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Careers in science: Policy issues according to *Nature* and *Science* editorials

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Abstract

This study analyzes the editorials in *Science* and *Nature* published between 2000 and 2012 about careers in science. Of the total body of documents, 8.8% dealt with science careers. The editorials were manually classified by topics and then mapped using the VOSviewer. This revealed six easily distinguishable clusters: career conditions in science, the attractiveness of science as a career, merit-based career policies, the effect of research funding on careers, specific groups underrepresented in science, and mobility of scientists. The paper summarizes the main thrust of the arguments in these editorials. There is strong agreement about the problems in scientific careers, but less consensus on the solutions to these problems. The paper also explored whether mapping on the basis of automatically identified terms could have provided adequate results, but concludes that manual classification is needed.

Keywords: scientific careers, classification, bibliometric mapping, editorials

Introduction

In science, quality is intimately connected to the ingenuity, creativity and persistence of its practitioners. Therefore, a high-quality research system has a vital need to attract and retain the most talented scientists. In the past years difficulties in pursuing an academic career have been noted by researchers, journalists, and governments alike (2003; 2005; Schiermeier 2004; Van Balen and Van den Besselaar 2007; Zimmer 2012). Research into academic careers encompasses various issues: career determinants, mobility, and gender, to name just a few (Ceci and Williams 2011; Jonkers 2011; Kaminski and Geisler 2012; Levin and Stephan 1999; Timmers et al. 2010). In this study our aim was to determine which issues in academic careers are most important to opinion leaders in science.

To this end we analyzed the contents of editorials from *Science* and *Nature*. These are the world's most widely read and authoritative multidisciplinary scientific journals. *Science* is a publication of the American Association of the Advancement of Science, which is a general-science learned society, whereas *Nature* is published by the British Nature Publishing Group, an independent commercial publisher. In addition to research papers "from all fields of science and from any source" (Sciencemag.org, "General information for authors") and "from any area of science with great potential impact" (Nature.com, "About Nature Publishing Group"), *Science* and *Nature* publish other sections, e.g., news, book reviews, and opinion pieces. The main opinion pieces are editorial material written by the editors or invited writers. The editorials of *Nature* are written by unnamed editors, who are typically PhD-holding scientists who have pursued a career in science journalism and publishing. Conversely, editorials in *Science* display the name of the author, which is either the editor-in-chief or a guest writer. The editor-in-chief is a distinguished scientist who has taken up the job of editor-in-chief of *Science* after a long career in science. Guest writers are usually policy makers in the field of science, including science ministers or persons occupying comparable posts. Thereby, analyzing the editorials of *Science* and *Nature* gives a varied overview of the opinion of different policy makers and opinion leaders in science. The high global impact and visibility of *Science* and *Nature*, not just in scientific research but also in research and science policy, as well as the nature of the editorial writers, virtually guarantee that the content of the editorials does not merely reflect the specific perspective of practicing researchers, but also that of the leaders of major scientific institutions, science media and policy makers at both national and international levels. With this in mind, it seems fair to describe the editorials as an authoritative indication of the views of opinion leaders in the global science community. The editorials are concerned with a range of current topics on the boundary between science and policy (Waaijer et al. 2010; Waaijer et al. 2011). Over the past decade, a significant number of these editorials concerned careers in science. Classifying these particular editorials thus provides information on the main concerns of this global science opinion leaders in the field of research careers.

Data and methods

Data

Nature and *Science* editorials published between January 2000 and January 2012 were collected in html format. 'World View' opinion pieces from *Nature*, which are written by invited scientists and policy makers across the globe (published September 2010 – January 2012) were also included in the sample set since they have a scope that is similar to the editorials and are clearly directed at the same general audience as the editorials.

Nature also publishes columns and features on scientific careers in a designated section ("Naturejobs" from 2000 until September 2010 and "Career" from September 2010 onwards). This section is connected to the service *Naturejobs*. The columns and brief essays in this section have not been included, since they are clearly part of a special niche rather than being directed at a general audience. Including this niche would overstate the relative importance of scientific careers in the total editorialization of *Nature*. The html files were processed in such a way that only titles and body text remained.

We have selected the editorials concerning career policy on the basis of the occurrence of terms considered to be indicative of this subject (cf. Supplementary Information Table 1 for the precise list of terms). The main goal was not to miss any editorials concerning careers; hence the terms used were quite broad. Using this method 326 editorials (out of a total of 2151) were selected.

