***	-0.012	-0.020**
	(0.008)	(0.012)	(0.010)
Mean outcome (female)	0.850	0.850	0.850
F-statistic of the first stage			30.76
Observations	6,745	6,745	6,745

Table A.6 note: this table shows our estimates of how the NSFC affirmative action policy affects women's likelihood of being promoted to associate or full professor, as compared with men who are not affected by the policy. We apply the *short time series* and *policy* sample restrictions to the data to generate these analyses. * p<0.1, ** p<0.05, *** p<0.01. This table is an analog to Table 8, but with the *policy* sample restriction relaxed.

Appendix A: Additional information about Scopus.com

We chose to use Scopus for collecting academic productivity data over other bibliographic databases – such as Web of Science – for three reasons. The first is size: Scopus is the world's largest abstract and citation database of scientific publications (Baas et al. 2020). The second is coverage: Scopus covers far more Chinese-language journals than Web of Science (Vera-Baceta, Thelwall, and Kousha 2019). This is particularly important for our analysis because many Chinese university professors publish in both English- and Chinese-language peer-reviewed journals. The third is ease of match: Scopus allows us to identify authors by their full names, and each author has a unique ID assigned by the site. In contrast, Web of Science identifies authors only by first initial and last names, increasing the difficulty of match, and on Web of Science author IDs are established by authors themselves, allowing greater potential for selective reporting.

In cases where Scopus cannot decide whether to assign an article to a given author based on this information, it creates a new author profile; given this, among the authors with the same names and with the same affiliations, the author with the largest number of academic outputs is likely to be the "true" author if Scopus' algorithm can match the majority of papers to "correct" authors. We randomly selected 50 cases in which multiple records were identified, manually checking whether the match was accurate. We found that the match was indeed correct in all 50 cases.