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Assessing evaluation procedures for individual researchers: The case of the Italian National Scientific Qualification

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ABSTRACT

The Italian National Scientific Qualification (ASN) was introduced as a prerequisite for applying for tenured associate or full professor positions at state-recognized universities. The ASN is meant to attest that an individual has reached a suitable level of scientific maturity to apply for professorship positions. A five member panel, appointed for each scientific discipline, is in charge of evaluating applicants by means of quantitative indicators of impact and productivity, and through an assessment of their research profile. Many concerns were raised on the appropriateness of the evaluation criteria, and in particular on the use of bibliometrics for the evaluation of individual researchers. Additional concerns were related to the perceived poor quality of the final evaluation reports. In this paper we assess the ASN in terms of appropriateness of the applied methodology, and the quality of the feedback provided to the applicants. We argue that the ASN is not fully compliant with the best practices for the use of bibliometric indicators for the evaluation of individual researchers; moreover, the quality of final reports varies considerably across the panels, suggesting that measures should be put in place to prevent sloppy practices in future ASN rounds.

1. Introduction

The National Scientific Qualification (ASN) was introduced in 2010 as part of a global reform of the Italian university system. The new rules require that applicants for professorship positions in state-recognized universities must first acquire a National Scientific Qualification for the discipline and role applied to.

The ASN is to be held once a year; at the time of writing, two rounds have been completed, started in 2012 and 2013, respectively. Applicants are evaluated using quantitative indicators as well as expert assessment. The Italian Ministry of University and Research (MIUR) appoints 184 evaluation committees, one for each scientific discipline. Each committee is made of five members: four are selected among full professors from Italian universities, and one from foreign universities or research institutions. Each committee processes all applications for both the associate and full professor levels in its field of competence.

Candidates are evaluated according to their scientific profile (research output and other scientific titles, see Section 2). However, as an attempt to limit the unfair selection practices that have been associated with the Italian *concorso* (Gerosa, 2001), applicants are also evaluated according to three bibliometric indicators of impact and scientific productivity defined by the MIUR. The reliance of the ASN on bibliometric indicators was welcome by part of the academic community as a step

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towards more objective evaluation practices, but was also heavily criticized by others as a form of "career assessment by numbers" – a term first used in Kelly and Jennions (2006) – and against the best practices for the correct use of bibliometrics for the evaluation of individual researchers (Banfi & De Nicolao, 2013). Further complaints were raised as soon as the final results were made available. The fraction of qualified applicants varied considerably across Scientific Disciplines (SDs), from a minimum of 15.1% to a maximum of 81.1% (Marzolla, 2015). Such large differences can not be explained in terms of uncompetitive applicants; rather, they suggest that the committees adopted different criteria for qualification, if not unfair evaluation practices (Abramo & D'Angelo, 2015). In addition, many applicants perceived the individual evaluations they received as hastily written and poorly motivated.

The issues above are not specific to the ASN: indeed, defining open, fair, and transparent evaluation procedures for career advancement of scientists is a challenging task, as witnessed by the plurality of hiring practices adopted in different countries (Bennion & Locke, 2010; Dettmar, 2004; van den Brink, Fruytier, & Thunnissen, 2013; Vicker & Royer, 2006). The ASN is an interesting case study, since it produced a large amount of data that have been made available on the Web for a short period of time. The data include, for each applicant: the list of publications and other scientific titles; the values of bibliometric indicators; the outcome of the application (qualified/not qualified), and a written assessment by the evaluation panel.

In this paper we address the following two questions: (*i*) does the ASN comply with the best practices for the use of bibliometric indicators for evaluating individual researchers? (*ii*) do the final reports provide useful feedback to the applicants? Both questions refer to the *quality* of the ASN, intended as its level of transparency and fairness.

The case study illustrated in this paper provides some important lessons about the risks and unintended side-effects of evaluation procedures for academics, especially when too much emphasis is put on quantity rather than quality. As bibliometrics is used more and more frequently to support hiring and promotion decisions (Sahel, 2011), it is important to share the experience gathered from the field so that errors are not repeated. On top of that, national-wide research evaluation campaigns such as the ASN face additional challenges due to the large number of applications that must be processed. In these situations it is tempting for evaluation committees to "cut corners" and employ sloppy practices to speed up the evaluation process, that reflect negatively on those being evaluated.

As valuable byproducts, we study the frequency of publication categories appearing in the application forms, and the structure of collaboration networks across scientific fields. The distribution of publication types can be used to understand how researchers in different disciplines disseminate their work. The investigation of the structure and dynamics of inter-disciplinary research collaboration is an important topic by itself that attracted considerable interest (Abbasi, Hossain, & Leydesdorff, 2012; Newman, 2001; van Rijnsoever & Hessels, 2011; Wagner et al., 2011), and is important, e.g., for funding agencies to identify and possibly support joint research and development activities.

Related work. Hiring and promotion procedures for academic staff vary considerably across countries. The Academic Career Observatory from the European University Institute published a comprehensive overview of the recruiting and career advancement procedures in European countries and abroad,[1] including information on salaries, access to non-nationals and gender issues.

Qualification procedures somewhat similar to the ASN are already in place in other European countries, like Germany, France, and Spain. In Germany there are two paths towards professorship positions: Assistants working towards the *Habilitation*, and Junior Professors that must carry out a variety of tasks (including research, teaching, management) but are not required to get the Habilitation. The German Habilitation is essentially a second PhD, and may consist of either a thesis, or several publications of high quality (Enders, 2001). Similarly, the French *habilitation à diriger des recherches* is awarded to applicants with a strong publication record over a period of years, and is required to supervise PhD students and to apply to professor positions (Musselin, 2004). Finally, Spain introduced the *accreditation* [2] as a prerequisite to apply to *Agregat* and *Catedràtic* positions (roughly equivalent to associate and full professor). The accreditation is granted by the Spanish national evaluation agency (ANECA) after detailed assessment of the applicant CV, including teaching, research experience, and list of publications. Of the three procedures above, the Spanish accreditation is the most similar to the ASN. However, the ASN is, to the best of our knowledge, the only scientific qualification that explicitly relies on bibliometric indicators of scientific productivity and impact to evaluate applicants. Also, while teaching activities play a significant role in the Spanish accreditation, they are barely considered by the ASN (see Appendix B).

A quantitative account of the ASN is given by Marzolla (2015): the author computes a set of descriptive statistics, showing among other things the fraction of qualified applicants, and the distribution of the values of bibliometric indicators. The study shows that the fraction of successful applicants varies considerably across SDs, suggesting that the qualification criteria were interpreted differently by each evaluation panel. This is confirmed by the comparison of bibliometric indicators of qualified and not qualified applicants, showing that some panels were more likely to deviate from purely quantitative considerations for granting or denying qualification. Abramo and D'Angelo (2015) examine the relationship of the ASN outcome with the scientific merit of applicants, in order to identify possible cases of discrimination or favoritism. Discrimination refers to skilled (according to their bibliometric indicators) applicants that are denied qualification, while favoritism refers to under-performing applicants that are granted qualification. The results reveal that applicants that are not already employed by an academic institution ("outsiders") tend to be more penalized. Finally, Pautasso (2015) studies the proportions and success

[1] http://www.eui.eu/ProgrammesAndFellowships/AcademicCareersObservatory/Index.aspx, accessed on 2015-10-06.
[2] http://www.aneca.es/eng/Programmes/PEP, accessed on 2015-10-03

Table 1
The table reports, for each area, the total number of submitted qualification applications (*Applications*) and the number (*Sample size*) and percentages (*Coverage*) of applications for which the CV and evaluation forms have been collected.

Id	Code	Area Name	Applications	Sample size	Coverage
1	MCS	Mathematics and Computer Sciences	2492	2116	84.91%
2	PHY	Physics	4372	4372	100.00%
3	CHE	Chemistry	2344	2344	100.00%
4	EAS	Earth Sciences	1231	1231	100.00%
5	BIO	Biology	6244	6244	100.00%
6	MED	Medical Sciences	9987	9266	92.78%
7	AVM	Agricultural Sciences and Veterinary Medicine	2093	1895	90.54%
8	CEA	Civil Engineering and Architecture	3599	3284	91.25%
9	IIE	Industrial and Information Engineering	4535	3860	85.12%
10	APL	Antiquities, Philology, Literary Studies, Art History	6324	6322	99.97%
11	HPP	History, Philosophy, Pedagogy and Psychology	5909	3975	67.27%
12	LAW	Law	3037	2774	91.34%
13	ECS	Economics and Statistics	4853	4848	99.90%
14	PSS	Political and Social Sciences	2129	1274	59.84%
			59,149	53,805	90.97%

rates of female applicants across the various SDs to investigate gender issues. While in most disciplines the success rates of female applicants are comparable to that of male candidates, the study observes a significantly lower proportion of female scientists applying to most SDs, especially for the full professor role.

Organization of this paper. This paper is organized as follows. In Section 2 we give some information on the ASN. In Section 3 we examine the evaluation forms: we study their length and average similarity as proxies of their perceived quality. In Section 4 we discuss whether the ASN methodology follows the current best practices for the correct use of bibliometric indicators for the evaluation of researchers. Finally, conclusions are presented in Section 5. Some interesting descriptive statistics on the ASN dataset that have been produced as a byproduct of the main analysis are described in Appendix B.

2. Background

In this section we provide some background on the ASN and the Italian university system; for an historical perspective, see Degli Esposti and Geraci (2010).

In Italy, each professor and researcher is bound to a SD representing a specific field of study. There are 184 SDs organized in 14 areas shown in Table 1. Each SD is identified by a four-character code of the form *AA*/*MC* where *AA* is the numeric ID of the area (01–14), *M* is a single letter identifying the macro-sector, and *C* is a single digit identifying the discipline within the macro-sector. The full list can be found in Appendix A.

Before 2010, there were three tenured roles at Italian universities: assistant professor (*ricercatore universitario*), associate professor (*professore associato*) and full professor (*professore ordinario*). Hiring procedures were handled by universities advertising the position, according to centrally-defined rules mandated by state laws. Applicants had to undergo a written and/or oral examination (*concorso*) whose exact details differed for each role.

Law 240/2010 replaced the role of tenured assistant professor with two fixed-term positions, called *Type A* and *Type B* researcher. Type B positions are supposed to be a path towards the associate professor role, since universities hiring Type B researchers must allocate funding for promotion in advance. Under the new rules, to apply for a permanent professor positions at any state-recognized university, one has to first obtain the ASN in the same SD and role (associate or full professor) applied for. A five-member evaluation panel, appointed by the MIUR for each discipline, grants or denies qualification after assessing the scientific profiles of applicants. The evaluation must take into account both the qualitative and quantitative scientific profile of candidates. The *qualitative* profile consists of the list of publications and other scientific titles, such as coordination of research projects, patents, visiting positions at foreign institutions, and so on (the teaching activity is not considered, though); each panel must also provide an opinion on a limited set of publications submitted by each applicant in full text. The *quantitative* profile is assessed using three numeric indicators of impact and productivity.

Two sets of indicators are defined: *bibliometric* and *non-bibliometric* indicators. Bibliometric indicators apply to disciplines such as the hard sciences, biology and medicine, for which "sufficiently complete" citation databases exist. Specifically, bibliometric indicators apply to all disciplines of the nine areas Mathematics and Computer Sciences (MCS), Physics (PHY), Chemistry (CHE), Earth Sciences (EAS), Biology (BIO), Medical Sciences (MED), Agricultural Sciences and Veterinary Medicine (AVM), Civil Engineering and Architecture (CEA) and Industrial and Information Engineering (IIE), except 08/C1 – *Design and technological planning of architecture*, 08/D1 – *Architectural design*, 08/E1 – *Drawing*, 08/E2 – *Architectural restoration and history* and 08/F1 – *Urban and landscape planning and design*, but including the whole macro sector 11/E – *Psychology*. The bibliometric indicators are the following (the normalization procedure will be described shortly):

B.1 normalized number of journal papers;
B.2 normalized number of citations received;

B.3 normalized *h*-index.

Non-bibliometric indicators apply to all other disciplines (in general, social sciences and humanities), and are:

N.1 normalized number of authored books;
N.2 normalized number of journal papers and book chapters;
N.3 normalized number of papers published on "top" journals.

The lists of "top" journals mentioned in N.3 have been defined by panels of experts from the relevant SDs, appointed by the Assessment of Universities and Research (ANVUR), a public entity under control of MIUR.

Normalization of the raw indicators[3] is used to limit the bias against young applicants, and is based on the concept of *scientific age*: the scientific age $SA(A)$ of applicant A that published the first paper in year $t_0(A)$ is defined as:

$$SA(A) := \max\left\{10, (2012 - t_0(A) + 1)\right\}$$

Indicators B.1, N.1, N.2 and N.3 are normalized by multiplying their raw value by $10/SA(A)$. Indicator B.2 is normalized by dividing the raw number of citations by the scientific age. Finally, the value of B.3 is computed from the normalized number of citations per paper. Specifically, given a paper p, published in year t_p, that at time $t \geq t_p$ has received $C(p, t)$ citations, the normalized number of citations $S(p, t)$ for p is defined as:

$$S(p, t) := \frac{4}{t - t_p + 1} C(p, t)$$

The normalized h-index h_c is then the maximum integer such that h_c papers of a given applicant received at least h_c *normalized* citations each (Sidiropoulos, Katsaros, & Manolopoulos, 2007).

We remark that the terms *bibliometric* and *non-bibliometric* are used in the official MIUR documentation, although their meaning does not match the one used by the scientometric community. For this reason we will use the generic term "quantitative indicator" to refer to both bibliometric and non-bibliometric indicators.

The values of quantitative indicators are compared to minimum thresholds, defined as the medians of the values of the same indicators for tenured professors of the same role and SD applied for. Both the medians and of the values of quantitative indicators for each applicant are computed by ANVUR using data from Scopus and Web of Science (WoS). The list of publications used to compute the medians, and the quantitative indicators of tenured professors, have not been made publicly available, so the computations can not be independently verified.

Under the initial interpretation of the ASN rules, qualification could be granted only to applicants that strictly exceed at least two (one, for non-bibliometric disciplines) medians; this was understood to be a necessary but not sufficient condition for qualification. Later, MIUR relaxed this interpretation by allowing panels to grant qualification also to applicants that do not satisfy the constraint above, provided that such decision is motivated[4]. Applicants who failed to get the qualification were prevented from applying again during the next two years.

All ASN applications were submitted electronically through the Web site http://abilitazione.miur.it; each application was then automatically converted to a PDF document, like the one shown in Fig. 1. The form contains the following elements:

1 Unique application ID;
2 Applicant first, last name, and date of birth; the date of birth is a valuable detail because the triplet *first name*, *last name*, and *date of birth* is a robust unique identifier (Smalheiser & Torvik, 2009);
3 List of publications;
4 List of additional scientific qualifications and titles.

The values of quantitative indicators, the application forms, and the final evaluations have been made publicly available for a short period of time at the ASN Web site. Table 1 shows the number of submitted applications for each area, and the number of application forms and final reports that have been collected and will be analyzed in this paper. Our dataset includes 53,805 pairs of forms (for each applicant, we either managed to get both the application and final report, or none of them). This corresponds to about 90% of all application forms, representing a sufficiently large subset. Unfortunately, the coverage is not uniform across the scientific areas: from Table 1 we observe that the dataset is complete for areas PHY,

[3] ANVUR (2013), National Scientific Qualification – normalization of indicators by academic age (*Abilitazione scientifica nazionale – la normalizzazione degli indicatori per l'età accademica*), http://www.anvur.org/attachments/article/253/normalizzazione_indicatori_0.pdf, accessed on 2015-10-06.

[4] F. Profumo, Newsletter of the ministry of education, university and research concerning some aspects of the new discipline for granting the National Scientific Qualification introduced by law 240 on Dec. 30, 2010 (Newsletter of the Ministry of Education, University and Research concerning some aspects of the new discipline for acquiring the National Scientific Qualification introduced with Law 30 December 2010, n. 240 (*Nota Circolare del Ministero dell'Istruzione, dell'Università e della Ricerca su alcuni aspetti della nuova disciplina per il conseguimento dell'abilitazione scientifica nazionale introdotta dalla legge 30 dicembre 2010, n. 240*), January 11, 2013, http://www.anvur.org/attachments/article/252/Circolare accessed on 2015-10-06.

