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Does It Pay to Do Novel Science? The Selectivity Patterns in Science Funding

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Abstract

Public funding agencies aim to fund novel breakthrough research to promote the radical scientific discoveries of tomorrow. Identifying the profiles of scientists being financed to pursue their research is therefore crucial. This paper shows that the funding process is not always awarding the most novel scientists. Exploiting rich data on all applications to a leading Swiss research funding program, we find that novel scientists have a higher probability of applying for funds than non-novel scientists, but they get on average lower ratings by grant evaluators and have fewer chances of being funded. We discuss the implications for the allocation of scientific research spending.

Key words: public funding; scientific research; novelty; selectivity; research evaluation

JEL classification: I23, O38

1. Introduction

The innovation fueling the engine of economic growth (Romer 1986, 1990) increasingly relies on government-funded research to find useful ideas (Arora et al., 2018; Fleming et al. 2019; Poege et al. 2019). Nevertheless, public funding of science is currently witnessing a double hurdle in promoting the production of new knowledge. On the one hand, competition for funds in science is becoming increasingly severe, making it harder for scientists to finance their research. For instance, the success rate for research grants of the National Institute of Health (NIH), the national funding agency sponsoring the majority of biomedical research in the USA, has decreased from 33 per cent in 2000 to 20 per cent in 2017.[1] On the other hand, scientific research seems to be hitting a plateau in its productivity with impactful scientific breakthroughs becoming harder to produce (Bloom et al. 2017) leading some observers to question the ability of the scientific system to effectively promote novel research (Alberts et al. 2014).[2] Consequently, with the growing difficulty for scientists to secure funds and the need for novel research, the academic community would benefit from evaluating which scientists are applying for funds and whether the most novels ones are getting funded.

The competitive grant allocation system involves two major players: the funding agencies allocating their budget to a restricted number of awarded researchers, and the scientists who decide whether they enter the competition or not. Funding agencies have a crucial role to play in promoting risk-taking research that would otherwise remain underprovisioned (Nelson 1959; Arrow 1972; Stephan 2012), while scientists produce scientific research and propose different research avenues for which they ask funds to funding agencies. A growing corpus of scholarly research is questioning the process of selection by estimating the impact of the evaluators' characteristics on the selection decision (Boudreau et al. 2016; Li 2017). However, little attention has been devoted to assessing the effect of scientists' profiles on both the evaluators' judgment and the propensity of scientists to apply for funds. Some systematic biases against women (Bornmann et al. 2007) and minorities (Ginther et al. 2011) have been recorded. However, to the best of our knowledge, there is little to no evidence of potential bias against novel researchers in funding. This paper aims to fill this gap by empirically evaluating the selectivity patterns of scientists in the funding process. Specifically, within the current debate on the incentives encouraging scientists to pursue novel research lines (Azoulay et al. 2011;

Ayoubi et al. 2019), we evaluate the impact of the novelty profile of a scientist on her decision to apply for a grant and on her success rate.

When allocating funds, the funding agencies aim to use taxpayers' money efficiently. Since funding agencies are asked to report to the general public about the outcomes of their activity, they might tend to support those scientists maximizing the number of scientific discoveries produced (Lorsch 2015). When asked to choose between scientists pursuing novel research—usually implying higher uncertainty (Azoulay et al. 2011; Wang et al. 2017)—and scientists pursuing more conventional incremental research, funding agencies face a challenging trade-off. Specifically, the evaluation committee has to choose between scientists conducting research that might lead to breakthrough discoveries but with a high risk of failure (novel scientists) and scientists conducting research that might lead to incremental scientific advancements but with low risk of failure (non-novel scientists). In this context, funding agencies can have different risk aversion lines. Risk-averse funding agencies would minimize the threat of wasting taxpayers' money by sponsoring only non-novel research reducing the risk for scientific failures and ensuring a constant flow of incremental discoveries. In this scenario, the trade-off for society would be the risk of facing a shortage of impactful discoveries. Conversely, risk-taking funding agencies would favor novel research with the potential for groundbreaking discoveries by dedicating specific grants to sponsor novel and risky research and accepting a higher rate of scientific failures.

Extant studies consider the content of scientists' proposals and find that funding agencies are negatively biased against novelty when selecting among alternative projects. For instance, Boudreau et al. (2012) find that 'evaluators uniformly and systematically give lower scores to proposals with increasing novelty; i.e., there is an economically significant novelty discount.' (p. 3). Boudreau et al. (2012) create an experimental context of a double-blinded evaluation where neither the funding agency's evaluators nor applicants know their respective identities and find that scientists' characteristics do not significantly affect the evaluators' scoring. However, this setting is rarely met in the context of the evaluation of scientific proposals for funding. Most funding agencies follow a single-blind review process where evaluators have access to applicants' profiles and consider them in their assessment. In our study, we account for this setting by evaluating the effect of applying scientists' characteristics on their probability to be awarded the funds.

Are funding agencies awarding scientists conducting novel research? To address this question, we examine one of the flagship programs of the Swiss National Science Foundation (SNSF)'s grant portfolio, SINERGIA, from 2008—the year when the program was launched—to 2012. SINERGIA is a collaborative research grant aiming to promote scientific breakthroughs for which applicants team up to craft a joint application. The awardees of the grant are then selected based both on the scientific quality of the proposal and the scientific profile of the applicants. The program targets well-established senior scientists with strong scientific records. This setting offers a suitable empirical framework for evaluating how scientists' tendency to pursue novel research affects their funding opportunities. We flag as novel those scientists who have published a novel paper in a short window before the application time. Considering 717 unique scientists who crafted 255 applications for SINERGIA and controlling for a broad set of bibliometric and demographic characteristics, we find that applications in which the responsible applicant is a novel scientist as well as those applications with a higher share of novel scientists receive lower evaluation scores on average and have less chance of being awarded.

Restricting the analysis to the funding selection phase implies limiting the focus on a fraction of the scientific community, the scientists who decided to compete for funds (Ayoubi et al. 2019). However, with competition for funds becoming increasingly arduous, some scientists, especially the ones considering they have little chances, might be discouraged from applying for funds. Therefore, we ask: are novel scientists deterred from applying for grants? Applying for grants is one of the scientists' core responsibilities (Etzkowitz 2003). Researchers need funds to ensure a constant flow of research funding to their laboratories to support PhDs and Postdocs salaries and to secure state-of-the-art equipment (Stephan 2010). Scientists conducting novel research, although under the pressure of providing funds for their laboratories, might refrain from participating in granting competitions if they perceive that funding agencies are discounting novel research.

To the best of our knowledge, this paper is the first study exploring the self-selection by scientists into a grant competition. Extant studies estimate the attitude of scientists after receiving funds by assessing the ex-post novelty profile of funded researchers under different funding schemes. For instance, Azoulay et al. (2011) find that less stringent grants such as the Howard Hughes Medical Institute fellow that 'tolerates early failure, rewards long-term success, and gives its appointees great freedom to experiment' encourage recipients to 'explore novel lines of inquiry' (pp. 527). In our study, we analyze the impact of the ex-ante novelty profile of a scientist on her probability of applying for SINERGIA by identifying a sample including all scientists eligible for a SINERGIA application and estimating the propensity to apply for the grant. Interestingly, comparing the novelty profile of the applying scientists with a pool of 15,121 active scientists with a Swiss affiliation who have never applied to SINERGIA, we find that novel scientists have a higher probability of applying for funds than non-novel scientists. Our results suggest that, while funding agencies seem to be risk-averse, novel scientists do not refrain from applying for funding and seek the funds they need for their research.

The rest of the paper is organized as follows: Section 2 introduces the concepts of novelty and novel scientists, Section 3 describes the data and main variables, Section 4 presents the findings, and Section 5 concludes with a discussion of the results and their implications.

