Connections and Scientific Grants

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Abstract: While funding is essential for promoting science, little is known about how connections affect allocation of scientific funding resources. In this paper, we investigate how connections with a grant review committee member ("panelist") affect researchers' chances of getting funded by NSFC (National Natural Science Foundation of China), one of the world's largest scientific funding agencies. Using both hand-collected and administrative data, we find that connected researchers are more likely to be awarded scientific grants and closer connections are associated with a larger likelihood of being funded. We also find that connected researchers have poorer publication quality and fewer first-authored publications than unconnected ones, despite no difference in the total number of publications. Our findings suggest that nepotism in scientific funding evaluation may lead to misallocation of research resources.

Keywords: networks; nepotism; scientific grants; China

1. Introduction

Scientific funding is vital to a country's innovation capabilities and long-term economic development (Furman et al., 2002). But scientific funding decisions are usually made only by a small number of "powerful" gatekeepers such as panelists of the grant review committee (Li, 2017; Viner et al., 2004). If people use connections to acquire scientific grants, funding resources may be wasted, hurting the development of a country's innovation capabilities (Shi and Rao, 2010; Wenneras and Wold, 1997). Despite plenty of anecdotal accounts on this issue (Zhou, 2019), however, little causal evidence is available on how connections affect scientific funding.

In this paper, we study how connections with funding review committees affect the allocation of basic research funding resources in China. We use both hand-collected and administrative data that include about 9000 panelists of review committees and several hundred thousand scientific grants of NSFC (National Natural Science Foundation of China), the world's largest funding agency in terms of applications. We exploit the rotation of panelists across committees and over time to account for possible panelists' selection into review committees.

The setting is ideal due to the following reasons. First, China has the second-highest R&D spending in the world and research funds from Chinese government have been continuously growing (Ni, 2015; Normile, 2020; Zhou and Leydesdorff, 2006). It is, therefore, important to study how efficiently government research funds are allocated, which also provides lessons for other countries. Second, China has a culture of favor exchange (*guanxi*) that plays an important role in Chinese society (Fisman et al., 2018; Shi and Rao, 2010). Because China adopts a top-down approach to allocate research funding, connections with powerful gatekeepers such as panelists of review committees may be important for scientists' chances of being funded (Shi and Rao, 2010; Zhou, 2019).

We find that connection with a panelist more than doubles the number of scientific grants awarded to researchers when the panelist sits on a NSFC review committee in

the grant-application year. The closer the connection, the more likely the chance of being funded. The connection effect becomes much smaller in other years when a panelist does not sit on an NSFC review committee. Furthermore, the connection effect almost disappears for researchers if their "connected" panelists do not sit on a review committee evaluating applications that have the same field or the same grant type with researchers' applications.

Our analysis with grant productivity shows that while connected researchers have almost the same total number of publications as unconnected ones, connected researchers have poorer publication quality and fewer first-authored publications both before and after funding. For instance, connected researchers have 9% fewer first-authored papers and associated 15% fewer citations than unconnected researchers after being awarded the scientific grant. These results suggest that connected grant awardees may be more likely than unconnected ones to use their networks to help increase publications, which may have a lower quality.

While it is a priori unclear how connections affect one's chance of getting a scientific grant (Bagues et al., 2019; Brogaard et al., 2014), our findings suggest that the favoritism from connected panelists may be the main underlying mechanism. On one hand, the effect is most salient when "connections" work (i.e. a panelist sits on a review committee evaluating the applications that have the same grant type and the same field and are submitted in the same year as researchers' applications do). In other cases, the connection effect is much smaller or almost disappear. On the other hand, the scientific performance of connected researchers is poorer than that of unconnected ones both before and after funding, suggesting that favoritism may play an important role in grant approval. We can reasonably rule out possible insider information sharing and selective application channels.[1]

This paper contributes to the literature in the following ways. First, this paper is among the first to causally examine how connections with scientific funding evaluators affect applicants' chances of scientific funding. While the literature (Bagues et al., 2019;

[1] See Section 4.D for a detailed discussion of possible mechanisms.

Brogaard et al., 2014; Colussi, 2018; Laband and Piette, 1994; Zinovyeva and Bagues, 2015) has documented how connections affect academic promotion or journal publication, little is known about how connections casually affect scientific funding, which is very important for scientific progress (Viner et al., 2004).[2] The closest to ours is Mom and van den Besselaar (2021), which reports the correlation between organizational proximity and chances of grant success.[3] Our paper differs from Mom and van den Besselaar (2021) at least in the following two aspects. On one hand, we provide casual evidence, rather than descriptive evidence, on how connections with panelists of grant review committees affect the chance of grant success. On the other hand, we use a much larger sample that involves about 9000 panelists and several hundred thousand grants over a seven-year period, while Mom and van den Besselaar (2021) use an analysis sample of 2832 observations.

Second, this paper contributes to the growing literature on in-group favoritism that may distort resources allocation (Akhtari et al., 2022; Azoulay et al., 2010; Bandiera et al., 2009; Haselmann et al., 2018). For instance, Fisman et al. (2018) find that hometown ties significantly increase the election probability in fellow selection of the Chinese Academies of Sciences and Engineering. The connected elected fellows have fewer high-impact publications than unconnected ones, but they have a high probability of being promoted to university leadership and have a large increase in the amount of scientific funding. We contribute to this literature by showing that connections with panelists of scientific funding review committees increases the probability of getting scientific grants and such favoritism is associated with relatively poorer performance of grant recipients.

The rest of our paper proceeds as follows. Section 2 provides the background on NSFC funding and NSFC grant review procedure. Section 3 introduces the main

[2] For example, Brogaard et al. (2014) and Colussi (2018) find that connections with editors increase the possibility of publishing in top economics or finance journals.

[3] Several other studies also provide descriptive evidence on the nepotism in funding applications based on small-size samples. For instance, Sandstrom and Hallsten (2008) study the nepotism in peer review based on 280 Swedish research grant applications and Wenneras and Wold (1997) provide descriptive evidence on the nepotism in postdoctoral fellowship applications based on a sample of 55 reviewers.

datasets used in our analyses. Section 4 studies how connections affect scientific funding and explores possible mechanisms. The final section concludes.

2. Institutional background

In this section we first provide the background information on the NSFC (National Natural Science Foundation of China), and then introduce the NSFC's grant review procedure.

A. NSFC funding

The NSFC (National Natural Science Foundation of China) was established in 1986 aiming to support basic research and to foster talented scientists based on a rigorous merit-review system. Its funding budget has increased from about 10 million US dollars in 1986 to 4.5 billion in 2019. Like its counterpart NSF in the U.S., the NSFC is China's largest funder of basic science research.[4] In recent years, the NSFC has become the world's largest funding agency in terms of applications (Cyranoski, 2019; Yang, 2017).[5] For example, in 2019 the NSFC received about 230,000 applications, more than three times that of NSF or NIH.

The NSFC has eight scientific departments that sponsor funding in different fields and one transdisciplinary research department established at the end of 2020. These departments are Department of Mathematical and Physical Sciences, Department of Chemical Sciences, Department of Life Sciences, Department of Earth Sciences, Department of Engineering and Material Sciences, Department of Information Sciences, Department of Management Sciences, Department of Health Sciences, and Department of Interdisciplinary Sciences. Each department is responsible for selecting grant proposals and managing approved grants in its field.

[4] By 2017, 11.63% of all scientific papers in the world are sponsored by the NSFC (Yang, 2017).

[5] http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/35861/37047/.

The NSFC has more than ten types of programs, including general grant that everyone can apply, youth grant with an age limit, grant for less developed regions, excellent young scholar grant, distinguished young scholar grant, international (regional) joint research grant, and large grants such as key grant and major grant.[6] The youth grant and the general grant are the two largest funding types of the NSFC, accounting for 88% of the total number of approved NSFC grants during the 2014-2019 period.

