Potential Bias in Peer Review of Grant Applications at the Swiss National Science Foundation

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Abstract

Background. The Swiss National Science Foundation (SNSF) supports fundamental and use-inspired research in all academic disciplines. As part of the evaluation procedure, grant applications to the SNSF are reviewed by external reviewers. The legitimacy of funding decisions depends on its ability to base funding decisions solely on the scientific merit of grant applications.

Aim. We examined whether the following factors influenced the scores given to grant applications submitted to the SNSF: (1) source of nomination of the reviewer, (2) the gender of the applicant and the reviewer, and (3) the country of affiliation of the reviewer.

Methods. We gathered data on 38,250 external reviews of 12,294 unique grant applications across all disciplines between 2006 and 2016. Proposals were rated on a scale from 1 (=poor) to 6 (=outstanding) by 26,836 reviewers. We used linear mixed effects regression models adjusted for research topic, applicant's age, nationality and affiliation.

Results. We found that in univariable analysis applicant-nominated reviewers awarded higher evaluation scores than reviewers nominated by the SNSF. Further, reviewers affiliated with research institutions outside of Switzerland gave more favourable evaluation scores than reviewers affiliated with Swiss institutions. Finally, male reviewers awarded higher evaluation scores than female reviewers and male applicants received more favourable evaluation scores than female applicants. When we controlled for confounding factors, adjusted differences changed little for source of nomination and country of affiliation. In contrast, the gender differences nearly disappeared, which indicates that most of the gender effects observed in univariable analysis is explained by differences in scores between research topics and applicant affiliations.

Conclusions. Our study showed that peer review of grant applications at SNSF may be prone to biases stemming from different applicant and reviewer characteristics. Based on this study the SNSF abandoned nomination of reviewers by applicants, and made members of panels aware of the other systematic differences in scores. We encourage other public funding bodies to conduct similar studies.

Introduction

In public research funding, peer review of proposals by experts in each field is the accepted best practice for determining which projects are allocated funding. Peer review is an important element of quality assurance in the scientific community (Harman 1998). Against this background, a wealth of literature is concerned with the question of the legitimacy of peer review decisions. Generally speaking, the legitimacy of funding decisions relies on a funder's ability to minimize distortions in grant evaluations resulting from the influence of factors that are unrelated to the actual quality of the grant applications (Lutz Bornmann and Daniel 2007). Empirical studies usually examine whether and to what degree such factors influence funding decisions (Demicheli and Di Pietrantonj 2007). These studies suggest that the evaluation of applications is prone to biases that can stem from a number of sources that are related to both applicants' and reviewers' characteristics, including, but not limited to, age or institutional affiliation (Lutz Bornmann and Daniel 2007).

Mandated by the Swiss Confederation, the Swiss National Science Foundation (SNSF) supports basic research and use-inspired basic research in all academic disciplines. With the aim of detecting and reducing potential biases in funding allocation, the SNSF started monitoring its evaluation processes in 2006. The main funding scheme of the SNSF is project funding, which provides support to independent researchers who propose research on self-chosen topics (Swiss National Science Foundation 2016). The final decision on funding is taken by the National Research Council (NRC), a body consisting of pre-eminent researchers based in Switzerland, which takes into account the reports of two or more external expert reviewers. Several factors are of concern in the context of external peer review of grant applications at the SNSF, including:

1. *Nomination of reviewers:* The SNSF previously allowed grant applicants to suggest reviewers to evaluate submissions via a "positive list". A study of the Australian Research Council found that applicant-nominated reviewers tend to give better ratings than panel-nominated reviewers (Marsh, Bond, and Jayasinghe 2007). Similarly, a study of peer review in biomedical journals found that author-nominated reviewers made more favourable recommendations than editor-nominated reviewers (Schroter 2006).