2. Identifying novel scientists

Scholars converge on the fact that novel research is highly impactful, but have used different approaches to measure novelty. In a seminal work, Uzzi et al. (2013) used the combinations of referenced journals to determine the level of novelty of an article. They use all the publications appearing in the Web of Science (Clarivate Analytics) database to calculate the frequency of the articles in which two journals are cited together (observed frequency). They define the level of novelty of each article according to how rare are the journal combination appearing in the article bibliography. Wang et al. (2017) also use referenced journals to define novelty, but they use unprecedented combinations instead of frequencies to construct their novelty measure. Precisely, they consider as novel any article exhibiting a combination of journals in its references which has never appeared in prior literature. Then, for each novel combination, they calculate the degree of novelty of the unprecedented combination using the distance between the two journals.[3] Other approaches of novelty include the use of atypical keyword combinations[4] (Boudreau et al.

2016; Carayol et al. 2018) and the new combination of International Patent Classification (IPC) codes for evaluating the novelty of patents (Pezzoni et al. 2018). More recently, Mairesse and Pezzoni (2018), building on the approach of Wang et al. (2017), require unprecedented combinations of journals to be reused a minimum number of times in follow on articles to be defined as novel. Imposing a minimum number of reuses allows us to avoid considering unprecedented combinations of journals that represent unproductive or trivial ideas, focusing only on the novelty that contributes to advancing the scientific frontier. This definition of novelty requiring its reuse is theoretically grounded on the creativity literature that considers creative work only the work that is both new and useful (Stein 1963 ; Fleming et al. 2007).

The various novelty measures in the literature are constructed at the article level and have been validated by experts asked to classify articles as novel and not novel (Bornmann et al. 2019). We extend the concept of novelty from the article level to the level of the scientist. To do so, we consider that a scientist is novel in a given year if she has published at least one novel article in the three years before the year of observation. Following Wang et al. (2017), we define a publication including a novel scientific idea as an article reporting in its bibliography an unprecedented combination of referenced journals. To account for the usefulness of a novel idea, similarly to Mairesse and Pezzoni (2018), we require a minimum level of success after its first appearance, that is that the combination of journals is reused in a minimum number of follow-on articles.

Having identified the novel scientists, we then analyze the impact of being a novel scientist on the propensity to get funded and to apply for a grant (see Section 4) using an original sample of Swiss scientists. As empirical context, we consider the scientists' exposure to SINERGIA, a Swiss funding program sponsoring collaborative breakthrough research.

3. Data and variables

The SINERGIA program was launched in 2008 and represents a flagship grant of the SNSF's funding portfolio. As the principal funding agency in the country, the SNSF plays in Switzerland a similar role as the National Science Foundation (NSF) in the USA. SINERGIA promotes collaborative breakthrough research: scientists, as suggested by its name, are asked to apply in teams where each member brings different competencies and has to prove her ability to develop valuable synergies with her co-applicants to submit 'research work carried out collaboratively' (SNSF 2011). A responsible applicant—often the one at the origin of the project—is then designated to coordinate the process among the members of the team. SINERGIA is designed for established and reputed researchers and guarantees to the awarded scientists a significant amount of funding. Similarly, to NSF or European Research Council grants, researchers submit their proposals to a selection committee that funds the most promising proposals on a competitive basis. The selection process is single-blind, meaning that the selection committee has access to the researchers' identity and judges the applications both on the scientific quality of the research proposal and on the academic profile of applicants. The profiles of all applicants listed on the application count in the evaluation of the committee but only the responsible applicant is 'legally responsible vis-à-vis the SNSF, and any grant awarded shall be paid to his/her institution' (SNSF guidelines for SINERGIA).[5] Once submitted, the research proposals are evaluated in a two-step procedure. First, external reviewers, selected by the SNSF on their scientific knowledge and expertise, rate each application. After this first round, the internal committee of the SNSF attributes a final score to each proposal submitted based on the evaluations of the first step. The final grade is assigned on a scale ranging from 1 to 6, with 6 being the highest score attainable for a proposal and 1 the lowest. As for the allocation of funds, the scientific proposals are ranked based on their final score, with funds being allocated until the annual budget quota is reached. In this setting, proposals receiving scores above 4 are always funded while the ones below 3 are never funded. The applications receiving a grade of 4 are ranked and receive funds until the total available funds are exhausted. Table 1 illustrates the details of the grade distribution on our sample of applications. We observe 255 applications to SINERGIA, with 114 of them ending being funded, that is a success rate of 45 per cent.[6]

Table 1. Distribution of the number of grant applications by the final score assigned and final funding decision.

	Awarded		
Final score	No	Yes	Total
1	38	0	38
2	56	0	56
3	38	0	38
4	9	34	43
5	0	58	58
6	0	22	22
Total	141	114	255

To analyze the impact of being a novel scientist on the probability of being awarded, we focus on the 255 SINERGIA applications during the period 2008–2012. We first consider the novelty profile of the responsible applicant, then the share of novel scientists listed in the application and estimate their effect on the evaluation by the evaluation committee.

We mark a scientist as being novel in year t if she published at least a novel article in the past three-year window, from $t-1$ to $t-3$. We define an article as novel if it includes at least one novel combination of referenced journals. To identify novel combinations of journals in year t, we proceed in two steps. First, we flag those combinations that appear for the first time ever[7] in the universe[8] of existing articles in t. Then, we consider novel those combinations that are used at least in twenty follow-on articles in the five years after their first appearance.

In our econometric exercises considering applicant teams, we calculate as main explanatory variables the dummy variable *Novel responsible applicant*, that equals one if the responsible applicant of the proposal is a novel scientist and zero otherwise, and the variable *Share of novel applicants* giving the proportion of novel scientists in the applying team. In our econometric exercises considering the decision of the individual scientist to apply to SINERGIA, we consider as main explanatory variable the dummy *Novel Scientist*, a dummy that equals one if the scientist is novel, zero otherwise.

The applications to SINERGIA involve 775 unique individuals with few cases of multiple applications for a total of 1,060 application–applicant pairs. For the second part of the analysis, analyzing the impact of being a novel scientist on the probability of applying for SINERGIA, we identify all the scientists affiliated to one of the twelve major Swiss universities[9] and active in the period 2008–2012. Those scientists represent the pool of researchers who are eligible to apply for SINERGIA. For each year t in the period 2008–2012, we

Table 2. Descriptive statistics by group of scientists.

Panel A	Awarded (114 applications)			Non-awarded (141 applications)		
	Mean	Min	Max	Mean	Min	Max
Share of novel scientists	0.14	0	1	0.18	0	1
Novel responsible applicant	0.09	0	1	0.18	0	1
Academic profile of the applicants						
Average seniority	17.33	7.67	33.5	18.17	7.33	41
Other active funding	0.92	0	1	0.82	0	1
Previous expired funding	0.81	0	1	0.79	0	1
Previous SINERGIA application	0.38	0	1	0.41	0	1
Previous SINERGIA awarded	0.18	0	1	0.24	0	1
Average publications	30.34	6	98	34.11	9.33	112.50
Average IF	6.27	0.68	13.86	5.41	0.83	14.30
Average citations	4.66	0.44	13.34	4.17	0.55	15.37
Average co-authors	5.28	2.71	7.68	5.11	2.67	7.76
Average N. of journal combinations	104.99	0	332.60	100.10	0	280.59
Application characteristics						
N. of co-applicants	4.14	2	11	4.23	2	11
All Swiss applicants	0.14	0	1	0.11	0	1
At least one female researcher	0.41	0	1	0.48	0	1
Science & Medicine	0.64	0	1	0.64	0	1
Amount requested	1.75	0.51	6.86	1.61	0.35	4.99
N. of disciplines	3.06	1	9	3.50	1	11

Panel B	Applicants to SINERGIA (775 scientists) (1,060 observations)			Non-applicants to SINERGIA (15,121 scientists) (47,439 observations)		
	Mean	Min	Max	Mean	Min	Max
Novel scientist	0.17	0	1	0.05	0	1
Academic profile						
Seniority	17.69	0	52	11.79	0	52
Other active funding	0.43	0	1	0.07	0	1
Previous expired funding	0.36	0	1	0.10	0	1
Publication count	32.52	1.00	225.00	7.84	1.00	233.00
Average IF	5.61	0.10	28.61	4.68	0.05	51.66
Average citations	4.29	0.04	48.62	4.37	0	214.39
Average co-authors	5.16	1	10.40	3.55	1	15
Average N. of journal combinations	97.75	0	1169.31	81.92	1	6968.67

extract from all the publications reporting a Swiss affiliation recorded in the Elsevier Scopus database the list of scientists having at least one publication in the time window $t-5$ to $t-1$ and at least one between t and $t+4$. We retrieve 15,121 eligible scientists who are observed yearly for a total of 47,439 observations referring to scientist-year pairs for non-applicants. Adding these observations to the 1,060 observations relating to the scientist-year pairs for the applicants, we end up with a study sample of 48,499 observations.