Sensitivity analysis selection editorials

Below we will conclude that a substantial part of these 326 editorials do not actually concern careers, but are about completely different subjects. Therefore, we determined whether the selection of editorials according to terms occurring in the texts could have benefited from the omittance of certain terms during selection. This revealed that some terms were redundant for selection (Supplementary Table 2), but omitting them would not have led to a smaller number of non-relevant editorials either. No other terms used for selection could have been omitted without losing relevant editorials.

Document map on the basis of manual classification

In order to analyze the contents of the editorials, the editorials were manually classified by subject. The subject descriptions are shown in Table 1. Each editorial is described by one or more subject names. In addition, the extent to which scientific careers actually were the subject of the 326 originally selected editorials was determined. To this end, the editorials were separated into three groups: scientific careers as main subject, scientific careers as one of multiple subjects, and scientific careers not a subject. All editorials with scientific careers as their subject or one of their subjects were selected, adding to a total of 190 out of the original 326 editorials. A document map, which shows the similarity and dissimilarity of documents within a set, was made. For this map a 'co-subject' matrix was constructed. Thus, two editorials that are about 'women' and 'minorities' have a higher number of subjects in common in the matrix than two editorials with 'women' and 'mobility', and 'women' and 'salary', as their subjects, respectively. The clustering method is a weighted variant of modularity-based clustering (Waltman et al. 2010). Using the editorials' subjects the similarities between editorials were determined by calculating the association strength measure (van Eck and Waltman 2009). The VOS mapping technique was then applied to the association strengths to yield a two-dimensional map of the editorials (van Eck et al. 2010). Finally, the two-dimensional map of the clusters of editorials was visualized using the VOSviewer (van Eck and Waltman 2010).

Document map by automatically identified common terms

We also applied document mapping on the basis of automatic term identification, in order to analyze whether this would approximate the clustering on the basis of manual classification. The same technique as mentioned above was used, but in this case mapping was based on common automatically identified terms instead of common manually determined subjects. Terms in the editorials were identified by matching them against the OpenNLP library (http://opennlp.apache.org/), which parses noun phrases from texts. Then, the specificity of the terms was determined by calculating their Kullbeck-Leibler distance (van Eck and Waltman 2011). Parameters (binary/full counting, threshold of occurrences and percentage of most specific terms) were varied and the parameters yielding the best term map were determined.

Results and discussion

Topics in academic career policy

The manual determination whether scientific careers were a subject in the selected editorials showed that 113 editorials had academic careers as their main subject, 77 had academic careers as one of several subjects, and 136 did not have academic careers as their subject. This means 5.3% of all *Science* and *Nature* editorials were mainly concerned with scientific careers, and that another 3.6% had careers as one of several subjects, the total share of editorials to deal with scientific careers thus amounting to 8.8%.

The manual classification showed that the editorials discussed many different topics within the field of academic careers. Table 2 shows how frequently each topic occurred. The most frequent topics were science policy (43.7%), mobility (21.1%), attractiveness (20.5%), career perspectives (16.8%), women (16.5%), promotion criteria (14.7%), education (13.7%), and independence (10%). However, more than one topic can be discussed in one editorial, and some topics might be correlated. In order to obtain an overview of all editorials at a glance, the document map on the basis of our manual classification as described above was used to cluster the editorials into larger groups. The constructed map distinguishes six different clusters, which we will refer to as ‘main groups’ (Fig. 1).

The first and largest main group (in red) deals with *conditions* for careers in science. Most opinion pieces in this group are concerned about a lack of career perspectives for young scientists. Many editorials note that this situation has led to longer postdoctoral periods; consequently, the period until researchers can pursue their own research lines has increased. This situation needs to change according to multiple editorials, and initiatives promoting early career independence are praised. Some editorials also argue that the increased period until independence is stifling innovative and creative research. Another worry is that the current difficulties in academic careers make science less attractive to prospective entrants. However, a few editorials (from both *Science* and *Nature*) make the case that faculty members and science as a whole might actually *benefit* from a system with a shortage of faculty positions, because it keeps labor costs of a well-trained workforce at a low level. Within the red main group there also is a small number that does not deal with career conditions as such, but with scientific misconduct, and more specifically with the causes of scientific misconduct. Authors of these editorials see the competitive system of science (e.g., for funding, appointments, and tenure) as a factor that may promote scientific misconduct.