2. *Country of affiliation of reviewers:* The SNSF frequently invites reviewers from abroad to review grant applications. The Australian study found that reviewers affiliated with an US research institution were more lenient than reviewers affiliated with institutions located in the United Kingdom, Germany and Australia (Wood and Australian Research Council 1997). In contrast, a study of the Austrian Science Fund suggested that reviewers affiliated with research institutions located in countries known for high scientific productivity were generally more stringent (Fischer and Reckling 2010).

3. *Gender of principle applicants and reviewers:* Potential discrimination against women is the most frequently investigated bias in the context of grant peer review (Mutz,

126 Bornmann, and Daniel 2012). A meta-analysis of gender bias studies showed small
127 gender differences in grant awards where men were more likely to receive research
128 funding than women. This meta-analysis also showed that gender differences in
129 evaluation scores vary substantially between funding schemes and funding bodies and
130 may be explained by other, confounding variables (L Bornmann, Mutz, and Daniel 2007).
131
132 We analyzed the database of the SNSF to examine whether scores from applicant-nominated
133 external reviewers differed from those from reviewers proposed by the SNSF, whether they
134 differed between reviewers affiliated with a Swiss research institution and reviewers from
135 foreign institutions, and whether they differed depending on the gender of the applicant or
136 reviewer.
137

Materials & Methods

140 **Evaluation of Grant Applications at the SNSF**
141
142 The evaluation of grant applications at the SNSF consists of four steps. After researchers have
143 submitted their applications, the administrative office performs a formal verification in the first
144 step and assign grant applications to two members of the NRC (referee and co-referee) based on
145 their field of expertise. In a second step, eligible proposals are peer-reviewed by external experts
146 according to the following criteria (Swiss National Science Foundation 2016): with regard to the
147 applicant: 1) *Scientific track-record and ability to carry out the research project*; with regard to
148 the project: 2) *Scientific relevance, originality and topicality* and 3) *Suitability of methods and
149 feasibility*. Reviewers score each criteria on a scale from 1 to 6: (1) *poor*, (2) *fair*, (3) *average*,
150 (4) *good*, (5) *excellent*, and (6) *outstanding*. In addition, reviewers submit an overall score of the
151 proposal.
152
153 During the study period, expert reviewers were identified in several ways: (1) grant applicants
154 suggested experts via a "positive list", (2) NRC referees suggested reviewers, (3) the SNSF
155 administrative offices proposed experts, and (4) experts may have declined to review but
156 suggested other reviewers (Swiss National Science Foundation 2016). Applicants could also
157 submit a "negative list" of reviewers who, because of possible conflicts of interest, should not be
158 contacted. For each application, at least two external independent reviews were required.
159
160 In the third step of the evaluation, the two members of the NRC (referee and co-referee) assessed
161 the usefulness of the peer review reports and took them into account when ranking the
162 application relative to other proposals. In the fourth and final step, referee and co-referee present
163 their assessment at the meeting of the corresponding section of the NRC. Each application is
164 voted on and approved or rejected (Swiss National Science Foundation 2016).
165

Data and Variables

The outcome variable of interest was the overall evaluation score of a grant application ranging from 1 (=*poor*) to 6 (=*outstanding*). Explanatory variables included meta-data on applicants and external reviewers, including *source of reviewer nomination* (applicant-nominated vs. SNSF-nominated), *gender of the applicant and gender of the reviewer* (female vs. male) and *country of affiliation of the reviewer* (Switzerland vs. other). The category of SNSF-nominated experts includes reviewers who were proposed by the referee, the SNSF office or by experts who were initially contacted but declined to review. The latter three sources of reviewers were grouped together and categorized as "SNSF-nominated" in the analysis. We also considered meta-data regarding the *research topic* of a grant application, *type of affiliation* and *age of the applicant*. Last, because the SNSF introduced new guidelines for reviewers in October 2011, which had an effect on the distribution of evaluation scores, we introduced a dummy variable *application call deadline* that groups applications submitted before and after October 2011.