B. NSFC's grant review procedure

The NSFC has a two-round grant review procedure for most NSFC grant applications, which are required to be submitted in March each year (Yao and Xiong, 2017). After an initial screening of submitted applications, the NSFC invites experts to do the first-round correspondence review of qualified applications in April and May. The NSFC randomly selects three to five experts from the pool of eligible evaluators for each application. The correspondence review is single blind, with expert identities kept hidden from grant applicants. The evaluations are based on grant proposals' innovation and applicants' research ability or potential. Only a small share (for instance, about 30%) of grant applications pass the first-round correspondence review (Xie et al., 2020).

The NSFC usually holds the second-round panel meetings in July or August each year to decide on whether grant proposals that pass the first-round peer review will be approved finally. For each grant type of a certain field, the NSFC selects 13 to 20 panelists from its expert pool to form a committee to evaluate the grant applications that pass the first-round correspondence review.[7] The NSFC selects panelists under the constraint that no institution can have more than one panelist for the same grant type of the same NSFC department in the same year. Another selection criterion is that one

[6] For detailed information on NSFC grants, readers can check the NSFC's website: http://www.nsfc.gov.cn/english/site_1/pdf/NationalNaturalScienceFundGuidetoPrograms2020.pdf

[7] In some cases, the same second-round review committee may evaluate several grant types.

cannot be selected into the second-round panel meetings to evaluate the same grant type of the same NSFC department for more than two years in a row (Xie et al., 2020; Yao and Xiong, 2017; Zhang et al., 2015).

The second-round review committee makes its approval decision on a grant application based on both the application's first-round correspondence review score and the recommendation of the panelist who is responsible for evaluating the application. Grant applications with high first-round peer review scores are usually approved finally, while those with low scores have lower success chances. According to the NSFC statistics, about three quarters of grant applications that pass the first-round correspondence review will be finally approved after the second-round evaluation (Xie et al., 2020).[8]

While the first-round peer review is assumed to be largely fair, people may cast doubt on the fairness of the second-round panel review (National Center for Science and Technology Valuation, 2011; Shi and Rao, 2010; Zhou, 2019).[9] Since 2014, the NSFC has started to publicize the information on panelists of the second-round meetings to make the review procedure fairer and more transparent (Zhang et al., 2015). The information includes names of panelists, the NSFC departments they worked for, and the types of grants they reviewed. To minimize possible networking activities, the NSFC decides on the name list of panelists only several days before panel meetings and publicize the information on panelists after panel meetings, including panelists' names, NSFC departments that they belong to, and types of grants that they evaluate.[10]

[8] According to the NSFC statistics, the approval proportion in the second-round review is 62.5%-76.92%, depending on grant types and NSFC departments (Zhang et al., 2015).

[9] A survey of NSFC peer review experts shows that 83% of experts agree that the first-round correspondence review is fair but only about one half of them agree that the second-round panel review is fair (National Center for Science and Technology Valuation, 2011). Furthermore, only 30% of them agree that the procedure of panelist selection is reasonable.

[10] One exception is that the NSFC publicized the name list of panelists several days before the panel meetings in 2014.

3. Data sources

We use four main datasets in our paper: the hand-collected panelist information during the period between 2014 and 2020, administrative data on approved NSFC grants, administrative scientist network data from the NSFC, and scientific publications from the Scopus.

A. The panelist sample during the 2014-2020 period

We gather panelist name lists publicized by the NSFC during the 2014-2020 period from its official website or other websites if the information is currently unavailable from the NSFC website.[11] Finally, we have gathered a total of 9023 panelists. The NSFC also provides the information on panelists' research fields (NSFC departments), committees of specific grant types that panelists attend, and years of attending the committee. Based on the above information, we hand collect panelists' other information from their open CV data or homepages, including affiliated institutions, gender, education, year of birth, whether to be fellows of CAS (Chinese Academy of Sciences) or CAE (Chinese Academy of Engineering), and whether to be NSFC distinguished young scholars.[12]

[11] When the panelist name list is unavailable from the NSFC website due to the information expiration, we turn to other authoritative sources including Sciencenet (http://fund.sciencenet.cn/), a major science website supervised by Chinese Academy of Science, and Qingta (https://www.cingta.com/), a leading education and science information provider in China. Finally, we have acquired the panelist name lists for 89.15% of about 600 NSFC review committees publicized during the 2014-2020 period.

[12] Fellows of CAS (Chinese Academy of Sciences) or CAE (Chinese Academy of Engineering) are the highest official honors for Chinese scientists. NSFC distinguished young scholars, which are similar to NSF CAREER award, are considered as the most prestigious honor for Chinese young scientists aged below 45.

Table 1 Summary statistics of NSFC panelists

	Mean	Standard deviation	Observations
Female	0.124	0.330	8,826
Year of birth	1965.108	7.262	4,812
Education			
College graduating from a top-tier university	0.689	0.463	5,950
PhD graduating from an overseas university	0.231	0.421	6,741
CAS/CAE fellow	0.062	0.242	9,023
NSFC distinguished young scholar	0.311	0.463	9,023
Affiliation			
Top-tier Chinese university	0.567	0.495	8,984
Non-top-tier Chinese university	0.177	0.381	8,984
Chinese Academy of Sciences	0.134	0.341	8,984
Others	0.122	0.327	8,984

Note: CAS/CAE fellows are highest official honors for Chinese scientists. NSFC distinguished young scholars are considered as the most prestigious honor for Chinese young scientists aged below 45. A top-tier university is one of 116 "211-project" Chinese universities. Chinese Academy of Sciences is the world's largest research organization, with about 60,000 researchers working in more than 100 research institutions. Affiliation category "Others" contains other Chinese institutions or overseas universities.

Table 1 presents the summary statistics of NSFC panelists. Female scientists account for only 12.4% of all NSFC panelists, suggesting a large gender gap in membership of scientific grant committees. The majority of NSFC panelists obtained their bachelor degrees from top-tier Chinese universities, and nearly one quarter of them obtained their PhDs from overseas universities. While we have no information on the pool of candidate experts, from which NSFC panelists are chosen, our summary statistics suggest that fellows of CAS or CAE and awardees of NSFC distinguished young scholars are two important sources for NSFC panelists.[13]

Our summary statistics also show that most NSFC panelists come from high-ranked institutions including top-tier universities and Chinese Academy of Sciences. For example, experts from 116 top-tier Chinese universities account for 56.7% of the total NSFC panelists, while experts from more than 1000 non-top-tier universities account for only 17.7% of the total. This suggests that if networks play an important

[13] About 70% of CAS/CAE fellows aged under 80 have acted as NSFC panelists during the 2014-2020 period. About three quarters of NSFC distinguished young scholars have acted as NSFC panelists during this period.

role in allocating research resources, scientists from low-ranked institutions may be in a worse position to compete for prestigious NSFC grants.

While we are unclear about how the NSFC selects panelists, the pattern of average panelist characteristics suggests that the NSFC may attempt to balance the composition of panelists along various dimensions over time. As shown by Figure 1, almost all characteristics of panelists remain stable over time.

