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Evaluating Research Activity: Impact Factor vs. Research Factor

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Abstract - The Impact Factor (IF) “has moved ... from an obscure bibliometric indicator to become the chief quantitative measure of the quality of a journal, its research papers, the researchers who wrote those papers, and even the institution they work in” ([2], p. 1). However, the use of this index for evaluating individual scientists is dubious. The present work compares the ranking of research units generated by the Research Factor (RF) index with that associated with the popular IF. The former, originally introduced in [38], reflects article and book publications and a host of other activities categorized as coordination activities (e.g., conference organization, research group coordination), dissemination activities (e.g., conference and seminar presentations, participation in research group), editorial activities (e.g., journal editor, associate editor, referee) and functional activities (e.g., Head of Department). The main conclusion is that by replacing the IF with the RF in hiring, tenure decisions and awarding of grants would greatly increase the number of topics investigated and the number and quality of long run projects.

Keywords: scientific research assessment, Impact Factor, bibliometric indices, feasible Research Factor

JEL Classification: A11, A12

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1. Introduction

One of the most popular bibliometric indices in the scientific field is the so called Impact Factor (IF). Proposed by Garfield in the mid-1950s, it has been regularly calculated, since the early 1960s, by the Institute for Scientific Information (ISI), now Thomson Scientific, using the Science Citation Index and the Science and Social Citation Index and is annually reported in the Journal of Citation Reports.[2] This index is obtained as the ratio between the number of cites, in the indexed journals, in the benchmark year to articles published in the two preceding years in a certain journal and the number of 'citable' articles published in that journal over the same period.[3]

IF was originally designed to measure the impact of a journal on the dissemination of scientific knowledge. However, in recent years it has become central to many evaluation processes.[4] In other words, it "has moved ... from an obscure bibliometric indicator to become the chief quantitative measure of the quality of a journal, its research papers, the researchers who wrote those papers, and even the institution they work in" ([2], p. 1). Consequently the IF is currently used for a wide variety of 'unplanned' purposes. Often librarians decide which subscription to renew and publishers plan their editorial strategy according to this index.[5] For university departments and research institutes it represents a useful tool to rank candidates in the case of recruitment or promotion.[6] Sometimes national governments or private sponsors adopt it to allocate resources among university departments or research centers.[7] Lastly, it is helpful to

[2] See the website http://admin-apps.isiknowledge.com/JCR/JCR.

[3] This means that the 2008 IF of *Journal Y* is computed using the number of cites received in that year by articles appeared in *Y* in 2006-7 and the number of articles published in *Y* in the same two-year period. For this reason it is always released the following year to make sure that all publications have been received. The number of citations is taken from a data bank with over 9000 journals and the denominator of this ratio does not include items labeled 'front-matter' such as news items, correspondence and errata. However there is not a fixed rule for the distinction between "citable' and 'front-matter' items [31].

[4] For details see, e.g., [27], [28] and [37].

[5] As an example see the library website of the *Oregon State University*, http://osulibrary.oregonstate.edu/scholarly_communication/, and that of the *Universiteitsbibliotheek Gent Algemeen*, http://lib1.ugent.be/cmsites/default.aspx?alias=EN_SEARCH.

[6] For more details see, e.g., [6], [27] and [28].

[7] This subject is also discussed in [11] and [23].

individual researchers to determine what to read and where to publish.[8] Summarizing, "once you have a figure that reflects, say, scientific excellence, you can use it for all sorts of purposes" ([28], p. 209).

Several authors, e.g., [1], [2], [14] and [34], discuss the drawbacks of the IF when properly used.[9] Equally, if not more important, is the fact that its abuse may lead to unintended results. For instance, the ever-increasing tendency to use it as a measure of an individual researcher quality is highly questionable. In [2], it is noticed that "the use of journal impact factors for evaluating individual scientists is … dubious, given the statistical and sociological variability in journal impact factors" (p. 5). Garfield himself acknowledges that "the use of journal impacts in evaluating individuals has its inherent dangers" ([18], p. 92).[10] An even more radical stand is taken in [1] where it is argued that "it makes no sense to use the impact factor to evaluate (the articles,) the authors of the articles, the programs in which they work and - most certainly - the disciplines they represent" (p. 12).[11] As observed in [29], when the number of citations received by a certain article is viewed as a measure of its quality it is noticeable that, considering a 25-year time span, the best article published in an average-quality journal like *The Oxford Bulletin of Economics and Statistics* gets more citations than the worst four articles published in a high-level journal like *The American Economic Review*.[12]

A number of corrections and integrations have been proposed in the literature to overcome the most obvious limitations of IF. The *Journal to field Impact Score* is introduced in [39] to correct

[8] See for example [5].

[9] For instance, in [14] it is noticed that the IF may change considerably from one year to the next and that it is affected by the average number of coauthors per article. In [34] the authors state that they are unable to replicate the IF values published by Thomson Scientific. See also [15], [22] and the website http://en.wikipedia.org/wiki/Impact_factor, and the references therein cited, for a nice introduction to this literature.

[10] See also [16] and [17].

[11] It is here considered the case where two journals, say *Journal 1* and *Journal 2*, have IF equal to 0.434 and 0.846, respectively. Then "the probability that a randomly selected … paper (from *Journal 1*) has at least as many citations as a randomly selected … (*Journal 2*) paper … is 62%" (p. 11). This is due to "the highly skewed distribution (of citations) and the narrow window of time used to compute the impact factor – which is the reason for the high percentage of uncited papers" (p. 12). It is then concluded that "while it is incorrect to say that the impact factor gives no information about individual papers in a journal, the information is surprisingly vague and can be dramatically misleading." (p. 12). The risks associated with the abuse of IF are discussed also in the section "*Limitations of impact factors as markers of 'scientific excellence'"* in [28] and "*Cult of the Factor*" and "*Crooked citations"* in [27].

[12] In [1], pages 14-16, there is a very nice discussion of "the meaning of citations". The main conclusion is that it "is not simple and citation-based statistics are not nearly as 'objective' as proponents assert." Finally, see [19] for a radical critique to the use of the number of citations, or any other measure based on contemporary judgment, as an indicator of the quality of scientific research.

the distortion due to the exclusion of non 'citable' articles from the denominator. In [20], there is a suggestion to overcome the limit of a two-year time horizon, typical of the IF, by using the *Adjusted Impact Factor*. Alternatively, an index called the *Disciplinary Impact Factor* is used in [32] to take into account the different citation habits prevailing in the various scientific areas. The VICER public body annually computes a version of IF based on Euro-Factor, a databank with over 500 journals, mainly European. An index similar to IF ignoring self-citations, i.e. the *Journal Diffusion Factor*, is discussed in [35]. In [4] the *Relative Impact Factor* and the *Activity Index* are derived in order to evaluate scientific productivity at the national, or regional, level and to determine the regional specializations and the national centers of excellence. Finally, some argue in favor of the *Web impact factor*, an index based on the number of hits on personal web pages and links between different sites.[13]

However, neither IF nor these alternatives are able to summarize the quality and quantity of the research activity carried out by a certain unit, be it an individual researcher or a university department, in a given period of time.[14] Publishing articles in scientific journals is only one aspect of this activity. Indeed it does not even cover the whole publishing activity which should include journal articles as well as monographs, essays in collective volumes and working papers. Moreover, there are a bunch of other research activities that, even though not immediately related to articles or citations, greatly contribute to scientific progress and the diffusion of knowledge. To name just a few, think about the organization of conferences and seminars, the coordination of research groups, the participation to conferences, seminars and research groups, the importance of a journal Editor and referee, the teaching at graduate and post-graduate level, the supervision of doctoral theses, and borderline activities, from a research point of view, such as the membership in scientific associations and the role of Department Chairman.[15] All these

[13] See, e.g., [25]. A comprehensive review of these alternative measures can be found in [15].

[14] These considerations hold for all the indices presently discussed in the literature. The Page Rank algorithm discussed in [3] simply gives a greater weight to citations from high-impact journals than citations from low-impact journals. Some indices combine the number of publications (journal articles and high impact conferences) of a certain scholar with the number of citations. This is the case of the *h*-index, or Hirsch number, introduced in [21] and its various modifications included the *g*-index proposed in [13]. A scholar has an index *h* when he/she has published *h* papers each of which has at least *h* citations. The *g*-index, "in addition, takes into account the citation scores of the top articles" ([13], p. 131). Even the journal-to-field impact score recently discussed in [43] is limited to journal publications. For a discussion of the differences between the various databases available to compute these indices see [26].