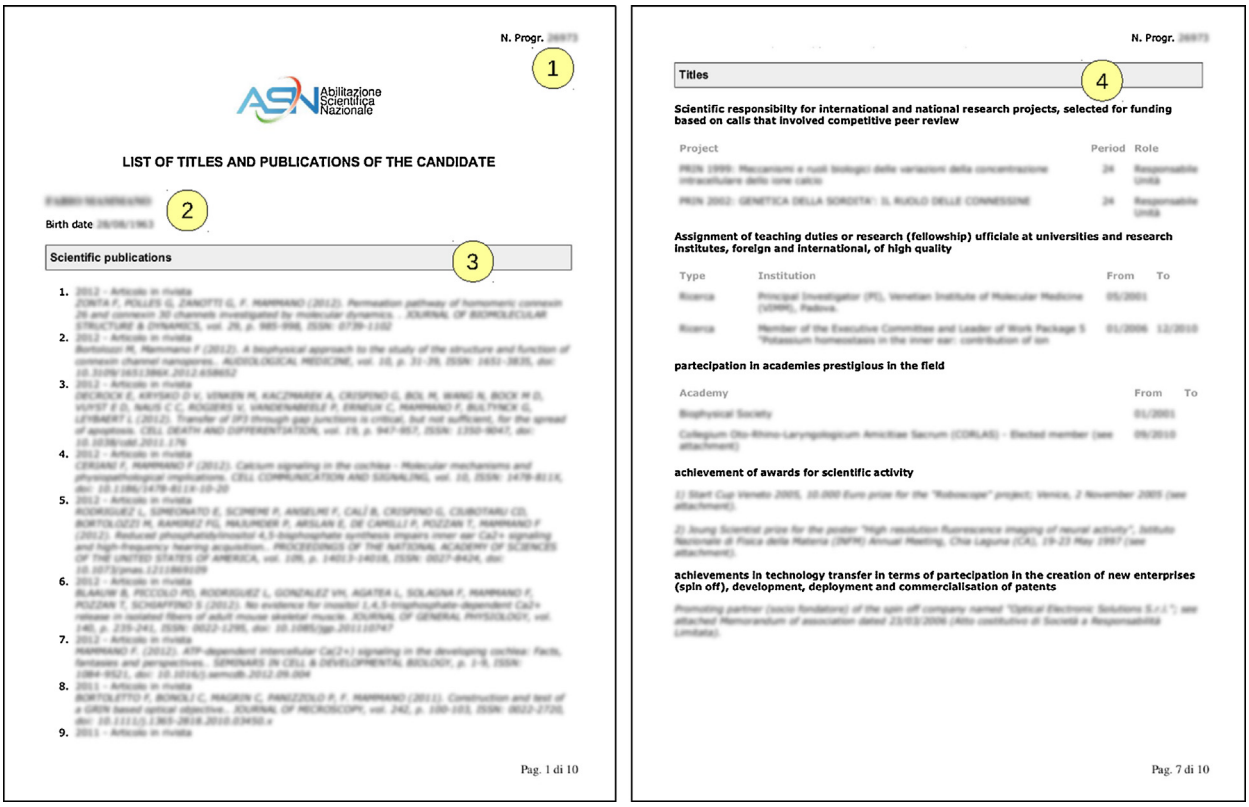

Fig. 1. Structure of an application form.

CHE, EAS and BIO. Areas History, Philosophy, Pedagogy and Psychology (HPP) and Political and Social Sciences (PSS) are only partially covered, and no reports at all are available for the following 14 SDs:

- 01/A4 – *Mathematical physics*
- 06/D3 – *Blood diseases, oncology and rheumatology*
- 06/E1 – *Heart, thoracic and vascular surgery*
- 07/H1 – *Veterinary anatomy and physiology*
- 07/H5 – *Clinical veterinary surgery and obstetrics*
- 08/A1 – *Hydraulics, hydrology, hydraulic and marine constructions*
- 09/H1 – *Information processing systems*
- 11/A1 – *Medieval history*
- 11/A3 – *Contemporary history*
- 11/A4 – *Science of books and documents, history of religions*
- 11/C2 – *Logic, history and philosophy of science*
- 11/C4 – *Aesthetics and philosophy of languages*
- 12/B1 – *Business, navigation and air law*
- 14/C1 – *General and political sociology, sociology of law*

We remark that the coverage refers to the fraction of applications for which the PDF forms have been collected; the values of the quantitative indicators for all applicants have been collected, and where the subject of the analysis in (Marzolla, 2015).

It is interesting to observe that each application form has a unique ID that appears to have been generated sequentially. There are gaps in the sequence of IDs; these gaps can be attributed to the fact that our sample is not complete, to applications that have been created but not finalized, and to applications that have been withdrawn after submission. The maximum ID in our dataset is 94,765, much larger than the number of applications (59,149, see Marzolla (2015)). The *German tank problem* (Ruggles & Brodie, 1947) technique can be used to get an accurate estimate of the total number of applications. A 95% confidence interval (CI) is [94,765.04, 94,771.5], which is compatible with the rough estimate using the maximum ID alone.

Appendix B provides additional descriptive statistics of the ASN dataset.

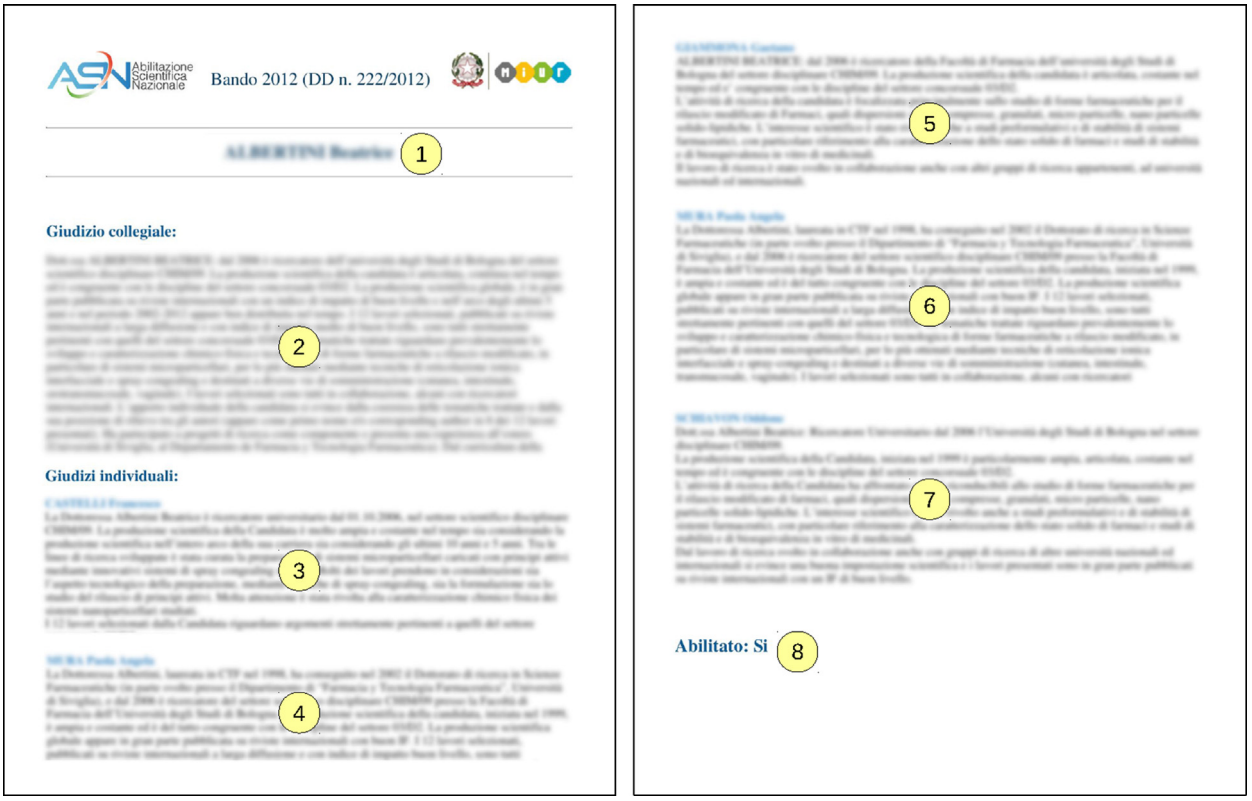

Fig. 2. Structure of a final report.

3. Analysis of final reports

In this section we focus our attention on the final reports containing the assessment of each applicant. A typical report is shown in Fig. 2, and contains the following elements:

1. Applicant's last and first name;
2. Collegial assessment (*Giudizio collegiale*) formulated by the whole panel;
3–7. Individual assessment (*Giudizi individuali*) formulated by each member of the evaluation committee; the name of the committee member is indicated above the evaluation, that are therefore not anonymous;
8. Result (qualified / not qualified).

Most of the final reports are written in Italian, with the possible exception of the evaluations written by the foreign panel members. However, a few panels used a different language for the whole report.

The reports are extremely important, especially for applicants who failed to get qualification: in these cases, it is reasonable to expect that the reports motivate the decision for denying qualification, and provide feedback to improve the quality of the applicant research output. A good report should list the strengths and weaknesses of each applicant, and provide an evaluation on each paper submitted in full text: does the paper address a topic that falls within the aim and scope of the SD? is the contribution significant? is the publication type appropriate? did the publication produce an impact on the scientific community? This is not dissimilar to the feedback that authors of a scientific paper submitted to peer-review expect to receive (Shashok, 2008).

Unfortunately, as soon as the reports started to be made available, complaints were raised about their perceived poor quality. Among others, two issues were frequently reported: (*i*) very short reports that do not provide any useful feedback; (*ii*) reports that are very similar across applicants for the same SD, as if they were based on a template with only minor modifications. These issues are examples of *anti-patterns* (Koenig, 1995), i.e., common but counterproductive solutions to some problem.

The task of deciding whether a report is appropriate can not be fully automated, since this would require natural language processing capabilities far beyond the current state of the art; besides, the definition of "appropriate" is subjective and can

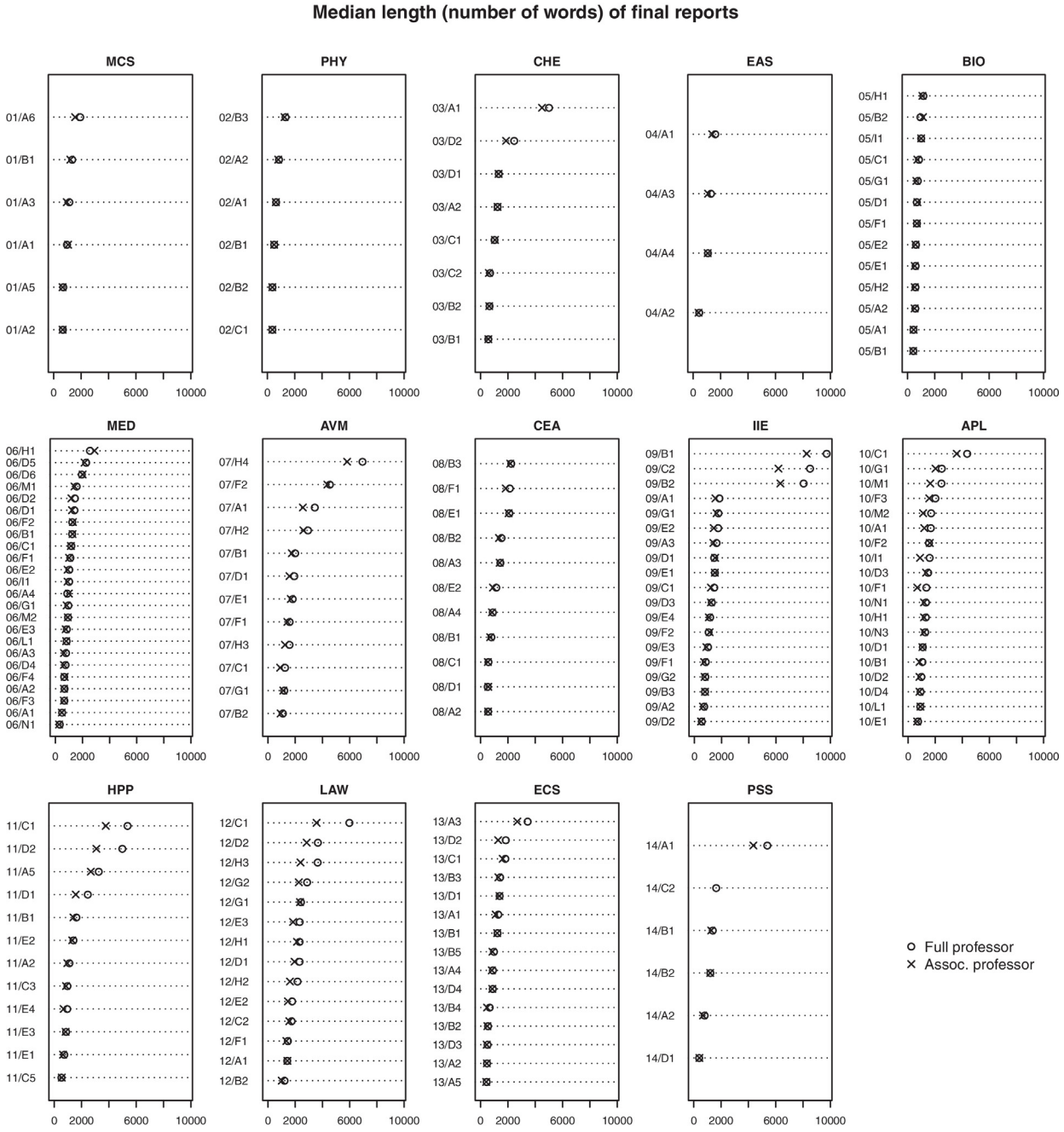

Fig. 3. Median length (number of words) of final reports for each discipline and role.

not be encoded in any formal rule. However, the two anti-patterns above can be identified with the help of simple text metrics. In the following we focus on the length of the reports and their dissimilarity, measured through a suitable *text distance* function.

3.1. Length of final reports

The length of final reports is the number of characters or words they contain; we use the number of words as a matter of convenience, since this allows us to deal with smaller numbers that are more easy to grasp intuitively.

Fig. 3 shows the median length of the final reports for each discipline in our dataset; Table 2 shows the five number summary (Tukey, 1977) of all lengths. The medians for full and associate professor applications are both about 1000 words,

Table 2
Five number summary for the length (number of words) of final reports.

	Min.	1st Qu.	Median	3rd Qu.	Max.
Associate	153	616	936	1342	10,030
Full	185	658	1050	1481	10,970

Collegial evaluation

The scientific production of the applicant lies in the area of *AAA BBB CCC*, shows good coherence with the scientific discipline and good continuity, but is of limited quality. The applicant took part to national and international research projects.

Individual evaluations

PANEL MEMBER XXX

Publications: the applicant presents publications related to *AAA BBB CCC*; good fit with this discipline and temporal continuity; quality is poor and international visibility is very poor. Scientific titles: the applicant took part to national and international research projects. The applicant is not qualified.

(Four other similar individual evaluations omitted)

Fig. 4. A fragment of an actual report (translation from the original in Italian).

Table 3
Five number summary for the relative difference of the average length of final reports for qualified and not qualified applicants.

	Min.	1st Qu.	Median	3rd Qu.	Max.
RD full prof. applications	0	0.003	0.009	0.021	0.239
RD assoc. prof. applications	0	0.005	0.012	0.023	0.237

corresponding roughly to two pages like those shown in Fig. 2. However, there are also a significant number of very short reports (200–300 words or less). They may be appropriate in some circumstances, e.g., if the applicant is obviously under-qualified, or has applied to an unrelated SD: in these cases there is no need to provide a lengthy explanation. Fig. 3, however, shows that there are panels that systematically produced shorter reports, and this can not be explained by occasional low-quality candidates.

As an actual example, Fig. 4 shows the English translation of a portion of one of the short reports (about 300 words) for an applicant who failed to get qualification; we only show the collegial evaluation and one of the individual assessments, the other four being very similar. As can be seen, the content is quite vague: the publications are considered of "limited quality", and the international visibility "very poor", without any further explanation. Such evaluation is far from useful, and does not provide any of the feedback mentioned at the beginning of this section.

As a general rule, short reports should be closely scrutinized since they are likely to be of low quality, such as the one above. However, long reports should not be blindly considered better. For example, some panels listed the publications provided in full text by the applicant; in some cases the list appears multiple times in the same report, i.e., in the collegial assessment and in the five individual evaluations. The mere fact of listing the same publications over and over again increases the length but does not improve the quality of the evaluation, unless the lists are used to provide an assessment of each publication, as is actually done by some panels (e.g., the reports of 09/B1 – *Manufacturing technology and systems* provide a detailed evaluation on each publication submitted for consideration). We will show later on how the length of final reports should be combined with their textual distance to obtain a less fragile quality indicator.

To study whether there are significant differences between the average lengths of reports for qualified and not qualified applicants, we define the following quantities. Let LQ_i be the average length of reports for qualified applicants in discipline i, and LNQ_i the average length of reports for *not* qualified applicants in i. The relative difference RD_i of the lengths is defined as:

$$RD_i := \frac{|LQ_i - LNQ_i|}{\max(LQ_i, LNQ_i)}$$

Table 3 shows the five number summary of RD_i for full and associate professor applications, respectively. The 3rd quartile is about 0.02 for both roles; this means that the relative difference between reports for successful and unsuccessful applications is very small, less than 2% in 75% of the disciplines.