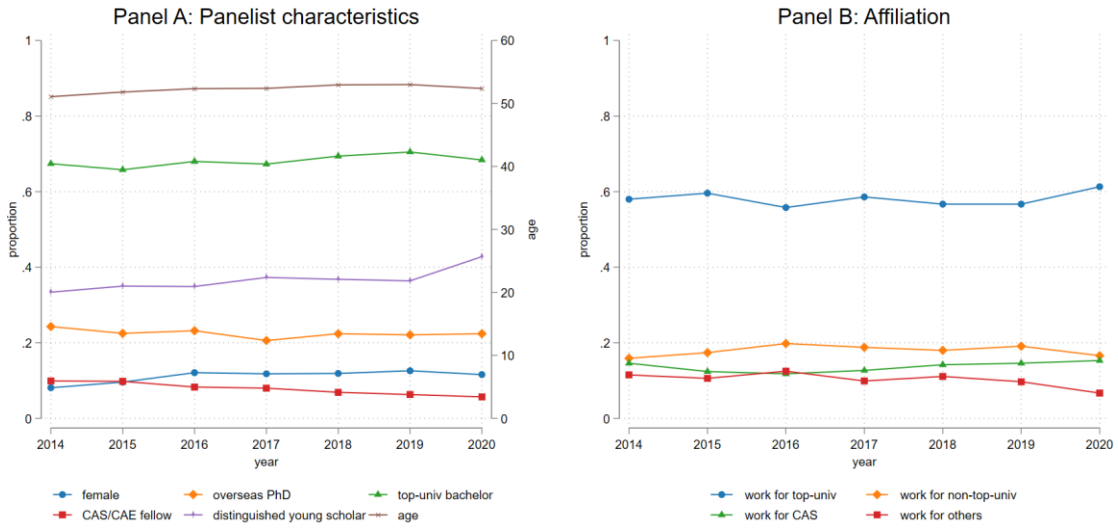

Figure 1 Panelists' characteristics over the 2014-2020 period

B. Administrative NSFC grant data

The NSFC publicized the basic information on approved grants annually before 2020. The information includes grant awardee's name and institution, grant type, approval year, and the NSFC department that a grant belongs to. We webscraped the administrative NSFC grant data from its official website (http://kd.nsfc.gov.cn/).[14]

We focus on grants that are evaluated by the second-round review committees in July or August each year. We exclude several grant types that have specific goals, such

[14] The NSFC only provides searching services of individual grants based on personal name or institution and does not provide searching services of all grants on its knowledge sharing platform since late 2020. Therefore, we cannot get the full information on NSFC grants approved in 2020 after we have webscrapped the NSFC grant data in March 2020.

as targeting a specific province ("NSFC-Henan Talent Training Joint Funds") or aiming to support the development of a specific field ("Tianyuan Fund on Mathematics"). Finally, our main analysis sample includes 233433 NSFC grants which were approved during the 2014-2019 period.

C. Administrative NSFC scientist network data

The administrative NSFC scientist network is based on whether two scientists have been co-PIs (principal investigators) or participants of at least one NSFC grant before.[15] The NSFC publicizes the network information on its knowledge sharing platform, including network member's personal information, which is linked to individual grant information. We define a scientist connected to a panelist if she belongs to the panelist's network.

We have identified 8497 panelists in the NSFC's knowledge sharing platform.[16] These panelists have an average network size of 42 members, with 54.74% of them being colleagues. Among network members, 81.21% of them have been co-PIs or participants of one previous NSFC grant with a panelist, and the rest of them have worked with a panelist on at least two NSFC grants. These network members have been awarded 112839 NSFC grants during the 2014-2020 period.[17]

D. Scientific publications from the Scopus

We use the Scopus database to search for faculty's scientific publications. We

[15] In this paper we do not construct the network measure based on coauthorship. The reason is that many Chinese scientists publish mainly in English-language journals and it is difficult to link coauthors' English names to their exact Chinese names. We, therefore, cannot link coauthors to their possible NSFC grants, making it impossible to study the effect of coauthorship-based connections on getting NSFC grants.

[16] The panelists who are not recorded in the NSFC's knowledge sharing platform are mostly experts working in the industry or from overseas institutions.

[17] We webscrape the 2014-2020 NSFC grants based on the identity of networked researchers, though the NSFC has not publicly provided the information on all NSFC grants starting the year 2020. The number of grants awarded to network members of NSFC panelists is 97855 during the 2014-2019 period, accounting for 41.92% (= 97855/233433) of all NSFC grants during this period.

choose Scopus rather than other bibliographic databases such as Web of Science (WOS) based on the following three reasons: (1) Scopus is the world's largest abstract and citation database of scientific publications. (2) Scopus covers much more Chinese-language journals than Web of Science, which is very important because many Chinese university professors publish both English- and Chinese-language papers.[18] (3) It is much easier for us to identify an author by her full name using Scopus rather than Web of Science. In the Scopus each author has a unique id, which is established by the Scopus team.[19] By contrast, Web of Science identifies authors only by first initial and last names and author ids are established by authors themselves.

Finally, we obtained the paper information from the Scopus for 81.33% of our scientist sample. Those unsuccessful ones are either not publishing in English at all or those in the fields of economics or management, most of whom only publish in Chinese. We use the Scopus API to extract the publication information of our scientist sample.

We use the annual number of academic papers to measure the quantity of scientists' publications and the annual number of citations received and the average number of citations per paper to measure the quality of scientists' publications. We also measure scientists' performance based on the annual number of first-authored papers, the average number of coauthors per paper, the annual number of citations for first-authored papers, and associated average number of citations per paper.

[18] We do not use publication records from CKNI, the Chinese version of JSTOR that publishes academic papers in Chinese, because most Chinese scientists publish in English-language journals and non-Scopus indexed Chinese-language journals may not be well regarded by the scientific society (Fisman et al., 2018).

[19] Scopus uses an algorithm based on authors' names, affiliations and email addresses to determine whether a paper is added to that author profile. When Scopus cannot decide based on the information, it will create another author profile. Therefore, among the authors with the same names, the same affiliations, and the same fields, 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 have randomly chosen 50 cases for manual checking and found that the correction proportion is 100%.

4. Empirical results

In this section we first show how being a panelist affects the number of NSFC grants of her home institution and the number of NSFC grants of her networked researchers. We then study the quality difference between connected and unconnected grants in terms of scientific publications to understand possible consequences of networking in scientific funding. Finally, we explore possible underlying mechanisms.

A. Being a panelist and scientific grants of her home institution

While the NSFC may not randomly select panelists from its expert pool, whether any scientist is chosen as a panelist for a certain review committee in a certain year may be plausibly exogenous from the perspective of institutions.[20] This is because the NSFC's panelist choice decision is independent of experts' home institutions and grant applications are usually submitted at least four months before the NSFC's choice decision. We first exploit this exogenous variation to study the impact of having an NSFC panelist on the number of grants received by an institution. We estimate the following regression model:

$$NumGrant_{idpt} = \alpha_0 + \alpha_1 Panelist_{idpt} + \theta_i + \mu_d + \eta_p + \lambda_t + \varepsilon_{idpt} \quad (1)$$

where $NumGrant_{idpt}$ is the number of grants received by institution i in year t for type p of grants from NSFC department d. The dummy variable $Panelist_{idpt}$ indicates whether institution i has an NSFC panelist in year t for grant type p from NSFC department d. Our main coefficient of interest is α_1, the impact of having an NSFC panelist on the number of grants.

We control for institution fixed effects, θ_i, to account for institution-specific factors

[20] Our empirical results suggest that NSFC panelists may not be randomly chosen among the expert pool. As shown in Table A1 of the Appendix, the possibility of serving as a panelist is associated with an expert's gender, whether she is a CAS/CAE fellow, or whether she is an awardee of NSFC distinguished young scholar.

that may lead to persistently more or fewer grants. We control for year fixed effects, λ_t, to account for common shocks. We also control for NSFC department fixed effects, μ_d, and grant type fixed effects, η_p, to account for possible differences across scientific fields and grant types. Our assumption is that the timing of a panelist appointment is exogenous conditional on the above fixed effects. we will validate the assumption in robustness checks. The standard errors are clustered at the institution level.

