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Does it pay to do novel science? The selectivity patterns in science funding

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Does it Pay to Do Novel Science?

The Selectivity Patterns in Science Funding

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Abstract

Public funding of science aims to provide the necessary investment for the radical scientific discoveries of tomorrow. This paper brings evidence 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 lower chances of being funded.

Keywords: competitive research grants, public funding evaluation, novelty in science

JEL codes: I23, O38

1. Introduction

Public funding of science is currently witnessing a double hurdle in promoting the production of new ideas. 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 vast majority of biomedical research in the United States, has decreased from 33% in 2000 to 20% 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

[1] Source: NIH Funding Facts, https://report.nih.gov/fundingfacts/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".

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 (Bormann 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 these two phases of 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 maximising 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 profiles. Risk-averse funding agencies would minimise

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 favour 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 and his colleagues (2012) find that 'evaluators uniformly and systematically give lower scores to proposals with increasing novelty; i.e., there is an economically significant novelty discount.' 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 crafting 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. 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 labs 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 labs, 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, Zivin, and Manso (2011) find that less stringent grants such as the Howard Hughes Medical Institute (HHMI) 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 analyse 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 organised 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. In a seminal

work, Uzzi et al. (2013) used the combinations of referenced journals to determine the level of novelty of an article. Specifically, 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), and they compare it to a baseline frequency constructed with a randomised citation network. 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]. More recently, Mairesse and Pezzoni (2018) building on the approach of Wang et al. (2017), include the reuse of novel combinations to evaluate the impact of novelty which has been confirmed by follow-on research. Other approaches of novelty include the use of atypical keyword combination[4] (Boudreau et al., 2016; Carayol et al., 2018) and the new combination of IPC codes for evaluating the novelty of patents (Pezzoni et al., 2018).

The various novelty measures in the literature are constructed at the article level. We extend the concept of novelty from the article level to the level of the scientist. To do so, we build on Wang et al. (2017), and we consider that a scientist is novel in a given year if she has published a novel article in the three years before the year of observation. We define a publication including a novel scientific idea as an article reporting in its bibliography an

[3] To establish this distance, they identify common "friends", i.e. 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 value of 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.

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, i.e., that the combination of journals is reused in a minimum number of follow-on articles.

Having identified the novel scientists, we then analyse 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 Swiss National Science Foundation (SNSF)'s funding portfolio. As the principal funding agency in the country, the SNSF plays in Switzerland similar role as the National Science Foundation (NSF) in the United States. 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. 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 ERC 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]

To analyse 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 paper in the past 3-year window, from *t-1* to *t-3*. To estimate whether an article is novel at time *t* we run a comparison within the entire universe of existing papers at that time[6]. As detailed in the previous section, in defining novelty, we follow the combinatorial approach introduced by Uzzi et al. (2013) and adapted by Wang et al. (2017): novelty appears when existing knowledge components are combined for the first time to generate new knowledge. We identify the knowledge components on which a paper relies as the list of journals reported in its references (Uzzi et al. 2013, Wang et al. 2017, Ayoubi et al., 2017; Mairesse and Pezzoni 2018). For each

[5] http://www.snf.ch/SiteCollectionDocuments/sinergia_leitfaden_e.pdf

[6] 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, i.e. 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.

article, we calculate all the possible referenced journals' combinations and mark as novel an article where at least one of these combinations appears for the first time ever[7].

Subsequently, in evaluating the propensity to be awarded a SINERGIA grant, we consider as main explanatory variables the dummy *Novel responsible applicant*, capturing if the responsible applicant of the proposal is novel or not as well as the variable *Share of novel applicants* giving the proportion of novel scientists in the applying team.

The applications to SINERGIA involve 775 unique individuals with few cases of multiple applications for a total of 1060 application-applicant pairs. For the second part of the analysis, analysing 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[8] 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 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.

[7] For instance, in evaluating the novelty of the combination J1-J2 included in an article published in t=2005, we screen all the articles published in the period 2000-2004 to verify if the same combination J1-J2 have previously appeared. If not, then J1-J2 is a novel combination. We consider only successful novelty namely, the novelty that is reused in other scientific articles after its first appearance. Thus, we restrict our definition of novelty to the journal combinations that are used at least in 10 articles in the 5 years after their first appearance.

[8] 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.

For assessing the self-selection by scientists into applying for the grant, we consider as dependent variable the dummy *Applicant*, equal to one if the scientist applied for SINERGIA and zero otherwise. Then, as main explanatory variable, we use the dummy *Novel scientist*, equal to one if the scientist is novel and zero otherwise based on the definition of a novel scientist given above.