We observe negative correlation between the median length of evaluations and the number of applications in each SD (Fig. 5). The rank order correlation coefficient is $\rho = -0.29$ with 95% CI $[-0.43, -0.14]$ for associate professor, and $\rho = -0.35$ with 95% CI $[-0.48, -0.20]$ for full professor applications. The negative correlation may be explained by the fact that the

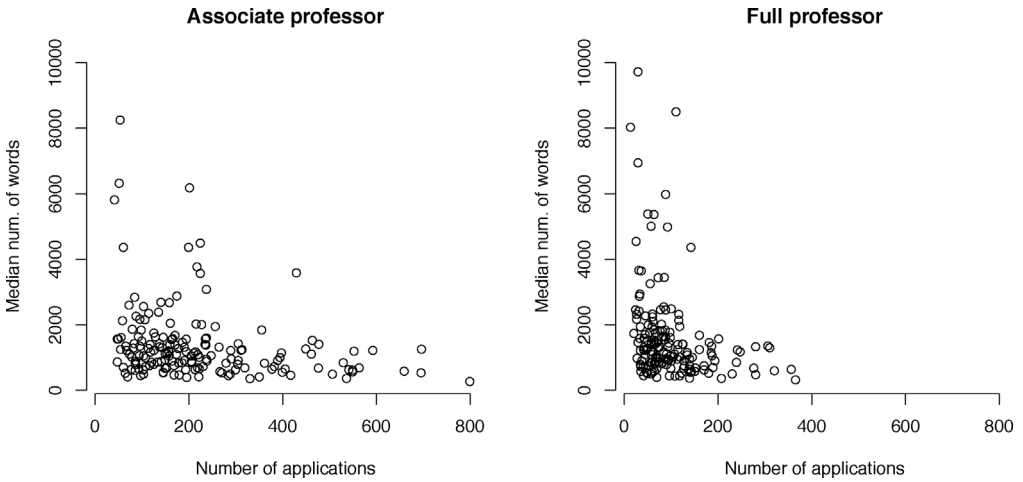

Fig. 5. Correlation between the number of applications and the median length of the final reports.

Applicant *A*

The publications presented by the applicant are considered **sufficiently consistent** with the scope of discipline XX/XX or the related interdisciplinary topics. The evaluation of the scientific contribution of the publications, in relation to the scope of scientific discipline XX/XX, is assessed using parameter set 1 in Annex B of the minutes of the meeting held on X XXXX 2013 describing the criteria adopted by the panel, is **good**. The productivity of the applicant, assessed on the basis of publications submitted in relation to discipline XX/XX, with particular reference to the last five years prior to the call, using the parameter set 2 in Annex B of the minutes of the meeting held on XX XXXX 2013 describing the criteria adopted by the panel, is overall good. Other qualifications submitted by the applicant to support his authority and scientific maturity in relation to scientific discipline XX/XX, are considered, based on the parameter set 3 described in Annex B of the minutes of the meeting held on XX XXXX 2013 which describes the criteria adopted by the panel, **excellent**.

Applicant *B*

The publications presented by the applicant are considered **consistent** with the scope of discipline XX/XX or the related interdisciplinary topics. The evaluation of the scientific contribution of the publications, in relation to the scope of scientific discipline XX/XX, is assessed using parameter set 1 in Annex B of the minutes of the meeting held on X XXXX 2013 describing the criteria adopted by the panel, is **fair**. The productivity of the applicant, assessed on the basis of publications submitted in relation to discipline XX/XX, with particular reference to the last five years prior to the call, using the parameter set 2 in Annex B of the minutes of the meeting held on XX XXXX 2013 describing the criteria adopted by the panel, is overall good. Other qualifications submitted by the applicant to support his authority and scientific maturity in relation to scientific discipline XX/XX, are considered, based on the parameter set 3 described in Annex B of the minutes of the meeting held on XX XXXX 2013 which describes the criteria adopted by the panel, **good**.

Fig. 6. Two assessments written by the same member of one evaluation panel on two applicants (translation by the author). The differences are reported in bold.

panels that had to process more applications could dedicate less time to each one. However, the correlation is weak, so we can not rule out the possibility that the lengths are unrelated to the number of applications.

3.2. Similarity among evaluation forms

Another problem that has been observed in some SDs is that the evaluations are almost identical, as if they were variations of the same template. To illustrate the problem, we report in Fig. 6 the translation of two actual evaluations written by the same committee member for two applicants, *A* (who got the qualification) and *B* (who was denied qualification). The differences between the two texts consists of the three words shown in bold. From these tiny differences it is difficult to understand why applicant *A* was granted qualification but *B* was not: indeed, the terms "consistent", "fair" and "good" bears a positive meaning, suggesting that *B* met all the criteria for qualification. The practice of "cloning" the evaluations to change just a few words is a sloppy practice that reduces the quality of final reports. In the following we assess the extent of this practice in all SDs.

We measure the similarity among the reports of each SD by computing the *text distance* among documents. Two families of text distances are used in the literature: *semantic distances*, that measure whether two documents contains the same information, and *string distances*, that measure the similarity of their syntactic representation. String distances have the advantage of being easy to compute and content-agnostic; furthermore, they provide a stronger evidence that two documents share a common textual template, as in the example above.

The *Levenshtein distance* (Levenshtein, 1965) measures the similarity of two documents as the minimum number of edit operations required to transform one document into the other (see Appendix D for details). We use the *normalized* Levenshtein distance that produces a value in the interval [0, 1]. A distance of 0 denotes that the two documents are identical, while 1 denotes that the documents have no character in common. In practice, the normalized Levenshtein distance rarely exceeds 0.8 even between unrelated documents written in different languages; higher values are therefore very unlikely to be observed.

Given N reports $\{R_1, \ldots, R_N\}$ for a given SD and role, we compute the pairwise distances L_{ij} between document R_i and R_j for all $1 \leq i < j \leq N$. We strip all non-alphanumeric characters and translate uppercase letters to lowercase, to make the distance robust against changes in formatting marks. The empirical distribution of L_{ij} provides information about the mutual similarity of the documents in the set. Since the computation of all distances is time consuming, we consider a random sample of $N = 100$ reports for each SD and role.

Fig. 7 shows the medians of the normalized Levenshtein distances among the reports in the samples, for each discipline and role. Low values are a clear indication of low quality reports that are similar each other. On the other hand, high values can not be automatically considered an indication of better reports. As an example, let us consider SD 06/N1 – *Applied medical technologies*. According to Fig. 7, its final reports have the higher distance within area MED; Fig. 3, however, shows that the reports are, on average, the shortest in MED. Manual examination of the reports shows that they are indeed short and uninformative. The problem here is that two short documents that differ in a few words have higher distance than two long documents that differ in the exact same words (see Appendix D for a technical explanation). Therefore, short documents are more likely to have higher normalized distance than longer ones.

The discussion above suggests that the length and normalized textual distance, if taken alone, are only weak indicators of the quality of the final reports since they can produce false positives: low values are clear indication of poorly written reports, but higher values do not automatically denote better ones. A more robust indicator can be obtained by jointly considering both metrics. A simple way to do so is to produce a scatter plot such as the one in Fig. 8, where data points represent SDs whose coordinates are the median distance and the median report length, respectively; the dashed lines in the figure correspond to the global median length and distance. The plot for the associate professor level is almost identical and is not shown. The "good" reports are those that are both long and with high pairwise normalized distance, that are located in the upper right portion of the scatter plot. "Bad" reports, that are both short and undifferentiated, are located in the lower left portion. Hence, the scatter plot provides an easy way to identify the SDs that more likely produced low quality reports.

4. Discussion

In the previous section we have analyzed whether the ASN results provide useful feedback to the applicants. In this section we take a broader view by discussing the appropriateness of the ASN methodology, including the use of bibliometric indicators to evaluate individual applicants. Indeed, the ASN is the only national scientific qualification procedure that also uses quantitative indicators of productivity and impact for assessing applicants.

The recently published *Leiden manifesto for research metrics* (Hicks, Wouters, Waltman, de Rijcke, & Rafols, 2015) describes ten best practices that should be followed when using bibliometrics as a tool to evaluate individuals or organizations. The best practices are quite general and can be applied to any scientific discipline; it is therefore instructive to understand whether the ASN complies with them. Since the best practices are provided as high-level requirements rather than formal rules, the discussion will be somewhat subjective; to substantiate our claims we will refer to the quantitative analysis from the previous section, whenever appropriate. The best practices from the Leiden manifesto are the following:

1 **Quantitative evaluation should support qualitative, expert assessment.** In the ASN, a five member panel is appointed for each SD, and must take into account both the quantitative and qualitative profile of applicants. Indeed, Marzolla (2015) observed that there is a considerable fraction of applicants that satisfies the quantitative requirements but is denied qualification; this fraction is not homogeneous across the SDs, suggesting that the qualitative assessment was carried out differently. Anyway, this denotes that the ASN is – at least in principle – not driven by the numbers only, and therefore this requirement appears to be met.
2 **Performance should be measured against the research missions of the institution, group or researcher.** The ASN rules have been centrally defined and applied to all SDs, with the only distinction between bibliometric and non-bibliometric disciplines (see Section 2). The quantitative indicators put in place for the two classes of disciplines are certainly not enough to cope with the variability of research practices and goals across fields of study. While each panel had the possibility to override at least part of the rules, very few of them did so. The Leiden manifesto remarks that "no single evaluation model applies to all contexts"; unfortunately this is precisely what happened with the ASN.
3 **Excellence in locally relevant research should be protected.** Research excellence should not be identified with English-language publications only, since that would penalize the activities that have regional or national scope (typical of social sciences and humanities). The ASN relies on bibliometric data from Scopus and Web of Science for bibliometric disciplines, where English is used the most anyway. Social sciences and humanities use paper-counting metrics and lists of "top" journals for each specific field. These journals are published in a variety of languages, allowing locally relevant research to be recognized.

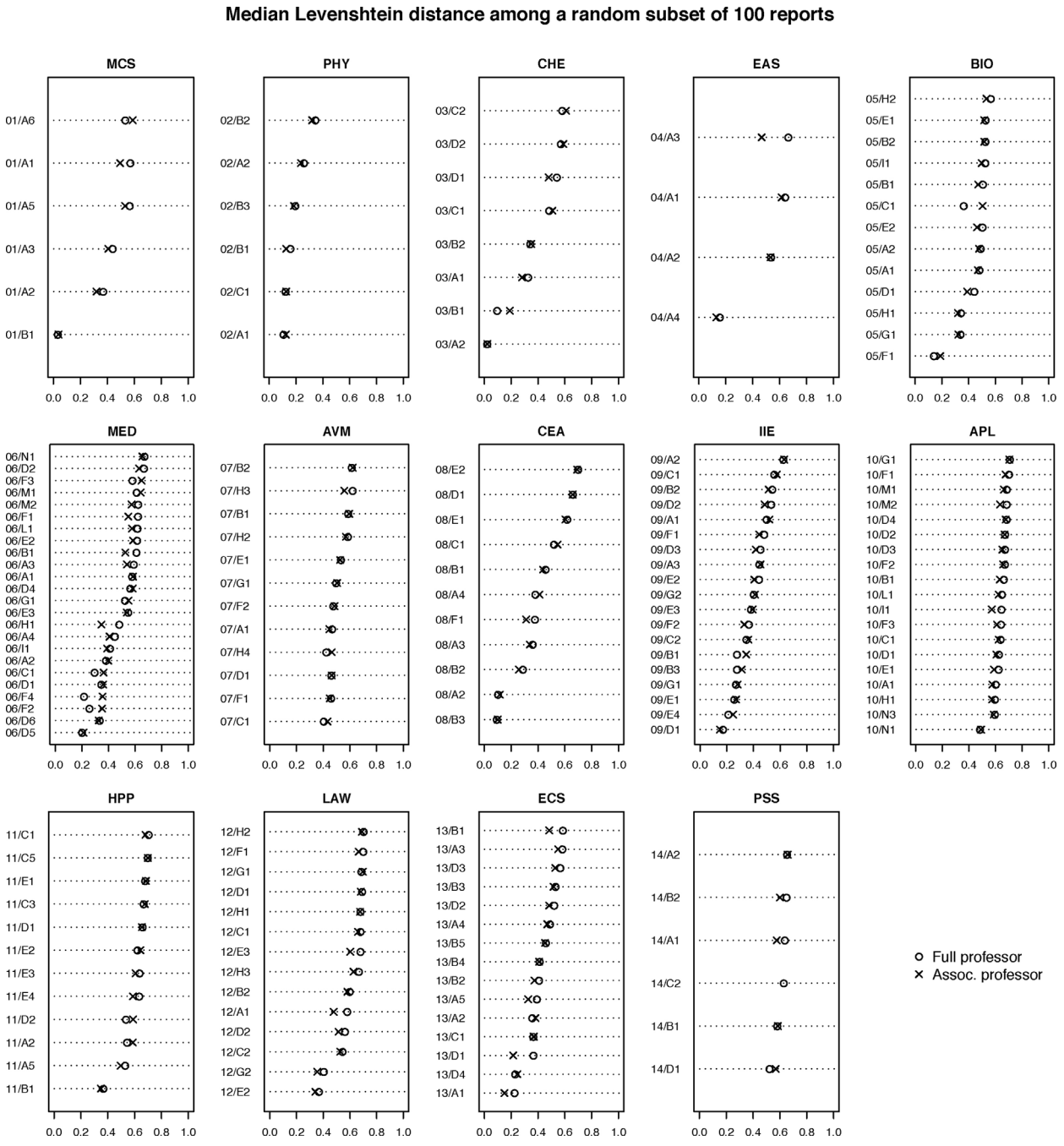

Fig. 7. Median of the normalized Levenshtein distance among a random sample of 100 reports, for each SD and role; higher is better.

4 **The data collection and analytical processes should be kept open, transparent and simple.** The ASN is based on a new and unproven methodology that has not been discussed with the scientific community, nor has been validated by experts in research evaluation. The official documents do not contain any reference to the state of the art and to the known best practices. Therefore we can conclude that the ASN does not provide a suitable level of openness and transparency.

5 **Allow those evaluated to verify data and analysis.** The ASN fails (badly) to meet this requirement. In principle, applicants could verify the values of their quantitative indicators by computing them using data from Scopus and WoS. However, not everyone has access to these databases; furthermore, the values can be updated by the providers without notice, and therefore there is no guarantee that the values observed by the applicants at some time are the same values that are made available to the panels. The situation concerning the medians is worse: the list of publications used to compute them has not been made public, and it is therefore impossible to verify that the medians are correct. It should be observed

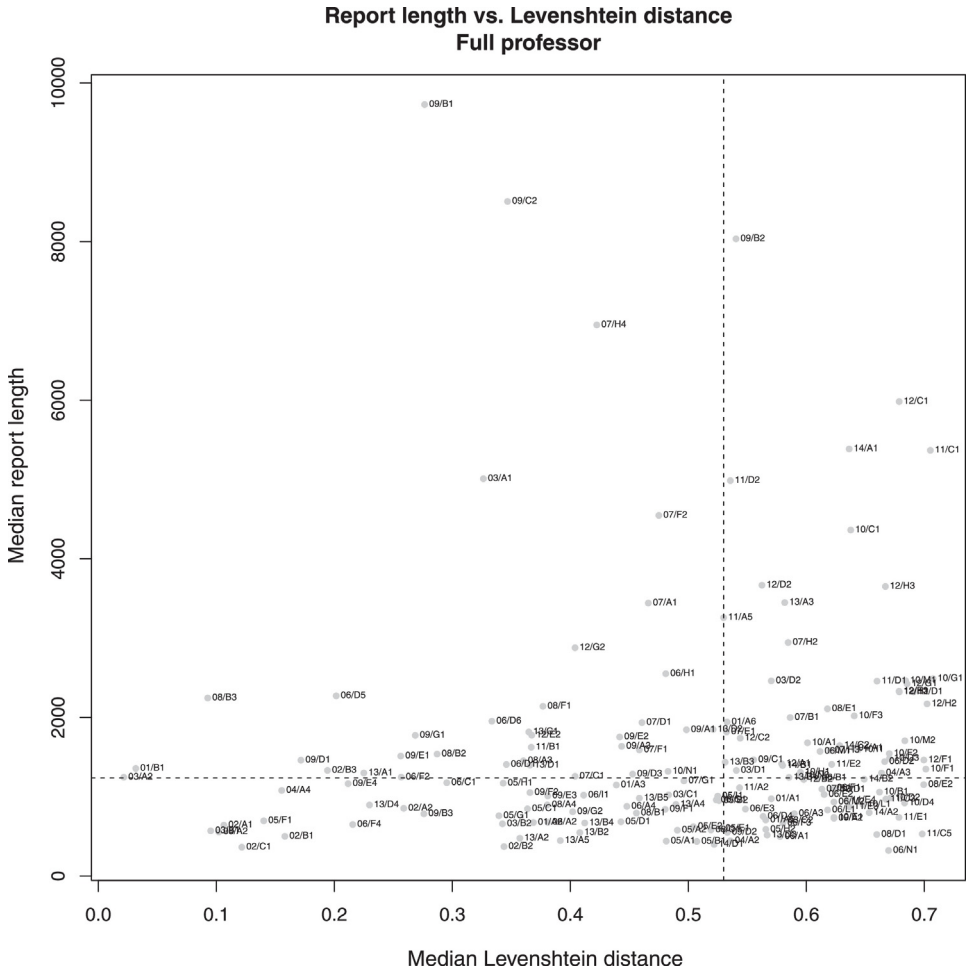

Fig. 8. Median report length versus normalized Levenshtein distance between final reports for the full professor applications. The dashed lines denote the median length and distance.

that ANVUR released an updated set of threshold values[5] to fix errors that were discovered after publication of the initial set of thresholds. This raises the serious concern that other issues may have gone unnoticed.