In our main analyses, we add fixed effects in sequence to shed light on the incremental importance of each of these variables. As Table 2 shows, institution-related factors may largely affect the number of approved NSFC grants. When we further control for year, NSFC department, and project type fixed effects, the estimates change little. According to our preferred and most rigorous specification in column (5) of Table 2, having a panelist leads to an increase of 4.53 scientific grants for her home institution. A simple calculation exercise shows that for those institutions that have had at least one panelist serving on the committee during the 2014-2019 period, having a panelist more than doubles (2.283 = 4.526/3.528 + 1) the number of grants in a certain year, suggesting large benefits associated with having an NSFC panelist.[21]

[21] Our estimates of the panelist effect may be underestimated due to the measurement noise when matching a panelist to NSFC grants. The NSFC only publicizes the full name list of all panelists for one or several grant types in a NSFC department, which usually has more than ten subfields. The NSFC does not disclose the information on whether a panelist belongs to a certain review committee that focuses only on one subfield. In our analysis we, therefore, assume that a panelist sits on all possible review committees that the name list contains. One consequence of such an assumption is that panelist-grant matches may be measured with noise, biasing the estimates to zero.

Table 2 Connections and number of scientific grants by an institution

	(1)	(2)	(3)	(4)	(5)
Having a panelist	5.677***	4.686***	4.686***	4.672***	4.526***
	(0.326)	(0.231)	(0.231)	(0.229)	(0.222)
Institution fixed effects		√	√	√	√
Year fixed effects			√	√	√
NSFC department fixed effects				√	√
Grant type fixed effects					√
Mean(outcome)	0.250	0.250	0.250	0.250	0.250
Mean(outcome) if an institution ever had a panelist	3.528	3.528	3.528	3.528	3.528
Observations	932,688	932,688	932,688	932,688	932,688
R-squared	0.105	0.135	0.135	0.136	0.153

Note: The outcome variable is number of NSFC grants at the institution-year-NSFC department-grant type level. The key explanatory variable is a dummy variable indicating whether there is any affiliated panelist siting on the review committee of a certain grant type of an NSFC department in a certain year. We control for institution, year, NSFC department, and NSFC grant type fixed effects in sequence in columns (2)-(5). *** < 0.01.

We do a battery of robustness checks to show the sensitivity of our main results. First, although we have controlled for institution fixed effects in our preferred specification as shown in the final column of Table 2, people may still be concerned about possible estimation bias due to the selective nature of having a panelist on the NSFC review committee. To alleviate this concern, we further control for panelists' characteristics, including gender, whether to be a CAS/CAE fellow, and whether to be an NSFC distinguished young scholar. As the first column of Table 3 shows, the estimate remains robust to controlling for panelists' characteristics, suggesting that the selection of NSFC panelists may be random from the perspective of institutions.

Second, to account for possible time-varying unobservable confounding factors at the institution or NSFC department level and for the fact that some institutions may have persistent advantages in specific fields, we further control for two-way fixed effects (i.e. institution-year, NSFC department-year, and institution-NSFC department fixed effects). As shown in the second column, the estimated effect of having a panelist is similar to that in the final column of Table 2.

Third, because sometimes the NSFC put together the names of panelists for many grant types in the same announcement, we cannot identify experts for a specific grant type in such cases.[22] We define the key explanatory variable "having a panelist" to be one for all grant types if an expert's name appears in an announcement that involves several grant types. Therefore, we may underestimate the effect of having a panelist on an institution's number of scientific grants for a specific grant type. To partially alleviate this concern, we repeat the analysis by excluding those announcements for more than three grant types. As shown by column (3) of Table 3, the results remain robust to excluding such observations.

Fourth, because some panelists may migrate across institutions during the study period, we may have assign “wrong” years of a migrant panelist to her institutions. To address this concern, we drop these migrant panelists from our analysis sample. As shown by column (4) of Table 3, we find very similar results, suggesting that the migration concern is minor.

Fifth, because the outcome variable is restricted to non-negative integers and has a large share of zeros, we do the Poisson regression to account for these features. As shown in column (5), having a panelist has a positive and statistically significant effect on number of NSFC grants by an institution, which is consistent with the estimate in the final column of Table 2.[23]

Finally, we may overestimate the effect of having a panelist because we are comparing number of NSFC grants between institutions with panelists and those without panelists, many of which have not received any NSFC grant in a specific field. To alleviate this concern, we exclude those institutions that have not had any panelist during the study period. As the final column of Table 3 shows, even among the institutions that have NSFC panelists, the effect of having a panelist is very similar to the estimate in the final column of Table 2.

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[22] For instance, the NSFC Department of Engineering and Material Sciences announces its panelist name list for a total of six grant types during the period between 2014 and 2019.

[23] According to the Poisson estimation result in Column (5), the marginal effect of having a panelist is 4.675 (= exp(1.736) - 1), which is similar to the estimate in the final column of Table 2.

Table 3 Robustness: connections and number of scientific grants by an institution

	(1)	(2)	(3)	(4)	(5)	(6)
Having a panelist	4.183***	3.659***	4.592***	4.674***	1.736***	4.144***
	(0.191)	(0.225)	(0.249)	(0.231)	(0.060)	(0.194)
Institution fixed effects	√		√	√	√	√
Year fixed effects	√		√	√	√	√
NSFC department fixed effects	√		√	√	√	√
Grant type fixed effects	√	√	√	√	√	√
Institution*NSFC department fixed effects		√				
Institution*year fixed effects		√				
NSFC department*year fixed effects		√				
Observations	932,688	932,688	816,102	931,586	931,824	203,400
R-squared	0.156	0.261	0.147	0.154	-	0.187

Note: The outcome variable is number of NSFC grants at the institution-year-NSFC department-grant type level. The key explanatory variable is a dummy variable indicating whether there is any affiliated panelist siting on the review committee of a certain grant type of an NSFC department in a certain year. Column (1) further controls for panelists' characteristics, including gender, whether to be a CAS/CAE fellow, and whether to be an NSFC distinguished young scholar. Column (2) controls for two-way fixed effects (institution-year, NSFC department-year, and institution-NSFC department fixed effects) instead of institution, year, and NSFC department fixed effects. Column (3) excludes those observations with NSFC same announcements for more than three grant types. Column (4) excludes the panelists who migrate across institutions during the period between 2014 and 2020. Column (5) shows the Poisson regression results. Column (6) excludes those institutions that have not had any panelist during the period between 2014 and 2020. *** < 0.01.

Our previous results show a positive effect of having a panelist on number of scientific grants by an institution after controlling for institution, year, and NSFC department fixed effects or two-way fixed effects (institution-year, NSFC department-year, and institution-NSFC department fixed effects). To further explore the causal effect of having a panelist on number of grants by an institution, we do the following placebo tests.

First, if the NSFC's panelist selection decision is related to unobservable factors at the institution-NSFC department-grant type level, the estimates may still be biased even conditioning on two-way fixed effects as shown in column (2) of Table 3. In such a case, we are expected to find similar estimated effects of having a panelist during the

period of sitting on the review committee and in other periods. As Column (1) of Table 4 shows, however, we find a much larger effect during the period of having a panelist for a certain grant type than before or after that period, suggesting that the above concern may be minor.

Second, the NSFC sets up separate review committees for various grant types within the same NSFC department. An expert can only serve on one or several committees, not on all of them. If the selection of panelists is related to unobservable factors at the institution-NSFC department-year level, we are expected to find similar estimated effects of having a panelist across various grant types. As Column (2) shows, we find a much smaller effect on the number of approved grants for institutions without experts serving on the committees of specific grant types, though institutions may have panelists working for other committees of the same NSFC department in the same year.

Third, if the NSFC's panelist selection decision is related to unobservable factors at the institution-year level, we are expected to find similar effects of having a panelist across various NSFC departments. As the final column of Table 4 shows, we find a small and negative effects on the number of approved grants, though institutions may have panelists working for other NSFC departments in the same year, suggesting that this concern is minor.