[15] Teaching at undergraduate level deserves special attention and it is completely ignored here. For details see, e.g., [12], [8] and the references therein.

aspects, up to now completely ignored (or treated in an *ad hoc* manner) in the evaluation of research activity, should be fully and explicitly considered. [16]

For this reason the "Research Factor" (or simply the R-Factor), an index reflecting the multifaceted nature of scientific research discussed in [38], is introduced in Section 2. It is a weighted sum of a 'publications' index and a 'non-publications' index. The former reflects the quality and quantity of journal articles, books (both monographs and essays) and working papers (Section 3). The latter is computed considering all 'non-publications', or 'other', activities (Section 4). In Section 5, the ranking of research units associated with the approximated *feasible* R-Factor is contrasted with that generated by the popular IF in a numerical example using stylized scientific profiles.[17] If the two are identical, the easier to compute IF ranking can be viewed as a valid proxy for a measure of scientific activity. This is due to the fact that the involvement in 'other' activities is always proportional to 'journal article publication' activity. Otherwise the need for a 'multifaceted' index like R-Factor is manifest. To see how sensitive the conclusions are with respect to the weights needed for the computation of the latter, two different sets of weights are used. The main conclusions are summarized in Section 6.

2. The R-Factor: an intuitive introduction

As argued in the introduction, publishing articles in scientific journals represents only one aspect of the research activity. Furthermore, using the journal IF to measure research implies assuming that the quantity and quality of the whole activity is proportional to the quantity and quality of journal articles. This boils down to ignoring the existence of a trade-off between one scientific activity and another, due to the inescapable time constraint, and the fact that some activities bear little, or no, relationship with article publication. The trade-off between writing articles and

[16] When applying for an Advanced Grant funded by the European Research Council, the applicant must include journal publications, conferences proceedings, research monographs, chapters in collective volumes, invited presentations, organization of conferences, memberships to editorials boards of journals etc. ([41], p. 28). In addition the international recognition and diffusion that the major contributions have received from others (publications, citations, additional funding, students, etc.) must be described and evidence of efforts and ability to inspire younger researchers towards high quality research reported ([41], p. 28).

[17] A comparison of the R-Factor ranking with that associated to the other available bibliometric measures, such as the *h*-index, the Citation Impact, the Citation index and so on goes beyond the scope of the present paper.

drafting monographs is obvious. In the last few decades, the tendency to underestimate the importance of the latter has induced many scholars to shift toward short-run research projects, published as journal articles, at the expense of long-run projects. Given this incentive structure, it is not worth it working for several years on a monograph when, in that period of time, various articles can get published in high level journals. Sraffa! Who was he?[18]

Less apparent may seem the scientific relevance of the 'other' activities. An article is obviously the work of the author(s). However some credit should be given both to the Editor of the journal where it appears and to the anonymous referees who suggest improvements and highlight errors. Then it should be acknowledged that, in today's world, conferences represent a central moment to the diffusion of scientific results. Organizing a conference means to underline certain subjects, promoting some threads of research. Thus it is an active scientific role not a merely administrative activity. Analogously, presenting a work at a conference, or giving a seminar talk, doesn't only mean receiving suggestions and comments but also stimulating new ideas and considerations in the audience which can possibly originate new research. Again this is a fundamental moment in scientific activity that is not easily associated with articles directly linked to that conference, or to that participant, or with citations received by a certain work.

Proper credit for their activity should be also given to the coordinators of research groups that direct and coordinate the efforts of several people toward a common goal. Analogously, teaching at graduate level and supervising of doctoral theses have a great scientific value, even though hard to measure most the times, because they introduce future researchers to the 'frontiers of knowledge' and encourage them to go beyond.[19] Finally, there may be good reasons to re-evaluate from a scientific point of view even institutional roles such as Department Chair, Dean of a university, etc.. In many cases these roles have little or nothing to do with research in a strict sense.[20] However, when carried out with dedication and intelligence, they allow the research units to better concentrate on their work with a series of positive spin-offs that are hard to

[18] Piero Sraffa (1898-1983) was an Italian economist, good friend of Antonio Gramsci and John M. Keynes, who spent most of his life as a librarian at the University of Cambridge (UK) working on a monumental edition of Ricardo's "Works and Correspondence" and on his book "Production of commodities by means of commodities", published in 1960, which represents a milestone in the history of economic thought. See Roncaglia [33] and the websites http://cepanewschhol.edu/het/profiles/sraffa /htm and http://rabbit.trin.cam.ac.uk/~jon/Msscolls/Sraffa.html for details.

[19] This analysis does not consider the fundamental trade-off between teaching and research activities.

[20] Many thanks go here to an anonymous referee for underlying the importance to stress this point.

measure. Moreover, active researchers may feel encouraged to temporarily take on these duties.[21] By doing so, they may also benefit their institution which could find easier to raise research funds when represented by an 'active researcher' rather than a 'bureaucrat'.

An index constructed taking into account all these activities has been recently proposed in [38]. This is the R-Factor (*RF*). For a certain research unit, say the individual *Scholar A*, the *RF* for year *t* is defined as[22]

$$RF_{A,t} = \alpha_1 RF_{A,t,pub} + \alpha_2 RF_{A,t,oth} + \alpha_3 f(RF_{A,t,pub}, RF_{A,t,oth}) \quad (1)$$

where $RF_{A,t,pub}$ reflects the 'quality contribution' of *A* to a certain field, or scientific area, due to 'publications', $RF_{A,t,oth}$ the 'quality contribution' due to 'other' activities and α_1 and α_2 are the weights attributed to $RF_{A,t,pub}$ and $RF_{A,t,oth}$, respectively. The function $f(RF_{A,t,pub}, RF_{A,t,oth})$ is used to capture the fact that *A* is simultaneously publishing works and carrying out other research activities in the time lapse considered. Then when $\alpha_3 > 0$ a premium is awarded to 'well-rounded' research units characterized by a diversified research portfolio.

Obviously, the appropriate values for α_1, α_2 and α_3 depend upon the goals of the research institution or an overseeing research funding agency (for instance the UK higher education funding bodies and research councils or the Association of The Netherlands Universities). Once these objectives are identified, the appropriate values for the weights are selected (maybe different for the various fields and institution type) and consistently applied.[23] Presently, they are usually set at $\alpha_1 = 1$ and $\alpha_2 = \alpha_3 = 0$, but in general they can be $\alpha_1 > 0$ and $\alpha_2, \alpha_3 \geq 0$.

A possible specification for Formula (1), when the weights sum up to one and $\alpha_1 = \alpha_2$,[24] is

[21] Not many such researchers, apart from Larry Summers (the nephew of two Nobel Prizes in Economics, one of the youngest tenured professors at Harvard, Treasury Secretary in the second Clinton Administration, President of Harvard University afterward and currently Head of National Economic Council), are interested in institutional positions unless they are appropriately rewarded once they go back to active research.

[22] Patents and other forms of copyrighted works which can be fundamental in some areas, such as screenplays and movies, concerts, soundtracks and music records, architectural projects and alike, artistic performances, prizes are deliberately ignored in this discussion.

[23] They can be identified either using a top-to-bottom approach, i.e. imposing them from the top, or a bottom-up approach, where they are agreed upon by the various sub-units or the interested scientifique community.

[24] This can be interpreted as giving the same dignity to 'publications' and 'other' activities.

$$RF_{A,t} = 0.414 RF_{A,t,pub} + 0.414 RF_{A,t,oth} + 0.414^2 \left[\left(na_{A,t} - 1 \right) \left(RF_{A,t,pub} + RF_{A,t,oth} \right) / 2 \right] \qquad (2)$$

with $na_{A,t}$ the number of research activities carried out, at most two.[25] Then the 'well-rounded' unit with $RF_{A,t,pub} = RF_{A,t,oth} = 1$ is ranked higher than the 'more-of-the-same' unit with $RF_{A,t,pub} = 2$ and $RF_{A,t,oth} = 0$. In the latter case, the last term disappears because $(na_{A,t} - 1)$ is zero (Fig. 1).

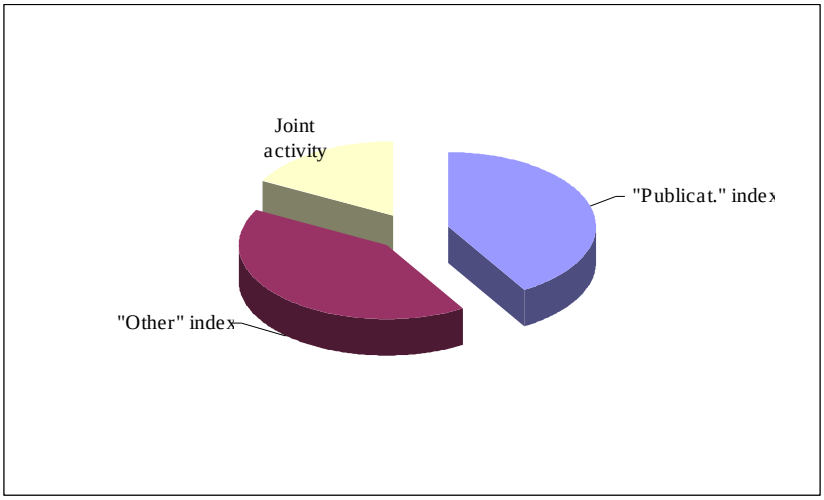

Figure 1. Graphic representation of Formula (2) when $RF_{A,t,pub} = RF_{A,t,oth} = 1$.

3. The 'publications' component of the R-Factor

The 'publications' component of *RF* is thought of as a weighted sum of subcomponents corrected for 'well-roundedness'.[26] It takes the form

[25] When each research activity is associated with an indicator equal to one if the activity is carried out in the relevant lapse of time and zero otherwise, $na_{A,t}$ is simply the sum of the indicators [38].