The second main group of editorials (in pink) treats the *attractiveness* of science as a career, especially as a future prospect. The editorials strongly emphasize the need for high-quality education, particularly in STEM fields, to stir up students' enthusiasm for science. A number of pieces applaud outreach initiatives to the general public, which they mark as good methods to increase interest in science and show its benefits. Although this group of editorials mainly deals with the attractiveness of a career *in* science, a few editorials actually recommend graduates with a scientific background to make their education and way of thinking useful to other fields and pursue careers such areas as education and policy.

The third main group of editorials (in yellow) focuses on *merit*-based career policies, mainly dealing with the question which factors and characteristics should be important in hiring, promotion, and tenure processes. Quite a number are concerned with countries where authors feel scientists are not promoted on the basis of their scientific credentials, but rather on more diffuse grounds. Other editorials argue that scientists should not be judged only on their research output in the form of journal articles, but also on their teaching excellence, writing books, or outreach to the general public. In relation to this subject, one of the editorials questions the use of journal impact factors as a measure of the scientific quality of papers, and argues that they should not be used for promotion processes. This main group of editorials also includes some that address the increasingly distrustful attitude towards science of (American) politicians, and the barriers for research into 'sensitive' topics politicians have raised on non-scientific grounds. They argue that this development has damaged the careers of researchers working in these fields.

The fourth main group (in turquoise) covers the effect of research *funding* on scientific careers. A number deal with how researchers' opportunities for a career in science are influenced by the amount of resources available to research.. Priority setting and its effect on careers are also important: editorials within this group discuss the effect of the allocation of funding to specific subjects on the careers of the researchers working in these fields and even more on the careers of those *not* working in these fields. Furthermore, a few editorials discuss which types of research and consequently whose careers should be supported. The prevailing opinion is that ground-breaking, innovative projects by young researchers should receive more funding, usually through personal grants. Surprisingly, the sentiment that resources should be given to researchers that have established themselves as excellent researchers was expressed to a much smaller extent. Nevertheless, the first editorial of the millennium in *Nature* advocated block funding for excellent researchers as a means to drive innovative research; without it, the author says, the laser would never have been invented. Like the main group on the attractiveness of science as a career, the funding cluster also contains a few editorials encouraging scientists to take up careers in policy, emphasizing the importance of having more people with scientific backgrounds in policymaking.

The fifth main group (in green) is concerned with *specific groups* in science. Mainly, this group deals with the lack of representation of women, racial minorities, and disabled persons in science. Over 80% of the editorials in this group touch upon the underrepresentation of women. The editorials do not only state the problem, but also propose causes of the underrepresentation, like attitude towards women (often subconscious) and gender bias in the promotion system.[1] Many measures are put forward to improve the position of women in science. A much smaller number of editorials deal with the position of minorities in science and measures to improve their number. A remarkable case put forward in a few editorials is South Africa, where a minority of the general population (white people) actually form a majority in science, and the majority in the general population are underrepresented in science and should be encouraged to pursue a career in it.

[1] A disproportionate number of editorials on women in science (almost 1 in 5) are especially concerned with the position of women scientists in Japan. As editorials on this subject only appeared in *Nature*, we suspect the influence a single editor here.

The final main group (in dark blue) contains editorials on the *mobility* of scientists. The prevailing opinion is that mobility between institutes, preferably internationally, should be encouraged. A few editorials explicitly say specific countries should become more attractive for foreign researchers (e.g., France, Spain, Russia, Germany and Japan). Other editorials call for unity in research systems and career structures among the different countries of the EU. Furthermore, an important category of opinion pieces is concerned with the international barriers put up by the US after the 9/11 attacks. Authors of editorials feel these barriers to international scientists are unjust and are actually damaging American science, because the United States is increasingly dependent on foreign scientists to fill its PhD student and postdoc demand. Finally, the importance of mobility for countries not at the scientific front is highlighted: the scientific standard of these countries can be improved through their scientists training in top science countries, provided the scientists are eventually repatriated.