Table 4 Placebo: connections and number of scientific grants by an institution

	(1)	(2)	(3)
Having a panelist in that year	4.738***		
	(0.221)		
Having a "placebo" panelist before or after that year	0.925***		
	(0.077)		
Having a "placebo" panelist for other grant types of the same dept.		0.264***	
		(0.027)	
Having a "placebo" panelist in other NSFC departments			-0.093***
			(0.008)
Institution fixed effects	√	√	√
Year fixed effects	√	√	√
NSFC department fixed effects	√	√	√
Grant type fixed effects	√	√	√
Observations	932,688	908,283	908,283
R-squared	0.155	0.084	0.082

Note: The outcome variable is number of NSFC grants at the institution-year-NSFC department-grant type level. Column (1) compares the effect of having a "real" panelist in a certain year and the effect of having a "placebo" panelist in other years. Column (2) shows the estimated effect of having a "placebo" panelist for other grant types of the same NSFC department. Column (3) shows the estimated effect of having a "placebo" panelist in other NSFC departments. *** < 0.01.

B. Being a panelist and scientific grants of her connected researchers

The previous section examines the effect of having a panelist on the number of NSFC grants of her home institution. We have used a series of robustness checks to provide suggestive evidence that whether to have a panelist in a specific year may be exogenous conditioning on a set of fixed effects including institution fixed effects. In this section, we further control for panelist fixed effects to account for possible unobservable confounding factors at the panelist level and use an alternative "connections" measure.

Specifically, we use the NSFC administrative data on the researcher network, which is based on whether two researchers have been co-PI or participant members of the same NSFC grant before. We limit the analysis to connected researchers to alleviate

the concern that researchers may be self-selected to the networks of an expert.[24] The grants awarded to those connected researchers account for 42% of all NSFC grants over our study period.

Conditioning on expert fixed effects, we exploit the exogenous variation in possibility of an expert being chosen as a panelist evaluating a certain grant type in a certain year due to the NSFC's rotation rule. We compare number of grants awarded to researchers when the connected expert sits on the NSFC committee with when the expert does not. We estimate the following regression model:

$$NumGrant_{ipt} = \beta_0 + \beta_1 Panelist_{ipt} + \delta_i + \eta_p + \lambda_t + \varepsilon_{ipt} \quad (2)$$

where $NumGrant_{ipt}$ is the number of grants awarded to researchers connected to expert i in year t for grant type p. The dummy variable $Panelist_{ipt}$ indicates whether expert i sits on an NSFC review committee in year t for grant type p. Our main coefficient of interest is β_1, the impact of having an NSFC panelist on the number of approved grants to connected researchers.

We control for panelist fixed effects, δ_i, to account for time-invariant unobserved quality of the network. Because panelists belong to specific NSFC departments and institutions, NSFC department and institution fixed effects are absorbed by panelist fixed effects. We control for year fixed effects, λ_t, to account for common shocks. We also control for grant type fixed effects, η_p, to absorb possible differences across NSFC grant types. Our assumption is that the timing of a panelist appointment is exogenous conditional on the three sets of fixed effects. The standard errors are clustered at the panelist level.

In our main analyses, we add fixed effects in sequence to shed light on the incremental importance of each of these variables. As shown by the results in columns (2) and (3) of Table 5, the panelist effect remains almost unchanged after controlling

[24] By only considering connected researchers, we wash out possible unobservable differences between connected and unconnected researchers that may also affect the outcome of interest.

for panelist fixed effects and year fixed effects. When an expert sits on the NSFC review committee, the number of grants awarded to her connected researchers increases by 37.14% (= 0.117/0.315). Even after we further control for NSFC grant type fixed effects in the final column, we still find that the connection to a panelist has a large impact on number of scientific grants awarded to researchers.[25]

Table 5 Connected panelist and number of scientific grants

	(1)	(2)	(3)	(4)
Having a connected panelist	0.129***	0.115***	0.117***	0.035***
	(0.004)	(0.004)	(0.004)	(0.003)
Panelist fixed effects		√	√	√
Year fixed effects			√	√
Grant type fixed effects				√
Mean(outcome)	0.315	0.315	0.315	0.315
Observations	309,190	309,190	309,190	309,190
R-squared	0.004	0.094	0.094	0.325

Note: The outcome variable is number of NSFC grants at the panelist-year-grant type level, which is aggregated over the networked researchers of a panelist (the average number of networked researchers of a panelist is 41.43). The key explanatory variable "having a connected panelist" is a dummy variable defined as one if a panelist sits on the NSFC review committee in a certain year. *** < 0.01.

To further explore the effect of connections with a panelist on possibility of getting a scientific grant, we do the heterogeneity analysis with the closeness of relationship between researchers and panelists (Zinovyeva and Bagues, 2015). We measure the closeness based on the following two criteria: (1) whether a researcher and her connected panelist are colleagues, and (2) times of a researcher and a panelist being co-PIs or participants of the same grant, with 0 for only once and 1 for more than once.

[25] The much smaller estimate in the final column reflects that we have several types of NSFC grants in our sample. In Table A2 of the Appendix, we present heterogeneity results with various grant types. The results show that being a panelist has larger effects on the number of youth or general NSFC grants awarded to connected researchers than the number of other types of grants. The estimates may be due to the lack of statistical power for other types of grants because we have a very small proportion (4.6%) of other types of grants in the analysis sample.

As Table 6 shows, when a panelist sits on a NSFC review committee, researchers with closer relationship (being colleagues or being co-PIs for more than once) are more likely to get a grant, suggesting that a panelist's favoritism may play an important role in allocating scientific research resources. For instance, according to the results in columns (3) and (4), the number of approved grants to closely connected researchers increases by 18.18% (=0.016/0.088) if a panelist sits on the committee, while the number of approved grants to non-closely connected researchers increases only by 8.37% (=0.019/0.227).

Table 6 Connected panelist and number of scientific grants: various connections

	(1)	(2)	(3)	(4)
	Colleagues	Non-colleagues	Being co-PIs >= twice	Being co-PIs only once
Having a connected panelist	0.020***	0.015***	0.016***	0.019***
	(0.002)	(0.002)	(0.002)	(0.003)
Panelist fixed effects	√	√	√	√
Year fixed effects	√	√	√	√
Grant type fixed effects	√	√	√	√
Mean (outcome)	0.150	0.166	0.088	0.227
Observations	309,190	309,190	309,190	309,190
R-squared	0.233	0.235	0.170	0.274

Note: The outcome variable is number of NSFC grants at the panelist-year-grant type level, which is aggregated over the networked researchers of a panelist. The key explanatory variable "having a connected panelist" is a dummy variable defined as one if a panelist sits on the NSFC review committee in a certain year. *** < 0.01.

We do the following robustness checks to show the sensitivity of our results. First, we further control for panelist-year fixed effects to account for possible time-varying panelist-level confounding factors. Second, we repeat the analysis by excluding panelists who have ever migrated across institutions during the 2014-2020 period to alleviate the concern that scientists may migrate because they have had served on the NSFC review committee. As the first two columns of Table 7 show, the results are similar to those in the final column of Table 5, suggesting that our main estimates are unlikely to be biased due to unobservable confounding factors.

We also do the following two placebo tests. First, we show whether the effect of having a connected panelist remains before or after she sits on the NSFC committee. As column (3) of Table 7 shows, we find a smaller and even negative effect in the years when the panelist does not sit on the committee. Second, we show whether having a panelist for a certain grant type has any impact on the number of grants of other types awarded to connected researchers. As the final column shows, we only find a small effect on the number of other grants. As a whole, our placebo test results suggest that a connected panelist favors her networked researchers mostly by attending the NSFC review committee, which is consistent with our previous results shown in Tables 2-4.