Statistical Analysis

We used a linear mixed effects model to examine the effect of explanatory variables on the overall peer-review scores (Bates et al. 2015). This model was chosen because our data are clustered and hierarchical (Jayasinghe, Marsh, and Bond 2003). Grant applications received two or more independent reviews, some reviewers had reviewed more than one application and many applicants had submitted more than one grant application over the study period, causing evaluation scores to be clustered at the levels of research projects, reviewers and applicants. We therefore introduced random effects on the IDs of the reviewer, the applicants and the project in the model, thus taking into account the non-independence between clustered scores (Harrison et al. 2018).[1] We present regression coefficients, which reflect differences in peer review scores, and coefficients adjusted for research topic, applicant's age, nationality and affiliation, with their 95\% confidence interval (CI).

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[1] The notebook of the analysis, including a summary of the different statistical models, is available online at www.git.io/fhaJx.

202 **Results**

203

204 **Descriptive Analysis**

205

206 We analyzed the overall assessment scores of 38,250 external peer review reports on 12,294
207 project grant applications across all disciplines that were submitted 2006 to 2016 by 26,836
208 external experts from Switzerland and abroad. The average number of reviews per grant
209 application was 3.1, applicants submitted an average of 2.1 grant applications and reviewers
210 reviewed an average of 1.4 applications.

211

212 In a first step, we examined overall score distributions for the different reviewer and applicant
213 characteristics that represent potential sources of bias in the external evaluation of grant
214 applications at the SNSF. Frequency distributions of external evaluation scores are shown in
215 Figures 1, 2, 3 and 4. Distributions were skewed for all variables, with grant applications more
216 frequently being awarded high evaluation scores than low scores.

217

218 Applicant-nominated reviewers awarded higher scores than SNSF-nominated reviewers. The
219 *source of external reviewer nomination* thus influenced evaluation scores (Fig. 1).

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221 **Figure 1: Frequency distributions of external evaluation scores by source of nomination of the**
222 **reviewer, ranging from 1 (=poor) to 6 (=outstanding).**

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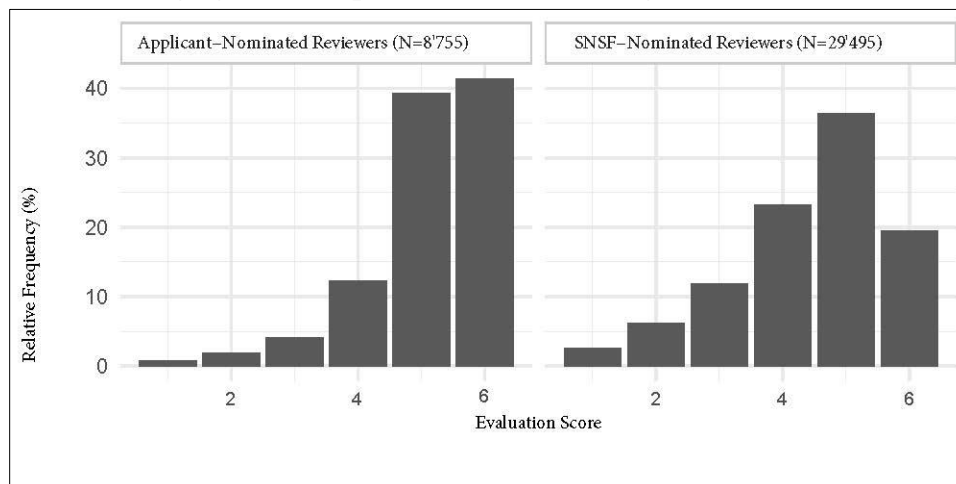
225 Similarly, reviewers affiliated with foreign research institutions awarded higher evaluation
226 scores than reviewers affiliated with Swiss research institutions: *country of reviewer affiliation*
227 could thus also influence the evaluation (Fig. 2).