6 **Account for variation by field in publication and citation practices.** It is well known that citation-based metrics vary significantly across fields of study Albarrán, Crespo, Ortu no, and Ruiz-Castillo (2011). Publication practices also vary: Table C.11 in the Appendix lists the four most frequent publication types for each SD in our dataset, showing considerable differences also among disciplines within the same macro-sector. The ASN addressed these issues by defining different thresholds for each SD and role. Provisions were also made to cope with multimodal distributions of quantitative indicators caused by the coexistence of different scientific communities within the same field of study.

7 **Base assessment of individual researchers on a qualitative judgment of their portfolio.** The ASN complies with this requirement. Indeed, applicants were required to submit a selection of their best publications to the evaluation panel. The quality of those publications had to be assessed as part of the applicant evaluation. Note, however, that the analysis of the final reports described in Section 3 questions the accuracy of the qualitative judgment of applicants on some SDs.

8 **Avoid misplaced concreteness and false precision.** The thresholds of the quantitative indicators used in the ASN were supposed to be "hard" values that had to be strictly exceeded by applicants to be considered for qualification. This neglects the fact that the indicators are subject to uncertainties: should an applicant with contemporary *h*-index equal to 10.4 be rejected if the minimum threshold is 10.5? While a few panels recognized the problem and adopted less stringent requirements, the vast majority stuck with the simplistic interpretation of the hard thresholds.

9 **Recognize the systemic effects of assessment and indicators.** Scientists that are evaluated according to a set of rules inevitably tend to optimize their behavior to better fit the rules. The Leiden manifesto suggests that a pool of different

[5] Consiglio direttivo ANVUR, On the computation of medians for the National Scientific Qualification (*Sul calcolo delle mediane per l'abilitazione nazionale*), Sep. 14, 2012, http://www.anvur.it/attachments/article/253/mediane_spiegate_definitivo_14_settembre_2012.pdf

Table 4
Ten criteria proposed in the Leiden manifesto for research metrics. See text for discussion.

Criterion		Pass	Fail
1.	Quantitative evaluation should support qualitative, expert assessment	√	
2.	Measure performance against the research missions of the institution, group or researcher		×
3.	Protect excellence in locally relevant research	√	
4.	Keep data collection and analytic processes open, transparent and simple		×
5.	Allow those evaluated to verify data and analysis		×
6.	Account for variation by field in publication and citation practices	√	
7.	Base assessment of individual researchers on a qualitative judgment of their portfolio	√	
8.	Avoid misplaced concreteness and false precision		×
9.	Recognize the systemic effects of assessment and indicators		×
10.	Scrutinize indicators regularly and update them	√	

metrics should be preferred to a single metric that can be easily gamed. The ASN complies with this suggestion, since it bases the evaluation on three quantitative indicators. However, we have observed that the values of the indicators are positively correlated in bibliometric disciplines (Marzolla, 2015), suggesting that in fact they might measure the same thing. This suggests that the systemic effects of indicators were not properly dealt with.

10 **Scrutinize indicators regularly and update them.** The MIUR made explicit provision to revise the criteria and parameters every five years.[6]

The discussion above is summarized in Table 4, where we show whether each requirement from the Leiden manifesto is satisfied or not. Since the ASN was defined before the publication of the manifesto, it is unreasonable to expect that the ASN fully complies. However, the manifesto did not appear out of the blue: the issues associated with the use of bibliometrics to evaluate individuals are well known and have already been described in the literature (IEEE, 2013; Institute de France, 2011; Laloë & Mosseri, 2009; Okubo, 1997; Sahel, 2011).

5. Conclusions

In this paper we have considered the Italian ASN as a case study in the evaluation of individual researchers for promotion. In particular, we were interested in assessing the appropriateness of the ASN in terms of fairness and quality of feedback provided to applicants. To do so, we addressed the following two questions: (i) does the ASN comply with the best practices for the use of bibliometric indicators for evaluating individual researchers? (ii) do the final reports provide useful feedback to the applicants?

The answer is partially positive for question (i). We have considered the ten best practices for evaluating individual researchers through bibliometrics, according to the Leiden manifesto for research metrics. The ASN fails to satisfy five out of then requirements: the metrics are defined without taking into consideration the mission of the institution, group or researcher; the data collection and analysis process is not transparent; applicants are unable to verify the data and analysis; the possible lack of precision of the quantitative indicators used is not taken into consideration; finally, the systemic effect of the assessment is overlooked.

To answer question (ii) we have used two simple measures (length and normalized Levenshtein distance) to analyze the content of the individual reports containing a written assessment of each applicant. These measures, both in isolation and in combination, show that the perceived poor quality of some reports is indeed justified.

Our analysis of the Italian ASN highlights several issues, listed below in no particular order:

1 **Understand and follow best practices.** Rules and procedures for evaluating individual researchers should be defined with the help of experts in research evaluation, and should be discussed and accepted by the scientific communities. In the case of the ASN, Marzolla (2015) observed that the definition of the quantitative indicators and their medians generated several unintended side effects, including the "paradox of academic twins"[7] (an applicant with a proper subset of the publications of another one might have *higher* – i.e., better – quantitative indicators). Also, in some disciplines the thresholds for qualification at the associate level were higher than those for the full professor level, implying that in those disciplines there are higher requirements for the lower academic rank. Finally, the use of journal rankings presents known issues (Vanclay, 2011) that have not been addressed in the list of top journals used in non-bibliometric disciplines.

2 **Allocate enough resources.** Nation-wide research evaluation procedures should expect to receive a large number of applications; it is therefore important that sufficient resources (time and manpower) are allocated so that all applications are evaluated fairly and accurately. Some evaluation panels of the ASN were subject to unrealistic deadlines, and therefore

[6] Ministerial Decree 76/2012, Criteria and Parameters for evaluation of applicants for the National Scientific Qualification (*Regolamento recante criteri e parametri per la valutazione dei candidati ai fini dell'attribuzione dell'Abilitazione Scientifica Nazionale*), Ministerial Decree 76, June 7, 2012, http://www.anvur.org/attachments/article/251/dm_07_06_12_regolamento_abilitazione.pdf, art. 9

[7] http://www.roars.it/online/sulla-revisione-dellasn-alcune-proposte/, accessed on 2015-10-06.

required multiple extensions that delayed publications of the results. This issue could be addressed by splitting the workload of the same SD across multiple panels and/or simplifying the qualification procedure in such a way that the workload becomes manageable.

3 **Check for common anti-patterns.** An obvious corollary of the point above is that when evaluation panels are subject to unrealistic deadlines they inevitably tend to work sloppily in order to save time. A frequent complaint on the ASN refers to the poor quality of the final reports. The analysis in Section 3 shows that those complaints are in some cases justified. Suitable quality assurance mechanisms are put in place to improve the quality of final reports and provide consistent feedback to applicants; such mechanisms are already being used in some conferences to improve the quality of the paper review process (Canfora & Elbaum, 2015).

4 **Be transparent.** Transparency is an important deterrent against unfair practices and corruption. In this context, transparency means that the output of the evaluation process should be public, so that *ex-post* analyses can be performed to identify issues. Moreover, if bibliometrics is used as part of the evaluation process, the indicators and their values should be verifiable by applicants.

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Author contributions

Conceived and designed the analysis: Moreno Marzolla
Collected the data: Moreno Marzolla
Contributed data or analysis tools: Moreno Marzolla
Performed the analysis: Moreno Marzolla
Wrote the paper: Moreno Marzolla

Appendix A. List of scientific disciplines

The list below enumerates all scientific areas (first indentation level), macro-sectors (second indentation level) and scientific disciplines.

- 01 Mathematics and computer sciences
  - 01/A Mathematics
    - 01/A1 Mathematical logic, mathematics education and history of mathematics
    - 01/A2 Geometry and algebra
    - 01/A3 Mathematical analysis, probability and statistics
    - 01/A4 Mathematical physics
    - 01/A5 Numerical analysis
    - 01/A6 Operational research
  - 01/B Computer Science
    - 01/B1 Computer Science
- 02 Physics
  - 02/A Physics of fundamental interactions
    - 02/A1 Experimental physics of fundamental interactions
    - 02/A2 Theoretical physics of fundamental interactions
  - 02/B Physics of matter
    - 02/B1 Experimental physics of matter
    - 02/B2 Theoretical physics of matter
    - 02/B3 Applied physics
  - 02/C Astronomy, astrophysics, Earth and planetary physics
    - 02/C1 Astronomy, astrophysics, Earth and planetary physics
- 03 Chemistry
  - 03/A Analytical and physical chemistry
    - 03/A1 Analytical chemistry
    - 03/A2 Models and methods for chemistry
  - 03/B Inorganic chemistry and applied technologies
    - 03/B1 Principles of chemistry and inorganic systems
    - 03/B2 Chemical basis of technology applications
  - 03/C Organic, industrial and applied chemistry
    - 03/C1 Organic chemistry
    - 03/C2 Industrial and applied chemistry

- 03/D Medicinal and food chemistry and applied technologies
  - 03/D1 Medicinal, toxicological and nutritional chemistry and applied technologies
  - 03/D2 Drug technology, socioeconomics and regulations
- 04 Earth sciences
  - 04/A Earth sciences
    - 04/A1 Geochemistry, mineralogy, petrology, volcanology, Earth resources and applications
    - 04/A2 Structural geology, stratigraphy, sedimentology and paleontology
    - 04/A3 Applied geology, physical geography and geomorphology
    - 04/A4 Geophysics
- 05 Biology
  - 05/A Plant biology
    - 05/A1 Botany
    - 05/A2 Plant physiology
  - 05/B Animal biology and anthropology
    - 05/B1 Zoology and anthropology
    - 05/B2 Comparative anatomy and cytology
  - 05/C Ecology
    - 05/C1 Ecology
  - 05/D Physiology
    - 05/D1 Physiology
  - 05/E Experimental and clinical biochemistry and molecular biology
    - 05/E1 General biochemistry and clinical biochemistry
    - 05/E2 Molecular biology
  - 05/F Experimental biology
    - 05/F1 Experimental biology
  - 05/G Experimental and clinical pharmacology
    - 05/G1 Pharmacology, clinical pharmacology and pharmacognosy
  - 05/H Human anatomy and histology
    - 05/H1 Human anatomy
    - 05/H2 Histology
  - 05/I Genetics and microbiology
    - 05/I1 Genetics and microbiology
- 06 Medicine
  - 06/A Pathology and laboratory medicine
    - 06/A1 Medical genetics
    - 06/A2 Experimental medicine, pathophysiology and clinical pathology
    - 06/A3 Microbiology and clinical microbiology
    - 06/A4 Pathology
  - 06/B General clinical medicine
    - 06/B1 Internal medicine
  - 06/C General clinical surgery
    - 06/C1 General surgery
  - 06/D Specialized clinical medicine
    - 06/D1 Cardiovascular and respiratory diseases
    - 06/D2 Endocrinology, nephrology, food and wellness sciences
    - 06/D3 Blood diseases, oncology and rheumatology
    - 06/D4 Skin, contagious and gastrointestinal diseases
    - 06/D5 Psychiatry
    - 06/D6 Neurology
  - 06/E Specialized clinical surgery
    - 06/E1 Heart, thoracic and vascular surgery
    - 06/E2 Plastic and paediatric surgery and urology
    - 06/E3 Neurosurgery and maxillofacial surgery
  - 06/F Integrated clinical surgery
    - 06/F1 Odontostomatologic diseases
    - 06/F2 Eye diseases
    - 06/F3 Otorhinolaryngology and audiology
    - 06/F4 Musculoskeletal diseases and physical and rehabilitation medicine
  - 06/G Paediatrics
    - 06/G1 Paediatrics and child neuropsychiatry

- 06/H Gynaecology
  - 06/H1 Obstetrics and gynecology
- 06/I Radiology
  - 06/I1 Diagnostic imaging, radiotherapy and neuroradiology
- 06/L Anaesthesiology
  - 06/L1 Anaesthesiology
- 06/M Public health
  - 06/M1 Hygiene, public health, nursing and medical statistics
  - 06/M2 Forensic and occupational medicine
- 06/N Applied medical technologies
  - 06/N1 Applied medical technologies

07 Agricultural and veterinary sciences
- 07/A Agricultural economics and appraisal
  - 07/A1 Agricultural economics and appraisal
- 07/B Agricultural and forest systems
  - 07/B1 Agronomy and field, vegetable, ornamental cropping systems
  - 07/B2 Arboriculture and forest systems
- 07/C Agricultural, forest and biosytems engineering
  - 07/C1 Agricultural, forest and biosystems engineering
- 07/D Plant pathology and entomology
  - 07/D1 Plant pathology and entomology
- 07/E Agricultural chemistry and agricultural genetics
  - 07/E1 Agricultural chemistry, agricultural genetics and pedology
- 07/F Food technology and agricultural microbiology
  - 07/F1 Food science and technology
  - 07/F2 Agricultural microbiology
- 07/G Animal science and technology
  - 07/G1 Animal science and technology
- 07/H Veterinary medicine
  - 07/H1 Veterinary anatomy and physiology
  - 07/H2 Veterinary pathology and inspection of foods of animal origin
  - 07/H3 Infectious and parasitic animal diseases
  - 07/H4 Clinical veterinary medicine and pharmacology
  - 07/H5 Clinical veterinary surgery and obstetrics

08 Civil engineering and architecture
- 08/A Landscape and infrastructural engineering
  - 08/A1 Hydraulics, hydrology, hydraulic and marine constructions
  - 08/A2 Sanitary and environmental engineering, hydrocarbons and underground fluids, safety and protection engineering
  - 08/A3 Infrastructural and transportation engineering, real estate appraisal and investment valuation
  - 08/A4 Geomatics
- 08/B Structural and geotechnical engineering
  - 08/B1 Geotechnics
  - 08/B2 Structural mechanics
  - 08/B3 Structural engineering
- 08/C Design and technological planning of architecture
  - 08/C1 Design and technological planning of architecture
- 08/D Architectural design
  - 08/D1 Architectural design
- 08/E Drawing, architectural restoration and history
  - 08/E1 Drawing
  - 08/E2 Architectural restoration and history
- 08/F Urban and landscape planning and design
  - 08/F1 Urban and landscape planning and design

09 Industrial and information engineering
- 09/A Mechanical and aerospace engineering and naval architecture
  - 09/A1 Aeronautical and aerospace engineering and naval architecture
  - 09/A2 Applied mechanics
  - 09/A3 Industrial design, machine construction and metallurgy
- 09/B Manufacturing, industrial and managenent engineering

09/B1 Manufacturing technology and systems
09/B2 Industrial mechanical plants
09/B3 Business and management engineering
09/C Energy, thermomechanical and nuclear engineering
09/C1 Fluid machinery, energy systems and power generation
09/C2 Technical physics and nuclear engineering
09/D Chemical and materials engineering
09/D1 Materials science and technology
09/D2 Systems, methods and technologies of chemical and process engineering
09/D3 Chemical plants and technologies
09/E Electrical and electronic engineering and measurements
09/E1 Electrical technology
09/E2 Electrical energy engineering
09/E3 Electronics
09/E4 Measurements
09/F Telecommunications engineering and electromagnetic fields
09/F1 Electromagnetic fields
09/F2 Telecommunications
09/G Systems engineering and bioengineering
09/G1 Systems and control engineering
09/G2 Bioengineering
09/H Computer engineering
09/H1 Information processing systems
10 Antiquities, philology, literary studies, art history
10/A Archaeological sciences
10/A1 Archaeology
10/B Art history
10/B1 Art history
10/C Cinema, music, performing arts, television and media studies
10/C1 Cinema, music, performing arts, television and media studies
10/D Sciences of antiquity
10/D1 Ancient history
10/D2 Greek language and literature
10/D3 Latin language and literature
10/D4 Classical and late antique philology
10/E Medieval latin and romance philologies and literatures
10/E1 Medieval latin and romance philologies and literatures
10/F Italian studies and comparative literatures
10/F1 Italian literature, literary criticism and comparative literature
10/F2 Contemporary Italian literature
10/F3 Italian linguistics and philology
10/G Glottology and linguistics
10/G1 Glottology and linguistics
10/H French studies
10/H1 French language, literature and culture
10/I Spanish and Hispanic studies
10/I1 Spanish and Hispanic languages, literatures and cultures
10/L English and Anglo-American studies
10/L1 English and Anglo-American languages, literatures and cultures
10/M Germanic and Slavic languages, literatures and cultures
10/M1 Germanic languages, literatures and cultures
10/M2 Slavic studies
10/N Eastern cultures
10/N1 Ancient Near Eastern, Middle Eastern and African cultures
10/N3 Central and East Asian cultures
11 History, philosophy, pedagogy and psychology
11/A History
11/A1 Medieval history
11/A2 Modern history
11/A3 Contemporary history