Academic career systems vary considerably throughout the world (Kreckel 2008). One might expect that the main groups of topics identified would therefore be nation-specific or continent-specific. However, the key topics of our main groups were described as a problem in countries across the globe. For example, a lack of career perspectives is felt in the United States, Europe, and Asia alike. The fear that science might not be sufficiently attractive is present even in a developing country such as India, where policy makers feel "banking, business, and information technology have become immensely popular", more so than science and engineering. A few topics within the main groups are more specific to certain countries, however. The issue within the main group of merit-based career policy of political connections playing a more important role than academic credentials is identified in former Soviet, Mediterranean, and Asian countries, but not in Anglo-Saxon countries. And not surprisingly, the issue of mobility of scientists is described differently in editorials depending on the perspective: the perspective of countries with a net influx of scientists, and the perspective of countries which have scientists leaving and hoping they will return to help improve the science system in their native country.

Mapping by automatically identified terms

Manual classification is usually informative and correct, apart from occasional reading errors or subjective decisions in assignment to subjects. The main drawback is its laboriousness. In our case of 326 fairly short texts this was not a major drawback, but with a large body of literature it would have been. Therefore, it is worthwhile to investigate whether similar results could have been obtained with fully computerized data processing techniques. Note that since we want an automated approach to emulate the manual one, we must here map all 326 editorials, including the ones that are not relevant according to the manual procedure. To map the documents by common terms, we first needed to automatically identify the most meaningful terms in the documents. To this end, term maps were constructed by varying parameters (full counting/binary counting, threshold for number of occurrences, and threshold for relevance). The best term selection was obtained by full counting and a threshold of 10 occurrences, of which the 70% terms with the highest termhood were selected (Supplementary Information Table 3). Although this term identification was the best we could find, the resulting term set still included terms like ‘April’, ‘question’, ‘argument’, ‘connection’, and ‘long way’. Terms that clearly specify quantities or periods (e.g., ‘none’, ‘April’, ‘day’) were removed from the data set so as not to impair subsequent mapping and clustering.

Crosstabulation of the manual main groups with the automatic clustering showed that there was only one case of a high concentration of a main group in a single cluster: the sixth main group concerned with specific groups (Table 3). In all other cases the concentration of main groups in clusters was much lower or even negligible.

If, as in the present case, the association between manual and automatic clusters is low, the automatic clustering cannot be used to analyze the content of the body of text in question. But if that body is too large to apply full manual classification, a sample will have to be drawn. Of course, this means that the results will have a certain variance due to sampling errors. In that case, automatic clustering may be a useful tool to reduce the sampling variance. Provided there is *some* association between automatic clusters and manual groups, the automatic clustering can be used as a sampling framework with different sampling fractions in each cluster, e.g., equal absolute sample sizes per cluster. This approach reduces the sampling variance compared to that when a sample is drawn from the entire population. We have successfully employed this method in our earlier study of editorials, substantially reducing the number of editorials that had to be read (Waaijer et al. 2011).

Conclusion

Main topics in editorials concerning careers

We identified the main topics on scientific careers in *Nature* and *Science* editorials as being career *conditions* while in academia, the *attractiveness* of science as a career to potential entrants, *merit*-based career policies, the effect of research *funding* on scientists' careers, *specific groups* underrepresented in science, and the *mobility* of scientists. The opinions expressed in the editorials were fairly unanimous in the identification of problems, e.g., a lack of career perspectives for young researchers, underrepresentation of specific groups in science, only output in the form of research articles being rewarded career-wise, and a lack of mobility of scientists. The proposed solutions to these problems, however, did differ. Some were quite straight-forward (e.g., increased allocation of funding to young researchers, to specific fields etc.) or non-controversial (e.g., more attention for female applicants, career mentoring for postdocs, and scientists becoming more involved in outreach to the general public). But some editorials mentioned more controversial plans. Several editorials call for fewer PhD students to be trained, and one even argued that the example of the Beijing Genomics Institute, where the PhD has been abolished, is one to watch. One solution most editorials do agree on is that more funding for research and academic positions is needed.

In this study we have shown what the main topics in academic career policy are according to opinion leaders in science. In further work, it might be interesting to compare the results of this study to what scientists themselves deem important influences on their own academic careers, according to such surveys as are available. Similarly, an interesting line of further research might be to compare the issues addressed in the scientific literature on human resource management and careers in science with the issues identified by the editorial writers.