Table 7 Connected panelist and number of scientific grants: robustness

	(1)	(2)	(3)	(4)
Having a connected panelist	0.037***	0.034***		
	(0.006)	(0.003)		
Having a connected panelist before or after the year			-0.010**	
			(0.005)	
Having a connected panelist for other grant types				0.006*
				(0.003)
Panelist fixed effects		√	√	√
Year fixed effects		√	√	√
Grant type fixed effects	√	√	√	√
Panelist*year fixed effects	√			
Mean (outcome)	0.315	0.313	0.295	0.295
Observations	309,190	293,615	261,594	261,594
R-squared	0.414	0.325	0.325	0.325

Note: The outcome variable is number of NSFC grants at the panelist-year-grant type level, which is aggregated over the networked researchers of a panelist. In columns (1) and (2) the key explanatory variable "having a connected panelist" is a dummy variable defined as one if a panelist sits on the NSFC review committee of a grant type in a certain year. Column (1) controls for two-way fixed effects "panelist-year fixed effects" instead of panelist fixed effects and year fixed effects. Column (2) excludes panelists who have ever migrated across institutions during the 2014-2020 period. In column (3) the key explanatory variable "having a connected panelist before or after the year" is a dummy variable defined as one if a panelist sits on the NSFC review committee of a grant type in other years. In column (4) the key explanatory variable "having a connected panelist for other grant types" is a dummy variable defined as one if a panelist sits on the NSFC review committee of other grant types in that year. *** < 0.01, ** < 0.05, * < 0.1.

C. Connections and quality of scientific funding

In this section, we study the differences in quality of scientific funding between connected and unconnected grants based on the NSFC administrative data on the researcher network documented in the previous section. First, we compare the Scopus publication records of connected and unconnected grant awardees before getting funded. Second, we examine the differences in Scopus publication records between connected and unconnected grants after scientists were awarded the grant.

C1. Connections and pre-funding performance

We limit the analysis to scientists who ever received an NSFC grant during the 2014-2020 period and were co-PIs or participants of the same grant with an NSFC panelist before. We further limit the analysis to those who have at least one Scopus journal publication during the three-year period before getting funded.[26] We compare pre-funding publication records of "connected" NSFC grant awardees (awardees associated with an expert who sit on the review committee in that year) to those of "unconnected" grant awardees (awardees associated with the same expert, but when the expert did not sit on the committee).

As shown by summary statistics in Table 8, we find little difference in the total number of journal papers and associated citations between connected and unconnected NSFC grant awardees during the three-year period before getting funded. However, the publication quality of connected awardees seems poorer than that of unconnected ones. Connected awardees have fewer first-authored journal papers and more coauthors per paper than unconnected ones. The publications of connected awardees also have fewer citations, indicating a lower publication quality. The above results suggest that while the overall number of publications may differ little between connected grants and unconnected ones, connected scientists may have poorer pre-funding scientific

[26] About three quarters of NSFC grant awardees have at least one Scopus journal publication record. According to the second column of Table A3 of the appendix, the sample selection concern may be minor: whether an awardee to have any Scopus journal publication record is unrelated to whether an expert sit on the review committee in the grant-awarding year conditional on expert, grant type, and year fixed effects.

performance than unconnected ones.

Table 8 Scientific productivity of NSFC grant awardees by connections

	Connected awardees (1)	Unconnected awardees (2)	Differences (1) - (2)
Number of journal papers	13.187	13.056	0.131
Number of citations of journal papers	362.981	367.119	-4.138
Average number of citations per paper	24.694	25.517	-0.824**
Average number of authors per paper	6.685	6.497	0.188***
Number of 1st-authored journal papers	2.400	2.483	-0.083***
Number of citations of 1st-authored journal papers	66.434	73.751	-7.317***
Average number of citations per 1st-authored paper	26.722	28.556	-1.833***
Observations	13,816	42,712	

Note: *** < 0.01, **< 0.05.

We next use regressions to further explore the pre-funding difference in scientific productivity of NSFC grant awardees. To control for possible observable differences between connected and unconnected NSFC grant awardees, we use a specification similar to Equation (2) in the previous section.

$$Quality_{ipt} = \gamma_0 + \gamma_1 Panelist_{ipt} + \delta_i + \eta_p + \lambda_t + \varepsilon_{ipt} \quad (3)$$

where $Quality_{ipt}$ is our outcome variable based on the above seven grant productivity measures of researchers connected to expert i in year t for grant type p. The dummy variable $Panelist_{ipt}$ indicates whether expert i sits on an NSFC review committee in year t for grant type p. We control for expert fixed effects (δ_i), grant type fixed effects (η_p), and year fixed effects (λ_t) in the model. We, therefore, have used a very demanding specification by comparing grant awardees associated with the same expert, with their differences being whether the expert sit on the review committee in their application year. The standard errors are clustered at the expert level.

As shown by the regression results in Table 9, we find that connected awardees

have poorer pre-funding performance than unconnected ones in terms of publication quality measured by citations, though the total number of publications differs little between connected and unconnected awardees. The results in columns (5)-(7) show that the pre-funding performance differences are more salient for first-authored papers. The above results suggest that grant evaluators may favor connected researchers at the cost of grant quality, though they are asked to review applications that have passed the first-round reviews and do not differ much in terms of quality.

Table 9 Connections and pre-funding productivity of grant awardees

	(1)	(2)	(3)	(4)
	Number of journal papers	**Number of citations of journal papers**	**Avg. number of citations per paper**	**Avg. number of authors per paper**
Having a connected panelist in the grant-awarding year	-0.022 (0.155)	-3.935 (6.308)	-0.717** (0.322)	0.021 (0.039)
Mean (outcome)	13.088	366.108	25.316	6.543
Observations	55,803	55,803	55,803	55,803
R-squared	0.318	0.337	0.327	0.515
	(5)	(6)	(7)	
	Number of 1st-authored journal papers	**Number of citations of 1st-authored papers**	**Avg. number of citations per 1st-authored paper**	
Having a connected panelist in the grant-awarding year	-0.044 (0.030)	-5.387*** (1.987)	-2.150*** (0.620)	
Mean (outcome)	2.463	71.962	28.111	
Observations	55,803	55,803	40,938	
R-squared	0.264	0.223	0.280	

Note: We control for expert fixed effects, grant type fixed effects, and year fixed effects in the model. The explanatory variable of interest is whether to have a connected panelist sitting on the review committee in the grant-awarding year. *** < 0.01, **< 0.05.

We do the following robustness checks. First, considering that conference papers are also counted into scientists' productivity in some fields (such as computer science),

we redefine our outcome variables based on both journal papers and conference papers. Second, we use the publication records of grant awardees in the previous five years rather than in the previous three years. As Table A4 of the Appendix shows, the estimates are consistent with our main results in Table 9.

C2. Connections and grant productivity

In this subsection, we examine the after-approval differences in scientific productivity between connected NSFC grants and unconnected ones. We limit the analysis to grants of awardees who have been co-PIs or participants of a previous NSFC grant and grants that have been acknowledged in publications in the Scopus dataset.[27] We compare the following productivity measures based on grant awardees' Scopus publication records: number of journal papers that acknowledge the NSFC grant, number of associated citations, average number of citations per paper, average number of authors per paper, number of first-authored journal papers, number of citations of those journal papers, and average number of citations per first-authored journal papers.

As shown by summary statistics in Table 10, connected NSFC grants produce fewer journal papers and associated citations than unconnected NSFC grants. Furthermore, connected grants are associated with a smaller number of first-authored journal papers and a larger average number of authors per paper than unconnected ones. The above descriptive evidences suggest that the productivity of connected grants may be lower than unconnected ones and awardees of connected grants may use their networks to improve their publication records.

