

AALTO UNIVERSITY BIBLIOMETRIC REPORT

2003 – 2007

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MAIN FINDINGS OF THE BIBLIOMETRIC STUDY

This report concerns the research potential of staff currently employed by Aalto University. Papers published by Aalto researchers are compared with papers published by their international colleagues during the period 2003–2007. The citation impact of the Aalto papers is significantly above international reference levels: they receive 25% more citations in their journals. This translates to a field-normalized citation impact of 23% above world average, which can be explained by the fact that Aalto researchers publish in journals with high impact-levels – 12% above the global reference value.

Several units perform well above global average and these units are found in almost all panel areas within the Aalto RAE.

Citation impact is generally high in several large areas, e.g. “Chemistry”, “Forestry”, “Mathematics”, “Radio Science”, “Computer Science”, “Innovation Research”, and “Management”.

The field-normalized impact of nine Units of Assessment (UoA:s) is well above average and for six of these there is a significantly high score. Whilst eighteen units are cited significantly below average or have zero publications (four units), it should be noted that these units have few publications, and their total activities are presumably not covered by the Web of Science database.

Aalto papers occur about 30% more often than expected among the top 5% most frequently cited papers in their subfields. Eleven out of the 46 units have at least the expected number of papers in the 5% category. Another important aspect is closeness to the research front. Aalto University has a high overall vitality, i.e. research published in international journals shows high reference recency. This indicates that the research performed have a potential of high impact in several areas of science and technology.

Aalto University researchers contribute substantially to international scientific networks: 40 per cent of papers are the result of international collaborations. A sizeable part of impact comes from publications that are internationally co-authored, and, clearly, collaborative papers receive higher citation impact.

AALTO BIBLIOMETRIC STUDY

As a complement to its International Research Assessment Exercise (RAE), in June 2009 Aalto University asked Ulf Sandström to undertake a bibliometric study of the publications produced during 2003–2007 by all members of Aalto's research staff employed by HSE, TaiK or TKK on the Aalto RAE census date of 1 October 2008. This bibliometric study comprises a supplement to the recently finished RAE.

The objective of the study is a bibliometric analysis based on citations of research papers from Aalto University researchers. The study is based on a quantitative analysis of scientific articles in international journals and serials processed for the Web of Science versions of the Citation Indices (SCI, SSCI and A&HCI). As such, this study is not a bibliographic exercise trying to cover all publications from Aalto researchers. The motivation for using Web of Science is that the database represents the most prestigious journals and serials in all fields of science. The database was set up in the early 1960s by an independent research-oriented company in order to meet the needs of modern science in library and information services. Evidently, the database is also a valuable asset for evaluative bibliometrics, as it indexes the references in articles and connects references to articles (citations).

The key consideration that has guided the approach taken here is a requirement to make use of multiple indicators in order to better describe the complex patterns of publications at a multidisciplinary research university. The study makes use of several methods, each deepening the understanding of a UoA's publication output from a different angle of incidence. No single indicator should be considered in isolation.

Publications and citations form the basis of the indicators used. Citations are a direct measure of impact but they measure the quality of an article only indirectly and imperfectly. Whilst we can undoubtedly measure the impact of a research unit by looking at the number of times its publications have been cited, there are limitations. Citation-based methods enable us to identify excellence in research, however these methods cannot, with certainty, identify the absence of excellence (or quality).

The various insights provided by this study – and the manifold limitations of any bibliometric study – mean that the results presented here should be used as a *starting point* by the Aalto University management for deeper discussion on the positioning of research groups, especially if there is a need for strategic change. If the university and its management are to gain from bibliometrics, focus should not fall only on top performers (Giske, 2008); greater potential for improvement might be found within those groups that underperform.

EVALUATIVE BIBLIOMETRICS

Bibliometric approaches, whereby the scientific communication process can be analyzed, are based on the notion that the essence of scientific research is the production of “new knowledge”. Researchers who have theoretical ideas or empirical results to communicate publish their contributions in journals and books. Scientific and technical literature is the constituent manifestation of that knowledge, and it can be considered as an obligation for researchers to publish their results, especially if public sector funding is involved.

In almost all areas, journals are the most important medium for communication of results. The process of publication of scientific and technical results involves referee procedures established by academic and scholarly journals. Therefore, internationally refereed journals imply that the research published has been under quality control and that the author has taken criticism from peers within the specialty. These procedures are a tremendous resource for the bettering of research, and are set in motion for free or at a very low cost. A researcher that chooses not to use these resources may seem to be very much outside of the international research community.

The reward system in science is based on recognition, and this emphasizes the importance of publications to the science system. Because authors cite earlier work in order to substantiate particular points in their own work, the citation of a scientific paper is an indication of the importance that the community attaches to the research presented in the paper.¹

Essentially, this is the starting point of all bibliometric studies: if the above assumption holds, then we should concentrate on finding the best methods for describing and analyzing all publications from those research groups under consideration.² When we are searching for such methods our emphasis is on one specific layer of research activities. There are several more layers that can be studied and evaluated, but in the present context our focus is on research, both basic and applied, and especially on excellence in research. Hence, publications are the center of attention. We could have included patents to the family of publications as they indicate a transfer of knowledge to industrial innovation, i.e. into commodities of commercial and social value. However, unlike in Panel Assessments, the sole focus of the bibliometric study is journal and conference publications.