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231 **Figure 2: Frequency distributions of external evaluation scores by country of affiliation of the**
232 **reviewer.**

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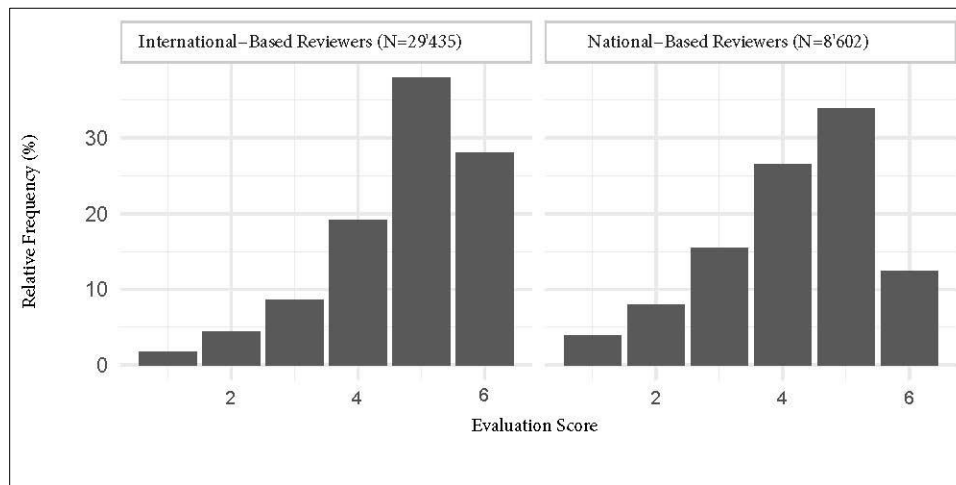
235 The distribution of evaluation scores by *gender of the principle applicant* (Fig. 3) shows that
236 male principle applicants received higher evaluation scores than female principle applicants.
237 Similarly, analysis of evaluation scores by *gender of the reviewer* showed that male reviewers
238 tended to award higher scores than female reviewers (Fig. 4).

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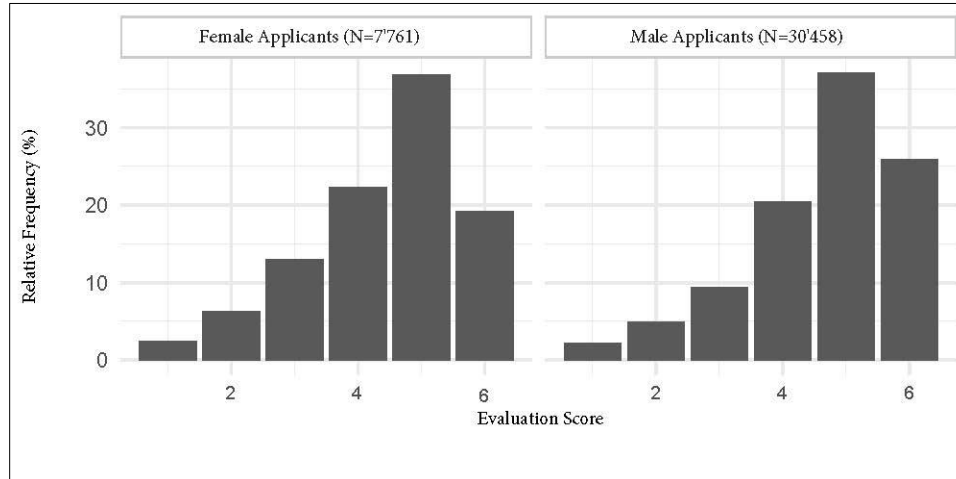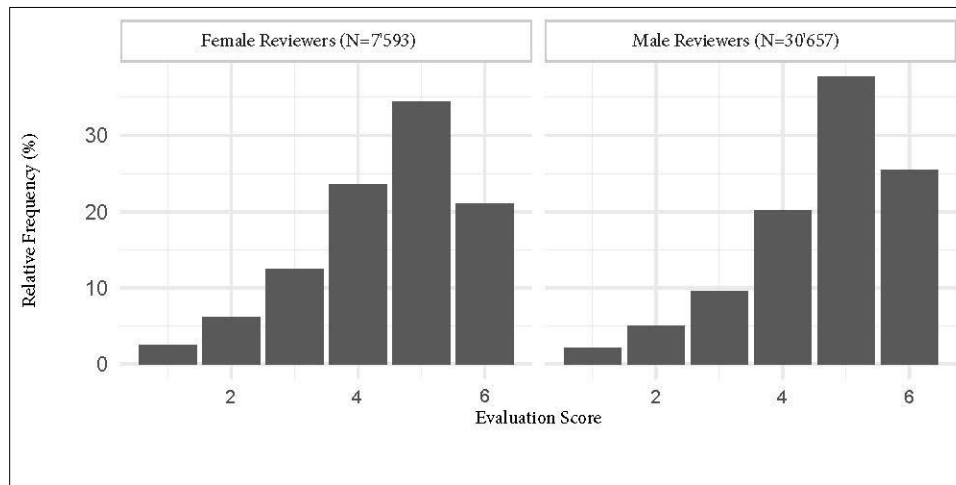240 **Figure 3: Frequency distributions of external evaluation scores by gender of the applicant.**