[26] This construction has the advantage that new subcomponents can be added, or the old ones removed, without affecting the computation of the others.

$$RF_{A,t,pub} = \beta_1 RF_{A,t,art} + \beta_2 RF_{A,t,books} + \beta_3 RF_{A,t,wp} + \beta_4 f(RF_{A,t,art}, RF_{A,t,books}, RF_{A,t,wp}) \quad (3)$$

where $RF_{A,t,art}$, $RF_{A,t,books}$ and $RF_{A,t,wp}$ are the annual average, for the period immediately preceding year *t*, of the 'quality contribution' due to journal articles, books (monograph and essays) and research working papers, respectively, published by *Scholar A*. The 'well-rounded' index is here given by the function $f(RF_{A,t,art}, RF_{A,t,books}, RF_{A,t,wp})$. Again, when $\beta_4 > 0$ a premium is awarded to research units with different types of publications. It should be observed that, if journal articles are evaluated by IF, $RF_{A,t,pub}$ is identical to $IF_{A,t}$, the index obtained by weighting *A*'s journal articles with IF, when $\beta_1 = 1$ and $\beta_2 = \beta_3 = \beta_4 = 0$ (Fig. 2). However, the appropriate values for β_1, β_2, β_3 and β_4 depend upon the needs of the research institution as the α's in Formula (1).[27]

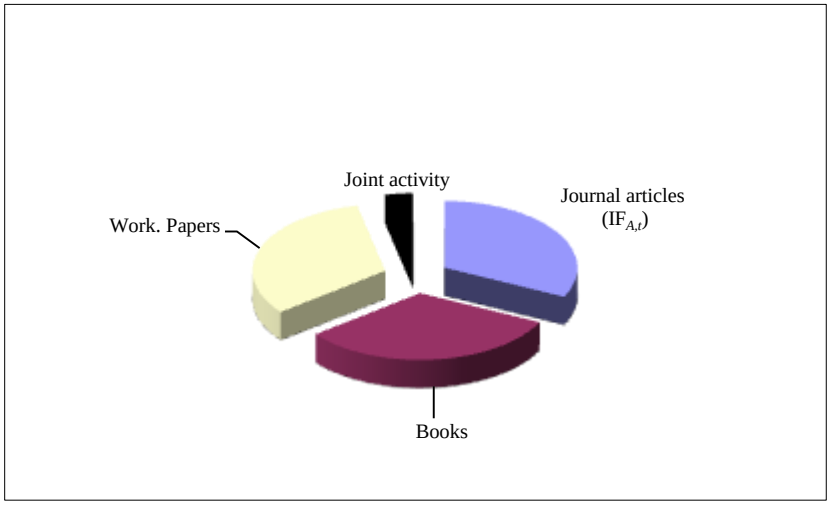

Figure 2. Graphic representation of Formula (4) when $RF_{A,t,art} = RF_{A,t,books} = RF_{A,t,wp} = 1$.

In general, β_1 is positive and the others are greater or equal to zero. When the weights sum up to one and all activities are equally important as in (2), Formula (3) looks like

[27] See footnote 23 above.

$$RF_{A,t,pub} = 0.322 RF_{A,t,art} + 0.322 RF_{A,t,books} + 0.322 RF_{A,t,wp} + 0.322^3 \left[\left(npa_{A,t} - 1 \right) \left(RF_{A,t,art} + RF_{A,t,books} + RF_{A,t,wp} \right) / 3 \right] \quad (4)$$

with $nap_{A,t}$ the number of the 'publications' activities performed by *A*, at most 3.[28]

As will become apparent from the following discussion, the 'quality contribution' terms used to compute the subcomponents in (3), or (4), are generally derived by multiplying the 'contribution' of *A* (1 when there are no coauthors) by the 'quality' of the research item.[29] Then in the presence of appropriate databanks for the different types of publication, the computation of $RF_{A,t,pub}$ is straightforward, given the β's.[30] Alternatively, the quality to attribute to each research item and the contribution to credit to the various coauthors of a work may be agreed upon by the community of researchers or a peer-review system may be set in place.[31] However, it is never stressed enough the fact that while there is a lively debate on how to measure the quality of journal articles, as summarized in the introduction, there is only a beginning of discussion on how to consistently evaluate books and research working papers. Sections 3.1, 3.2 and 3.3 review the derivation of $RF_{A,t,pub}$, $RF_{A,t,art}$, $RF_{A,t,books}$ and $RF_{A,t,wp}$, from now on simply RF_{pub}, RF_a, RF_b and RF_{wp} respectively, presented in [38].[32] To show the potential of RF_{pub} a set of *feasible* 'contribution' and 'quality' quantities, heavily dependent on existing journal article indices, is also provided.

3.1 An index for journal articles: RF_a

The index associated with journal articles for *Scholar A* at time *t* is written as

[28] When indicators are used $npa_{A,t}$ is simply their sum. See footnote 25 above.

[29] Then the 'quality contribution' of the individual items in each subcomponent can be added or removed simply by setting its 'quality' positive or equal to zero.

[30] As pointed out by an anonymous referee, the lack of these databanks may prevent the use of a full-fledged *RF* in the near future. However agreeing on the need for this type of indices will definitely speed up their implementation. In the meantime a set of agreed upon quantities, maybe in combination with some *feasible* quantities, may be used.

[31] See [42] for a way to construct a set of 'contribution' and 'quality' quantities agreed upon by the scientifique community.

[32] The notation used here is slightly different from that in [38].

$$RF_a = \frac{1}{T}\sum_{i=1}^{I} p_{a,i} Q_{a,i} \qquad (5)$$

where $p_{a,i}$ represents the portion of the *i*-th article due to *A*, $Q_{a,i}$ is the quality of that article and *I* is the number of articles published in year '$t-T$', ..., '$t-1$'. Therefore RF_a represents the average 'quality contribution', over the period *T*, to a certain scientific field due to journal articles. If *A* is the sole author, $p_{a,i}$ is equal to one. In the presence of co-authors each of them should get credit for the fraction of work actually done (for example, fraction of sections, or pages). When this is not possible, a *feasible* solution is based on the order in which the names appear. If they are in alphabetical order the weight $p_{a,i}$ is simply the inverse of the number of co-authors as reported in the upper portion of Table B1 in Appendix B. If not, it is assumed that the first author has contributed more than the second and so on (see lower portion of Table B1 in Appendix B).[33] Summarizing, if the *i*-th journal article has been written by three people with *A* as second author, not in alphabetical order, the appropriate weight is $p_{a,i} = 1/3$. In any case, the sum of the *p*'s is equal to one for each journal article.

The quality of article *i*, $Q_{a,i}$, can be measured in various ways. One possible choice is the IF associated with the journal where it appears, i.e. $Q_{a,i} = IF_i$.[34] However, this is possible only in a small number of cases. The journals included in the "economics" sector by ISI are only 191 (175) for the year 2007 (2006).[35] For this reason the categorization proposed in [9] might prove

[33] In the presence of articles with co-authors, there is a recent tendency to identify a corresponding author. If this information is available an alternative is to consider the corresponding author as the 'first' author with *p* taken from the lower portion of Table B1. Then, the quantity (1–*p*) is equally distributed among the others. For instance, in the presence of an article with 4 coauthors the corresponding author will get a 'contribution' equal to ½ and the others one third each of the remaining 0.5. See [42] for an alternative way to credit co-authors.

[34] See footnote 11 above.

[35] This data bank does not include journals like *Computational Economics* and *Structural Change and Economic Dynamics*. Moreover, the French *Revue d'Etudes Comparative Est-Ouest*, the Finnish *Ekonomiska Samfundets Tidskrift*, the German *Jahrbucher Fur Nationalokonomie und Statistic* and the Argentinian *Desarrollo Economico* show an IF equal to 0.07, 0.06, 0.06 and 0.05, respectively. This may be due to the fact that they are not completely in English and focus on subjects outside the interest of the other journals indexed by Thomson Scientific.

useful, with $Q_{a,i}$ set equal to the number of stars.[36] Alternatively the number of citations received by the article could be used, as suggested in [29]. Then $Q_{a,i}$ is equal to the number of citations.[37]

Finally, the importance of *T* should be stressed. It represents the time span considered to evaluate the average annual impact of the research carried out by a certain research unit, in this case *A*. Choosing *T* = 3, 5 or 7 years depends upon the institutional needs.[38] A reasonable value must be long enough to encourage long run projects, for example the drafting of monographs, and at the same time not too long so as to hide the difference between productive and non-productive periods. When this index is used for ranking, an appropriate choice, to avoid penalizing 'young' units, is to define *T* as the minimum between 3-5-7 years and the actual research period. Then *RF* for the 'old' calculated using *T* is compared with that for the 'young' based on the actual interval.

[36] In the October 2007 the section classified as "economics and management" includes 705 journals; around sixty of them are French. The Tinbergen Institute considers 132 economics journals classified as excellent, very good and good. See the website http://www.tinbergen.nl/research/ranking2.html.