[27] Only about one quarter of grants have been specifically acknowledged in our Scopus publication records. The Scopus database API may not correctly record all grant acknowledgements of Scopus publications, but it is reasonable to assume that grant acknowledgements are randomly recorded in the database due to its algorithm. In Table A3 of the appendix, we show that whether a grant to be acknowledged in the Scopus dataset may be random conditional on a set of fixed effects (expert, grant type, and year fixed effects).

Table 10 Scientific productivity of NSFC grants by connections

	Connected grants (1)	Unconnected awardees (2)	Differences (1) - (2)
Number of journal papers	3.893	4.029	-0.136*
Number of citations of journal papers	34.556	35.945	-1.389
Average number of citations per paper	6.852	6.803	0.049
Average number of authors per paper	5.853	5.772	0.081*
Number of 1st-authored journal papers	0.739	0.844	-0.105***
Number of citations of 1st-authored journal papers	6.138	7.438	-1.300**
Average number of citations per 1st-authored paper	7.610	8.022	-0.412
Observations	4,453	15,343	

Note: *** < 0.01, ** < 0.05, * < 0.1.

Similarly, we use regressions to explore how connections affect grant productivity by controlling for possible observable differences between connected and unconnected NSFC grants. We use a specification similar to Equation (3) in the previous section. Our explanatory variable of interest is whether to have a connected panelist sitting on the review committee in the grant-awarding year and our outcome variables are the above seven grant productivity measures. We control for expert fixed effects, grant type fixed effects, and year fixed effects in the model. Therefore, we compare productivity of "connected" NSFC grants (grants of awardees associated with an expert who sit on the review committee in that year) to productivity of "unconnected" grants (grants of awardees associated with the same expert, but when the expert did not sit on the committee). The standard errors are clustered at the expert level.

As shown by the regression results in Table 11, we find little productivity difference between connected and unconnected grants in terms of the total number of journal papers, the number of associated citations, and average number of authors per paper, suggesting that the overall grant productivity may not differ much between connected and unconnected grants. We, however, find that awardees of connected grants produce 9% (=0.07/0.82) fewer first-authored journal papers and 15% (=1.087/7.145) fewer associated citations than unconnected ones, suggesting that these awardees are more likely than unconnected ones to use their networks to help produce

publications, which have a lower quality.

Table 11 Connections and grant productivity

	(1)	(2)	(3)	(4)
	Number of journal papers	**Number of citations of journal papers**	**Avg. number of citations per paper**	**Avg. number of authors per paper**
Having a connected panelist in the grant-awarding year	0.083 (0.098)	-0.550 (1.882)	-0.225 (0.221)	0.005 (0.050)
Mean (outcome)	3.999	35.632	6.814	5.790
Observations	17,907	17,907	17,907	17,907
R-squared	0.372	0.309	0.363	0.497
	(5)	(6)	(7)	
	Number of 1st-authored journal papers	**Number of citations of 1st-authored papers**	**Avg. number of citations per 1st-authored paper**	
Having a connected panelist in the grant-awarding year	-0.070** (0.033)	-1.087** (0.511)	-0.351 (0.494)	
Mean (outcome)	0.820	7.145	7.932	
Observations	17,907	17,907	5,739	
R-squared	0.330	0.275	0.453	

Note: We control for expert fixed effects, grant type fixed effects, and year fixed effects in the model. The explanatory variable of interest is whether to have a connected panelist sitting on the review committee in the grant-awarding year. ** < 0.05.

We do the following robustness checks. First, as we have done before, we redefine our outcome variables based on both journal papers and conference papers. Second, considering that grants awarded in more recent years may have not produced publications, we limit the analysis to the grants awarded three years before (i.e., before 2018). As Table A5 of the Appendix shows, the estimates are consistent with our main results in Table 11.

Overall, our grant quality analysis shows that connected researchers have almost the same total number of publications as unconnected ones before and after getting

funded. However, connected researchers have poorer publication quality and fewer first-authored publications both before and after funding. These results suggest that connected grant awardees are more likely than unconnected ones to use their networks to help increase publications, which have a lower quality.

D. Mechanisms

It is a priori unclear how connections affect one's chance of getting a scientific grant. At least three possible forces are at work. First, one gets a scientific grant because connected panelists favor her grant proposal in NSFC grant review meetings. Second, one may get insider information or valuable mentoring from connected panelists of NSFC grant review committees, which increases her chance of getting a scientific grant. Third, one may be more likely to apply if she anticipates that her connected expert will sit on the grant review committee (Bagues et al., 2019). In this case, we will observe a positive relationship between the possibility of being awarded a grant in that year even if one's grant application has not been favored by a connected panelist or one has not learned any valuable information from a connected panelist.

Before exploring the favoritism channel, we first show that the information and selective application channels are unlikely. The information channel is unlikely due to the following two reasons. First, according to the NSFC rule, panelists are required not to reveal their panelist identity or other related information to others. Otherwise, they will be seriously punished. Furthermore, the decision on selection of panelists is made by the NSFC only several days before the meeting date, leaving almost no time for panelists to communicate with their connected researchers. Second, if panelists have learned some insider information from their experience of working for the NSFC, they should have disseminated such information in the year of serving on the NSFC committee and in later years or for all grant types of the same field. But as the results of Table 4 suggest, the information cannot explain the large difference in the estimates of having a panelist between in the serving years and in other years and the large difference in the estimates of having a panelist evaluating her "assigned" grant types

and “not-assigned” grant types.

The selective application channel is also unlikely due to the following three reasons. First, the submission date of NSFC grant proposals are at least four months before the NSFC’s decision on choosing panelists. Therefore, it is impossible for a researcher to decide whether to apply for an NSFC grant based on whether a connected expert sits on an NSFC committee. Second, even if a researcher expects that her connected experts will sit on an NSFC committee, the decision on whether to submit an NSFC grant proposal is unlikely to be related to whether a connected expert sits on an NSFC committee. Almost all Chinese institutions encourage or even require their faculty to apply for NSFC grants, which are usually tied to faculty promotion (National Center for Science and Technology Valuation, 2011).[28] Third, the NSFC has some rules for whether one can apply for an NSFC grant, limiting the flexibility of choosing to apply by a connected researcher in a specific year.[29]

Our findings suggest that favoritism is likely to be the main underlying mechanism. First, the connections effect is most salient when a panelist sits on a review committee evaluating applications that have the same grant type and the same field and are submitted in the same year as researchers' applications do. Otherwise, the connection effect is much smaller or almost disappears. We also find that the closer the connection, the larger the chance of being funded. Second, while connected researchers have almost the same total number of publications as unconnected ones, connected researchers have poorer publication quality and fewer first-authored publications both before and after funding. This suggests that favoritism may lead to relatively poorer scientific performance of connected grant recipients because they are more likely than unconnected ones to use their networks to help produce publications, which have a lower quality.

[28] According to a survey conducted by the NSFC, 92% of Chinese institutions have set up policies to encourage scientists to apply for NSFC grants and 58% of them require that an assistant professor has to get a NSFC fund before applying for the promotion to associate professor (National Center for Science and Technology Valuation, 2011).

[29] For example, a researcher is not allowed to apply if failing for two consecutive years and is not allowed to apply if she has an ongoing grant that will not end next year.

5. Conclusions

In this paper, we study how connections with grant review committee members ("panelists") affect scientific grant success. To this end, we hand-collect data on about 9000 committee members who have evaluated several hundred thousand NSFC grant applications during the 2014-2020 period in China. We match panelists data with various administrative data, including administrative NSFC network data, scientific grant data, and the Scopus publication data. Our paper is among the first to causally examine how connections with scientific funding evaluators affect applicants' chances of scientific funding.