- 11/A4 Science of books and documents, history of religions
- 11/A5 Demography, ethnography and anthropology
- 11/B Geography
  - 11/B1 Geography
- 11/C Philosophy
  - 11/C1 Theoretical philosophy
  - 11/C2 Logic, history and philosophy of science
  - 11/C3 Moral philosophy
  - 11/C4 Aesthetics and philosophy of languages
  - 11/C5 History of philosophy
- 11/D Educational theories
  - 11/D1 Educational theories and history of educational theories
  - 11/D2 Methodologies of teaching, special education and educational research
- 11/E Psychology
  - 11/E1 General psychology, psychobiology and psychometrics
  - 11/E2 Developmental and educational psychology
  - 11/E3 Social psychology and work and organizational psychology
  - 11/E4 Clinical and dynamic psychology

12 Law studies

- 12/A Private law
  - 12/A1 Private law
- 12/B Business, navigation and air law and labour law
  - 12/B1 Business, navigation and air law
  - 12/B2 Labour law
- 12/C Constitutional and ecclesiastical law
  - 12/C1 Constitutional law
  - 12/C2 Ecclesiastical law and canon law
- 12/D Administrative and tax law
  - 12/D1 Administrative law
  - 12/D2 Tax law
- 12/E International and European Union law, comparative, economics and markets law
  - 12/E1 International and European Union law
  - 12/E2 Comparative law
  - 12/E3 Economics, financial and agri-food markets law and regulation
- 12/F Civil procedural law
  - 12/F1 Civil procedural law
- 12/G Criminal law and criminal procedure
  - 12/G1 Criminal law
  - 12/G2 Criminal procedure
- 12/H Roman law, history of medieval and modern law and philosophy of law
  - 12/H1 Roman and ancient law
  - 12/H2 History of medieval and modern law
  - 12/H3 Philosophy of law

13 Economics and statistics

- 13/A Economics
  - 13/A1 Economics
  - 13/A2 Economic policy
  - 13/A3 Public economics
  - 13/A4 Applied economics
  - 13/A5 Econometrics
- 13/B Business administration and Management
  - 13/B1 Business administration and Management
  - 13/B2 Management
  - 13/B3 Organization studies
  - 13/B4 Financial Markets and Institutions
  - 13/B5 Commodity science
- 13/C Economic history
  - 13/C1 Economic history
- 13/D Statistics and mathematical methods for decisions
  - 13/D1 Statistics

13/D2 Economic statistics
13/D3 Demography and social statistics
13/D4 Mathematical methods of economics, finance and actuarial sciences
14 Political and social sciences
14/A Political theory
14/A1 Political philosophy
14/A2 Political science
14/B Political history
14/B1 History of political thought and institutions
14/B2 History of international relations and of non-European societies and institutions
14/C Sociology
14/C1 General and political sociology, sociology of law
14/C2 Sociology of culture and communication
14/D Applied sociology
14/D1 Sociology of economy and labour, sociology of land and environment

Appendix B. Descriptive statistics

In this section we report some descriptive statistics that can be derived from the application forms. The statistics provide useful contextual information on the demography and behavior of applicants, including: the age distribution, the frequency of publication types and scientific titles in each area, and the structure of the co-qualification graph.

Age distribution of applicants. Fig. B.9 shows the age distribution of applicants for the full and associate role; individuals applying for multiple qualifications are counted once per role. The five number summary shows that applicants for the full professor role are, on average, slightly older than those applying for the associate level: the sample median is 49 years for full and 42 years for the associate role.

Looking at the individual scientific areas (Fig. B.10) we observe that the age of applicants spans a large range. Area Medical Sciences (MED) has the highest median age for both associate (46 years) and full professor applicants (53 years). The youngest successful applicant was 27 years old (in 2012), while the oldest was 69 years old. It is worth noticing that the retirement age for university professors in Italy is currently set to 70 years; yet, 12 qualified applicants for the associate and 85 for the full professor role are over 65 years old. These applicants are unlikely to be promoted before they retire.

Are older applicants more (less) likely to get qualification than younger ones? To answer this question we use a probit regression model (Bliss, 1934) to study the dependency of the ASN result (qualified/not qualified) on the applicant's age. A probit model assumes that the qualification probability for a given age x can be expressed as:

$$\Pr(\textit{Qualified} \mid \textit{Age} = x) = \Phi(\beta \times x) \tag{B.1}$$

for a suitable scalar parameter β, where $\Phi(\cdot)$ is the cumulative distribution function of the normal distribution. Positive values of β denote that older applicants are more likely to qualify, while negative values denote negative correlation.

Table B.5 shows 95% CIs for the value of β for each area and role. Positive correlation is observed, among others, for both roles in areas MCS, CHE, Law (LAW) and Economics and Statistics (ECS). Negative correlation is observed in area Antiquities, Philology, Literary Studies, Art History (APL). Where the CI for β includes zero, we can not reject the hypothesis that the qualification probability is unrelated to the age.

Table B.5
Confidence intervals for β (Eq. (B.1)). '+' denotes positive correlation between age and qualification probability, i.e., older applicants are more likely to qualify; '–' denotes negative correlation.

	Area	95% CI for β			
		Full professor		Associate professor	
MCS	Mathematics and Computer Sciences	[−0.0270, −0.0002]	–	[−0.0461, −0.0225]	–
PHY	Physics	[−0.0169, 0.0025]		[0.0015, 0.0157]	+
CHE	Chemistry	[−0.0334, −0.0055]	–	[−0.0211, −0.0003]	–
EAS	Earth Sciences	[−0.0070, 0.0360]		[0.0098, 0.0382]	+
BIO	Biology	[−0.0037, 0.0138]		[0.0011, 0.0122]	+
MED	Medical Sciences	[−0.0106, 0.0014]		[−0.0142, −0.0062]	–
AVM	Agricultural Sciences and Veterinary Medicine	[−0.0196, 0.0156]		[−0.0030, 0.0170]	
CEA	Civil Engineering and Architecture	[0.0002, 0.0224]	+	[−0.0095, 0.0058]	
IIE	Industrial and Information Engineering	[−0.0053, 0.0162]		[−0.0237, −0.0066]	–
APL	Antiquities, Philology, Literary Studies, Art History	[0.0028, 0.0187]	+	[0.0021, 0.0119]	+
HPP	History, Philosophy, Pedagogy and Psychology	[−0.0018, 0.0177]		[−0.0290, −0.0166]	-
LAW	Law	[−0.0444, −0.0192]	–	[−0.0562, −0.0367]	–
ECS	Economics and Statistics	[−0.0403, −0.0228]	–	[−0.0393, −0.0242]	–
PSS	Political and Social Sciences	[−0.0060, 0.0281]		[−0.0194, 0.0034]	

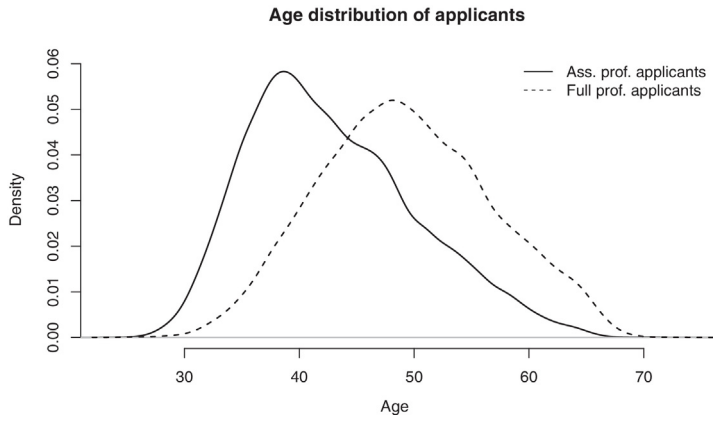

Fig. B.9. Age distribution of applicants.

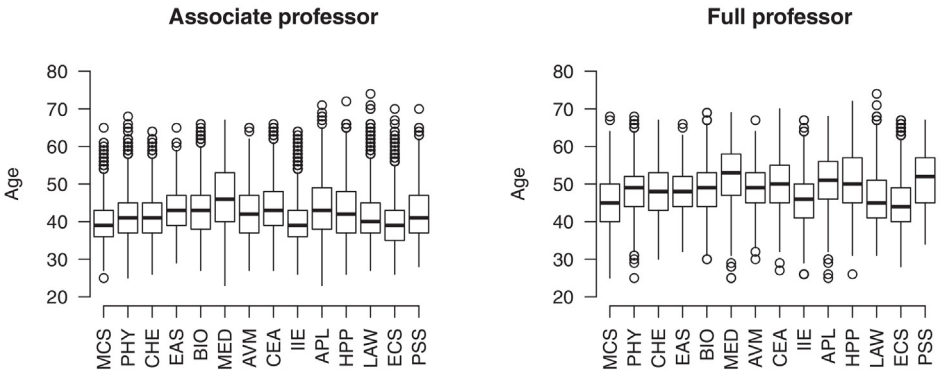

Fig. B.10. Age distribution of applicants by area.

Distribution of publication types. The publications that can be listed in the applications forms are divided into seven categories: journal contribution, volume contribution, book, contribution in proceeding, patent, curatorship, and other publication type. Table B.6 shows the list of the seven main categories and all sub-categories with their counts. The same publication may be counted multiple times, e.g., if it has multiple authors that are applying for qualification, or one of the authors applied for qualification on several disciplines or roles. We did not attempt to remove duplicates, since that would have had little impact on the rank of publication types at the cost of considerable technical complexity.

The five most frequent types – journal article, paper in proceedings, book chapter, abstract in proceedings, and abstract in journal, respectively – represent more than 90% of all publications appearing in the dataset. The small but non-negligible fraction of "Other publication types" (1.39%) consists mostly of technical reports that have not been formally published.

Each SD has its own practices regarding the preferred venues for disseminating their research output; these differences are apparent if we look at Table C.11 in the Appendix, that lists the four most common publication types for each SD. Journal papers are common in areas Mathematics and Computer Sciences, Physics, Chemistry, Earth Sciences, Biology, Medical Sciences, and Agricultural Sciences and Veterinary Medicine, with the notable exception of 01/B1 – *Computer Science* where the most common publication type is the conference proceeding. This peculiarity of 01/B1 is in accordance with the DBLP computer science bibliography, that indexes 2.6 million publications by 1.4 million authors; at the time of writing, 55.99% of the bibliographic entries in DBLP are conference proceedings, and 39.94% are journal papers[8].

A common trait of the areas above, apart from a few cases, is that the four most common publication types account for more than 90% of the total number of publications. In the remaining areas (Civil Engineering and Architecture, Industrial and Information Engineering, Antiquities, Philology, Literary Studies, Art History, History, Philosophy, Pedagogy and Psychology, Law, Economics and Statistics, and Political and Social Sciences), the most frequent publication type is again the journal article, with a significant number of disciplines where conference proceedings or book chapters are the preferred media. Interestingly, the social sciences and humanities adopt more diversified dissemination practices: the four most frequent publication types account for about 70–80% of the publications.

[8] http://dblp.uni-trier.de/statistics/distributionofpublicationtype, accessed on 2015-10-06.

Table B.6
Counts of publication types. Percentages refer to the fraction of each type with respect to the total number of publications submitted by all applicants; *Rank* is the rank of each type according to the frequency of occurrence in the CVs.

Publication Type	Count	%	Rank
Journal contribution	**2,276,633**	**62.68**	
Journal paper	2,115,083	58.23	1
Abstract in journal	100,142	2.76	5
Review in journal	49,099	1.35	8
Comment of verdict	9457	0.26	14
Translation in journal	2402	0.07	21
Bibliography	450	0.01	33
Volume contribution	**417,025**	**11.48**	
Book chapter	356,326	9.81	3
Dictionary or encyclopedia entry	28,635	0.79	10
Catalogue entry	15,476	0.43	12
Preface/postface	7881	0.22	15
Translation in volume	4382	0.12	17
Introduction	3529	0.10	18
Review in volume	796	0.02	28
Book	**93,475**	**2.57**	
Monograph or scientific treatise	80,800	2.22	6
Book translation	4935	0.14	16
Bibliographic entry	3209	0.09	19
Critical edition of books/archaeological excavation	2676	0.07	20
Scientific commentary	791	0.02	29
Publication of new literary or archivistic document	647	0.02	31
Index	260	0.01	36
Concordance	157	0.00	37
Contribution in proceedings	**728,415**	**20.05**	
Paper in proceedings	538,856	14.84	2
Abstract in proceedings	164,951	4.54	4
Poster	24,608	0.68	11
Patents	**14,446**	**0.4**	
Patent	14,446	0.40	13
Curatorship	**40,196**	**1.11**	
Curatorship	40,196	1.11	9
Other	**62,064**	**1.71**	
Other publication types	50,554	1.39	7
Composition	2043	0.06	22
Database	1732	0.05	23
Exhibition	1604	0.04	24
Software	1497	0.04	25
Exposition	1324	0.04	26
Chart	1133	0.03	27
Drawing	660	0.02	30
Design	591	0.02	32
Performance	401	0.01	34
Artifact	373	0.01	35
Art prototype	152	0.00	38
Total	3,632,254	100.00	

While there are yet no comprehensive studies on the frequency of publication types on different scientific areas, some data have been analyzed for Norway and Australia. Sivertsen (2009) analyzes the frequency of articles in journals (with ISSN), articles in books (with ISBN), and books for all scientific fields in Norway higher education sector; articles in books here include also papers in conference proceedings. The data shows that publication patterns are quite different across SDs and also within subfields of the same discipline, in particular within the social sciences and humanities. This is in accordance with our findings (see Appendix C). Also, publication types in the computer science community in Norway show the same skewness towards conference papers that we observe.

The report of the Excellence in Research for Australia (ERA) evaluation (Report, 2012) contains statistics on the publications submitted as part of the national evaluation of Australian universities and research institutes. Caution should be adopted in comparing ERA and ASN, since they have very different goals – ERA aims at evaluating research institutes, while the ASN evaluates individuals. ERA classifies research outputs in three main categories:

Table B.7
Application counts with at least one instance of a given scientific title. Percentages refer to the fraction of applications with at least one instance of the given title, therefore the percentages do not sum to 100.

Scientific title	Associate			Full		
	Count	% Appl.	Rank	Count	% Appl.	Rank
Other titles	28,459	76.60	1	12,936	77.69	1
Participation to research projects	27,754	74.70	2	1	0.01	10
Research or teaching fellowships abroad	18,192	48.96	3	9246	55.53	3
Scientific awards	16,566	44.59	4	8135	48.86	5
Membership of editorial board of journals	13,954	37.56	5	8837	53.07	4
Involvement with foreign research institutes	11,521	31.01	6	1	0.01	10
Technology transfer activities (e.g., startups)	5548	14.93	7	3642	21.87	7
Direction of research institutes	1	0.00	9	1466	8.80	9
Membership of scientific academies	1	0.00	9	3661	21.99	6
Coordination of research projects	1	0.00	9	11,275	67.71	2
Editor in chief of journals, encyclopedias, or treatises	0	0.00	11	2796	16.79	8
Number of applications	37,154			16,651		

Traditional outputs: Books, book chapters, conference publications and journal articles;
Non-traditional outputs: Curated or exhibited event, live performance, original creative work, recorded/rendered work, portfolio of non-traditional research outputs;
Output types within portfolios: Curated exhibited events, live performance, original creative work, recorded rendered work.