[37] See footnote 12 above. Then it cannot be ruled out that new quality measures may soon appear. Extremely interesting seems the MESUR project. Carried out by the Digital Library Research and Prototyping Team of the Los Alamos National Laboratory and presented in [3], its goal is to change "the evaluation of scholarly impact from the present mono-culture of one-dimensional rankings to one in which a multitude of well understood metrics are combined to produce multi-dimensional assessments which positions each scholarly communication item according to its true merits." Then, $Q_{a,i}$ may be constructed combining several different aspects of what is meant by 'quality'. Another promising tool is the Citations in Economics, http://citec.repec.org/, which takes account of the citations across the papers included in the digital library RePEc.

[38] For some grants funded by the European Research Council, the relevant time span is 10 years ([41], p. 28).

3.2 An index for the evaluation of monographs and essays: RF_b

It is a widely-held opinion that the diffusion of bibliometric tools like the journal IF for the evaluation of research has heavily penalized the drafting of monographs in recent years. The lack of a similar tool for books has generally made it hard to assess the quality of these items. In many cases they have been evaluated on a purely subjective basis. For this reason the need for some bibliometric measure applicable to books is, presently, particularly felt by the scientific community.

The index for books (monographs and essays) written by *Scholar A* takes the form

$$RF_b = \frac{1}{T}\sum_{j=1}^{J} p_{b,j} Q_{b,j} \qquad (6)$$

where $p_{b,j}$ is the contribution to the *j*-th work and $Q_{b,j}$ its quality. As for journal articles, $p_{b,j}$ is equal to 1 when *A* is the sole author otherwise, when it is impossible to quantify the contribution of each co-author, the *feasible* solution in Table B1 could be used.

The quality of the monograph or essay $Q_{b,j}$ can be measured in various ways. A research project aims at calculating, for the first time, a book impact factor based on citations is presented in [7]. This requires a data bank of citations online, with the largest possible number of monographs. To that end the authors themselves may be involved in the process of self-archivation of their own books in freely accessible institutional archives.[39] Alternatively a peer-review system may be set up to rank publishers, books series or even individual books.[40] In the mean-time, a *feasible* measure of the quality of monograph, or essay, *j* could be

[39] For every book, the meta-data, i.e. author, title, date, editor, keywords, abstract and bibliography, should be inputted in the data bank. Based on this, book-to-book citations will also be calculated for the books as well as for the authors of the books.

[40] As for journal articles, $Q_{b,j}$ may be constructed as a quality index to reflect a multidimensional 'meaning' of the term quality.

$$Q_{b,j} = \left(\frac{RF_{C_j,pby,a} + RF_{A_j,pby,a}(essays)}{nc_j + 1} \right) f_j(essays) \qquad (7)$$

with $RF_{C_j,pby,a}$ the sum of the RF_a's relative to the editors of the book series for the '*year of publication of the book*' (*pby*), nc_j the number of editors and $RF_{A_j,pby,a}(essays)$ the RF_a of the author(s) of the *j*-th work at time *pby*.[41] More precisely, $RF_{A_j,pby,a}(essays)$ is equal to the RF_a of the author(s) before starting the monograph when *essays*=1 and it is equal to the RF_a of the author(s) at time *pby* otherwise. In practice, $RF_{A_j,pby,a}(1)$ is the maximum of $RF_{A_j,pby-(T-1),a}$, i.e. the RF_a of the author(s) at time '*pby – (T–1)*', $RF_{A_j,pby-(T-1)+1,a}$, ..., $RF_{A_j,pby,a}$.[42] Finally, the function $f_j(essays)$ is used to discriminate between an essay and a monograph. In [38], it is arbitrarily defined as

$$f_j(essays) = 3 \qquad \text{if } essays = 1 \text{ (i.e., monograph)} \qquad (8a)$$

$$f_j(essays) = \left(\frac{1}{num.essays} \right) \qquad \text{if } essays > 1. \qquad (8b)$$

This implies that a monograph is approximately evaluated as three years of 'average' journal articles publication (Table B2, Appendix B).[43]

A few interesting characteristics of the *feasible* index based on (7) should be pointed out. Firstly, using the sum of the *RF* of the book series editors makes every series, even when from the same publisher, different. Then it takes into account the fact that the drafting of a monograph

[41] In Formula (7), the term in brackets on the right-hand side of the equality sign represents the 'average' RF_a of the book series editors and author. It reduces to the RF_a of the author when the volume is not included in a series. In the presence of co-authors, the quantity $RF_{Aj,pby,a}$ is given by $p_{1,b,j}RF_{1,pby,a} + p_{2,b,j}RF_{2,pby,a} + \ldots$ where $RF_{s,pby,a}$ and $p_{s,b,j}$ stand for the RF_a of the *s*-th author and her/his contribution to the *j*-th work, respectively.

[42] In the presence of an instantaneous referee and editorial process this maximum would always be $RF_{Aj,pby-(T-1),a}$.

[43] Equation (8b) assumes that the essays are qualitatively homogeneous. Alternatively, it may be rewritten as $RF_{Aj,pby,a}/\ RF_{AA,pby,a}$ where $RF_{AA,pb,a}$ is the sum of the RF_a's associated with the authors of the various essays in the book. Then the quality of each essay is closely related to the 'productivity' of its author(s). When there are co-authors, the addenda in $RF_{AA,pby,a}$ should be computed as in footnote 41 above.

represents a long-term project. Lastly, it recognizes the 'trailer' effect of the author. Indeed, the $RF_{A_j,pby,a}$ of a famous scholar is presumably greater than that of a lesser known one and for this reason likely to be cited more often. Obviously the *feasible* RF_b index shares many of the merits and limits that characterize RF_a. For example, the 'trailer' effect depends entirely on past 'productivity' and bears no relationship with the monograph. Nonetheless, Formula (7) may prove a useful shortcut in some occasions.

3.3 An index for the evaluation of research working papers: RF_{wp}

The index for research working papers looks like

$$RF_{wp} = \frac{1}{T}\sum_{l=1}^{L} p_{wp,l} Q_{wp,l} \qquad (9)$$

with $p_{wp,l}$ her/his contribution to work *l* and $Q_{wp,l}$ the quality of *l*. Again, when it is impossible to determine $p_{wp,l}$ the *feasible* solution in Table B1 could be used. As in the previous sections, $Q_{wp,l}$ can be measured in various ways. A methodology similar to that for calculating journal IF, or one of the variants discussed in the literature, may be applied.[44] Alternatively, the ranking of working papers series by peer-review or the number of citations received by a certain work may be preferred. When these, or other, measures of $Q_{wp,l}$ are not readily available, a *feasible* quantity is

$$Q_{wp,l} = \frac{1}{4}\left(\frac{RF_{X,pwy*,a} + RF_{A_j,pwy,a}}{3} \right) \qquad (10)$$

[44] See footnote 40 above.

where $RF_{X,pwy^*,a}$ is the sum of the RF_a's, relative to the period (*pwy*–2*T*)-*pwy* with *pwy* being the 'year of publication of the working paper', of the '*Best*' and '*Worst*' author in the series and $RF_{A_l,pwy,a}$ is the RF_a associated with the author(s) of the working paper at time *pwy*.[45] This means that the quality of a working paper series is assumed non-linearly related with the quality, namely journal article productivity, of those who publish in there. The arbitrary multiplier ¼ has the sole scope of not overly rewarding this activity, usually characterized by a lighter referee process, with respect to journal articles and monographs (Table B3, Appendix B).[46]

3.4 How different is RF_{pub} from an index based exclusively on the classic IF?

To see the difference between the RF_{pub} and an index based on journal IF, consider the case where *Scholar A* publishes, as sole author, an article every year on a journal with a constant IF equal to 1. After a certain period *A* starts working on a monograph and stops publishing articles. At the end of the three-year period the monograph appears in a series book with no editors and *A* resumes publishing once a year on her/his favorite journal.

Figure 3 shows that, for *T*=3, RF_a decreases when *Scholar A* is working on the monograph (year = 10, 11, 12).[47] It touches zero the year of its publication (at the end of year 12).

[45] When dealing with a joint paper $RF_{Al,pwy,a}$ is computed as in footnote 41.

[46] In [38] it is argued that something similar to Formula (10) may prove useful to assess the quality of journals without a qualitative index, for instance IF. They propose $Q_{journal}=(R_{X,pjy^*,a}+RF_{Al,pjy,a})/3$ where $RF_{X,pjy^*,a}$ is the sum of RF_a of the '*Best*' and '*Worst*' author that have published in that journal in the period '*pjy–2T*'-*pjy*, with *pjy* being the 'year of publication of the journal article', and $RF_{Aj,pjy,a}$ the RF_a of *A* at time *pjy* when there are no coauthors.

[47] In order to make RF_a and RF_{pub} easier to compare the former is multiplied by 0.322 in Figure 3.