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Table 1. Subject name descriptions

Human resource management in science	
Career perspectives	Perceived number of available (higher) academic positions
Promotion criteria	Criteria on which researchers are promoted to a higher position
Mobility	Extent to which researchers are willing and able to move between countries, institutions etc.
Independence	Ability to pursue own research ideas
Tenure	Permanent academic position
Salary	Remuneration of scientists
Attractiveness	Extent to which a career in science is viewed as desirable
PhD students	Persons working to obtain a PhD or equivalent academic degree
Postdocs	Postdoctoral fellows (PhD graduates typically on a fixed-term contract)
Habilitation	Second academic degree after PhD
Minorities	Groups underrepresented in science (not including women)
Women	Position of women in science
Mentoring	Advisory relationship between experienced and less experienced researcher
Age	Age-specific issues in science career policy
Retirement	Policies concerning scientists' retirements
Creativity	Ability to invent and pursue original scientific ideas
General policy and politics	
Science policy	Regulations that optimize science output (funding, organizational structure etc.) in order to pursue policy goals
Priority setting	Determination of relative value of research (fields, types of research, types of researchers) and consequently where funding should be allocated (subfield of science policy)
Competitive recruitment	Amount of competition needed to leave the best researchers in the system (subfield of science policy)
Politics	Principles that inform government policy
Other	
Peer review	Self-regulation of scientific quality
Education	(Science) teaching of students at all levels (primary school, secondary school, college, university) and teaching of general public
Scientific misconduct	Violation of good research practices
NES	Not elsewhere specified

Table 2. Topics in scientific careers, as % of number editorials with keyword as subject or one of subjects, divided by the total number of editorials

Topic	***% of total number of relevant editorials***
Science policy	43.7
Mobility	21.1
Attractiveness	20.5
Career perspectives	16.8
Women	16.3
Promotion criteria	14.7
Education	13.7
Independence	10.0
Minorities	8.4
Postdocs	7.9
Tenure	7.4
Competitive recruitment	6.8
PhD students	5.8
Age	4.7
Salary	4.7
Scientific misconduct	4.7
Peer review	4.2
Politics	3.7
Mentoring	3.2
Priority setting	3.2
Creativity	1.6
Habilitation	1.1
Retirement	1.1
NES	1.6

