Journal of Informetrics 2 (2008) 280–287

Contents lists available at ScienceDirect

Journal of Informetrics

journal homepage: www.elsevier.com/locate/joi

How to detect indications of potential sources of bias in peer review: A generalized latent variable modeling approach exemplified by a gender study

Lutz Bornmann [a,*], Rüdiger Mutz [a], Hans-Dieter Daniel [b]

[a] *Professorship for Social Psychology and Research on Higher Education, Swiss Federal Institute of Technology Zurich (ETH Zurich), Zähringerstr. 24, 8092 Zurich, Switzerland*
[b] *Evaluation Office, University of Zurich, Switzerland*

ARTICLE INFO

Article history:
Received 8 July 2008
Received in revised form 5 September 2008
Accepted 5 September 2008

Keywords:
Grant peer review
Gender bias
Gender effect
Gender differences

ABSTRACT

The universalism norm of the ethos of science requires that contributions to science are not excluded because of the contributors' gender, nationality, social status, or other irrelevant criteria. Here, a generalized latent variable modeling approach is presented that grant program managers at a funding organization can use in order to obtain *indications* of potential sources of bias in their peer review process (such as the applicants' gender). To implement the method, the data required are the number of approved and number of rejected applicants for grants among different groups (for example, women and men or natural and social scientists). Using the generalized latent variable modeling approach indications of potential sources of bias can be examined not only for grant peer review but also for journal peer review.

1. Introduction

According to Merton (1942), the founder of the modern sociology of science, the functional goal of science is the expansion of "true" and secure knowledge. To fulfill this function in society, a set of ideal norms became established among scientists: the ethos of science. The universalism norm requires that contributions to science are not excluded because of the nationality, gender, social status of the contributors or other irrelevant personal or social criteria (MacCoun, 1998; Ziman, 2000). Critics of peer review argue that decisions in peer review are, nevertheless, frequently biased—that is, that they are not based solely on scientific merit but are influenced also by personal attributes of the applicants (Daniel, Mittag, & Bornmann, 2007; Marsh, Jayasinghe, & Bond, 2008). But an evaluation of a peer review process that can yield reliable and valid results on the influence of potential sources of bias on the review process is as a rule very elaborate and costly. The reasons for this are: (1) The research on peer review has identified a large number of attributes of applicants that can represent potential sources of bias in the peer review process (Wessely, 1998), (2) The study design should meet the highest requirements in order to establish unambiguously that the work from a particular group of applicants has a higher rejection rate due to biases in the peer review process and not simply as a consequence of the lesser scientific merit of the group of applications, and (3) The grant peer review process is a secret activity (Tight, 2003); reviews are secured with assurance of confidentiality.

Before a research funding organization conducts an extensive evaluation study, it should therefore seek indications of the influence of potential sources of bias in the grant peer review process, (1) in order to determine the necessity for

* Corresponding author. Tel.: +41 44 632 48 25; fax: +41 44 632 12 83.
E-mail address: bornmann@gess.ethz.ch (L. Bornmann).

1751-1577/$ – see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.joi.2008.09.003

Table 1
Absolute and relative number of women among all applicants for a research grant from the SNSF and among awardees in 2004.

Disciplines (and subject areas)	Abbreviation	Number of submitted applications		Number of projects funded		Percent women among applicants	Percent women among awardees	Difference in percentages
		Women	Men	Women	Men			
Social medicine	SOMED	5	14	3	5	26	38	−11
General biology	GEBIOL	11	70	8	31	14	21	−7
Philosophy, religious studies, pedagogy, psychology	PHILO	68	126	47	71	35	40	−5
Engineering (including computer sciences)	ENGIN	17	179	15	113	9	12	−3
Experimental medicine	EXMED	19	67	12	38	22	24	−2
Social and economic sciences, jurisprudence	SOCEC	58	182	36	107	24	25	−1
Historical studies	HISTOS	11	75	8	48	13	14	−1
Basic medical sciences	BAMED	28	109	17	62	20	22	−1
Mathematics	MATHE	4	51	3	40	7	7	0
Physics	PHYSI	8	139	6	111	5	5	0
Astronomy and space research	ASTRO	4	18	3	14	18	18	1
Environmental sciences	ENVIR	12	52	8	38	19	17	1
Basic biological sciences	BABIOL	24	124	15	81	16	16	1
Chemistry	CHEMI	10	91	7	79	10	8	2
Clinical medicine	CLMED	38	134	14	55	22	20	2
Archaeology, ethnology, art history, and urban studies	ARCHO	17	62	7	33	22	18	4
Linguistics and literary studies	LINGUI	18	57	10	40	24	20	4
Earth sciences	EARTH	9	66	4	53	12	7	5
DORE (practical research)	DOREP	17	33	6	18	34	25	9
Preventative medicine (epidemiology/early detection/prevention)	PRMED	17	45	4	24	27	14	13
Total		395	1694	233	1061	19	18	1

Source: SNSF, at http://www.snf.ch/SiteCollectionDocuments/por_fac_sta_jb04_d.pdf (page 36; Retrieved: 20 November, 2007).

an evaluation study, and (2) if a necessity is found, to identify the sources of bias that should be examined more closely (Ledin, Bornmann, Gannon, & Wallon, 2007). In the following, we present a statistical method that program managers at a research funding organization can use to obtain *initial indications* of potential sources of bias in their peer review process. The method has already been used for a meta-analysis investigating gender differences in grant award decisions (Bornmann, 2007; Bornmann, Mutz, & Daniel, 2007). To demonstrate application of the method for examining the peer review process, we utilized data from the Swiss National Science Foundation (SNSF) that are published on the Internet (http://www.snf.ch/E/aboutus/facts/Pages/statistics.aspx; Retrieved: November 23, 2007). The SNSF statistics show gender-specific figures for the research projects that were approved and rejected for funding in a total of 20 disciplines and subject areas in the years 2004–2006 (see Tables 1–3).

With our statistical approach to obtaining *initial* indications of potential sources of bias in peer review processes, we are operating under the assumption that the odds of being approved among women applicants should be equal to the odds of being approved among men applicants. Unequal odds indicate a gender effect. If the effect is statistically significant, it is an evidence of bias and a detailed study of the peer review process should be conducted (see here also Women in Science & Engineering Leadership Institute, 2006).

2. Methods

For the statistical analysis we considered estimations of the odds ratio as a dependent variable. For one discipline (or subject area) j, to which the grant applications to the SNSF in a certain year were assigned, this odds ratio can be estimated as

$$o_j = \frac{d_{1j}/(n_{1j} - d_{1j})}{d_{0j}/(n_{0j} - d_{0j})}, \quad (1)$$

where d_{1j} and n_{1j} are the number of women among approved applicants and all applicants, respectively, and d_{0j} and n_{0j} are the number of men among approved and all applicants, respectively.

The approach is to analyze the estimated gender effect across several application years at the level of different disciplines (or subject areas). As we assume that the true gender effect varies between all combinations of disciplines and application years, we estimated a *generalized linear mixed model* that explicitly allows for this variation in a multilevel framework. As