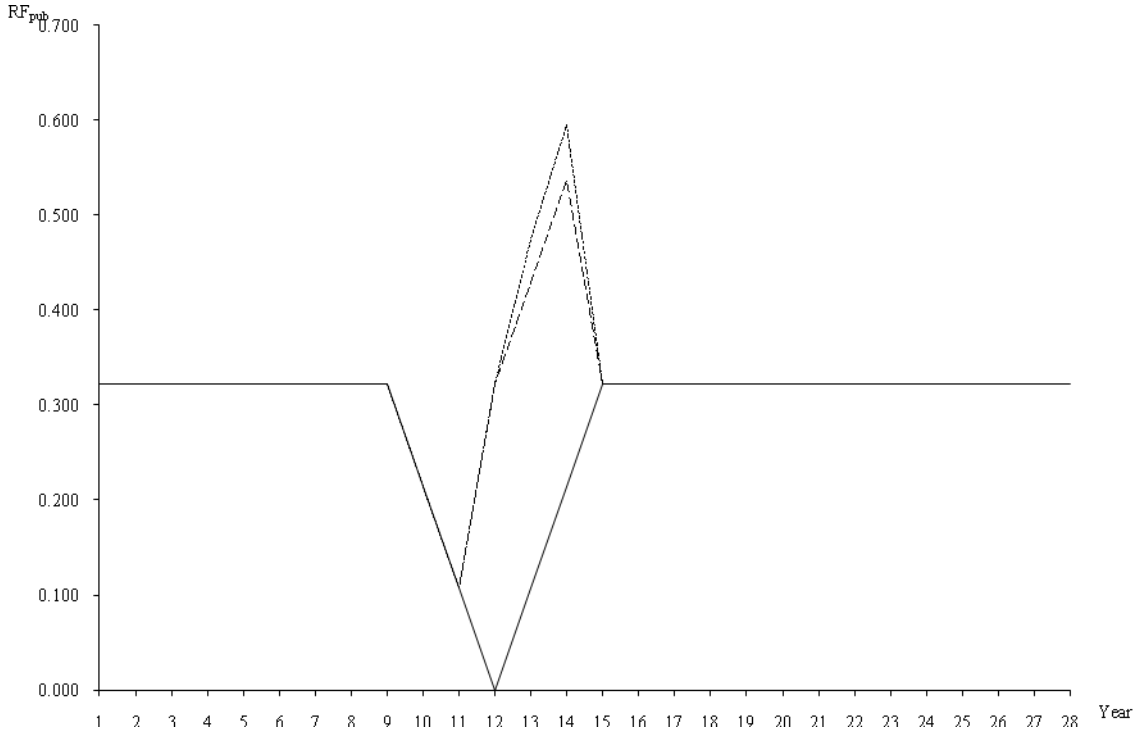

Figure 3. Behavior of an index based on the classic journal IF (-), i.e. 0.322RF_a, RF_{pub} with $\beta_1=\beta_2=\beta_3$=0.322, β_4=0 (- -) and RF_{pub} with $\beta_1=\beta_2=\beta_3$=0.322, β_4=0.322[3] (. . .) when T=3.

This loss is less severe for higher values of T [38]. Evaluating the book as a research product, both with or without the 'well-rounded' premium (i.e. $\beta_4>0$ or $\beta_4=0$), makes the drop in RF_{pub} less pronounced. In this case, RF_{pub} starts increasing when the monograph appears. Moreover when β_4 is positive, dotted line in Figure 3, there is a cumulative advantage in having published both a book and journal articles in a certain three-year period. This advantage increases as T grows.[48] Therefore the use of RF_{pub} with the 'well-rounded' premium encourages the drafting of monographs.

[48] The cumulative advantage goes from 0.104 to 0.257 when T rises from 3 to 7.

4. The 'other' component of the R-Factor

As argued in Section 2, journal editors and referees deserve partial credit for suggesting improvements and highlighting errors in submitted papers. The case of one of the most cited articles in econometrics, [24], is illuminating. In the first footnote, usually used for acknowledgements, the author writes "*the proof given in this note was suggested by the Editor and replaces an earlier one* ...". There is no doubt that referee reports and editor's comments call for extra work on the side of the author most of the times. This is surely a nuisance. But it is also true that the published version of a paper is frequently better than that originally proposed: easier to read, with a consistent notation, more general results and, often times, more meaningful applications. In many cases the editorial/referee process spares the reader of wrong results, useless proofs and gross misunderstandings. Therefore, to ignore the role of editors and referees on scientific knowledge and its diffusion is clearly absurd.[49]

Conferences, too, have been largely neglected in the evaluation of research output. Indeed, they play a fundamental role in the scientific community. Conference organizers don't simply invite speakers and assemble sessions. They underline certain topics and promote precise strands of research. This is similar, to some extent, to the role played by the coordinators of research groups. Researchers presenting papers, then, know all too well the importance of the comments received either during their presentation or at a coffee break. Sometimes these comments help them to realize that there is no light at the end of the tunnel. Others give them a glimpse of unexpected opportunity. The young scholar that, at the beginning of his presentation, was abruptly interrupted by a voice asking "Do you know that the result you are going to generalize is wrong? I've shown it a few years ago!" shouldn't have been very happy at the moment. [50] But he surely owes his next paper to that comment. Even scholars that don't present a paper benefit from these meetings. Similar considerations apply to seminars, research groups and membership to scientific societies.

[49] In [36] it is pointed out that editors contribute also to promote or oppose lines of research. For example, Keynes, editor of the *Economic Journal* for a long period, strongly opposed the publication of econometric works, favoring in this way the success of *Econometrica* and *Review of Economic Studies*.

[50] This episode happened at the *2nd Conference on Computational Economics and Finance* in Geneva (June 27-29, 1996). The intruder was the econometrician Tsurumi and he was referring to a result contained in [10].

Teaching doctoral courses and supervising graduate students, too, has an undeniable scientific value. For example in [30], p. 119, it is remembered, that Sargan's "output of successful doctoral students, now approaching forty, has no parallel in the subject in econometrics. Successive waves of young econometricians have been … stimulated by his example".[51] The relationship between professor and doctoral students makes it possible that certain unpublished results presented in class are used in doctoral dissertations or master thesis. This explains the fact that "some of the work (done by Sargan) … has passed into econometric folklore; that is, people know the results without their even having appeared in print …" ([30], p. 130).

These are only some of the 'other' activities carried out by researchers and are categorized as coordination, dissemination, editorial and functional (or institutional) activities in [38]. The first group includes the organization of conferences and seminars, the coordination of research groups, the supervision of doctoral theses and similar. By dissemination activity is meant: participation to conferences and seminars, with or without a paper, or in research groups, visiting positions in scientific institutions other than that of origin, teaching at graduate level and so on. The editorial category comprises the role of: book and book series editor, journal editor, associate and guest editor, member of editorial board, referee etc. Finally, as observed above, it may be appropriate in some cases to consider also functional (or institutional) activities which include membership to scientific societies, the role of Head of Department, Dean, etc.

Constructing an index reflecting the quantity and quality of these 'other' activities is extremely challenging. On the one hand it attempts to quantify an extremely diversified set of activities. On the other hand, it cannot benefit from any previous discussion on this topic. Even though universally considered important and relevant, the 'other' activities have never been treated in a systematic way when evaluating the scientific performance of research units.[52] In [38] $RF_{A,t,oth}$, similarly to the 'publications' component, is thought of as a weighted sum of subcomponents corrected for 'well-roundedness'.[53] Then it is defined as[54]

[51] One of the first Sargan's students is Hendry and one of the last Peracchi.

[52] Therefore the relevance attributed to these activities has always been highly subjective.

[53] Again, this construction has the advantage that new subcomponents can be added, or the old ones removed, without affecting the computation of the others.

[54] As pointed out in [38],

$$RF_{A,t,oth} = \gamma_1 RF_{A,t,coord} + \gamma_2 RF_{A,t,diss} + \gamma_3 RF_{A,t,edit} + \gamma_4 RF_{A,t,\,func} + \gamma_5 f(RF_{A,t,coord}, RF_{A,t,diss}, RF_{A,t,edit}, RF_{A,t,\,func}) \quad (11)$$

where $RF_{A,t,coord}$, $RF_{A,t,diss}$, $RF_{A,t,edit}$, and $RF_{A,t,\,func}$ stand for the annual average, for the interval 't–T'-'t–1', of the 'quality contribution' due to the coordination, dissemination, editorial and functional activities, respectively. As in formulae (1) and (3), the presence of the 'well-rounded' index $f(RF_{A,t,coord}, RF_{A,t,diss}, RF_{A,t,edit}, RF_{A,t,\,func})$ means that a premium is awarded to research units simultaneously performing more than one of these activities when $\gamma_5 > 0$. As in the previous sections the actual values for the γ's, in general greater or equal to zero, depend upon the needs of the research institution or an overseeing research agency.[55] Once the institutional goals are identified, the appropriate weights selected and consistently applied.[56] A *feasible* specification of (11), similar in spirit to (2) and (4), is

$$RF_{A,t,oth} = 0.249 RF_{A,t,coord} + 0.249 RF_{A,t,diss} + 0.249 RF_{A,t,edit} + 0.249 RF_{A,t,\,func} + 0.249^4 \left[(noa_{A,t} - 1)(RF_{A,t,coord} + RF_{A,t,diss} + RF_{A,t,edit} + RF_{A,t,\,func}) / 4 \right] \quad (12)$$

where $noa_{A,t}$ is at most 4.[57]

As for the 'publications' component, the various subcomponents in (11)-(12) are computed summing up 'quality contribution' terms derived by multiplying the 'contribution' of *A* by the 'quality' of the research item.[58] Then in the presence of appropriate databanks for the different types of activities, the computation of this *RF* component is straightforward once the γ's have been selected. Alternatively, 'contribution' and 'quality' may be agreed upon by the community of researchers or a peer-review system set in place to rank conferences, research groups, editorial

[55] See also footnote 23 above.