For the full sample, we collect demographic and bibliometric details as well as information on the scientists' fundraising ability. Following Ayoubi et al. (2019), we calculate *Seniority* as the time since the oldest observed self-citation in the scientist's referenced articles or, in case of absence of self-citations, since the first scientist's publication in our dataset. Regarding the scientist's fundraising ability, we gather the previous and existing funded European and (other than SINERGIA) SNSF projects. The dummy variable *Other active funding* equals one if the scientist has at least one active project funded by European or other SNSF funds, while the dummy *Previous expired funding* equals one if the scientist has concluded a European or SNSF funded project. Similarly, we define the dummies *Previous SINERGIA applications* and *Previous SINERGIA awarded*. As bibliometric characteristics, we retrieve the number of articles published in the five preceding years (*Publication count*), the average impact factor of the journals where these articles were published (*Average IF*), the average number of citations received by paper per year (*Average citations*), and the average number of authors per paper (*Average co-authors*). We also collect the number of distinct journals listed in the references of the articles published by the scientist in the five preceding years and compute the number of possible combinations between these journals *(N. of journal combinations*).

For applicants, we also include application characteristics such as the team size dimension represented by the number of co-applicants (*N. of co-applicants*), the amount requested in the proposal (*Amount requested*), the main discipline of the project as a dummy equal to one if the subject is in Science and Medicine and equal to zero otherwise (*Science & Medicine*), and the number of sub-disciplines involved in the project proposed in the application (*N. of disciplines*). Finally, we measure the heterogeneity of the applying team

Table 3. Proportion of novel responsible applicants and average share of novel scientists per application by grade class assigned to applications (grade on a scale 1–6, where 6 is the maximum grade).

		Proportion of novel responsible applicants		Average share of novel scientists per application	
Grade	Share of awarded	Mean	SD	Mean	SD
1 = D	0	0.13	0.34	0.24	0.29
2	0	0.21	0.41	0.20	0.27
3	0	0.16	0.37	0.11	0.27
4	0.68	0.10	0.30	0.12	0.21
5	1	0.09	0.28	0.13	0.21
6 = A	1	0.14	0.35	0.22	0.29

composition by calculating the dummy *Swiss team* that equals one if all the team members are Swiss scientists and the dummy *At least one female researcher* if the team is not entirely formed by male scientists.

Table 2 reports statistics on the independent variables of the two analyses conducted in Section 4, that is the propensity of an application with novel scientists to be awarded a SINERGIA grant (Panel A) by the funding agency and the propensity of novel scientists to apply to SINERGIA (Panel B). Note that, in Table 2 Panel A, all the variables are calculated at the team level. The variables *Average seniority*, *Publication count*, *Average IF*, *Average citations*, *Average co-authors*, and *Average N. of journal combinations* represent the average of the values over the member of the applying team. Similarly, the dummies *Other active funding*, *Previous expired funding*, *Previous SINERGIA application*, and *Previous SINERGIA awarded* are equal to one if at least one of the applicants has the dummy equal to one.

For Panel A, we observe 255 SINERGIA applications, of which 114 awarded and 141 non-awarded. Among the awarded applications, 9 per cent have a novel responsible applicant, while the percentage rises to 18 per cent for the non-awarded. Coherently, awarded applications hold a lower share of novel applicant scientists than non-awarded applications (14 per cent versus 18 per cent). Furthermore, we observe that awarded applications comprise moderately more junior member than non-awarded ones (with 17.33 years of seniority on average versus 18.17 for non-awarded), and have successfully raised funding more often (92 per cent include at least one applicant with other active funded projects and 81 per cent have at least one applicant who has benefited from funding in the past, while for non-awarded these percentages are 82 per cent and 79 per cent, respectively). Looking at the SINERGIA past application records, SNSF seems to slightly favor applicants who are new to the program (62 per cent of awarded applications had all their applicant at their first application compared with the 59 per cent of non-awarded, 18 per cent of the awarded applications have at least one member who has been already awarded a SINERGIA grant, compared with the 24 per cent of the non-awarded applicants). Finally, awarded applications are made of scientists with fewer publications (30.34 article per application on average) than non-awarded ones (34.11), but published in journals with a higher impact factor on average (6.27 versus 5.41).

For Panel B, we observe 48,499 scientist-year pairs of which 17 per cent are novel scientists in the case of the applicants, and only 5 per cent are novel scientists in the case of the non-applicants. Moreover, we observe that SINERGIA applicants are senior scientists, they have, on average, 17.69 years of seniority. Applicants demonstrate strong fundraising skills: in the year of the application to SINERGIA, 43 per cent of them benefit from other active funding, and 36 per cent had some alternative funding that had expired at the time of application. They have a solid publications track, in high-quality journals, and are highly cited: they count, on average, 32.52 publications published in journals with an average impact factor of 5.61 and each article receives 4.29 citations per year. On average, applicants collaborate with 5.16 co-authors per article. As expected, scientists who refrain from applying to SINERGIA have less outstanding scientific profiles: they are younger and with a more modest publication record, and limited co-authorship network. On average a scientist who did not apply has a seniority of 11.79 years, has other active funding in only 7 per cent of the cases, benefited from funding that has expired in 10 per cent of the cases, has 7.84 publications on journals with an average impact factor of 4.68, and counts 3.55 co-authors per paper.

To better investigate the effect of the novelty profile of applicants on the evaluation of the application, Table 3 reports the proportion of applications with a novel responsible applicant and the average share of novel scientists per application, by grade class. It shows that novel responsible applicants are distributed rather homogeneously among the higher grades with grade classes above three containing between 9 per cent and 14 per cent of applications with a novel responsible applicant. However, below grade-class 3, which marks the lower bound for being awarded, the proportion of applications with novel applicants is higher (between 13 per cent and 21 per cent of applications with a novel responsible applicant). Concerning the proportion of novel applicants in the team, it is high in the extremes, with high shares at very low and very high grades. As for the full sample of scientists, it seems that novel scientists have a higher propensity to apply: 17 per cent of applicants are novel, while only 5 per cent of non-applicant scientists are. Going beyond descriptive observations, the regression analyses reported in the next section test analytically the relationship between the novelty profile and being awarded or applying for SINERGIA.

4. Results

This section gives an overview of our results on the evaluation of selectivity patterns in the two phases of a research grant competition, funding selection and application. First, for the process of awarding the grant, we present the results on the potential selection bias of funding agencies in favor or against novel scientists. Second, for the application phase, we exhibit the main findings concerning the self-selection of researchers into applying for a research grant.

Tables 4 and 5 exhibit the results of the regression evaluating the effect of novelty on being awarded a SINERGIA grant and on the average grade received by the selection committee.