More than 413,000 research outputs were submitted to the ERA: 69% were journal articles, 18% conference papers, 10% book chapters, 1% books, and the remaining 2% non-traditional outputs. These percentages are remarkably similar to the percentages of journal contributions, contributions in proceedings, volume contributions and books shown in Table B.6. Looking at individual disciplines, 62% of research outputs within the ERA research area "Information and computing sciences" are conference papers, 30% are journal articles, 7% book chapters, and less than 1% books. These are similar to those observed in our dataset for 01/B1 – *Computer Science*. Table C.11 shows that abstracts are unusually common in many ASN disciplines, in particular those of areas 5 (BIO) and 6 (MED). For example, abstracts represent more than 20% of all publications listed in the curricula of applicants for 06/E2 – *Plastic and paediatric surgery and urology*. Since the rank of publication types remains the same even if we consider successful applicants only, abstracts are not used by low quality applicants only, but instead play an important role in the dissemination of research results in some scientific communities. The role of abstracts that emerges from our dataset is more prominent than what can be desumed from other sources. For example, while abstracts represent 15% of the publications of successful qualifications in area MED, they constitute only 4% of the references listed by PubMed, a bibliographic database of biomedical research papers[9]. The origin of this difference should be investigated in future studies.

Distribution of scientific titles. The last part of the application forms contain the list of additional scientific qualifications (also called *scientific titles*) of the candidate. The list of allowed scientific titles, that is the same for both associate and full professor applicants, is reported in Table B.7. Candidates were required to supply additional details in some cases; for example, an applicant claiming "Participation to research projects" had to specify the project name, duration and role assumed (e.g., participant, task coordinator, affiliate member).

The most frequently mentioned title, appearing in 76.6% of the applications for the associate and 77.69% for the full professor role, is the catch-all category "Other titles". Manual examination reveals that candidates used this category to list teaching duties, service activities (conference organization, coordination of Master or PhD programs, program committee memberships), invited presentations and consulting activities. All these items seems relevant, and the fact that they appear frequently suggests that they should be given specific entries on their own.

Teaching experience is a conspicuous omission from the list of qualifications; research and teaching fellowships at *foreign* universities can be indicated, but teaching activities at Italian institutions can not. While the ASN is intended to attest only the scientific qualification of applicants, professors at Italian universities are required to teach (there are no research-only positions in Italy).

Table B.7 shows a couple of differences between associate and full professor applications. "Coordination of research projects", "Editor in chief of journals, encyclopedias, or treatises", "Membership of scientific academies" and "Direction of research institutes" are claimed by applicants for the full professor role only, with a single exception. This is understandable, since these roles, in particular direction of research institutes, are usually held by well-established scientists that are likely approaching the top of the academic rank. Note that department heads and team leaders of Italian national research centers (CNR, INFN, ENEA. . .), are not necessarily university professors, and some of them applied to the ASN claiming (correctly)

[9] http://www.nlm.nih.gov/bsd/licensee/2014_stats/2014_less_OLDMEDLINE_LO.html, accessed on 2015-10-06.

Table B.8
Number of individuals that submitted n applications; number of applicants that received n qualifications.

n	Number of applicants that submitted n applications	%	Number of qualified applicants that acquired n qualifications	%
1	27,374	73.37	17,123	86.50
2	6726	18.03	2071	10.46
3	1670	4.48	397	2.01
4	853	2.29	136	0.69
5	259	0.69	35	0.18
>5	430	1.15	34	0.17
Total	37,312	100.00	19,796	100.00

Table B.9
Five number summary of the nonzero entries of the co-qualification matrix.

Min.	1st Qu.	Median	3rd Qu.	Max.
0.001	0.004	0.006	0.014	0.338

direction of research institutes. Interestingly, of the 14,67 applications claiming direction of research institutes, only 762 were successful.

On the other hand, "Participation to research projects" and "Involvement with research institutes" are claimed by candidates for associate professor qualification only, again with a single exception. We see no obvious reason why applicants for the higher role should not pursue these activities; perhaps they are just considered not worth being mentioned.

Co-qualification analysis. The ASN allowed individuals to apply for qualification in multiple SDs and roles. Table B.8 shows how many candidates submitted n different applications, and how many received n qualifications. Our dataset contains 53,805 applications from 37,312 individuals. Most of the applicants (73.37%) submitted a single application, but a significant fraction (18.03%) submitted two. The maximum number of applications submitted by one individual is 34 (none of them was successful). Overall, 19,796 applicants were granted at least one qualification; 86.50% of them acquired exactly one qualification, and 10.46% got two. The most successful applicant qualified for both roles in 8 SDs, collecting a total of 16 qualifications.

The existence of individuals that qualified in two different SD, say i and j, is an indication that some overlap may exist between the scope of i and j, fostered by the personal interest of researchers working on cross-disciplinary boundaries. In this section we study *co-qualifications* in more detail, as a proxy for the level of affinity among SDs.

For each pair of disciplines $i, j, i \neq j$, we define the *co-qualification strength* M_{ij} as the fraction of applicants that qualified in either i or j that qualified in both:

$$M_{ij} = \frac{\text{N. of applicants that qualified in } \textit{both} \text{ SD } i \text{ and } j}{\text{N. of applicants that qualified in } \textit{either} \text{ SD } i \text{ or } j}$$

By definition, $0 \leq M_{ij} \leq 1$ and $M_{ij} = M_{ji}$. If $M_{ij} = 0$, then there is no applicant that received qualification in both i and j; this suggests that disciplines i and j might be unrelated. $M_{ij} = 1$ means that every applicant that qualified for SD i also qualified for j. It turns out that co-qualifications across disciplines are relatively rare: only 531 out of $170 \times 169/2 = 14{,}365$ pairs have nonzero co-qualification strength; the five number summary of the nonzero values of the co-qualification matrix are shown in Table B.9.

An effective way to visualize co-qualifications is to draw the *co-qualification graph* G (Fig. B.11). G is a weighted, undirected graph where each node represents a SD, and two nodes i, j are connected by an edge of weight M_{ij} if and only there exists at least one applicant that qualified in both i and j.

The co-qualification graph has 170 nodes and 531 edges. We use colors to distinguish the 14 scientific areas. The node sizes are proportional to the number of incident edges, and edge widths is proportional to the co-qualification strength: thick edges denote a higher fraction of co-qualified applicants (i.e., higher values of M_{ij}). We used Gephi (Bastian, Heymann, & Jacomy, 2009) and igraph (Csardi & Nepusz, 2006) to draw G and compute the metrics described in the following.

To study the relationships among SDs we look for two important structural patterns in the co-qualification graph: *hubs* and *cliques*. A hub is a node with a large number of neighbors, such as node E in Fig. B.12 (a). A hub in G can be interpreted as a "general" discipline with partial overlaps with more specific ones that are not necessarily related each other. A clique is a complete subgraph, i.e., a subset of nodes that are pairwise connected by an edge; as an example, nodes $\{A, B, C, D, E\}$ in Fig. B.12 (b) form a clique. Cliques in the co-qualification graph represent disciplines having mutual overlap, identifying a broader area of related research activities.

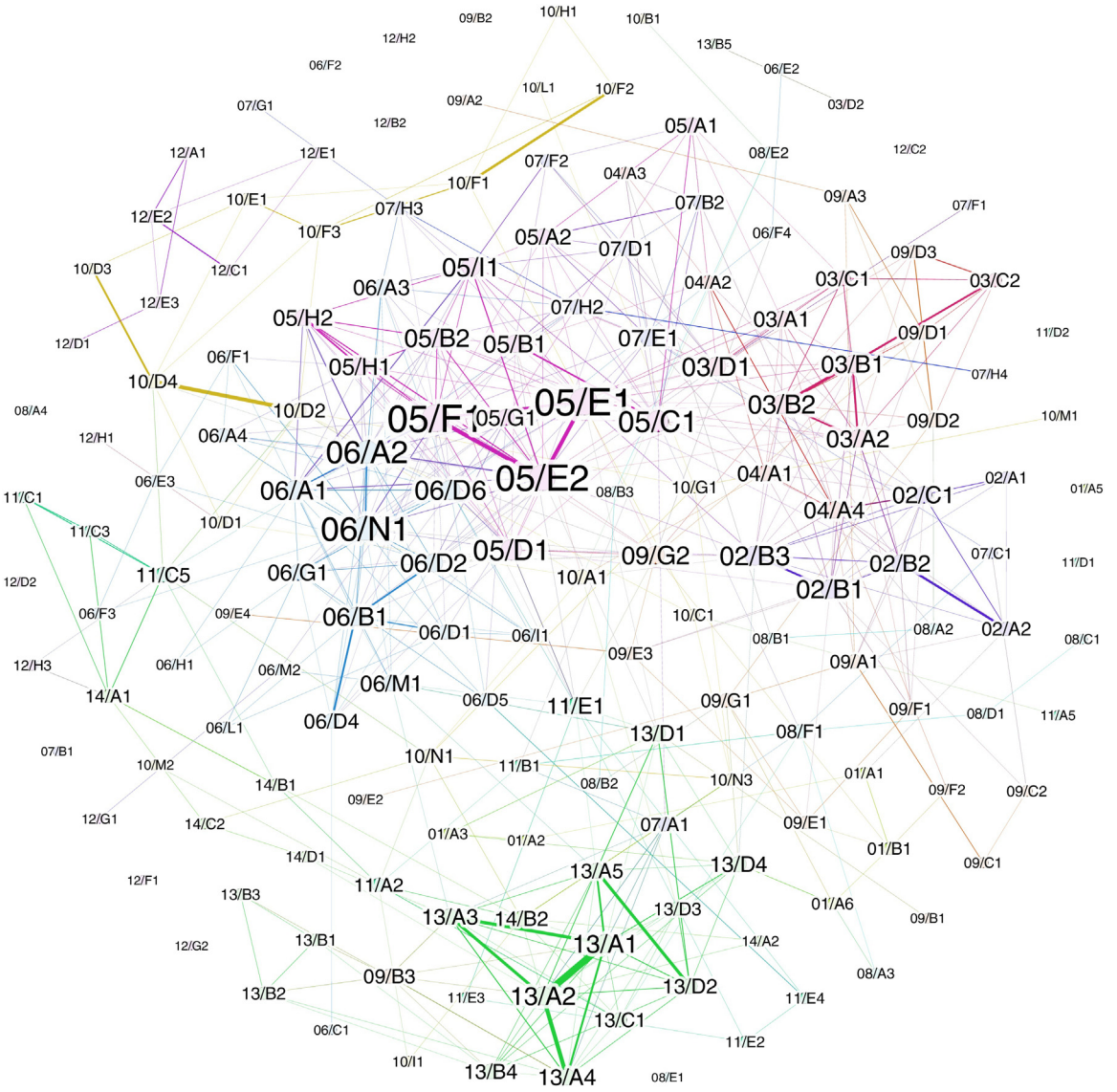

Fig. B.11. Co-qualification graph (best viewed in color). Colors denote the 14 scientific areas. Node sizes are proportional to the number of incident edges; edge widths are proportional to co-qualification strengths. See text for details. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article).

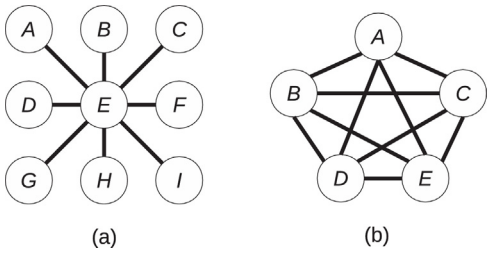

Fig. B.12. Important sub-structures of the co-qualification graph: (a) hub; (b) clique.

Table B.10
The ten disciplines with highest degree in the co-qualification graph.

Scientific discipline	N. of neighbors
05/F1 – *Experimental biology*	28
05/E1 – *General biochemistry and clinical biochemistry*	28
05/E2 – *Molecular biology*	26
06/N1 – *Applied medical technologies*	23
06/A2 – *Experimental medicine, pathophysiology and clinical pathology*	21
05/C1 – *Ecology*	19
05/D1 – *Physiology*	18
02/B3 – *Applied physics*	16
06/D6 – *Neurology*	16
02/B1 – *Experimental physics of matter*	15

Hubs can be identified by looking at the *node degree distribution* of G. The degree $\delta(v)$ of a node v is the number of incident edges (an edge is incident to a node if it has one of the endpoints on that node). The hubs in G are the disciplines with higher degree.

The ten biggest hubs are shown in Table B.10. Five of them (05/F1–*Experimental biology*, 05/E1–*General biochemistry and clinical biochemistry*, 05/E2–*Molecular biology*, 05/C1–*Ecology*, and 05/D1–*Physiology*) belong to area BIO; three (06/N1–*Applied medical technologies*, 06/A2–*Experimental medicine, pathophysiology and clinical pathology*, and 06/D6–*Neurology*) belong to area MED, and the remaining two (02/B3–*Applied physics* and 02/B1–*Experimental physics of matter*) belong to area PHY.

The co-qualification graph contains several cliques, i.e., complete subgraphs. A *maximal cliques* G' is a subgraph $G' \subseteq G$ such that no node can be added to G' to form a bigger clique. The largest clique in G has size 9, and consists of the following disciplines (all belonging to areas BIO and MED):

- 05/H1 – *Human anatomy*, 05/F1 – *Experimental biology*, 05/H2 – *Histology*, 05/B2 – *Comparative anatomy and cytology*, 06/N1 – *Applied medical technologies*, 06/A1 – *Medical genetics*, 06/A2 – *Experimental medicine, pathophysiology and clinical pathology*, 05/E2 – *Molecular biology*, and 05/E1 – *General biochemistry and clinical biochemistry*.

The ties between disciplines in area MED and BIO are confirmed by the existence of three maximal cliques of size 8 that include the following disciplines:

- 05/I1 – *Genetics and microbiology*, 05/F1 – *Experimental biology*, 05/B2 – *Comparative anatomy and cytology*, 05/H2 – *Histology*, 06/A1 – *Medical genetics*, 05/E2 – *Molecular biology*, 05/E1 – *General biochemistry and clinical biochemistry*, and 06/A2 – *Experimental medicine, pathophysiology and clinical pathology*.
- 05/H1 – *Human anatomy*, 05/F1 – *Experimental biology*, 05/H2 – *Histology*, 05/B2 – *Comparative anatomy and cytology*, 06/N1 – *Applied medical technologies*, 05/D1 – *Physiology*, 05/E2 – *Molecular biology*, and 05/E1 – *General biochemistry and clinical biochemistry*.
- 05/H1 – *Human anatomy*, 05/F1 – *Experimental biology*, 05/H2 – *Histology*, 05/B2 – *Comparative anatomy and cytology*, 06/N1 – *Applied medical technologies*, 06/A1 – *Medical genetics*, 06/A2 – *Experimental medicine, pathophysiology and clinical pathology*, and 06/D6 – *Neurology*.

Other smaller cliques exist: 5 maximal cliques of size 7, 17 maximal cliques of size 6, and 133 maximal cliques of size between 3 and 5 inclusive.

Appendix C. Most frequent publication types for each scientific discipline

The following table lists the four most frequent publication types for each SD. We use the following keys: **ABSJ** = Abstract in journal; **ABSP** = Abstract in proceedings; **AF** = Artifact; **ART** = Art prototype; **BIB** = Bibliography; **BIBE** = Bibliographic entry; **CAT** = Catalogue entry; **CH** = Chart; **CHAP** = Book chapter; **COM** = Composition; **COMM** = Scientific commentary; **CONC** = Concordance; **CRIT** = Critical edition of books/archaeological excavation; **CUR** = Curatorship; **DB** = Database; **DES** = Design; **DICT** = Dictionary or encyclopedia entry; **DRAW** = Drawing; **EXH** = Exhibition; **EXP** = Exposition; **IDX** = Index; **INTRO** = Introduction; **JRNL** = Journal paper; **MONO** = Monograph or scientific treatise; **OP** = Other publication types; **PAT** = Patent; **PERF** = Performance; **POS** = Poster; **PREF** = Preface/postface; **PROC** = Paper in proceedings; **REVJ** = Review in journal; **REVV** = Review in volume; **SRC** = Publication of new literary or archivistic document; **SW** = Software; **TRB** = Book translation; **TRJ** = Translation in journal; **TRV** = Translation in volume; **VERD** = Comment of verdict;

Table C.11
Four most frequent publication types for each scientific discipline.