[56] Formula (11) is general enough to accommodate several institutional needs. By setting $\gamma_5 = 0$ the component for 'other' activities reduces to a weighted average of the subcomponents. Alternatively the Institution that does not feel appropriate to rank researchers including functional activities can simply set $\gamma_4 = 0$.

[57] When indicators are used $noa_{A,t}$ is simply their sum. See footnote 25 above.

[58] See footnote 29 above.

functions, Ph.D. programs and so on.[59] In sections 4.1, 4.2, 4.3 and 4.4 the definitions of $RF_{A,t,coor}$, $RF_{A,t,diss}$, $RF_{A,t,edit}$ and $RF_{A,t,func}$ given in [38], from now on simply RF_c, RF_d, RF_e and RF_f, respectively, are reviewed.[60] To show the potential of $RF_{A,t,oth}$ a set of *feasible* quantities for 'contribution' and 'quality', based on RF_{pub}, is also provided.[61]

4.1 An index for the evaluation of the coordination activity: RF_c

The index for the coordination activity is constructed as

$$RF_c = \frac{1}{T}\sum_{n=1}^{N} p_{c,n} Q_{c,n} \tag{13}$$

with $p_{c,n}$ the contribution to activity *n*, $Q_{c,n}$ its quality and *N* the number of activities in this category carried out in the years '$t-T$' through '$t-1$'. When *n* indicates the organization of a conference $p_{c,n}$ represents the share of work done by *Scholar A* and $Q_{c,n}$ the quality of the conference. If these quantities are not available a *feasible* solution could be obtained by setting

$$p_{c,n} = \frac{1}{Ns}\ , \tag{14}$$

where $Ns = \min(no.\ sessions,\ 8)$,[62] and $Q_{c,n}$ equal to the quality of the connected journal or

[59] See footnote 31 above.
[60] The notation used here is slightly different from that in [38].
[61] When it is felt that information about specific research items in this group may be manipulated, it is possible to single out possibly 'manipulated items' by setting their quality equal to zero. Alternatively, a maximum number of these items may be allowed. In any case it should be stressed that the ranking generated by *RF* is affected by the introduction of 'manipulated items' only when research units behave differently.
[62] The introduction of the constant 8 has the sole purpose of not penalizing those who organize sessions in large conferences, e.g. the *Conference on Computational Economics and Finance* where 20/30 parallel sessions are held for 2 or 3 days, with respect to those involved in smaller meetings. When, in addition to session organizers, there is

$$Q_{c,n} = \frac{RF_{X,cy,pub}}{2} \tag{15}$$

where $RF_{X,cy,pub}$ is the sum of RF_{pub} of the '*Best*' and '*Worst*' speaker, i.e. the speaker with the highest and lowest RF_{pub} in the year of the conference (*cy*) respectively, taking part in the conference. [63]

When *n* indicates the coordination of a research group, $Q_{c,n}$ is the quality of the group. *Feasible* quantities are $p_{c,n}$ equal to the fraction of solar year in which *A* has been involved in the research divided by the number of people performing the same level of coordination and $Q_{c,n}$ as in (15) with $RF_{X,ry,pub}$ referring to the '*Best*' and '*Worst*' participants to the group at the beginning of the research year.[64] *Feasible* quantities for the organization of a doctoral courses and supervision of doctoral theses can be found in Table B4 (Appendix B).[65]

4.2 An index for the evaluation of the dissemination activity: RF_d

Similarly, the index for the evaluation of the dissemination activity is defined as

$$RF_d = \frac{1}{T}\sum_{m=1}^{M} p_{d,m} Q_{d,m} \tag{16}$$

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also an overlooking 'organizing committee' its members should also get some credit. The *feasible* solution suggested in [38] for this case is $p_{c,n} = 1/Nco$ with *Nco* the size of the committee.

[63] It should be stressed that there is no circularity problem here because RF_{pub} is computed, in the feasible solution, only considering publications. The quality of the connected journal(s) can be measured using one of the quantities discussed in Section 3.1.

[64] For example, in an Italian PRIN project lasting 24 months, from January 1st to December 31st, with one national coordinator and 3 local ones, the weights 1 and 1/3, respectively, will be attributed to the coordinators in each of the two years. Alternatively, the quality may be evaluated considering working papers, journal articles, monographs and essays produced by the group. Due to the in eliminable lag between the 'coordination' and 'publication' moments, this procedure may penalize long-term projects, sometimes lasting several years, with respect to short-term projects.

[65] Alternatively the quality of the previous thesis, if available, can be used.

with $p_{d,m}$ the contribution to activity *m*, $Q_{d,m}$ its quality and *M* the number of activities performed in the last *T* years. When *m* stands for a conference paper, $p_{d,m}$ is the contribution to the paper and $Q_{d,m}$ the quality of the conference. A *feasible* solution is obtained using Table B1 for $p_{d,m}$ and

$$Q_{d,m} = \frac{Q_{journal}}{\min(Nis, 4)} \qquad \text{or} \qquad Q_{d,m} = \frac{RF_{X,cy,pub}}{2\min(Nis, 4)} \tag{17}$$

depending on whether the conference is connected to a journal, or a group of journals, or not. In the former case $Q_{journal}$ denotes the quality of the journal(s) and *Nis* the number of speakers in the session.[66] In the latter $RF_{X,cy,pub}$ is as in Equation (15). When the work is presented as a Keynote Speech in a plenary session the quality is $Q_{d,m} = Q_{journal}$ or $Q_{d,m} = RF_{X,cy,pub} / 2$. In the case of a paper presented at a seminar, *feasible* quantities are $Q_{d,m} = RF_{Speaker,sy,pub}$ with *sy* the year the seminar was given and $p_{d,m}$ equal to 1/8 of the appropriate value in Table B1.[67]

Feasible quantities for the simple participation to a conference or seminar, visiting positions in scientific institutions (for example during a sabbatical period), participation to research groups (other than coordinator) and teaching of doctoral courses are reported in Table B5 (Appendix B).[68] It should be noticed that $p_{d,m}$ is much lower when a seminar is 'attended instead of given' and that the quality of the hosting institution and research groups depends upon their 'prestige' approximated here by the simple average between the '*Best*' and '*Worst*' member.

[66] The quality of the journal may be measured by one of the quantities discussed in Section 2.1. When a conference is not divided into sessions, using the total number of presentations in (17) would unfairly penalize the speakers. For this reason the minimum between the number of presentations in a session and 4 is preferred.

[67] This lower weight is due to the fact that the selection process for seminars is typically less rigorous than that for conferences and the same paper is presented in several occasions before taking the form of a working paper, article or book.

[68] The arbitrary multiplier ½ appearing in the teaching of doctoral courses is used to capture the fact that in many countries the same person teaches 2 courses per year. Other *feasible* measures of quality may be preferred.

4.3 An index for the evaluation of the editorial activity: RF_e

The editorial activity index takes the form

$$RF_e = \frac{1}{T}\sum_{h=1}^{H} p_{e,h} Q_{e,h} \tag{18}$$

As in the previous sections, the quantity $p_{e,h}$ depends upon the contribution to h–th activity and $Q_{e,h}$ is the quality of the journal, book or book series. A *feasible* measure of the former is the fraction of solar year in charge times one for journal editors, the inverse of the number of peers for associate editors and members of Editorial Boards, 1/5 for referees and one over the number of journal yearly issues for guest editors. In all these cases, $Q_{e,h}$ stands for the quality of the journal (Table B6, Appendix B). The *feasible* quantities for book (book series) editors are the $p_{e,h}$'s from Table B1 and $Q_{e,h} = RF_{X,pby,pub}/2$ with $RF_{X,pby,pub}$ the sum of the '*Best*' and '*Worst*' RF_{pub} of the authors of the essays (volumes in the series) in the year *pby* (in the interval '*pby*–2*T*' through '*pby*').[69]

4.4 An index for the evaluation of the functional activity: RF_f

Finally the index for the functional activity looks like

$$RF_f = \frac{1}{T}\sum_{k=1}^{K} p_{f,k} Q_{f,k} \tag{19}$$

where $p_{f,k}$ depends upon the portion of the *k* activity carried out, $Q_{f,k}$ reflects its quality and K is the number of functional activities performed in the last *T* years. *Feasible* quantities are $p_{f,k}$

[69] When the book series, or the essays of the volume, are co-authored RF_{pub} is calculated as in (7).

equal to the fraction of solar year in charge times one for Deans and Head of Departments, 0.02 for members of scientific societies and

$$Q_{f,k} = \max\left(\frac{1}{2} RF_{X,fy,pub}, RF_{A,fy,pub}\right), \tag{20}$$

where $RF_{X,fy,pub}$ is the sum of '*Best*' and '*Worst*' RF_{pub} of the Faculty members, Department and scientific society for Deans, Head of Departments and affiliated to societies, respectively, in the year (*fy*) the functional activity was carried out (Table B7, Appendix B).[70]

5. A numerical example: the approximated *feasible* R-Factor

To compute the *feasible RF* for a certain research unit, it is necessary to know the *RF*'s associated with several other units, say co-authors, book editors, book series editors, colleagues at conferences, seminars and in research groups and so on and so forth. A handy approximation, which removes all the links, can be obtained by setting all these *RF*'s equal to 1 and using the current *RF* of the unit, in place of the correct one, for monographs and working papers. A numerical example for a time horizon *T*=3 and two *Scholars*, one with very good journal articles and the other with a monograph and a working paper (Appendix A), is now presented.[71]

The starting point is the index for article publications, RF_a. Using Table B1 for 'contribution' and the journal IF for 'quality' (Table 1) in Formula (6), it yields 0.626 and 0.086 for *Scholar A* and *B*, respectively (Table 2). The latter looks penalized by the fact that only some journals are in the IF dataset.