Table 4 has as main explanatory variable the dummy *Novel responsible applicant*. Column 1 reports the Probit regression results

Table 4. Propensity to be awarded a SINERGIA grant and grade assigned to the application as function of having a novel responsible applicant. For Probit estimations, marginal effects are reported.[11]

	(1) Probit Awarded	(2) OLS Grade
Novel responsible applicant	−0.31***	−0.70**
	(0.085)	(0.35)
Academic profile of the applicants		
Average seniority	−0.0048	−0.0042
	(0.0087)	(0.025)
Other active funding	0.23**	0.53
	(0.10)	(0.34)
Previous expired funding	0.066	0.17
	(0.098)	(0.29)
Previous SINERGIA application	0.092	−0.12
	(0.11)	(0.32)
Previous SINERGIA awarded	−0.057	−0.24
	(0.12)	(0.34)
Publication count	−0.0012	0.0081
	(0.0030)	(0.0086)
Average IF	0.023	0.10
	(0.025)	(0.074)
Average citations	0.0055	0.014
	(0.023)	(0.068)
Average co-authors	0.032	0.10
	(0.044)	(0.13)
Average N. of journal combinations	−0.00053	−0.00081
	(0.00099)	(0.0029)
Application characteristics		
N. of co-applicants	−0.061*	−0.094
	(0.032)	(0.093)
Swiss team	0.067	0.21
	(0.12)	(0.34)
At least one female researcher	−0.075	−0.14
	(0.080)	(0.23)
Science & Medicine	−0.30**	−0.96**
	(0.15)	(0.43)
Log(Amount Requested)	0.13	0.61**
	(0.10)	(0.30)
N. of disciplines	−0.023	−0.069
	(0.019)	(0.053)
Constant		2.43***
		(0.91)
Dummy application year	Yes	Yes
Dummy institution	Yes	Yes
Dummy discipline	Yes	Yes
Observations	255	255
Pseudo-R^2/R^2	0.175	0.230

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***P < 0.01, **P < 0.05, *P < 0.1.

estimating the coefficient of *Novel responsible applicant* and controlling for a broad range of variables such as demographic attributes of the applicants (*Average seniority*), funding profile (*Other active funding* and *Previous expired funding*, *Previous SINERGIA application*, *Previous SINERGIA awarded*), bibliometric measures (*Publication count*, *Average IF*, *Publication count*, *Average citations*, *Average co-authors*, and *N. of journal combinations*), and characteristics of the application (*Swiss team*, *At least one female researcher*, *Amount requested*, *N. of co-applicants*, *N. of disciplines*, *Science & Medicine*). Column 2 reports the ordinary least square (OLS) estimations explaining the *Grade* with the same set of regressors.

To perform a more in-depth investigation, Table 5 considers as main explanatory variable the *Share of novel applicants* giving the proportion of novel scientists in the applying team. Table 5 helps assessing a potential bias against novel scientists beyond the profile of the responsible applicant. Column 1 reports the Probit regression results with *Share of novel applicants* as main explanatory variable controlling for the same variables as in Table 3 while Column 2 exhibits the OLS estimation explaining the *Grade* with the same set of explanatory variables.

Furthermore, in an attempt to investigate possible non-linearities of the effect of the *Share of novel applicants*, Table 5 also includes in Columns 3 and 4 a regression with tercile dummies of the share of novel applicants in the team. Specifically, in these two columns, the main explanatory variables are the dummies 0 < *Share of novel applicants* ≤ 1/3, 1/3 < *Share of novel applicants* ≤ 2/3, and *2/3< Share of novel applicants* ≤ 1 equal to one if the share of novel scientists is strictly comprised between the two bounds; the reference being applications with no novel scientists listed on the application. Among the applications with at least one novel scientist in the team, 34.3 per cent have a share of novel applicants between 0 (excluded) and 1/3, 41.5 per cent between 1/3 (excluded) and 2/3, and 24.2 per cent between 2/3 (excluded) and 1.

The results of Table 4 suggest a bias against novel scientists in the attribution of the grade by the committee and the awarding of the grant. Our findings suggest that applications with a novel responsible applicant receive, on average, 0.70 points less (on a maximum of 6) than applications with a non-novel responsible applicant and have 31 per cent less chance of getting awarded when controlling for other observables. The results on the other individual explanatory variables are in line with previous findings of the literature on funding. We observe the so-called Matthew effect at play (Merton 1968), early successes increasing future success chances, in being successful in fundraising. Scientists having other active grants have, on average, 23 per cent more chances of being awarded funds. This observation is in line with the recent findings of Bol et al. (2018) suggesting that even controlling for the quality of the scientist, awarded scientists accumulate around twice as many funds as non-awarded scientists in the eight years following the grant. For the rest, we find no significant effect of bibliometric characteristics of applicants on the probability of being awarded suggesting that the scientific quality is rather homogeneous among applicants and it is therefore not decisive for getting funded.

As for team-level characteristics, we observe that asking for a greater amount increases the grade received by the application suggesting that larger projects tend to be favored by the committee, with 0.61 points more on the grade for every million Swiss Francs requested by the applying team. Finally, concerning the subject of the project, we observe that Science & Medicine applications are less appreciated on average with 0.96 fewer grade points and around 30 per cent lower odds of being funded for applications in Science & Medicine.

The results of Table 5 confirm a bias of the committee against novel scientists since having a higher share of novel scientists in the team induces lower ratings by the committee and a lower probability of being awarded the grant. However, interestingly, the results of Columns 3 and 4 indicate that the effect of the novelty profile of applicants on the probability of being awarded is not linear. Only the applications with a high share of novel scientists onboard are significantly associated with lower ratings by the committee and a

Table 5. Propensity to be granted a SINERGIA grant and grade assigned as function of the share of novel applicants in the team. For Probit estimations, marginal effects reported.[12]

	(1) Probit Awarded	(2) OLS Grade	(3) Probit Awarded	(4) OLS Grade
Share of novel applicants	−0.50***	−1.21**		
	(0.18)	(0.51)		
No novel applicants			Ref.	Ref.
0 < Share of novel applicants ≤ 1/3			0.032	−0.18
			(0.13)	(0.36)
1/3 < Share of novel applicants ≤ 2/3			−0.19*	−0.45
			(0.11)	(0.35)
2/3 < Share of novel applicants ≤ 1			−0.32***	−0.96**
			(0.097)	(0.44)
Academic profile of the applicants				
Average seniority	−0.0039	−0.00030	−0.0041	−0.000064
	(0.0087)	(0.025)	(0.0088)	(0.025)
Other active funding	0.23**	0.52	0.23**	0.54
	(0.10)	(0.34)	(0.10)	(0.35)
Previous expired funding	0.046	0.15	0.043	0.13
	(0.099)	(0.28)	(0.100)	(0.29)
Previous SINERGIA application	0.10	−0.078	0.10	−0.078
	(0.11)	(0.32)	(0.11)	(0.32)
Previous SINERGIA awarded	−0.064	−0.24	−0.047	−0.24
	(0.12)	(0.34)	(0.12)	(0.35)
Publication count	−0.00033	0.0100	−0.00036	0.0094
	(0.0030)	(0.0085)	(0.0030)	(0.0086)
Average IF	0.028	0.11	0.030	0.11
	(0.025)	(0.073)	(0.026)	(0.074)
Average citations	0.0038	0.012	0.0058	0.011
	(0.023)	(0.067)	(0.023)	(0.068)
Average co-authors	0.030	0.093	0.027	0.089
	(0.044)	(0.13)	(0.044)	(0.13)
Average N. of journal combinations	−0.00073	−0.0010	−0.00097	−0.0013
	(0.00099)	(0.0029)	(0.0010)	(0.0029)
Application characteristics				
N. of co-applicants	−0.067**	−0.10	−0.072**	−0.11
	(0.033)	(0.093)	(0.033)	(0.094)
Swiss team	0.076	0.20	0.100	0.22
	(0.12)	(0.34)	(0.12)	(0.34)
At least one female researcher	−0.077	−0.16	−0.080	−0.16
	(0.079)	(0.23)	(0.080)	(0.23)
Science & Medicine	−0.23	−0.79*	−0.22	−0.79*
	(0.15)	(0.43)	(0.15)	(0.43)
Log(Amount Requested)	0.13	0.60**	0.14	0.61**
	(0.10)	(0.30)	(0.10)	(0.30)
N. of disciplines	−0.027	−0.080	−0.027	−0.084
	(0.019)	(0.053)	(0.019)	(0.053)
Constant		2.45***		2.50***
		(0.90)		(0.91)
Dummy application year	Yes	Yes	Yes	Yes
Dummy institution	Yes	Yes	Yes	Yes
Dummy discipline	Yes	Yes	Yes	Yes
Observations	255	255	255	255
Pseudo-R^2/R^2	0.172	0.235	0.174	0.234

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***P < 0.01, **P < 0.05, *P < 0.1.

lower probability of being awarded. This last result suggests that a small share of novel scientists in the application is not detrimental for obtaining the grant, but large shares are.