We find that connections with a panelist more than double the number of scientific grants awarded to researchers when a panelist sits on a NSFC review committee in the grant-awarding year. The connection effect becomes much smaller in other years, or almost disappears when "connected" panelists do not sit on a review committee evaluating applications that have the same field or the same grant type with researchers' applications. While connected researchers have almost the same total number of publications as unconnected ones, connected researchers have poorer publication quality and fewer first-authored publications both before and after funding. Our findings suggest that favoritism is likely to be the main underlying mechanism. We can reasonably rule out possible insider information sharing and selective application channels.

Our findings have important policy implications for allocation of scientific funding resources. On one hand, our results show that the performance of connected grant recipients is worse than that of unconnected ones, suggesting distortions in allocating scientific funding resources due to arbitrary judgement of funding evaluators. While many scientific funding agencies have implemented policies to address possible conflicts of interest between experts and grant applicants (Cyranoski, 2019; Shalev,

2004; Zhou, 2019), the review system should be further improved possibly by strengthening its transparency or focusing more on grant merit and relying less on experts' subjective judgement (Wenneras and Wold, 1997).

On the other hand, because the majority of "powerful" grant evaluators are male and come from elite institutions according to our analyses, the Matthew effect implies that disadvantaged groups such as female scientists or scientists from low-ranked institutions have fewer opportunities of getting funding resources, hampering scientific progress (Bol et al., 2018; Wenneras and Wold, 1997). This calls for policies that increase the diversity of grant reviewers, with more emphasis on disadvantaged or minority groups.

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Appendix

Table A1 Testing whether a panelist is randomly chosen

	(1)	(2)
Female	-0.006***	0.001
	(0.002)	(0.005)
CAS/CAE fellow	0.013***	0.012**
	(0.004)	(0.005)
Distinguished young scholar	0.022***	0.018***
	(0.002)	(0.003)
Age		0.001***
		(0.000)
Education		
Bachelor from a top-tier university		-0.002
		(0.004)
Overseas PhD		-0.003
		(0.004)
Observations	612,570	232,120
R-squared	0.076	0.082

Note: We use the panelist sample. The outcome variable is a dummy for whether one was a panelist in a year during the period between 2014 and 2020. We regress this outcome variable on a set of individual characteristics, including age, gender, education background, dummy for CAS/CAE fellow, and dummy for distinguished young scholar conditioning on a set of fixed effects (NSFC department, NSFC grant type, year, and institution fixed effects). *** < 0.01, ** < 0.05.

Table A2 Connection to a panelist and number of scientific grants by type

	(1) General grant	(2) Youth grant	(3) Regional grant	(4) Key grant	(5) Overseas grant
Having a connected panelist	0.072***	0.063***	0.008***	-0.002	-0.003
	(0.011)	(0.009)	(0.002)	(0.002)	(0.002)
Panelist fixed effects	√	√	√	√	√
Year fixed effects	√	√	√	√	√
Grant type fixed effects	√	√	√	√	√
Mean (outcome)	0.932	0.532	0.050	0.041	0.020
Observations	61,838	61,838	61,838	61,838	61,838
R-squared	0.468	0.262	0.464	0.238	0.226

Note: The outcome variable is number of NSFC grants at the panelist-year-grant type level, which is aggregated over the networked researchers of a panelist. The key explanatory variable "having a connected panelist" is a dummy variable defined as one if a panelist sits on the NSFC review committee of a grant type in a certain year. *** < 0.01.

Table A3 Sample selection in the analysis of grant quality

	(1)	(2)
	Whether a grant has been acknowledged in Scopus journal publications	**Whether an awardee has any Scopus journal publication**
Having a connected panelist in the grant-awarding year	-0.007 (0.005)	0.002 (0.004)
Mean (outcome)	0.342	0.727
Observations	57,895	79,661
R-squared	0.231	0.259

Note: We control for expert fixed effects, grant type fixed effects, and year fixed effects in the model. The explanatory variable of interest is whether to have a connected panelist sitting on the review committee in the grant-awarding year.

Table A4 Connections and pre-funding productivity of grant awardees: Robustness checks

	(1)	(2)	(3)	(4)
	Number of papers	**Number of citations of papers**	**Avg. number of citations per paper**	**Avg. number of authors per paper**
Panel A: also including conference papers				
Having a connected panelist	-0.021	-4.444	-0.710**	0.030
in the grant-awarding year	(0.176)	(6.370)	(0.316)	(0.038)
Mean (outcome)	14.482	373.687	24.195	6.524
Observations	55,803	55,803	55,803	55,803
R-squared	0.323	0.337	0.329	0.522
Panel B: previous 5-year instead of 3-year publications				
Having a connected panelist	0.024	-1.999	-0.581*	0.004
in the grant-awarding year	(0.212)	(9.203)	(0.318)	(0.037)
Mean (outcome)	19.119	569.790	26.945	6.418
Observations	56,983	56,983	56,983	56,983
R-squared	0.348	0.365	0.341	0.518

	(1)	(2)	(3)
	Number of 1st-authored papers	**Number of citations of 1st-authored papers**	**Avg. number of citations per 1st-authored paper**
Panel A: also including conference papers			
Having a connected panelist	-0.055*	-5.542***	-2.142***
in the grant-awarding year	(0.032)	(2.016)	(0.601)
Mean (outcome)	2.730	73.413	26.61
Observations	55,803	55,803	41,778
R-squared	0.294	0.224	0.281
Panel B: previous 5-year instead of 3-year publications			
Having a connected panelist	-0.047	-6.104**	-1.109**
in the grant-awarding year	(0.043)	(2.871)	(0.565)
Mean (outcome)	3.796	118.750	29.927
Observations	56,983	56,983	46,786
R-squared	0.285	0.257	0.296

Note: Our outcome variables are based on both journal and conference papers in Panel A and on only journal papers in Panel B. We control for expert fixed effects, grant type fixed effects, and year fixed effects in the model. The explanatory variable of interest is whether to have a connected panelist sitting on the review committee in the grant-awarding year. *** < 0.01, ** < 0.05, * < 0.1

Table A5 Connections and grant productivity: Robustness checks

	(1)	(2)	(3)	(4)
	Number of papers	**Number of citations of papers**	**Avg. number of citations per paper**	**Avg. number of authors per paper**
Panel A: also including conference papers				
Having a connected panelist	0.076	-0.732	-0.194	0.002
in the grant-awarding year	(0.104)	(1.892)	(0.217)	(0.049)
Mean (outcome)	4.382	36.607	6.601	5.773
Observations	17,907	17,907	17,907	17,907
R-squared	0.391	0.313	0.364	0.501
Panel B: grant awarding year <= 2018				
Having a connected panelist	0.083	-1.055	-0.163	0.029
in the grant-awarding year	(0.119)	(2.208)	(0.262)	(0.055)
Mean (outcome)	4.262	40.041	7.512	5.799
Observations	15,268	15,268	15,268	15,268
R-squared	0.383	0.325	0.366	0.515

	(5)	(6)	(7)
	Number of 1st-authored papers	**Number of citations of 1st-authored papers**	**Avg. number of citations per 1st-authored paper**
Panel A: also including conference papers			
Having a connected panelist	-0.066*	-1.115**	-0.388
in the grant-awarding year	(0.035)	(0.513)	(0.469)
Mean (outcome)	0.881	7.296	7.652
Observations	17,907	17,907	5,982
R-squared	0.342	0.297	0.451
Panel B: grant-awarding year <= 2018			
Having a connected panelist	-0.093**	-1.230*	-0.271
in the grant-awarding year	(0.039)	(0.645)	(0.591)
Mean (outcome)	0.862	7.976	8.621
Observations	15,268	15,268	4,883
R-squared	0.344	0.290	0.452

Note: Our outcome variables are based on both journal and conference papers in Panel A and on only journal papers in Panel B. We control for expert fixed effects, grant type fixed effects, and year fixed effects. The explanatory variable of interest is whether to have a connected panelist sitting on the review committee in the grant-awarding year. ** < 0.05, * < 0.1.