[70] This means that Deans and Head of Departments not active in research get approximately the average RF_{pub} of 'their' Faculty and department members, respectively, and an affiliate to scientific societies one-fiftieth.
[71] The Excel spreadsheet used for these computations is available on demand from the authors.

Table 1. The IF of selected journals and years published in the JCR and the CNRS categories.

	2007	**2006**	**2005**	**2004**	**Cat. CNRS**
Journal of Economic Growth	2.292	3.240	2.577	2.379	1
Journal of Economic Dynamics and Control	0.703	0.779	0.691	0.477	2
European Economic Review	0.994	1.019	0.958	1.169	1
Macroeconomic Dynamics	0.453	0.518	0.519	0.500	2
Computational Economics	Na	Na	Na	Na	3

Table 2. Computation of RF_a 2008 based on journals IF.

	2007		**2006**		**2005**			
	$p_{a,1}$	$Q_{a,1}$	$p_{a,2}$	$Q_{a,2}$	$p_{a,3}$	$Q_{a,3}$	$\sum_i p_{a,i}Q_{a,i}$	RF_a
Scholar A	0.33	0.994	0.33	0.779	0.5	2.577	1.879	0.626
Scholar B	1	0.0	0.5	0.518			0.259	0.086

When 'quality' is measured by CNRS categorization (Category 1=4, Cat. 2=3, Cat.3=2, Cat. 4=1) the difference is less striking (Table 3, row 5). This is due to the fact that differences tend to smooth out when a larger subset of journals has a nonzero 'quality'.

Table 3. Computation of *RF* index for 2008.

Index	***Scholar A***	***Scholar B***	***Scholar A****	***Scholar B****
RF_a (*IF*)	0.6263	0.0863	0.6263	0.0863
RF_{pub}	0.2017	0.2891	**0.4033**	**0.1769**
RF_{oth}	0.3158	0.3043	-	-
RF	**0.2586**	**0.2965**	-	-
RF_a (*CNRS*)	1.4437	1.1667	1.4437	1.1667
RF_{pub}	0.4649	0.7953	**0.9297**	**0.9354**
RF_{oth}	0.3158	0.3043	-	-
RF	**0.3901**	**0.5495**	-	-

Note: The first two columns use Formulae (2), (4) and (12), the last two assume weights $\alpha_1 = 1$, $\alpha_2 = \alpha_3 = 0$, $\beta_1 = 0.644$, $\beta_2 = \beta_3 = 0.161$ and $\beta_4 = 0$.

Then the indices for books and working papers are computed using approximations to Formula (7) and (10), respectively. In (7) the index associated with the book series editors $RF_{C_j,pby,a}$ is set equal to 2, one for each of them, and the max RF_a for *Scholar B* in the years 2005, 2004 e 2003, equal to her/his RF_a in 2008. Formula (10) is approximated assuming $RF_{X,pwy*,a}$=2.[72] At this point the 'publications' component is derived, (4), and *B* ranks higher than *A* (Table 3, rows 2 and 6, columns 2 and 3). Both researchers report some dissemination, editorial and functional activities in their curricula. Then the approximated *feasible* RF_{oth} index is computed for both of them. When all activities are considered, *B* is still ahead (Table 3, rows 4 and 8).[73]

To see how sensitive this conclusions are to the institutional weights, i.e. the α's, β's and γ's in (1), (3) and (11), an institution weighting journal publications 4 times as much as monographs and working papers and ignoring 'other' activities is considered (Table 3, last two columns).[74] In this case *A* ranks higher than *B* when IF is used, namely a small subset of journals have a positive 'quality', and the opposite is true when CNRS categorization is preferred. This shows how important is the set of activities considered. When journal articles are highly weighted with respect to other types of publications and IF is used to assess 'quality', research units will be encouraged to focus on 'journal publishable' research projects. When all types of publications are similarly weighted, or journal 'quality' is assessed using larger datasets, there will be an incentive to work on all 'publishable' projects.

7. Conclusion

The IF index, "once a simple way to rank scientific journals (it is) ... starting to control the scientific enterprise. In Europe, Asia and, increasingly, the United States (it) ... can play a crucial role in hiring, tenure decisions and awarding of grants" ([27], p. 1). This inappropriate use risks

[72] Setting the sum of the extremes in (10) equal to 1 does not affect the ranking of *A* and *B*.

[73] Adding the same publication or any kind of 'other' activity, to both units does not change the ranking. Then *RF* satisfies, differently from some popular bibliometric indices, the consistency criteria in [43].

[74] Many thanks go here to an anonymous referee for stressing the need of a careful consideration of different institutional priorities.

"to skew the course of scientific research. Investigators are now more likely to chase after fashionable topics – the kind that get into high-impact journals – than to follow important avenues that may not be the flavor of the year" ([27], p. 1).

For this reasons *RF*, an index reflecting the multifaceted nature of scientific research first introduced in [38], is reviewed and its ranking of research units contrasted with that generated by IF in a numerical example using stylized scientific profiles. The numerical example shows that the ranking of research units is highly sensitive to the set of activities included in the selected index. Moreover subcomponents based on an unnecessarily small set of items, like journal IF when compared to CNRS ranking, tend to exacerbate differences among units. The main conclusion is that by replacing IF with *RF* in hiring, tenure decisions and distribution of research funds would greatly increase the number of topics investigated and the number and quality of long run projects. This is due to the fact that by considering books, discussion papers and the 'other' activities higher credit is given to those involved in long-term projects. As a consequence researchers are encouraged to take into consideration new lines of research that may be the "flavor of next year."

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Appendix A

Curricula of the two *Scholars* used in the numerical example.

	Scholar A	***Scholar B***
Publications		
Articles	1) *European Economic Review*, 2007, 2nd author out of two (not alph. order); 2) *J. of Economic Dynamics and Control*, 2006, 2nd author out of three (alph. order); 3) *J. of Economic Growth*, 2005, 1st author out of two (alph. order).	*1) Computational Economics*, 2007, no co-authors; *2) Macroeconomic Dynamics*, 2006, 2nd author out of two (alph. order);
Books (monographs or essays)	NO	Springer, 2005, no co-authors, 2 editors.
Working Papers	NO	Dept. of Economics, 2006, no co-authors
Other activities		
Coordination activity:		
Organization of conferences	NO	NO
Coordination of research groups	NO	NO
Coordination of doctoral courses	NO	NO
Supervision of doctoral theses	NO	NO
Dissemination activity:		
Conference presentations	NO	*Conference on Computational Economics and Finance*, 2005, no co-author
Seminar presentations	1 in 2007, no co-authors; 1 in 2006, 2nd author out of 3 (alph. order); 1 in 2005, no co-authors.	NO
Attended conferences (no pres.)	NO	NO
Attended seminars (no pres.)	NO	NO
Participation in research groups	NO	Project "abc", solar years 2006-07, group of 5
Teaching of doctoral course	2 courses (in full) a year	1 course (in full) a year

	Scholar A	***Scholar B***
Editorial activity:		
Journal Editor	NO	NO
Associate Editor	*European Economic Review* with 7 Ass. Editors, since 2004;	NO
Guest Editor	NO	*Macroeconomic Dynamics*, 2005
Referee	NO	*Macroeconomic Dynamics* in 2006 and *J. of Economic Dynamics and Control* in 2005;
Member of Editorial Board	NO	NO
Boook Editor	NO	NO
Book series Editor	NO	NO
Functional activity:		
Member of scientific society	*European Economic Association* since 2004.	*Society of Computational Economics and Finance* since mid-2005.
Head of Department	NO	NO
Dean of Faculty	NO	NO

Appendix B

This appendix contains all the tables needed to compute the *feasible* R-Factor.