Table 6 reports the regression results estimating the impact of a scientist's characteristics, and novelty in particular, on her probability of applying for a SINERGIA grant. Column 1 reports the Probit regression results with *Novel scientist* as the main explanatory variable controlling for the number of publications (*Publication count*) and journals cited by the scientist (*N. of journal combinations*). Column 2 exhibits the results of the regression integrating a broader range of explanatory variables such as *Seniority*, funding profile (*Other active funding* and *Previous expired funding*), and

Table 6. Propensity to apply for SINERGIA based. Probit estimations, marginal effects reported.[13]

	(1) Probit Applicant	(2) Probit Applicant
Novel scientist	0.016***	0.0032***
	(0.0029)	(0.0011)
Academic profile		
Seniority		0.000067***
		(0.000019)
Other active funding		0.013***
		(0.0018)
Previous expired funding		0.0013**
		(0.00061)
Publication record		
Publication count		0.00018***
		(0.000016)
Average IF		0.00025***
		(0.000051)
Average citations		−0.00044***
		(0.000060)
Average co-authors		0.0021***
		(0.00015)
Average N. of journal combinations		−7.6e−07
		(1.8e−06)
Dummy application year	Yes	Yes
Dummy discipline	Yes	Yes
Dummy affiliation	Yes	Yes
Observations	48,499	48,499
Pseudo-R^2	0.320	0.489

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

bibliometric characteristics (*Average IF*, *Publication count*, *Average citations*, and *Average co-authors*).

Results exposed in Table 6 show that novel scientists are more likely to apply for a SINERGIA grant than non-novel ones, which suggests that, despite the committee's bias, novel scientists are not discouraged from asking for funds. Specifically, being novel increases the probability of applying to SINERGIA by 0.32 percentage points. Comparing this value to the average probability of applying to the grant for a random Swiss scientist (1,060/48,499 = 2.19 per cent), it represents a 14.61 per cent higher probability of applying for novel scientists compared with non-novel scientists.

Concerning the funding ability profile, we find that scientists holding other active funds at the moment of the application have a 1.3 per cent higher probability of applying for a SINERGIA grant. This last observation seems to rebut the hypothesis of Bol et al. (2018) suggesting that the Matthew effect in funding is partly driven by a 'participation effect' with scientists having raised fewer funds before the application time being discouraged from applying. Finally, as expected, we observe that more senior scientists and scientists with stronger scientific profiles—that is a higher number of publications and higher average impact factor of the journals where they publish—and a broader network (more co-authors) are more confident in applying for SINERGIA, but these effects remain quite weak on average.

In Appendix B, we assess the robustness of our results to changes in our novelty definition. Specifically, we make our novelty definition more stringent, requiring more reuses of the unprecedented combination of journal after its first appearance to be defined as novel (i.e. twenty-five reuses instead of twenty). In Table B.1, replicating the econometric exercises conducted in Tables 4 and 5, and in Table B.2, replicating the econometric exercises conducted in Table 6, we find substantial coherence with our main findings.

5. Discussion and conclusion

The intrinsic nature of novel research involving strong potential and high uncertainty makes it theoretically the ideal candidate for public funding (Nelson 1959; Arrow 1962). However, with its long-term impact and limited short-term recognition (Wang et al. 2017), novel research might struggle to ensure the necessary funds for its success. As suggested by Nicholson and Ioannidis (2012), it seems that the rule in science funding is closer to 'Conform and be funded' than to push for the most novel proposals. Similarly, Stephan et al. (2017) express their concerns on the existence of a bias against novelty in science. They warn that if funding agencies follow only short-term standard bibliometric measures in their decision of funding, then, although essential in the production of impactful science; novel research will be underfunded. Following their suggestion for empirical evidence on this bias, we empirically investigate the potential selection bias of evaluators against novel scientists.

Using extensive data on all applicants for a Swiss grant, our study confirms a bias against novel researchers in funding. We find that applications with a novel responsible applicant have, on average, 31 per cent fewer chances of being awarded by the selection committee and that large shares of novel applicants in a proposal are detrimental for being funded. Interestingly, looking more in detail at the share of novel scientists in the proponent team, we find that the effect is rather skewed and that only having a high proportion of novel scientists in the application is prejudicial for getting the funds while a small amount of novelty is not depreciated. Our findings are in line with the results observed in France with data from the French funding Agency (ANR) suggesting that more interdisciplinary and non-conventional research has lower chances of being funded (Lanoë 2018). Our results also complement the existing literature evaluating the effect of a scientist's profile on her ability to raise funds (Bornmann et al. 2007; Ginther et al. 2011). Showing that the tendency of a scientist to produce novel research reduces her chances to obtain funds, we bring further evidence of the inability of the current public funding system to ensure the 'norm of universalism' that Merton (1973) deems essential for the proper functioning of science. Several scholars have questioned the ability of the current single-blind peer-review system to efficiently allocate funds across researchers (Bornmann et al. 2007; Graves et al. 2011; Ioannidis 2011) putting forward the complexity of predicting future scientific successes and the persistence of biases in the judgment of the work of scientific peers. Potential alternatives such as collective allocation (Bollen et al. 2014), modified lotteries (Fang and Casadevall 2016), or focal randomization in the assignment of funds (Brezis 2007) have been suggested to replace the current system. These solutions have to be judged through the lens of accounting for the bias against novel researchers.

In order to assess the efficiency of the funding system, one must consider all the players involved. Limiting the focus on the impact of the allocation system on agents active in the funding system we could overlook the impact of being a novel scientist on the access to research funds. We contribute to concerns on potential repercussions of the bias against novel researchers on their motivation to apply. We find that novel scientists are on average, not discouraged from taking their chance in asking for public funds to finance their research. This result might look surprising regarding our first result on the lower chances of success of novel scientists. If novel scientists know they have lower chances of receiving the grant, why do they invest time to apply? One possible explanation is imperfect information. In other words, scientists collect their information about the grant from the description of the call of SINERGIA grant rather than on a detailed analysis of past awarded researchers. As specified in Section 3, SINERGIA calls for collaborative research that brings different disciplines together to create breakthrough science. In this context, we might expect that novel scientists working on unconventional ideas have an incentive to apply to get funds for their projects spanning the scientific disciplines' boundaries. Another potential explanation is that novel scientists do not self-select out of the funding competition driven by their intrinsic motives to bring recognition to unconventional ideas and projects. As suggested by Blasco et al. (2019), intrinsic motives such as public recognition and social contribution have a significant impact on the decision to participate in a competition even if the chances of winning are low.

Our results are a first step toward assessing the bias when evaluating the applicants' profiles and open for new line of research that deserves further investigation. We observe a direct effect of bias in the evaluation of the scientific profile of the applicants, with the evaluation committee disregarding the rather risky nature of the previous 'novel' contributions of the applying scientist. However, novel scientists might be also more inclined to produce a novel proposal that is in itself less attractive for reviewers of the proposal (Boudreau et al. 2012). Hence, one could further explore our line of research by combining our results at the researcher level with results at the proposal level. Doing so, we could judge whether the bias is mainly driven by the perception of a risky scientific profile of the applicant or by the riskiness of the proposed project or both. Furthermore, more evidence should be constructed to better understand the sources of bias against novelty and its consequences. For instance, it would be important to evaluate whether novel researchers are discouraged by not being awarded, and stop the projects they asked funds for, or if they manage to implement their project regardless the funds as suggested by Ayoubi et al. (2019). Furthermore, the need for a better consideration of novelty in the academic sphere is not limited to the access to funds and additional research is needed to test whether the bias against novelty also applies in the context of scientific publishing. In fact, several scholars have questioned the capacity of the peer review process to select and promote novel breakthrough research (Chubin and Hackett 1990; Braben 2004). Some of them suggesting that to be successful in the academic environment, a research agenda should not be too different from the incumbent scientific paradigm (Planck 1950; Kuhn 1962; Merton 1973; Trapido 2015).

Beyond the scientific realm, our findings inform other literature streams exploring the key components of success in competitive selection processes. Relying on expert evaluations to perform a selection is a common practice for several uncertain but potentially highly consequential choices such as venture capital investment or job candidates' recruitment (Baron and Hannan 2002; Baum and Silverman 2004). Entrepreneurship scholars have long investigated the factors influencing the decision of investors when picking the startup to fund (Chan 1983). Extant literature explores two sets of features affecting the decision process: the entrepreneurs' characteristics and the specificities of the project presented (MacMillan et al. 1985). Our results contribute to the corpus of empirical evidence underlining the importance of the profile of the proponent on success (MacMillan et al. 1987; Vogel et al. 2014) by indicating that investors could be overlooking highly novel startup projects with a risk of missing out on potentially profitable businesses. Similarly, in the context of a highly competitive job market,[10] we bring further empirical evidence to the observations of Zuckerman et al. (2003) with our findings suggesting that candidates combining unusual job experiences could be discriminated compared with more conventional profiles.