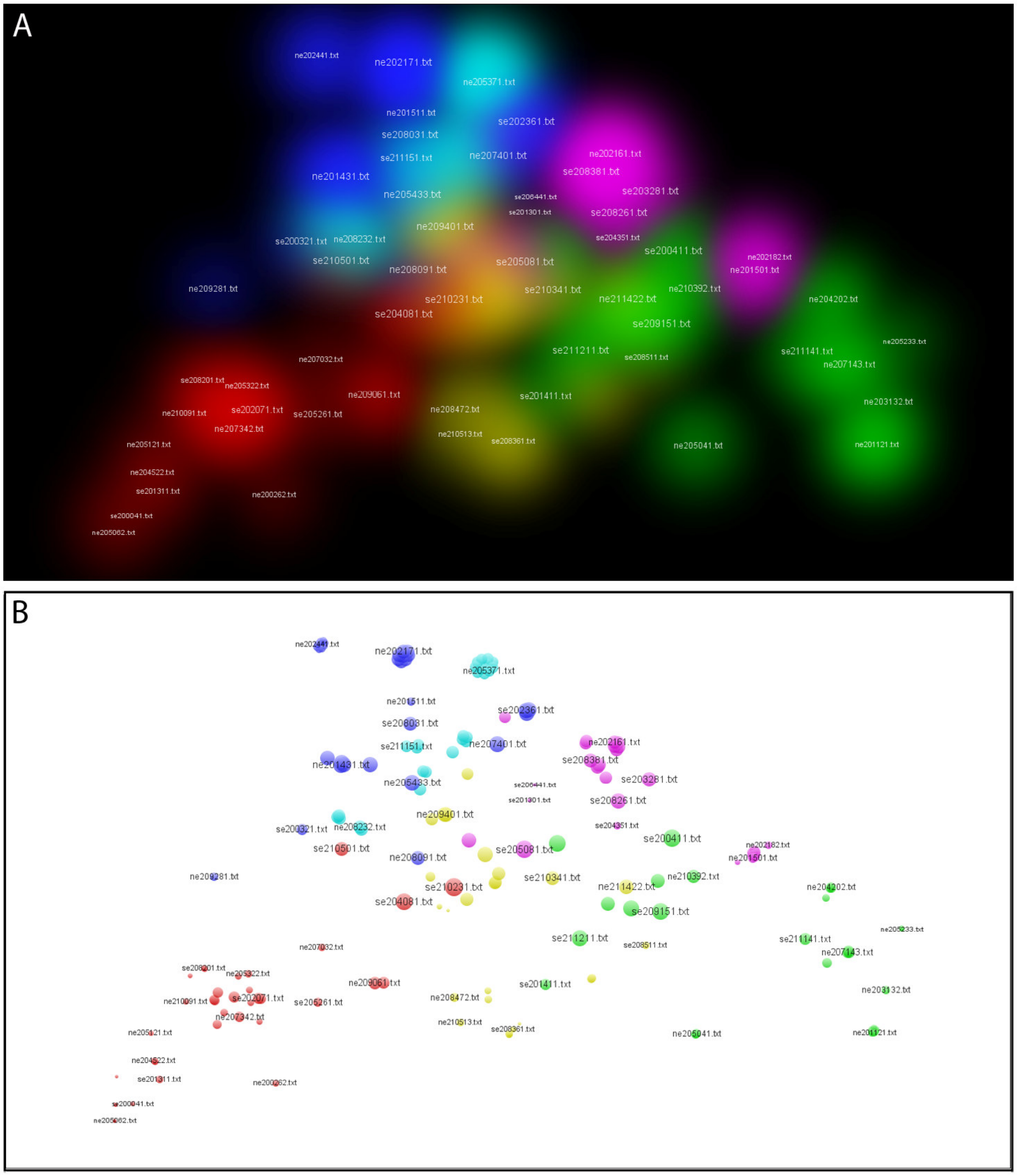

Figure 1. VOS map career-related editorials (career as main subject or one of several subjects) on the basis of manual classification; clustering by weighted modularity-based clustering. (A) Cluster density view of map. (B) Label view of map (size of circles represents number of keywords assigned to editorial).

Table 3. Crosstabulation table clustering on the basis of automatic term identification and manual classification

% of automatic clusters	*Manual clustering*						
Automatic clustering	Career conditions	Attractiveness of science as a career	Merit-based career policies	Research funding	Specific groups	Mobility	Non-relevant
1	7	9	7	14	9	24	30
2	24	2	15	2	1	2	54
3	8	3	3	14	3	0	69
4	10	26	13	5	13	10	23
5	0	0	0	0	82	5	14

Supplementary Information

Table 1. Terms used for selection of editorials

Used for selection editorials
Career
Tenure
Mobility
PhD system
Recruitment
Graduate school
Minority scientist
Woman scientist
Women scientists
Female scientist
Academic job
Junior researcher
Senior scientist
Senior researcher
Postgraduate training
Minorities
Did not result in additionally selected editorials
Junior scientist
Minority researcher
Female researcher

Table 2. Sensitivity analysis

	Number of editorials not in selection when omitted (% of total number editorials per category)		
Term used for selection	***Academic career as main subject***	***Academic career as one of several subjects***	***Academic career not a subject***
Career	36 (31.9%)	37 (48.1%)	72 (52.9%)
Tenure	4 (3.5%)	8 (10.4%)	17 (12.5%)
Mobility	2 (1.8%)	2 (2.6%)	8 (5.9%)
PhD system	0 (0%)	0 (0%)	0 (0%)
Recruitment	8 (7.1%)	4 (5.2%)	4 (2.9%)
Graduate school	1 (0.9%)	2 (2.6%)	1 (0.7%)
Minority scientist	0 (0.0%)	0 (0.0%)	0 (0.0%)
Woman scientist	0 (0.0%)	0 (0.0%)	0 (0.0%)
Women scientists	2 (1.8%)	0 (0.0%)	0 (0.0%)
Female scientist	1 (0.9%)	0 (0.0%)	0 (0.0%)
Academic job	0 (0.0%)	1 (1.3%)	0 (0.0%)
Junior researcher	0 (0.0%)	0 (0.0%)	0 (0.0%)
Senior scientist	0 (0.0%)	1 (1.3%)	7 (5.1%)
Senior researcher	0 (0.0%)	1 (1.3%)	3 (2.2%)
Postgraduate training	1 (0.9%)	1 (1.3%)	0 (0.0%)
Minorities	2 (1.8%)	2 (2.6%)	4 (2.9%)

Table 3. Separate Excel file containing terms used for mapping on the basis of common terms