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250 **Figure 4: Frequency distributions of external evaluation scores by gender of the reviewer.**

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253 To further explore gender differences in applicant scores, we stratified analyses by *research*
254 *topic* (Fig. 5, supplementary files), *applicant age* (Fig. 6, supplementary files) and *applicant*
255 *affiliation* (Fig. 7, supplementary files).

256

257 There were important differences in evaluation scores across *research topics*. For example, grant
258 applications in the natural and technical sciences or in linguistics and history received higher
259 evaluation scores than applications covering other topics. Gender differences in evaluation scores
260 were more pronounced for some research topics (for example mathematics and physics and
261 engineering, biology and medicine, sociology) than others (for example geology, history,
262 psychology). Female applicants were underrepresented (below 50 percent) in all research topics
263 (lower panel of Fig. 5, supplementary files).

264

265 Regarding *applicant age,* applicants aged 60 years or older received the highest evaluation
266 scores, independent of their gender. For the younger age groups, female applicants consistently
267 received lower evaluation scores than male applicants. For groups aged 65 or older, female
268 applicants received higher evaluation scores than male applicants. Female applicants were
269 underrepresented across all age groups, except for the youngest age group, and representation
270 was particularly low in older age groups (lower panel of Fig. 6, supplementary files).

271

272 Regarding *applicant affiliation*, applications submitted by applicants who are affiliated with the
273 Swiss Federal Institutes of Technology and associated research institutions ("ETH Domain")
274 received higher evaluation scores than applications from Cantonal universities or from other
275 research institutions. Gender differences in scores were evident for all three affiliations, and
276 women were underrepresented for all affiliations (lower panel of Fig. 7, supplementary files).

277

278 Analysis of the *nationality of the applicant* showed that grant applications submitted by
279 applicants with a Swiss nationality received slightly lower scores than those submitted by

280 applicants with other nationalities, with a similar gap between genders (Fig. 8, supplementary
281 files). Finally, Figure 9 (supplementary files) shows the effect of the *new evaluation guidelines*
282 *for reviewers* that were introduced in October 2011. Grant applications submitted before October
283 2011 received higher average scores than applications evaluated under the new guidelines.
284
285 **Linear Modeling of the Effects**
286
287 Table 1 presents the final, adjusted model and Table 2 (supplementary files) compared crude and
288 adjusted differences in average scores.
289
290 **Table 1: Differences in external peer review evaluation scores between characteristics of reviewers,**
291 **applicants and research proposals.**
292