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Conflict of interest statement

None declared.

Notes

1. Source: NIH Funding Facts, https://report.nih.gov/funding-facts/fundingfacts.aspx.
2. The authors state that 'the system now favors those who can guarantee results rather than those with potentially path-breaking ideas that, by definition, cannot promise success'.
3. To establish this distance, they identify common 'friends', that is journals often referenced with each of the two journals forming the combination. The distance function is then computed as follows: lower occurrences of common friends lead to higher distance between the two journals of the combination.
4. Boudreau et al. (2016) use MeSH terms combinations to evaluate the novelty of an article while Carayol et al. (2018) use the authors' keywords.
5. http://www.snf.ch/SiteCollectionDocuments/sinergia_leitfaden_e.pdf.
6. SINERGIA has recorded a stable success rate also in more recent years. In its latest call, the SNSF communicated about receiving fifty-eight applications, financing twenty-three of them, which represents a success rate of around 40 per cent, for a total investment of 50 million Swiss francs, that is 10 per cent of the SNSF's total investment in Science in 2019. http://www.snf.ch/en/researchinFocus/newsroom/Pages/news-191209-50-million-francs-for-sinergia-projects.aspx.
7. To evaluate if a combination of two journals (J1 and J2), appearing in the references of an article published in the year $t = 2005$ for instance, is novel, we search all the articles published in the five years before the publication

year *t* (2000–2004) in the web of science database. Doing so, we then check if the combination J1–J2 has appeared in the references of a published article before. If it has not appeared before then we note the combination of the journals J1–J2 as novel.

8. Publications are available starting from 2000. Our universe of articles is represented by all the articles that appear in the journals of the disciplines where Switzerland is active, that is those journals which published at least 200 articles signed by a Swiss researcher in the last 18 years (2000–2017). We look at 306 journals including top-ranked as well as less prestigious journals. To identify novel combinations, we define a buffer period of five years that represents the minimum period needed to claim that the journal combination is novel.
9. University of Neuchatel, ETHZ, EPFL, University of Lausanne, University of Fribourg, University of Genève, University of Bern, University of Basel, University of Lugano, University of Zurich, University of Luzern, and University of St. Gallen.
10. According to Glassdoor (Glassdoor U.S. Site Survey, January 2016) each corporate job offer attracts 250 applications, less than six candidates then reach the interview stage and only one succeeds in obtaining the job.
11. In Appendix A, we report OLS estimations for Tables 4 and 5 in Table A.1.
12. In Appendix A, we report OLS estimations for Table 5 in Table A.2.
13. In Appendix A, we report OLS estimations for Table 5 in Table A.3[AQ]Table A.3 is cited in the text footnote but not provided in the text. Please check.

References

Arora. et al., (2018). XXXX.

Arrow, K. J. (1962) 'Economic Welfare and the Allocation of Resources'. In Universities-National Bureau Committee for Research Economic, Committee on Economic Growth of the Social Science Research Council (ed.), *The Rate and Direction of Inventive Activity, Princeton University Press, New Jersey, pp. 609 - 626*.

——— (1972). 'Economic Welfare and the Allocation of Resources for Invention'. In: *Readings in Industrial Economics*, pp. 219–36. Palgrave: London.

Ayoubi, C., Pezzoni, M., and Visentin, F. (2017) 'At the Origins of Learning: Absorbing Knowledge Flows from Within or Outside the Team?', *Journal of Economic Behavior and Organization*, 134: 374–87.

———, ———, and ——— (2019) 'The Important Thing Is Not to Win, It Is to Take Part: What If Scientists Benefit from Participating in Research Grant Competitions?', *Research Policy*, 48/1: 84–97.

Azoulay, P., Graff Zivin, J. S., and Manso, G. (2011) 'Incentives and Creativity: Evidence from the Academic Life Sciences', *The RAND Journal of Economics*, 42/3: 527–54.

———, Stuart, T., and Wang, Y. (2013) 'Matthew: Effect or Fable?', *Management Science*, 60/1: 92–109.

Baron, J. N. and Hannan, M. T. (2002) 'Organizational Blueprints for Success in High-Tech Start-Ups: Lessons from the Stanford Project on Emerging Companies', *California Management Review*, 44/3: 8–36.

Baum, J. A. C. and Silverman B. S.(2004) 'Picking Winners or Building Them? Alliance, Intellectual, and Human Capital as Selection Criteria in Venture Financing and Performance of Biotechnology Startups', *Journal of business venturing*, 19/3: 411–36.

Blasco, A., Jung, O. S., Lakhani, K. R. et al. (2019) 'Incentives for Public Goods inside Organizations: Field Experimental Evidence', *Journal of Economic Behavior & Organization*, 160: 214–29.

Bloom, N., Jones, C. I., Van Reenen, J. et al. (2017) 'Are Ideas Getting Harder to Find?' (No. w23782). *National Bureau of Economic Research*.

Bol, T., de Vaan, M., and van de Rijt, A. (2018) 'The Matthew Effect in Science Funding', *Proceedings of the National Academy of Sciences of the United States of America*, 115/19: 4887–90.

Bollen, J., Crandall, D., Junk, D. et al. (2014) 'From Funding Agencies to Scientific Agency: Collective Allocation of Science Funding as an Alternative to Peer Review', *EMBO Reports*, 15/2: 131–3.

Bornmann, L., Mutz, R., and Daniel, H.-D. (2007) 'Gender Differences in Grant Peer Review: A Meta-Analysis', *Journal of Informetrics*, 1/3: 226–38.

———, Tekles, A., Zhang, H. H. et al. (2019) 'Do We Measure Novelty When We Analyze Unusual Combinations of Cited References? A Validation Study of Bibliometric Novelty Indicators Based on F1000Prime Data', *Journal of Informetrics*, 13/4: 100979.

Boudreau, K., Guinan, E. C., Lakhani, K. R. et al. (2012) 'The Novelty Paradox & Bias for Normal Science: Evidence from Randomized Medical Grant Proposal Evaluations'. *Harvard Business School working paper series# 13-053*.

Boudreau, K. J., ———, Lakhani, K. R. et al. (2016) 'Looking across and Looking beyond the Knowledge Frontier: Intellectual Distance, Novelty, and Resource Allocation in Science', *Management Science*, 62/10: 2765–83.

Braben, D. W. (2004) *Pioneering Research: A Risk Worth Taking*. John Wiley & Sons, Hoboken, New Jersey.

Brezis, E. S. (2007) 'Focal Randomisation: An Optimal Mechanism for the Evaluation of R&D Projects', *Science and Public Policy*, 34/10: 691–8.

Carayol, N., A., Lahatte, and O, Llopis. (2018) The Right Job and the Job Right: Novelty, Impact and Journal Stratification in Science, Available at SSRN: https://ssrn.com/abstract=3347326.

Chan, Y.-S. (1983) 'On the Positive Role of Financial Intermediation in Allocation of Venture Capital in a Market with Imperfect Information', *The Journal of Finance*, 38/5: 1543–68.

Chubin, D. E., Hackett, E. J., and Hackett, E. J. (1990) *Peerless Science: Peer Review and US Science Policy*. Suny Press.

Etzkowitz, H. (2003) 'Research Groups as "Quasi-firms": The Invention of the Entrepreneurial University', *Research Policy*, 32(1): 109–21.

Fang, F. C. and Casadevall A. (2016) 'Research Funding: The Case for a Modified Lottery'. 7(2): 1-7.

Fleming, L., Greene, H., Li, G. et al. (2019) 'Government-Funded Research Increasingly Fuels Innovation', *Science*, 364/6446: 1139–41.

———, Mingo, S., and Chen, D. (2007) 'Collaborative Brokerage, Generative Creativity, and Creative Success', *Administrative science quarterly*, 52/3: 443–75.