Table B1. Contribution of each author in in the case of a co-authored article

Weight given to:		1° author	2° author	3° author	4° author	5° author	6° author
Number of authors in alphabetical order	**1**	1					
	2	½	½				
	3	1/3	1/3	1/3			
	4	1/4	1/4	1/4	1/4		
	5	1/5	1/5	1/5	1/5	1/5	
	6	1/6	1/6	1/6	1/6	1/6	1/6
Number of authors not in alphabetical order	**1**	1					
	2	2/3	1/3				
	3	1/2	1/3	1/6			
	4	1/2	1/4	1/8	1/8		
	5	1/2	1/4	1/8	1/16	1/16	
	6	1/2	1/4	1/8	1/16	1/32	1/32

Table B2. Contribution and quality for the *feasible* evaluation of a published book.

Activity	Contribution $p_{c,n}$	Quality $Q_{c,n}$	Legend
Monograph	Table B1	$3[(RF_{C,pby,,a}+ RF^{*})/(nc+1)]$	$RF_{C,pby,,a}$ = sum RF_a book series editors at time *pby*; *pby* = "year of publication of book"; RF^{*} =max of ($RF_{A,pby,-(T-1),a}$, $RF_{A,pby,-(T-1)+1,a}$,, ...,$RF_{A,pby,a,}$); $RF_{A,pby,a}$ = RF_a author at time *pby*; *nc*= no. book series editors.
Essay	Table B1	$[(RF_{C,pby,,a} +RF_{A,pby,a,})/(nc+1)ns]$ or $[(RF_{C,pby,,a} +RF_{A,pby,a})/(nc+1)]fc$	*ns* = no. essays; $fc= RF_{A,pby,a}/ RF_{AA,pby,a}$; $RF_{AA,pb,a}$= sum RF_a authors of the essays in the book at time *pby*.

Table B3. Contribution and quality for the *feasible* evaluation of selected types of research publications.

Activity	Contribution $p_{c,n}$	Quality $Q_{c,n}$	Legend
Working Paper	Table B1	$\frac{1}{4}[(RF_{X,pwy*,a}+RF_{A,pwy,a})/3]$	$RF_{X,pwy*,a}$ = $RF_{Best,pwy*,a}+RF_{Worst,pwy*,a}$; $RF_{Best,pwy*,a}=RF_a$ of the '*Best*' author in the period (*pwy*−*2T*)-*pwy*; *pwy* = year of publication of the working paper, $RF_{A,pwy,a}=RF_a$ author at time *pwy*.
Article in new journal	Table B1	$(RF_{X,pjy*,a}+RF_{A,pjy,a})/3$	$RF_{X,pjy*,a}$ = $RF_{Best,pjy*,a}+RF_{Worts,pjy*,t}$; $RF_{Best,pjy*,a}=RF_a$ of 'Best' in period (*pjy*–*2T*)-*pjy*; *pjy* = year of publication of the journal article; $RF_{A,pjy,a}=RF_a$ author at time *pjy*.

Table B4. Contribution and quality for the *feasible* evaluation of selected coordination activities.

Activity	Contribution $p_{c,n}$	Quality $Q_{c,n}$	Legend
Conference organizer	1one organizer 1/*Ns* several organizers 1/*Nco* member of org. com.	$Q_{journal}$ linked to journals or $RF_{X,cy,pub}/2$ not linked	*Ns* = min(*no. sessions*, 8); *Nco* = no. members of organizing committee; $RF_{X,cy,pub}$ = $RF_{Best,cy,pub}+R_{Worst,cy,pub}$; $RF_{Best,cy,pub}=RF_{pub}$ of the '*Best*' speaker at the conf..
Research group coord.	(*ms*/12) highest level (*ms*/12)(1/*cd*) local level	$RF_{X,ry,pub}/2$	*ms* = months of work in the project in the solar year; *cd* =no. local coordinators; $RF_{X,ry,pub}$ = $RF_{Best,ry,pub}+R_{Worst,ry,pub}$; $RF_{Best,ry,pub}=RF_{pub}$ of the '*Best*' scholar in the group.
Doctoral course coord. (not entirely taught)	1 one coordinator 1/*Nc* several coordinators.	(1/8) $RF^{*}_{dy,pub}$	*Nc* = no. coordinators; $RF^{*}_{dy,pub}=q_{D1,dy}RF_{D1,dy,pub}+q_{D2,dy}RF_{D2,dy,pub}+...$; $RF_{s,dy,pub}=RF_{pub}$ docent *s* the year *dy*; $q_{s,dy}$ = fraction of course taught by *s* in year *dy*; *dy*= year of doctoral course.
Doctoral thesis supervisor	*ts*/8	$RF_{S,dt,pub}$	*ts* = no. supervised thesis, $RF_{S,dt,pub}=RF_{pub}$ supervisor the year thesis completed.

Table B5. Contribution and quality for the *feasible* evaluation of selected dissemination activities.

Activity	Contribution $p_{d,m}$	Quality $Q_{d,m}$	Legend
Conference presentation	Table B1	$Q_{journal}/Ns$ linked to journals or $RF_{X,cy,pub}/2Ns$ not linked	Ns = min(Nis,4); Nis =no. papers in session; Nis = 1 if *Keynote speech* $RF_{X,cy,pub}$ = $RF_{Best,cy,pub}+R_{Worst,cy,pub}$; $RF_{Best,cy,pub}$ = RF_{pub} of the '*Best*' speaker at the conf..
Conference (no present.)	1/pti	$Q_{journal}/Ns$ linked ... or $RF_{X,cy,pub}$ /2Ns not linked	pti = min(pt, 40); pt = avg. no. of attendants.
Seminar presentation	(1/8) Table B1	$RF_{Sp,sy,pub}$	$RF_{Sp,sy,pub}$ = RF_{pub} speaker the year of conf..
Seminar (no present.)	1/pti	$RF_{Sp,sy,pub}$	pti = min(pt, 40); pt =number of attendants.
Visiting position	$days$/365	$RF_{X,vy,pub}$/2	$days$ = no. days at host institution; $RF_{X,vy,pub}$ = $RF_{Best,vy,pub}+R_{Worst,vy,pub}$; $RF_{Best,vy,pub}$ = RF_{pub} of the '*Best*' scholar at host inst..
Research group particip. (not coordinator)	ms/12min(ptr,4)	$RF_{X,ry,pub}$ /2	ms = months of work in the project in the solar year; ptr =size of the group; $RF_{X,ry,pub}$ = $RF_{Best,ry,pub}+R_{Worst,ry,pub}$; $RF_{Best,ry,pub}$ = RF_{pub} of the '*Best*' scholar in the group.
Doctoral course docent	$q_{D,dy}$	½ $RF_{D,,dy,pub}$	$RF_{D,,dy,pub}$ = RF_{pub} docent D in year dy; $q_{D,dy}$ = fraction of course taught by D in year dy; dy= year of doctoral course.

Table B6. Contribution and quality for the *feasible* evaluation of selected editorial activities.

Activity	Contribution $p_{e,h}$	Quality $Q_{e,h}$	Legend
Editor	(*ms*/12)	$Q_{journal}$	*ms* = months in office in the solar year.
Associate Editor	(*ms*/12)(1/*nae*)	$Q_{journal}$	*nae* = no. Assoc. Editors.
Guest Editor	(1/*nua*)	$Q_{journal}$	*nua* = no. yearly issues.
Referee	1/5	$Q_{journal}$	
Editorial Board	(*ms*/12)(1/*neb*)	$Q_{journal}$	*neb* = size Editorial Board.
Book Editor	Table B1	$RF_{X,pby,pub}/2$	$RF_{X,pby,pub}$ = $RF_{Best,pby,pub}$+ $RF_{Best,pby,pub}$; $RF_{Best,pby,pub}$ =RF_{pub} of the '*Best*' author at time *pby*; *pby* = year of publication of the book.
Book series Editor	Table B1	$RF_{X,pby*,pub}/2$	$RF_{X,pby*,pub}$ = $RF_{Best,pby*,pub}$ +$RF_{Worst,pby*,pub}$; $RF_{Best,pby*,pub}$ = RF_{pub} of the '*Best*' author in the period (*pby–2T*)-*pby*.

Table B7. Contribution and quality for the *feasible* evaluation of selected functional activities.

Activity	Contribution $p_{f,k}$	Quality $Q_{f,k}$	Legend
Member of scientific society	2%(*ms*/12)	$Q_{journal}$ if available max(½$RF_{X,fy,pub}$, $RF_{A,fy,pub}$) otherwise	*ms*=months in office in the solar year; $RF_{X,fy,pub}$ = $RF_{Best,fy,pub}$+ $RF_{Best,fy,pub}$; $RF_{Best,fy,pub}$ =RF_{pub} of the '*Best*' member at time *fy*; *fy* = year of affiliation to the scientific society.
Head of Department	*ms*/12	max(½$RF_{X,fy,pub}$, $RF_{A,fy,pub}$)	$RF_{Best,fy,pub}$ =RF_{pub} of the '*Best*' member of the Dept..
Dean of University (Faculty)	*ms*/12	max(½$RF_{X,fy,pub}$, $RF_{A,fy,pub}$)	$RF_{Best,fy,pub}$ =RF_{pub} of the '*Best*' University (Faculty) member.