Variable	Difference in score (95% CI)	P-Value
Source of nomination of reviewer		<0.001
Applicant	0.49 (0.46 – 0.51)	
Office	0	
Country of affiliation of the reviewer		<0.001
Outside Switzerland	0.47 (0.44 – 0.50)	
Switzerland	0	
Gender of the applicant		<0.001
Male	0.09 (0.04 – 0.13)	
Female	0	
Gender of the reviewer		<0.001
Male	0.08 (0.05 – 0.11)	
Female	0	
Age of the applicant		<0.001
Per 10 year increase	0.05 (0.03 – 0.07)	
Affiliation of the applicant		<0.001
ETH Domain	0.11 (0.07 – 0.16)	
Other	-0.19 (-0.25 – -0.14)	
Universities	0	
Nationality of the applicant		0.218
Other than Swiss	0.47 (0.44 – 0.50)	
Swiss	0	
Field of research		<0.001
Medicine	0	
Architecture	0.15 (0.05 – 0.25)	
Biology	0.27 (0.21 – 0.33)	
Chemistry	0.24 (0.17 – 0.31)	
Economics	-0.01 (-0.09 – 0.06)	
Engineering	0.07 (0.00 – 0.13)	
Geology	0.25 (0.14 – 0.35)	
History	0.32 (0.24 – 0.40)	
Linguistics	0.26 (0.18 – 0.34)	
Mathematics / Physics	0.45 (0.39 – 0.52)	
Psychology	-0.08 (-0.15 – 0.00)	
Sociology	0.01(-0.07 – 0.08)	
Call-cut		<0.001
Before introduction of guidelines	0.43 (0.40 – 0.46)	
After introduction of guidelines	0	

293 *Notes.* Results from linear mixed effects models. Marginal R2: 0.13, Conditional R2: 0.526,
294 Intercept 4.45 (95% CI 4.34-4.57). Random effect variances: Between reviewers: 0.37,
295 Between applicants: 0.15, Between projects: 0.08, Residual: 0.72.

296   In the adjusted model, substantial differences of about 0.5 points are observed for *source of*
297   *reviewer nomination* and *country of affiliation of the reviewer*. Small differences (less than 0.1
298   point) are evident for *gender of the principle applicant* and *gender of the reviewer*. Substantial
299   differences are also observed across disciplines. For example, scores are on average 0.45 points
300   higher in mathematics and physics than in medicine, but about 0.1 point lower in psychology
301   (Table 1).
302
303   Compared to crude differences, adjusted differences tended to be attenuated. For example, the
304   crude difference between male and female applicants was 0.19 points, compared to 0.09 points in
305   the adjusted analysis (Table 2, supplementary files).
306

Discussion

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308
309   We retrospectively examined whether the scores given by external reviewers to grant
310   applications submitted to the SNSF were influenced by the following factors: (1) *the source of*
311   *nomination of the reviewer*; (2) *the country of affiliation of the reviewer*; (3) *the gender of the*
312   *principle applicant* and *the gender of the reviewer*. We analysed data on 38,250 reviews of
313   12,294 unique grant applications across all disciplines between 2006 and 2016 using linear
314   mixed effects regression.
315
316   Our analyses showed that the source of nomination of a reviewer has a statistically significant
317   effect upon evaluation scores in the external peer review of grant applications at the SNSF.
318   Reviewers who were nominated by applicants via the "positive list'" on average tended to award
319   higher evaluation scores than reviewers nominated by SNSF administrative offices, referees or
320   other reviewers. This effect can be interpreted in several ways. First, applicant-nominated
321   reviewers may award more favorable evaluation scores because they know the applicants
322   personally and/or have received positive evaluations from the applicant in the past (Schroter
323   2006). This would mean a conflict of interest. Second, applicants may nominate reviewers who
324   are experts within their field and therefore might be particularly familiar with their research and
325   will recognize the impact and importance of their grant application. The SNSF decided to
326   discontinue the use of the "positive list", thereby abolishing the possibility for grant applicants to
327   suggest their own reviewers. Of note, applicants can still submit negative lists of reviewers that
328   should not be used because of conflicts of interest.
329
330   Our analyses further showed that the country of affiliation of the reviewer affects evaluation
331   scores. Reviewers affiliated with a research institution outside of Switzerland tend to give higher
332   evaluation scores than reviewers affiliated with a Swiss institution. It is possible that reviewers
333   affiliated with institutions in countries known for high scientific productivity generally are less
334   favorable in their evaluation of grant applications than reviewers from countries lagging behind
335   in terms of their scientific productivity (Fischer and Reckling 2010). Switzerland consistently