Ginther, D. K., Schaffer, W. T., Schnell, J. et al. (2011) 'Race, Ethnicity, and NIH Research Awards', *Science*, 333/6045: 1015–9.

Graves, N., Barnett, A. G., and Clarke, P. (2011) 'Funding Grant Proposals for Scientific Research: Retrospective Analysis of Scores by Members of Grant Review Panel', *BMJ* 343: d4797.

Ioannidis, J. P. A. (2011) 'More Time for Research: Fund People Not Projects', *Nature*, 477/7366: 529.

Kuhn, T. S. (1962) The Structure of Scientific Revolutions. University of Chicago press, Chicago.

Lanoë, M. (2018) '*The Evaluation of Competitive Research Funding: An Application to French Programs*', Doctoral dissertation, Bordeaux.

Li, D. (2017) 'Expertise versus Bias in Evaluation: Evidence from the NIH', *American Economic Journal: Applied Economics*, 9/2: 60–92.

Lorsch, J. R. (2015) 'Maximizing the Return on Taxpayers' Investments in Fundamental Biomedical Research', *Molecular Biology of the Cell*, 26/9: 1578–82.

MacMillan, I. C., Siegel, R., and Subba Narasimha, P. N. (1985) 'Criteria Used by Venture Capitalists to Evaluate New Venture Proposals', *Journal of Business venturing*, 1/1: 119–128.

———, Zemann, L., and Subbanarasimha, P. N. (1987) 'Criteria Distinguishing Successful from Unsuccessful Ventures in the Venture Screening Process', *Journal of Business Venturing*, 2/2: 123–37.

Mairesse, J. and Michele, P. (2018) Novelty in Science: The Impact of French Physicists' Novel Articles. *Conference Proceedings STI2018*.

Merton, R. K. (1973) 'The Normative Structure of Science', In: N. W., Storer (ed.) *The Sociology of Science: Theoretical and Empirical Investigations*, pp. 267–73. University of Chicago Press: Chicago.

—— (1968) 'The Matthew Effect in Science', *Science*, 159/3810: 56–63.

Nelson, R. R. (1959) 'The Simple Economics of Basic Scientific Research', *Journal of Political Economy*, 67/3: 297–306.

Nicholson, J. M. and Ioannidis, J. P. A. (2012) 'Research Grants: Conform and Be Funded', *Nature*, 492/7427: 34.

Pezzoni, M., Veugelers, R., and Visentin, F. (2018) 'Is This Novel Technology Going to Hit?', *Academy of Management Proceedings*, 2018/1.

Planck, M. (1950) 'Scientific Autobiography, and Other Papers with a Memorial Address on Max Planck by Max von Laue'. Translated From German by Frank Gaynor.

Poege, F., Harhoff, D., Gaessler, F. et al. (2019) 'Science Quality and the Value of Inventions', *Science Advances*, 5/12: eaay7323.

Romer, P. M. (1986) 'Increasing Returns and Long-Run Growth', *Journal of Political Economy*, 94/5: 1002–37.

—— (1990) 'Endogenous Technological Change', *Journal of Political Economy*, 98/5: S71–S102.

SNSF. (2011) Regulation on Sinergia Grants. National Research Council. http://www.snf.ch/SiteCollectionDocuments/sinergia_reglement_e.pdf.

Stein, M.I., (1963). A transactional approach to creativity, In C. W. Taylor and F. Barron (eds.),Scientific Creativity: Its Recognition and Development, New York: Wiley.

Stephan, P. (2010) 'The Economics of Science: Funding for Research', *International Centre for Economic Research Working Paper No*. 12.

Stephan, P. E. (2012) *How Economics Shapes Science*. Vol. 1. Cambridge, MA: Harvard University Press.

Stephan, P., Veugelers, R., and Wang, J. (2017) 'Blinkered by Bibliometrics', *Nature*, 544/7651: 411–2.

Trapido, D. (2015) 'How Novelty in Knowledge Earns Recognition: The Role of Consistent Identities', *Research Policy*, 44/8: 1488–500.

Uzzi, B., Mukherjee, S., Stringer, M. et al. (2013) 'Atypical Combinations and Scientific Impact', *Science*, 342: 468–72.

Vogel, R., Puhan, T. X., Shehu, E. et al. (2014) 'Funding Decisions and Entrepreneurial Team Diversity: A Field Study', *Journal of Economic Behavior & Organization*, 107: 595–613.

Wagner, C. S., Whetsell, T. A., and Mukherjee, S. (2019) 'International Research Collaboration: Novelty, Conventionality, and Atypicality in Knowledge Recombination', *Research Policy*, 48/5: 1260–1270.

Wang, J., Veugelers, R., and Stephan, P. (2017) 'Bias against Novelty in Science: A Cautionary Tale for Users of Bibliometric Indicators', *Research Policy*, 46: 1416–1436.

Zuckerman, E. W., Kim, T.-Y., Ukanwa, K. et al. (2003) 'Robust Identities or Nonentities? Typecasting in the Feature-Film Labor Market', *American Journal of Sociology*, 108/5: 1018–74.

Appendix A

This appendix reports in Table A.1 the OLS estimates for the regression models in Column 1 of Table 4 and Columns 1 and 3 of Table 5. Table A.2 reports the OLS estimations of the model in Table 6. Results are qualitatively the same as applying Probit estimations.

Table A.1. Propensity to be awarded a SINERGIA grant. OLS estimations.

	(1) OLS Awarded	(2) OLS Awarded	(3) OLS Awarded
Novel responsible applicant	−0.29***		
	(0.11)		
Share of novel applicants		−0.39**	
		(0.16)	
No novel applicants			Ref.
$0 <$ Share of novel applicants $\leq 1/3$			0.023
			(0.12)
$1/3 <$ Share of novel applicants $\leq 2/3$			−0.16
			(0.11)
$2/3 <$ Share of novel applicants ≤ 1			−0.31**
			(0.14)
Academic profile of the applicants			
Average seniority	−0.0030	−0.0024	−0.0025
	(0.0079)	(0.0079)	(0.0080)
Other active funding	0.19*	0.19*	0.19*
	(0.11)	(0.11)	(0.11)
Previous expired funding	0.052	0.038	0.037
	(0.090)	(0.090)	(0.091)
Previous SINERGIA application	0.075	0.091	0.088
	(0.10)	(0.10)	(0.10)
Previous SINERGIA awarded	−0.074	−0.074	−0.058
	(0.11)	(0.11)	(0.11)
Publication count	−0.00071	−0.000050	−0.00012
	(0.0027)	(0.0027)	(0.0027)
Average IF	0.021	0.025	0.026
	(0.023)	(0.023)	(0.024)
Average citations	0.0064	0.0043	0.0049
	(0.021)	(0.021)	(0.021)
Average co-authors	0.030	0.027	0.025
	(0.040)	(0.040)	(0.041)
Average N. of journal combinations	−0.00068	−0.00077	−0.00093
	(0.00092)	(0.00092)	(0.00093)
Application characteristics			
N. of co-applicants	−0.050*	−0.052*	−0.056*
	(0.029)	(0.029)	(0.030)
Swiss team	0.057	0.058	0.076
	(0.11)	(0.11)	(0.11)
At least one female researcher	−0.048	−0.049	−0.052
	(0.072)	(0.072)	(0.073)
Science & Medicine	−0.21	−0.15	−0.14
	(0.14)	(0.14)	(0.14)
Log(Amount Requested)	0.11	0.10	0.11
	(0.094)	(0.094)	(0.095)
N. of disciplines	−0.016	−0.020	−0.021
	(0.017)	(0.017)	(0.017)
Constant	0.41	0.41	0.44
	(0.29)	(0.29)	(0.29)
Dummy application year	Yes	Yes	Yes
Dummy Institution	Yes	Yes	Yes
Dummy discipline	Yes	Yes	Yes
Observations	255	255	255
R^2	0.212	0.208	0.211

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***P < 0.01, **P < 0.05, *P < 0.1.

Table A.2. Propensity to apply for SINERGIA. OLS estimations.