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 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 1 reports statistics on the independent variables of the two analyses conducted in Section 4, i.e., 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, the SINERGIA grant being awarded at the application level, in the first analysis on the propensity to be awarded, the academic profile variables of the applicants are adapted to the team. Specifically, in Table 1 Panel A, 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% have a novel responsible applicant, while the percentage rises to 18% for the non-awarded. Coherently, awarded applications hold a lower

share of novel applicant scientists than non-awarded applications (14% versus 18%). 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% include at least one applicant with other active funded projects, and 81% have at least one applicant who has benefited from funding in the past, while for non-awarded these percentages are 82% and 79%, respectively). Looking at the SINERGIA past application records, SNSF seems to slightly favour applicants who are new to the programme (62% of awarded applications had all their applicant at their first application compared to the 59% of non-awarded, 18% of the awarded applications have at least one member who has been already awarded a SINERGIA grant, compared to the 24% 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% are novel scientists in the case of the applicants, and only 5% 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% of them benefit from other active funding, and 36% had some alternative funding which 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% of the cases, benefited from funding that has expired in 10% of the cases, has 7.84 publications on journal with an average impact factor of 4.68, and counts 3.55 co-authors per paper.

Table 1: 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 obs.)			Non-Applicants to SINERGIA (15,121 Scientists) (47,439 obs.)		
	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

To better investigate the effect of novelty profile of applicants on the evaluation of the application, Table 2 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% and 14% of applications with a novel responsible applicant. However, below grade-class three, which marks the lower bound for being awarded, the proportion of applications with novel applicants is higher (between 13% and 21% 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% of applicants are novel, while only 5% 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.

Table 2: Proportion of novel responsible applicants and average share of novel scientists per application by grade class assigned to applications (grade on a scale 1 to 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

4. Selection of novel scientists

This section gives an overview of our results on the evaluation of selectivity patterns in the two phases of a research grant competition through the lens of scientific novelty. First, for the process of awarding the grant, we present the results on the potential selection bias of funding agencies in favour 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 3 and 4 exhibits 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 3 has as main explanatory variable the dummy *Novel responsible applicant*, equal to one if the responsible applicant of the proposal is novel and zero otherwise, to evaluate a potential bias against applications lead by a novel scientist. Column 1 gives the Probit regression results with *Novel responsible applicant* as main explanatory variable 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 on *Grade* with the same set of explanatory variables.

To perform a more in-depth investigation, Table 4 considers as main explanatory variable the *Share of novel applicants* giving the proportion of novel scientists in the applying team. The estimations of Table 4 help 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 on *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 4 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 scientists in the team, 34.3% has a share of novel applicants between 0 (excluded) and 1/3, 41.5% between 1/3 (excluded) and 2/3, and 24.2% between 2/3 (excluded) and 1.

Table 3: Propensity to be awarded a SINERGIA grant and grade based on observables. For Probit estimations, marginal effects are reported.

	(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-R2/R2	0.175	0.230

In reporting the statistical significance of the coefficients, we apply the standard thresholds, i.e., *** p<0.01, ** p<0.05, * * p<0.1.

Table 4: Propensity to be awarded a SINERGIA grant and grade based on observables. For Probit estimations, marginal effects are reported.

	(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 applicant			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-R2/R2	0,172	0.235	0,174	0.234

In reporting the statistical significance of the coefficients, we apply the standard thresholds, i.e., *** p<0.01, ** p<0.05, * * p<0.1.

The results of Table 3 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 0.70 points less (on a maximum of 6) on average than applications with a non-novel responsible applicant and have 31% 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% 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 favoured 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% lower odds of being funded for applications in Science & Medicine.

The results of Table 4 confirm a bias of the committee against novel scientists since having a higher share of novel scientists in the team induces lower rating 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 a lower rating by the committee and a lower probability of being awarded. This last result suggests that a small share of novel scientists in the application is not detrimental for getting the grant, but large shares are.

Table 5 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 gives the Probit regression results with novelty 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 bibliometric characteristics (*Average IF*, *Publication count*, *Average citations*, and *Average co-authors*).

Table 5: Propensity to apply for SINERGIA based on observables. Probit estimations, marginal effects reported.

	(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-R2	0,320	0,489

Results exposed in Table 5 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%), it represents a 14.61% higher probability of applying for novel scientists compared to non-novel scientists.

Concerning the funding ability profile, we find that scientists who have successfully raised funds in the past do not have a significantly higher propensity of applying to SINERGIA and scientists holding other active funds at the moment of the application have 1.3% 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 less funds before the application time being discouraged from applying. Finally, as expected, we observe that more senior scientists and scientists with stronger scientific profiles -i.e., 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.

5. Discussion and conclusion

Novel research involves strong potential and high uncertainty making it 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 could 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 boldest 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 novel responsible applicants have, on average, a 31% lower chance 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 details at the share of novel scientists in the applying 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 but a small amount of novelty is not depreciated. Our findings 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, 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 randomisation 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 – i.e., applicants to grants- 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.

Our results are a first step towards assessing the bias when evaluating the applicants' profile. Two effects could drive the observed bias against novel researchers. On the one hand, a direct effect of bias in the evaluation of the scientific profile of the applicants, with the evaluation committee disregarding the rather adventurous nature of the previous "novel" contributions of the applying scientist. On the other hand, a more indirect bias could be due to a strong correlation between the novelty profile of the scientist and her tendency 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 this 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).

The need for a better consideration of novelty also extends beyond the context of funding science. Further research could test whether the bias against novelty also applies in the context of scientific publishing. For example, 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).

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