336   has been shown to belong to the most productive countries in terms of its research outputs
337   (Bonaccorsi and Cinzia Daraio 2007) and this might explain why we found that reviewers
338   affiliated with Swiss research institutions award lower evaluation scores than reviewers affiliated
339   with foreign universities. It should be noted, however, that this interpretation is based on the
340   assumption that a country's scientific productivity is influenced by standards of scientific quality
341   and excellence of its national research system. A further interpretation for this bias is that Swiss-
342   based reviewers might be downgrading their competitors, in order for there to be more funds for
343   their own projects to be funded. As the Swiss research community is small, it is basically
344   impossible to rule out conflicts of interest as a potential reason for biases stemming from country
345   of affiliation of the reviewer. Another possible explanation for the effect we observed is that
346   there are other factors that contribute to the stringency of reviewers affiliated with Swiss
347   institutions. For example, it could be that Swiss reviewers are commonly asked to review on
348   topics related to the social sciences, law and humanities as the focus of topics within these fields
349   is often more national than international, which would require domestic experts. As we have seen
350   in our analyses, reviewers within these fields award lower evaluation scores than reviewers in the
351   natural and technical sciences.
352

353   Finally, our study has shown that both the reviewer's gender and the applicant's gender influence
354   evaluation scores. In the external evaluation of grant applications submitted to the SNSF, male
355   reviewers tend to award higher evaluation scores than female reviewers and male applicants tend
356   to receive higher evaluation scores than female applicants. Both of these effects were small.
357   These findings are in line with previous research that found robust evidence of small gender
358   differences in grant award procedures (Bornmann, Mutz, and Daniel 2007). It should be
359   mentioned that when we adjusted for research topic, applicant's age, nationality and affiliation in
360   the regression model, the effects related to gender decreased significantly. This indicates that
361   observed gender differences in the external evaluation of grant applications at the SNSF can, in a
362   large part, be explained by other, confounding factors. The SNSF started to monitor gender
363   differences on a regular basis in 2013, overseen by an independent commission on gender and
364   equality. The annual analyses provide the opportunity to detect and address gender effects in a
365   timely manner and to take precautionary measures. Remaining gender effects could be explained
366   by factors that we could not include in our model, or by the fact that external reviewers indeed
367   might have a small bias against female applicants.
368

369   Our study has several limitations. First, this is an observational study and our inferences are from
370   data retrospectively gathered on evaluation scores as the outcome variable and reviewer and
371   applicant characteristics as the independent variables. The latter were not under our control and it
372   is difficult to infer causality. Chance, bias, and confounding variables must always be considered
373   as possible explanations for associations between reviewer and applicant characteristics on the
374   one hand and evaluation scores on the other hand. We tried to mitigate the influence of
375   confounding variables by adjusting for these in our regression model. Second, there were low

proportions of female reviewers and applicants, which reduces the resolution power of our
observational study in terms of gender effects. From a more general point of view, it should be
noted that our study covers SNSF project funding only, and does not relate to other SNSF
research funding schemes including career funding for early career researchers, programme
funding, awards and prizes as well as infrastructure and science communication funding. In
addition to this, our results pertain to the external review of grant applications submitted to the
SNSF. Our study does not cover evaluation scores awarded by members of the NRC, who serve
as (co-)referees, or the final funding decisions of the evaluation body. This restricts the
generalizability of our results concerning SNSF evaluation procedures as a whole.

We encourage funding bodies to monitor their evaluation processes in order to detect and
adequately address potential biases in evaluation scores and final funding decisions. Further
research is needed that aims to disentangle the underlying mechanisms of biases in grant
funding.

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