SD	Most common publication types								Other
	1st		2nd		3rd		4th		
01/A1	JRNL	1487 (42.26 %)	PROC	848 (24.10 %)	CHAP	542 (15.40 %)	DICT	138 (3.92 %)	504 (14.32%)
01/A2	JRNL	3369 (84.65 %)	PROC	264 (6.63 %)	OP	144 (3.62 %)	CHAP	109 (2.74 %)	94 (2.36%)
01/A3	JRNL	6564 (84.38 %)	PROC	567 (7.29 %)	CHAP	262 (3.37 %)	OP	237 (3.05 %)	149 (1.91%)
01/A5	JRNL	1415 (65.30 %)	PROC	432 (19.94 %)	CHAP	172 (7.94 %)	OP	50 (2.31 %)	98 (4.51%)
01/A6	JRNL	1031 (55.46 %)	PROC	497 (26.73 %)	CHAP	152 (8.18 %)	ABSP	89 (4.79 %)	90 (4.84%)
01/B1	PROC	13,318 (57.16 %)	JRNL	6353 (27.26 %)	CHAP	2116 (9.08 %)	CUR	526 (2.26 %)	988 (4.24%)
02/A1	JRNL	157,547 (94.91 %)	PROC	6774 (4.08 %)	OP	620 (0.37 %)	CHAP	390 (0.23 %)	672 (0.41%)
02/A2	JRNL	23,983 (80.09 %)	PROC	4740 (15.83 %)	CHAP	517 (1.73 %)	OP	164 (0.55 %)	542 (1.80%)
02/B1	JRNL	41,390 (81.24 %)	PROC	6745 (13.24 %)	CHAP	1269 (2.49 %)	ABSP	698 (1.37 %)	848 (1.66%)
02/B2	JRNL	20,305 (86.23 %)	PROC	1754 (7.45 %)	CHAP	791 (3.36 %)	ABSP	267 (1.13 %)	430 (1.83%)
02/B3	JRNL	18,162 (71.45 %)	PROC	4370 (17.19 %)	ABSP	884 (3.48 %)	CHAP	859 (3.38 %)	1143 (4.50%)
02/C1	JRNL	26,605 (79.91 %)	PROC	4937 (14.83 %)	ABSP	617 (1.85 %)	CHAP	447 (1.34 %)	689 (2.07%)
03/A1	JRNL	7597 (68.61 %)	PROC	1617 (14.60 %)	ABSP	890 (8.04 %)	CHAP	765 (6.91 %)	204 (1.84%)
03/A2	JRNL	16,780 (84.15 %)	PROC	1328 (6.66 %)	CHAP	732 (3.67 %)	ABSP	637 (3.19 %)	463 (2.33%)
03/B1	JRNL	24,713 (84.11 %)	PROC	1594 (5.42 %)	ABSP	1415 (4.82 %)	CHAP	913 (3.11 %)	748 (2.54%)
03/B2	JRNL	13,866 (68.40 %)	PROC	3659 (18.05 %)	ABSP	1174 (5.79 %)	CHAP	730 (3.60 %)	844 (4.16%)
03/C1	JRNL	9291 (74.31 %)	PROC	1712 (13.69 %)	CHAP	552 (4.41 %)	ABSP	434 (3.47 %)	514 (4.12%)
03/C2	JRNL	4547 (61.45 %)	PROC	1585 (21.42 %)	ABSP	532 (7.19 %)	CHAP	352 (4.76 %)	383 (5.18%)
03/D1	JRNL	10,941 (75.61 %)	PROC	1324 (9.15 %)	ABSP	948 (6.55 %)	PAT	437 (3.02 %)	820 (5.67%)
03/D2	JRNL	3502 (52.92 %)	PROC	1648 (24.90 %)	ABSP	895 (13.52 %)	CHAP	222 (3.35 %)	351 (5.31%)
04/A1	JRNL	6719 (60.94 %)	ABSP	1509 (13.69 %)	PROC	1350 (12.24 %)	CHAP	538 (4.88 %)	910 (8.25%)
04/A2	JRNL	6606 (60.01 %)	PROC	1360 (12.35 %)	ABSP	977 (8.88 %)	CHAP	829 (7.53 %)	1236 (11.23%)
04/A3	JRNL	3620 (41.34 %)	PROC	2193 (25.04 %)	CHAP	1134 (12.95 %)	ABSP	780 (8.91 %)	1030 (11.76%)
04/A4	JRNL	3939 (65.85 %)	PROC	946 (15.81 %)	ABSP	481 (8.04 %)	CHAP	357 (5.97 %)	259 (4.33%)
05/A1	JRNL	8641 (59.94 %)	PROC	2612 (18.12 %)	ABSP	1201 (8.33 %)	CHAP	1129 (7.83 %)	832 (5.78%)
05/A2	JRNL	1893 (72.47 %)	PROC	250 (9.57 %)	CHAP	199 (7.62 %)	ABSP	154 (5.90 %)	116 (4.44%)
05/B1	JRNL	8267 (63.70 %)	ABSP	1772 (13.65 %)	PROC	1188 (9.15 %)	CHAP	1046 (8.06 %)	706 (5.44%)
05/B2	JRNL	4347 (74.51 %)	PROC	628 (10.76 %)	ABSP	315 (5.40 %)	CHAP	248 (4.25 %)	296 (5.08%)
05/C1	JRNL	9785 (67.39 %)	PROC	1573 (10.83 %)	ABSP	1534 (10.56 %)	CHAP	914 (6.29 %)	714 (4.93%)
05/D1	JRNL	8545 (73.32 %)	PROC	1230 (10.55 %)	ABSJ	629 (5.40 %)	CHAP	474 (4.07 %)	777 (6.66%)
05/E1	JRNL	31,942 (77.93 %)	PROC	2872 (7.01 %)	ABSP	1657 (4.04 %)	CHAP	1476 (3.60 %)	3043 (7.42%)
05/E2	JRNL	16,448 (81.51 %)	PROC	1176 (5.83 %)	ABSP	735 (3.64 %)	ABSJ	604 (2.99 %)	1215 (6.03%)
05/F1	JRNL	26,147 (76.72 %)	ABSJ	2036 (5.97 %)	PROC	1991 (5.84 %)	ABSP	1669 (4.90 %)	2239 (6.57%)
05/G1	JRNL	11,862 (78.12 %)	PROC	960 (6.32 %)	ABSP	856 (5.64 %)	ABSJ	668 (4.40 %)	839 (5.52%)
05/H1	JRNL	6237 (72.72 %)	PROC	1144 (13.34 %)	ABSP	428 (4.99 %)	ABSJ	394 (4.59 %)	374 (4.36%)
05/H2	JRNL	2966 (80.80 %)	CHAP	217 (5.91 %)	PROC	193 (5.26 %)	ABSP	85 (2.32 %)	210 (5.71%)
05/I1	JRNL	3761 (80.95 %)	ABSP	326 (7.02 %)	CHAP	250 (5.38 %)	PROC	155 (3.34 %)	154 (3.31%)
06/A1	JRNL	9269 (73.76 %)	ABSJ	1451 (11.55 %)	ABSP	784 (6.24 %)	POS	342 (2.72 %)	720 (5.73%)
06/A2	JRNL	22,580 (83.24 %)	PROC	1221 (4.50 %)	CHAP	992 (3.66 %)	ABSJ	606 (2.23 %)	1727 (6.37%)
06/A3	JRNL	4681 (68.23 %)	PROC	771 (11.24 %)	ABSP	625 (9.11 %)	ABSJ	231 (3.37 %)	553 (8.05%)
06/A4	JRNL	10,291 (84.56 %)	ABSJ	635 (5.22 %)	ABSP	435 (3.57 %)	PROC	379 (3.11 %)	430 (3.54%)
06/B1	JRNL	24,506 (74.67 %)	ABSJ	2827 (8.61 %)	PROC	2327 (7.09 %)	CHAP	1367 (4.17 %)	1792 (5.46%)
06/C1	JRNL	30,621 (56.47 %)	ABSP	6951 (12.82 %)	PROC	6589 (12.15 %)	ABSJ	5830 (10.75 %)	4236 (7.81%)
06/D1	JRNL	18,763 (76.95 %)	ABSJ	2044 (8.38 %)	PROC	1568 (6.43 %)	CHAP	1060 (4.35 %)	949 (3.89%)
06/D2	JRNL	16,398 (76.87 %)	ABSP	1938 (9.08 %)	PROC	920 (4.31 %)	CHAP	912 (4.28 %)	1165 (5.46%)
06/D4	JRNL	35,973 (76.16 %)	ABSJ	3582 (7.58 %)	ABSP	2967 (6.28 %)	CHAP	2375 (5.03 %)	2337 (4.95%)
06/D5	JRNL	7876 (71.24 %)	CHAP	953 (8.62 %)	PROC	913 (8.26 %)	ABSJ	573 (5.18 %)	740 (6.70%)
06/D6	JRNL	22,221 (77.58 %)	ABSJ	2935 (10.25 %)	CHAP	1313 (4.58 %)	ABSP	962 (3.36 %)	1210 (4.23%)

Table C.11 (*Continued*)

SD	Most common publication types								Other
	1st		2nd		3rd		4th		
06/E2	JRNL	7343 (51.25 %)	ABSP	2886 (20.14 %)	ABSJ	1797 (12.54 %)	PROC	1293 (9.02 %)	1009 (7.05%)
06/E3	JRNL	6269 (64.46 %)	ABSP	1179 (12.12 %)	PROC	815 (8.38 %)	CHAP	650 (6.68 %)	812 (8.36%)
06/F1	JRNL	11,694 (62.97 %)	PROC	2910 (15.67 %)	ABSP	1284 (6.91 %)	ABSJ	1047 (5.64 %)	1635 (8.81%)
06/F2	JRNL	2086 (59.28 %)	PROC	491 (13.95 %)	ABSP	462 (13.13 %)	ABSJ	202 (5.74 %)	278 (7.90%)
06/F3	JRNL	7486 (59.48 %)	ABSP	1832 (14.56 %)	PROC	1500 (11.92 %)	CHAP	1066 (8.47 %)	702 (5.57%)
06/F4	JRNL	6870 (55.19 %)	PROC	1988 (15.97 %)	ABSP	1183 (9.50 %)	ABSJ	979 (7.87 %)	1427 (11.47%)
06/G1	JRNL	21,611 (74.44 %)	ABSJ	2601 (8.96 %)	PROC	1556 (5.36 %)	ABSP	1397 (4.81 %)	1865 (6.43%)
06/H1	JRNL	13,354 (68.32 %)	ABSP	1867 (9.55 %)	PROC	1408 (7.20 %)	ABSJ	1386 (7.09 %)	1530 (7.84%)
06/I1	JRNL	16,560 (58.21 %)	ABSP	3532 (12.41 %)	ABSJ	3429 (12.05 %)	PROC	2130 (7.49 %)	2800 (9.84%)
06/L1	JRNL	3154 (60.42 %)	ABSP	549 (10.52 %)	ABSJ	459 (8.79 %)	CHAP	378 (7.24 %)	680 (13.03%)
06/M1	JRNL	17,965 (75.45 %)	PROC	2124 (8.92 %)	ABSP	1344 (5.64 %)	CHAP	934 (3.92 %)	1442 (6.07%)
06/M2	JRNL	6911 (59.64 %)	PROC	2234 (19.28 %)	ABSP	1085 (9.36 %)	CHAP	629 (5.43 %)	728 (6.29%)
06/N1	JRNL	17,614 (77.38 %)	PROC	1558 (6.84 %)	ABSJ	1275 (5.60 %)	ABSP	1024 (4.50 %)	1291 (5.68%)
07/A1	JRNL	2252 (39.77 %)	CHAP	1623 (28.66 %)	PROC	1105 (19.52 %)	MONO	279 (4.93 %)	403 (7.12%)
07/B1	JRNL	4043 (54.81 %)	PROC	2270 (30.78 %)	CHAP	514 (6.97 %)	ABSP	251 (3.40 %)	298 (4.04%)
07/B2	JRNL	4843 (57.74 %)	PROC	2022 (24.11 %)	CHAP	632 (7.53 %)	ABSP	503 (6.00 %)	388 (4.62%)
07/C1	JRNL	1725 (41.92 %)	PROC	1570 (38.15 %)	CHAP	377 (9.16 %)	ABSP	220 (5.35 %)	223 (5.42%)
07/D1	JRNL	6609 (52.01 %)	PROC	2403 (18.91 %)	ABSP	1801 (14.17 %)	ABSJ	720 (5.67 %)	1174 (9.24%)
07/E1	JRNL	5242 (51.55 %)	PROC	2202 (21.65 %)	ABSP	1347 (13.25 %)	CHAP	704 (6.92 %)	674 (6.63%)
07/F1	JRNL	3917 (56.49 %)	PROC	1740 (25.09 %)	ABSP	555 (8.00 %)	CHAP	376 (5.42 %)	346 (5.00%)
07/F2	JRNL	2633 (62.57 %)	PROC	610 (14.50 %)	ABSP	519 (12.33 %)	CHAP	303 (7.20 %)	143 (3.40%)
07/G1	JRNL	5106 (51.04 %)	PROC	3077 (30.76 %)	ABSP	781 (7.81 %)	ABSJ	371 (3.71 %)	668 (6.68%)
07/H2	JRNL	3434 (55.09 %)	PROC	1777 (28.50 %)	ABSP	481 (7.72 %)	ABSJ	244 (3.91 %)	298 (4.78%)
07/H3	JRNL	3567 (62.73 %)	PROC	1374 (24.16 %)	ABSP	390 (6.86 %)	ABSJ	126 (2.22 %)	229 (4.03%)
07/H4	JRNL	1604 (50.79 %)	PROC	842 (26.66 %)	ABSP	347 (10.99 %)	ABSJ	201 (6.36 %)	164 (5.20%)
08/A2	PROC	2787 (48.95 %)	JRNL	1915 (33.63 %)	CHAP	651 (11.43 %)	ABSP	117 (2.05 %)	224 (3.94%)
08/A3	PROC	1721 (40.20 %)	JRNL	1146 (26.77 %)	CHAP	968 (22.61 %)	MONO	151 (3.53 %)	295 (6.89%)
08/A4	PROC	1606 (52.67 %)	JRNL	1069 (35.06 %)	CHAP	260 (8.53 %)	MONO	32 (1.05 %)	82 (2.69%)
08/B1	PROC	1989 (58.07 %)	JRNL	889 (25.96 %)	CHAP	260 (7.59 %)	OP	114 (3.33 %)	173 (5.05%)
08/B2	PROC	2272 (48.76 %)	JRNL	1763 (37.83 %)	CHAP	278 (5.97 %)	ABSP	177 (3.80 %)	170 (3.64%)
08/B3	PROC	4945 (61.94 %)	JRNL	1986 (24.88 %)	CHAP	687 (8.61 %)	OP	190 (2.38 %)	175 (2.19%)
08/C1	JRNL	4268 (31.82 %)	CHAP	3500 (26.09 %)	PROC	3018 (22.50 %)	MONO	793 (5.91 %)	1834 (13.68%)
08/D1	JRNL	3975 (34.79 %)	CHAP	3535 (30.94 %)	MONO	674 (5.90 %)	CUR	585 (5.12 %)	2658 (23.25%)
08/E1	CHAP	1770 (34.05 %)	PROC	1377 (26.49 %)	JRNL	766 (14.74 %)	MONO	369 (7.10 %)	916 (17.62%)
08/E2	CHAP	3575 (38.04 %)	JRNL	1919 (20.42 %)	PROC	1277 (13.59 %)	CAT	630 (6.70 %)	1996 (21.25%)
08/F1	CHAP	5447 (34.94 %)	JRNL	4751 (30.48 %)	PROC	2082 (13.36 %)	MONO	866 (5.56 %)	2443 (15.66%)
09/A1	PROC	5292 (56.96 %)	JRNL	3001 (32.30 %)	CHAP	344 (3.70 %)	OP	333 (3.58 %)	321 (3.46%)
09/A2	PROC	2227 (57.18 %)	JRNL	1267 (32.53 %)	CHAP	193 (4.96 %)	OP	76 (1.95 %)	132 (3.38%)
09/A3	PROC	6278 (53.91 %)	JRNL	4326 (37.15 %)	CHAP	497 (4.27 %)	ABSP	147 (1.26 %)	397 (3.41%)
09/B1	PROC	2065 (47.19 %)	JRNL	1840 (42.05 %)	CHAP	298 (6.81 %)	PAT	63 (1.44 %)	110 (2.51%)
09/B2	PROC	1912 (53.75 %)	JRNL	1218 (34.24 %)	CHAP	162 (4.55 %)	MONO	125 (3.51 %)	140 (3.95%)
09/B3	PROC	1771 (45.79 %)	JRNL	1254 (32.42 %)	CHAP	578 (14.94 %)	OP	91 (2.35 %)	174 (4.50%)
09/C1	PROC	3857 (61.53 %)	JRNL	1833 (29.24 %)	CHAP	281 (4.48 %)	OP	114 (1.82 %)	183 (2.93%)
09/C2	PROC	5338 (50.77 %)	JRNL	4054 (38.56 %)	CHAP	395 (3.76 %)	MONO	256 (2.43 %)	471 (4.48%)
09/D1	JRNL	6988 (55.65 %)	PROC	3906 (31.11 %)	ABSP	573 (4.56 %)	CHAP	559 (4.45 %)	531 (4.23%)
09/D2	JRNL	3476 (48.07 %)	PROC	2741 (37.91 %)	CHAP	421 (5.82 %)	ABSP	339 (4.69 %)	254 (3.51%)
09/D3	JRNL	3464 (49.51 %)	PROC	2611 (37.32 %)	CHAP	468 (6.69 %)	ABSP	234 (3.34 %)	220 (3.14%)
09/E1	PROC	2855 (44.56 %)	JRNL	2739 (42.75 %)	ABSP	384 (5.99 %)	CHAP	263 (4.10 %)	166 (2.60%)