	(1) OLS Applicant	(2) OLS Applicant
Novel scientist	0.031***	0.013***
	(0.0027)	(0.0026)
Academic profile		
Seniority		−0.00024***
		(0.000066)
Other active funding		0.051***
		(0.0023)
Previous expired funding		0.0077***
		(0.0020)
Publication record		
Publication count		0.0025***
		(0.000057)
Average IF		0.00034**
		(0.00016)
Average citations		−0.00091***
		(0.00011)
Average co-authors		0.011***
		(0.00034)
Average N. of journal combinations		$-2.1\,^{*}\,10^{-6}$
		$(4.5\,^{*}\,10^{-6})$
Constant	−0.0083***	−0.046***
	(0.0020)	(0.0024)
Dummy application year	Yes	Yes
Dummy discipline	Yes	Yes
Dummy affiliation	Yes	Yes
Observations	48,499	48,499
R^2	0.244	0.308

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***P < 0.01, **P < 0.05, *P < 0.1.

Appendix B

This appendix aims to assess whether adopting a more stringent definition of novelty impacts the results that we obtained. The most important parameter in our novelty definition is the number of reuses imposed when looking at the appearance of an unprecedented combination of journals. In the main text, we impose at least twenty reuses in the next five years after the appearance of the unprecedented combination of journals. In this appendix, we impose a higher threshold to define novelty, that is twenty-five reuses. This higher threshold makes it less likely to observe novel articles and, therefore, novel scientists.

When we impose twenty-five reuses to define novelty, the main applicant is a novel scientist in 10.98 per cent of the cases (13.7 per cent with the standard parameterization), while the average share of novel scientists in the team is 11.8 per cent (16.52 per cent with the standard parameterization). In the whole population of Swiss scientists, 3.8 per cent are novel scientists (5.1 per cent with the standard parameterization). The results of the main regression exercises with this alternative definition of novelty are reported in Tables B.1 and B.2. Comparing Table B.1, Columns 1 and 2, with Table 4 in the main text, we find coherent signs for the coefficient of the variable *Novel responsible applicant*, although the coefficient loses its

Table B.1. Propensity to be awarded a SINERGIA grant. Novelty defined using a threshold of twenty-five reuses.

	(1) Probit Awarded	(2) OLS Grade	(3) Probit Awarded	(4) OLS Grade	(5) Probit Awarded	(6) OLS Grade
Novel responsible applicant	−0.20*	−0.40				
	(0.11)	(0.38)				
Share of novel applicants			−0.41**	−1.07*		
			(0.21)	(0.58)		
No novel applicants					Ref.	Ref.
0 < Share of novel applicants ≤ 1/3					0.089	−0.16
					(0.14)	(0.41)
1/3 < Share of novel applicants ≤ 2/3					−0.21**	−0.61
					(0.11)	(0.37)
2/3 < Share of novel applicants ≤ 1					−0.24*	−0.71
					(0.13)	(0.51)
Academic profile of the applicants						
Average seniority	−0.0067	−0.0089	−0.0052	−0.0038	−0.0049	−0.0032
	(0.0087)	(0.025)	(0.0087)	(0.025)	(0.0088)	(0.025)
Other active funding	0.22**	0.52	0.22**	0.54	0.23**	0.54
	(0.10)	(0.35)	(0.10)	(0.35)	(0.10)	(0.35)
Previous expired funding	0.042	0.13	0.039	0.13	0.046	0.14
	(0.098)	(0.29)	(0.099)	(0.29)	(0.099)	(0.29)
Previous SINERGIA application	0.10	−0.092	0.095	−0.10	0.10	−0.079
	(0.11)	(0.32)	(0.11)	(0.32)	(0.11)	(0.32)
Previous SINERGIA awarded	−0.071	−0.27	−0.070	−0.26	−0.056	−0.26
	(0.11)	(0.35)	(0.11)	(0.35)	(0.12)	(0.35)
Publication count	−0.00067	0.0091	−0.00010	0.010	−0.00059	0.0095
	(0.0029)	(0.0086)	(0.0030)	(0.0086)	(0.0030)	(0.0086)
Average IF	0.025	0.11	0.030	0.12	0.029	0.12
	(0.025)	(0.074)	(0.025)	(0.074)	(0.025)	(0.074)
Average citations	0.0019	0.0017	0.0012	0.0030	0.0038	0.0057
	(0.023)	(0.068)	(0.023)	(0.067)	(0.023)	(0.068)
Average co-authors	0.031	0.10	0.031	0.100	0.027	0.095
	(0.044)	(0.13)	(0.044)	(0.13)	(0.044)	(0.13)
Average N. of journal combinations	−0.00060	−0.00088	−0.00073	−0.0011	−0.00092	−0.0014
	(0.00099)	(0.0029)	(0.00099)	(0.0029)	(0.0010)	(0.0029)
Application characteristics						
N. of co-applicants	−0.054*	−0.081	−0.058*	−0.087	−0.066**	−0.091
	(0.032)	(0.093)	(0.032)	(0.093)	(0.033)	(0.094)
Swiss team	0.080	0.23	0.100	0.26	0.12	0.30
	(0.12)	(0.34)	(0.12)	(0.34)	(0.12)	(0.34)
At least one female researcher	−0.057	−0.11	−0.066	−0.14	−0.077	−0.15
	(0.079)	(0.23)	(0.079)	(0.23)	(0.079)	(0.23)
Science & Medicine	−0.27*	−0.90**	−0.24	−0.83*	−0.21	−0.80*
	(0.15)	(0.44)	(0.15)	(0.43)	(0.15)	(0.44)
Log(Amount Requested)	0.13	0.61**	0.14	0.62**	0.14	0.62**
	(0.10)	(0.30)	(0.10)	(0.30)	(0.10)	(0.30)
N. of disciplines	−0.024	−0.074	−0.024	−0.076	−0.024	−0.078
	(0.019)	(0.053)	(0.019)	(0.053)	(0.019)	(0.053)
Constant		2.42***		2.30**		2.31**
		(0.91)		(0.91)		(0.91)
Dummy application year	Yes	Yes	Yes	Yes	Yes	Yes
Dummy institution	Yes	Yes	Yes	Yes	Yes	Yes
Dummy discipline	Yes	Yes	Yes	Yes	Yes	Yes
Observations	255	255	255	255	255	255
Pseudo-R^2/R^2	0.158	0.219	0.162	0.227	0.167	0.229

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***P < 0.01, **P < 0.05, *P < 0.1.

Table B.2. Propensity to apply for SINERGIA. Probit estimations, marginal effects reported. Novelty defined using a threshold of twenty-five reuses.

	(1) Probit Applicant	(2) Probit Applicant
Novel scientist	0.030***	0.0075***
	(0.0044)	(0.0018)
Academic profile		
Seniority		0.000064***
		(0.000019)
Other active funding		0.013***
		(0.0018)
Previous expired funding		0.0013**
		(0.00059)
Publication record		
Publication count		0.00017***
		(0.000016)
Average IF		0.00025***
		(0.000051)
Average citations		−0.00044***
		(0.000059)
Average co-authors		0.0021***
		(0.00015)
Average N. of journal combinations		−6.6e−07
		(1.8e−06)
Dummy Application year	Yes	Yes
Dummy Discipline	Yes	Yes
Dummy Affiliation	Yes	Yes
Pseudo-R2	0.325	0.492
Observations	48,499	48,499

In reporting the statistical significance of the coefficients, we apply the standard thresholds, that is ***$P < 0.01$, **$P < 0.05$, *$P < 0.1$.

significance when explaining the *Grade* (Column 2). Columns 3 and 4 of Table B.1 show coherent results with Table 5 in the main text (Columns 1 and 2) when estimating the *Share of novel applicants* coefficient. Results reported in Column 5 Table B.1, show that the coefficients of the set of dummy variables Share of novel applicants, are coherent with those reported in Table 5 Column 3. Differently from Table 5, the variable *2/3 < Share of novel applicants ≤ 1* loses its significance when explaining the *Grade* (Column 6), although keeping the same sign and magnitude of the coefficient. Concerning the regression results explaining the decision to apply for the grant (Table B.2), they are coherent with those reported in Table 6 in the main text. In the light of this robustness check, we can conclude that our results are sufficiently robust to the threshold chosen.