09/E2	PROC	5841 (68.73 %)	JRNL	2244 (26.40 %)	CHAP	159 (1.87 %)	MONO	83 (0.98 %)	172 (2.02%)
09/E3	PROC	6793 (49.16 %)	JRNL	5939 (42.98 %)	CHAP	397 (2.87 %)	PAT	304 (2.20 %)	384 (2.79%)
09/E4	PROC	3816 (61.77 %)	JRNL	1920 (31.08 %)	CHAP	146 (2.36 %)	ABSP	111 (1.80 %)	185 (2.99%)
09/F1	PROC	4165 (51.45 %)	JRNL	3359 (41.49 %)	ABSP	216 (2.67 %)	CHAP	182 (2.25 %)	174 (2.14%)
09/F2	PROC	7341 (61.78 %)	JRNL	3677 (30.95 %)	CHAP	368 (3.10 %)	PAT	284 (2.39 %)	212 (1.78%)
09/G1	PROC	5778 (57.62 %)	JRNL	3256 (32.47 %)	CHAP	579 (5.77 %)	MONO	120 (1.20 %)	294 (2.94%)
09/G2	JRNL	6124 (52.37 %)	PROC	3394 (29.03 %)	ABSP	723 (6.18 %)	CHAP	613 (5.24 %)	839 (7.18%)
10/A1	CHAP	9208 (31.89 %)	JRNL	7511 (26.01 %)	PROC	5722 (19.81 %)	CAT	1414 (4.90 %)	5023 (17.39%)
10/B1	CHAP	5711 (33.88 %)	CAT	3368 (19.98 %)	JRNL	2617 (15.52 %)	DICT	1313 (7.79 %)	3850 (22.83%)
10/C1	CHAP	3895 (30.24 %)	JRNL	3382 (26.26 %)	PROC	1043 (8.10 %)	CUR	935 (7.26 %)	3624 (28.14%)
10/D1	JRNL	757 (28.74 %)	CHAP	687 (26.08 %)	PROC	365 (13.86 %)	REVJ	310 (11.77 %)	515 (19.55%)
10/D2	JRNL	2976 (34.75 %)	CHAP	1585 (18.51 %)	REVJ	1203 (14.05 %)	DICT	730 (8.53 %)	2069 (24.16%)
10/D3	JRNL	1283 (33.52 %)	CHAP	816 (21.32 %)	REVJ	747 (19.52 %)	MONO	239 (6.25 %)	742 (19.39%)
10/D4	JRNL	2657 (36.27 %)	CHAP	1736 (23.70 %)	REVJ	870 (11.88 %)	PROC	540 (7.37 %)	1523 (20.78%)
10/E1	JRNL	1550 (27.39 %)	CHAP	1254 (22.16 %)	REVJ	750 (13.26 %)	DICT	428 (7.56 %)	1676 (29.63%)
10/F1	JRNL	2830 (27.17 %)	CHAP	2642 (25.37 %)	REVJ	1250 (12.00 %)	PROC	877 (8.42 %)	2816 (27.04%)
10/F2	JRNL	2502 (30.41 %)	CHAP	1908 (23.19 %)	REVJ	854 (10.38 %)	MONO	689 (8.37 %)	2274 (27.65%)
10/F3	JRNL	2344 (27.26 %)	CHAP	2124 (24.70 %)	DICT	862 (10.02 %)	REVJ	829 (9.64 %)	2440 (28.38%)
10/G1	CHAP	2166 (30.23 %)	JRNL	1957 (27.31 %)	PROC	819 (11.43 %)	MONO	520 (7.26 %)	1704 (23.77%)
10/H1	CHAP	1436 (23.96 %)	JRNL	1434 (23.92 %)	REVJ	781 (13.03 %)	PROC	600 (10.01 %)	1743 (29.08%)
10/I1	JRNL	1129 (24.37 %)	CHAP	1128 (24.35 %)	PROC	574 (12.39 %)	REVJ	392 (8.46 %)	1409 (30.43%)
10/L1	CHAP	3065 (30.17 %)	JRNL	3014 (29.67 %)	REVJ	757 (7.45 %)	MONO	701 (6.90 %)	2622 (25.81%)
10/M1	CHAP	1213 (30.94 %)	JRNL	847 (21.61 %)	REVJ	383 (9.77 %)	PROC	300 (7.65 %)	1177 (30.03%)
10/M2	CHAP	633 (29.28 %)	JRNL	526 (24.33 %)	PROC	234 (10.82 %)	REVJ	233 (10.78 %)	536 (24.79%)
10/N1	JRNL	1742 (27.19 %)	CHAP	1548 (24.16 %)	REVJ	625 (9.76 %)	PROC	605 (9.44 %)	1886 (29.45%)
10/N3	CHAP	1200 (24.46 %)	JRNL	1047 (21.34 %)	DICT	490 (9.99 %)	REVJ	475 (9.68 %)	1694 (34.53%)
11/A2	CHAP	1800 (30.29 %)	JRNL	1553 (26.14 %)	DICT	591 (9.95 %)	REVJ	531 (8.94 %)	1467 (24.68%)
11/A5	CHAP	1264 (35.43 %)	JRNL	988 (27.69 %)	MONO	353 (9.89 %)	CUR	286 (8.02 %)	677 (18.97%)
11/B1	CHAP	4145 (35.32 %)	JRNL	2822 (24.05 %)	PROC	1558 (13.28 %)	REVJ	724 (6.17 %)	2487 (21.18%)
11/C1	JRNL	2145 (30.62 %)	CHAP	1596 (22.78 %)	REVJ	635 (9.06 %)	MONO	624 (8.91 %)	2005 (28.63%)
11/C3	CHAP	1324 (25.72 %)	JRNL	1318 (25.60 %)	REVJ	603 (11.71 %)	MONO	442 (8.59 %)	1461 (28.38%)
11/C5	JRNL	2882 (24.92 %)	CHAP	2687 (23.23 %)	REVJ	1420 (12.28 %)	DICT	1338 (11.57 %)	3238 (28.00%)
11/D1	CHAP	992 (32.64 %)	JRNL	907 (29.85 %)	MONO	311 (10.23 %)	REVJ	177 (5.82 %)	652 (21.46%)
11/D2	CHAP	1109 (34.91 %)	JRNL	994 (31.29 %)	MONO	337 (10.61 %)	PROC	258 (8.12 %)	479 (15.07%)
11/E1	JRNL	8406 (62.19 %)	PROC	1859 (13.75 %)	CHAP	1216 (9.00 %)	ABSP	824 (6.10 %)	1211 (8.96%)
11/E2	JRNL	1704 (44.71 %)	CHAP	777 (20.39 %)	PROC	729 (19.13 %)	ABSP	162 (4.25 %)	439 (11.52%)
11/E3	JRNL	2035 (50.27 %)	CHAP	960 (23.72 %)	PROC	493 (12.18 %)	ABSP	262 (6.47 %)	298 (7.36%)
11/E4	JRNL	2473 (50.88 %)	CHAP	944 (19.42 %)	PROC	539 (11.09 %)	ABSP	281 (5.78 %)	623 (12.83%)
12/A1	CHAP	1787 (38.18 %)	JRNL	1494 (31.92 %)	VERD	641 (13.69 %)	MONO	344 (7.35 %)	415 (8.86%)
12/B2	JRNL	952 (45.40 %)	CHAP	679 (32.38 %)	VERD	237 (11.30 %)	MONO	75 (3.58 %)	154 (7.34%)
12/C1	JRNL	1945 (39.10 %)	CHAP	1788 (35.95 %)	MONO	284 (5.71 %)	VERD	280 (5.63 %)	677 (13.61%)
12/C2	JRNL	432 (42.11 %)	CHAP	191 (18.62 %)	MONO	93 (9.06 %)	PROC	92 (8.97 %)	218 (21.24%)
12/D1	JRNL	1855 (42.38 %)	CHAP	1398 (31.94 %)	VERD	429 (9.80 %)	MONO	229 (5.23 %)	466 (10.65%)
12/D2	JRNL	725 (47.54 %)	CHAP	356 (23.34 %)	VERD	317 (20.79 %)	MONO	80 (5.25 %)	47 (3.08%)
12/E1	JRNL	1229 (43.23 %)	CHAP	870 (30.60 %)	MONO	163 (5.73 %)	VERD	109 (3.83 %)	472 (16.61%)
12/E2	JRNL	1697 (38.71 %)	CHAP	1390 (31.71 %)	MONO	250 (5.70 %)	VERD	215 (4.90 %)	832 (18.98%)
12/E3	CHAP	1044 (38.42 %)	JRNL	969 (35.66 %)	VERD	310 (11.41 %)	MONO	166 (6.11 %)	228 (8.40%)
12/F1	JRNL	412 (39.85 %)	CHAP	257 (24.85 %)	VERD	195 (18.86 %)	MONO	62 (6.00 %)	108 (10.44%)

Table C.11 (*Continued*)

SD	Most common publication types								Other
	1st		2nd		3rd		4th		
12/G1	CHAP	748 (40.06%)	JRNL	567 (30.37%)	VERD	195 (10.44%)	MONO	128 (6.86%)	229 (12.27%)
12/G2	CHAP	1080 (40.00%)	JRNL	959 (35.52%)	VERD	238 (8.81%)	MONO	149 (5.52%)	274 (10.15%)
12/H1	JRNL	365 (35.10%)	CHAP	272 (26.15%)	MONO	128 (12.31%)	PROC	71 (6.83%)	204 (19.61%)
12/H2	CHAP	334 (27.72%)	JRNL	259 (21.49%)	REVJ	146 (12.12%)	PROC	137 (11.37%)	329 (27.30%)
12/H3	JRNL	1196 (37.32%)	CHAP	793 (24.74%)	MONO	266 (8.30%)	REVJ	212 (6.61%)	738 (23.03%)
13/A1	JRNL	4600 (64.85%)	CHAP	1260 (17.76%)	OP	637 (8.98%)	MONO	185 (2.61%)	411 (5.80%)
13/A2	JRNL	7127 (54.52%)	CHAP	3066 (23.45%)	OP	1242 (9.50%)	PROC	586 (4.48%)	1052 (8.05%)
13/A3	JRNL	1642 (58.94%)	CHAP	574 (20.60%)	OP	243 (8.72%)	PROC	114 (4.09%)	213 (7.65%)
13/A4	JRNL	3119 (47.39%)	CHAP	1688 (25.65%)	PROC	607 (9.22%)	OP	591 (8.98%)	576 (8.76%)
13/A5	JRNL	759 (69.57%)	CHAP	161 (14.76%)	PROC	69 (6.32%)	OP	69 (6.32%)	33 (3.03%)
13/B1	JRNL	2668 (35.50%)	CHAP	2526 (33.61%)	PROC	1015 (13.50%)	MONO	725 (9.65%)	582 (7.74%)
13/B2	JRNL	2149 (31.27%)	CHAP	2061 (29.99%)	PROC	1615 (23.50%)	MONO	437 (6.36%)	610 (8.88%)
13/B3	CHAP	963 (34.83%)	PROC	738 (26.69%)	JRNL	708 (25.61%)	MONO	148 (5.35%)	208 (7.52%)
13/B4	JRNL	1853 (40.10%)	CHAP	1515 (32.79%)	PROC	418 (9.05%)	OP	332 (7.18%)	503 (10.88%)
13/B5	PROC	971 (35.43%)	JRNL	915 (33.38%)	CHAP	414 (15.10%)	ABSP	193 (7.04%)	248 (9.05%)
13/C1	CHAP	1958 (35.85%)	JRNL	1742 (31.90%)	MONO	472 (8.64%)	REVJ	344 (6.30%)	945 (17.31%)
13/D1	JRNL	2346 (47.15%)	PROC	1365 (27.43%)	CHAP	616 (12.38%)	OP	244 (4.90%)	405 (8.14%)
13/D2	JRNL	1058 (46.40%)	CHAP	518 (22.72%)	PROC	407 (17.85%)	OP	162 (7.11%)	135 (5.92%)
13/D3	CHAP	917 (34.63%)	JRNL	824 (31.12%)	PROC	412 (15.56%)	OP	152 (5.74%)	343 (12.95%)
13/D4	JRNL	1705 (61.80%)	CHAP	330 (11.96%)	PROC	314 (11.38%)	ABSP	159 (5.76%)	251 (9.10%)
14/A1	JRNL	1808 (34.04%)	CHAP	1332 (25.08%)	MONO	459 (8.64%)	REVJ	434 (8.17%)	1279 (24.07%)
14/A2	JRNL	991 (40.32%)	CHAP	790 (32.14%)	MONO	193 (7.85%)	REVJ	161 (6.55%)	323 (13.14%)
14/B1	JRNL	1210 (27.60%)	CHAP	1135 (25.89%)	REVJ	562 (12.82%)	MONO	348 (7.94%)	1129 (25.75%)
14/B2	JRNL	1452 (30.68%)	CHAP	1365 (28.84%)	REVJ	544 (11.49%)	MONO	423 (8.94%)	949 (20.05%)
14/C2	CHAP	1029 (39.81%)	JRNL	774 (29.94%)	MONO	284 (10.99%)	CUR	199 (7.70%)	299 (11.56%)
14/D1	CHAP	1753 (39.56%)	JRNL	1388 (31.32%)	MONO	385 (8.69%)	CUR	257 (5.80%)	648 (14.63%)

Appendix D. Levenshtein distance

The Levenshtein distance between two strings (sequences of characters) is the number of edit operations that are required to transform one string into the other. The following single-character edit operations are permitted: (*i*) deletion of a character; (*ii*) insertion of a character; (*iii*) replacement of a character with a different one.

Let $S[1\,..\,n]$ and $T[1\,..\,m]$ be two strings of length $n := |S|$ and $m := |T|$, respectively. The Levenshtein distance $L(S, T)$ of S and T is the value of the auxiliary function $L_{S,T}(n, m)$, where $L_{S,T}(i, j)$ is defined for all $0 \le i \le n$, $0 \le j \le m$ as follows:

$$L_{S,T}(i,j) := \begin{cases} \max\{i,j\} & \text{if } i = 0 \text{ or } j = 0 \\ \min\{L_{S,T}(i-1,j)+1,\, L_{S,T}(i,j-1)+1,\, L_{S,T}(i-1,j-1)+1_{S[i]\neq T[j]}\} & \text{otherwise} \end{cases} \tag{D.1}$$

where $1_{\mathcal{P}}$ if the indicator function, whose value is 1 if the predicate $\mathcal{P}$ is true, 0 otherwise. $L_{S,T}(i, j)$ is the minimum number of edit operations needed to transform the prefix $S[1\,..\,i]$ of S into the prefix $T[1\,..\,j]$ of T. If one of the prefixes is empty ($i = 0$ or $j = 0$), then the distance is simply the length of the nonempty prefix. If both prefixes are nonempty, $S[1\,..\,i]$ can be transformed into $T[1\,..\,j]$ by either:

1 deleting the character $S[i]$ and transforming $S[1\,..\,i-1]$ into $T[1\,..\,j]$; this requires $L_{S,T}(i-1, j)+1$ edit operations;
2 deleting $T[j]$ and transforming $S[1\,..\,i]$ into $T[1\,..\,j-1]$; this requires $L_{S,T}(i, j-1)+1$ edit operations;
3 replacing $S[i]$ with $T[j]$ (if they are different, otherwise do nothing) and transforming $S[1\,..\,i-1]$ into $T[1\,..\,j-1]$; this require $L_{S,T}(i-1, j-1)+1_{S[i]=T[j]}$ edit operations.

The value $L_{S,T}(n, m)$ can be computed in time $O(nm)$ by tabulating all values $L_{S,T}(i, j)$ starting from $L_{S,T}(0, 0)$. The Levenshtein distance is zero if and only if S and T are equal; the maximum value is $\max\{|S|, |T|\}$ when S and T contain distinct sets of characters (e.g., $S =$ " abcdef", $T =$ " ghijklmnopqrst"). The *normalized* Levenshtein distance $L_n(S, T)$ is defined as:

$$L_n(S,T) := \frac{L_{S,T}(|S|, |T|)}{\max\{|S|, |T|\}} \tag{D.2}$$

and assumes values in the range [0, 1].

By definition, a small difference between short documents results in a larger normalized distance than the same difference between long documents. Formally, given two pairs of documents S, T and S', T' where $|S| < |S'|$, $|T| < |T'|$ and such that $L_{S,T}(|S|, |T|) = L_{S',T'}(|S'|, |T'|)$, then according to Eq. (D.2) we have $L_N(S, T) > L_N(S', T')$. In short, the same (absolute) difference matters more for short documents than for long ones.

It is important to remark that the normalized Levenshtein distance among real-world documents is usually much lower than 1.0. For example, the normalized distance between a portion of the United States Declaration of Independence and a portion of equal length from the *Divine Comedy* by Italian poet Dante Alighieri is less than 0.8; the distance between two random character sequences is about 0.9.

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