There are some minor inconsistencies, but at the end of the day, *relative scale-independent bibliometric indicators* can indicate the standing and position of a research group³: are they clearly above average, are they around average or do the indicators

¹ CWTS (2008).

² Narin & Hamilton (1996), CWTS (2008).

³ van Raan (2004).

show that the group is clearly below average when they are compared with their international colleagues?

Basics of bibliometrics

International scientific influence (impact) is an often used parameter in assessments of research performance. Impact on the research of others can be considered as an important and measurable aspect of scientific quality, but of course, not the only one. Within most international bibliometric analyses there are a series of basic indicators that are widely accepted.

In most bibliometric studies of science and engineering, data is confined to **articles, letters, proceedings papers and reviews** in refereed research journals. The impact of a paper is often assumed to be judged by the reputation of the journal in which it was published. This can be misleading because the rate of manuscript rejection is generally low even for the most reputable journals. Of course, it is reasonable to assume that the average paper in a prestigious journal will, in general, be of a higher quality than one in a less reputable journal.⁴ However, the quality of a journal is not necessarily easy to determine⁵ and, therefore only counting the number of articles in refereed journals will produce a disputable result (Butler, 2002; Butler, 2003).

It should be underlined that we measure citations to articles, letters, proceedings papers and reviews, and also we consider only citations from these documents. Accordingly, a reference in an editorial to an article will not count as a citation.

The question arises whether a person who has published more papers than his or her colleagues has necessarily made a greater contribution to the research front in that field. All areas of research have their own institutional “rules”, e.g. the rejection rate of manuscripts differs between disciplines: while some areas accept 30–40 per cent of submitted manuscripts due to perceived quality and space shortages, other areas can accept up to 80–90 per cent. Therefore, a differentiation between *quantity* of production and *quality* (impact) of production has to be established. Several bibliometric indicators are relevant in a study of “academic impact” – the number of citations received by the papers, as well as various influence and impact indicators based on field-normalized citation rates. Accordingly, we will not use the number of papers as an indicator of performance, but we have to keep in mind that fewer papers indicates a low general impact, while a high number of cited papers indicates a higher total impact.

Brain power of research units

The present analysis focuses on the *brain power* (also called the “back-to-the-future or *prospective* approach”⁶ of the research personnel employed by Aalto University in Oc-

⁴ Cole et al. (1988).

⁵ Hansson (1995), Moed (2005), ch. 5.

⁶ Visser & Nederhof (2007), s. 472.

tober 2008. Regardless of where individuals were employed before being hired by Aalto University, all of their publications are counted for the whole evaluation period. Consequently, it is impossible to use the number of papers as an informative indicator when relating to the input indicators for Aalto University departments or research units. Instead, we use relative bibliometric indicators which set the citation counts in relation to the global journal average and the global field average.

Studies indicate that the size of an institution is seldom of any significance in measuring the quality of its research output.⁷ Productivity and quality vary widely, but are not primarily driven by organizational size. When citations are normalized, small highly specialized institutions can produce papers that are of equally high quality per funding increment as the larger well known institutions.

It should be observed that we are dealing with short-term impact (less than ten years) in this evaluation. The focus is on what has happened during the period 2003–2007. A longer impact (>10 yrs) is harder to measure, as research groups have a dynamic of their own and are therefore not easy to follow over time.⁸ A longer evaluation period, at least back to year 2000, could have yielded more stable citation statistics.

Citations and theories of citing

The choice of citations as the central indicator calls for a theory of citing: a theory that makes it possible to explain why author x cited article a at time t . What factors should be considered when we discuss why researchers cite back to former literature? The need for a theoretical underpinning of citation analysis has been acknowledged for a long time and several theories have been put forward.⁹ In summary, there are three types of theories: normative, constructive and pragmatic. Normative theories are based on a naïve functionalist sociology, and constructivist theories are opposed to these assumptions. According to the Nordic pragmatist school (e.g. Seglen, 1998, Luukonen, 1997, Amsterdamska & Leydesdorff, 1989; Aksnes 2003), utility in research is one important aspect, and cognitive quality is another, and together they are criteria for reference selection. Based on Cole (1992) the Norwegian Aksnes (2003b) introduces the concepts *quality and visibility dynamics* in order to depict the mechanisms involved.

Factors like journal space limitations prevent researchers from citing all the sources they draw on; it has been estimated that only a third of the literature base of a scientific paper is rewarded with citations. Therefore, citation does not implicate that the cited author was necessarily “correct”, but that the research was **useful**. Do not forget that negative findings can be of considerable value in terms of direction and method. If a paper is used by others, it has some importance. In retrospect, the idea or method may be totally rejected; yet use of the citation is clearly closer to “important contribution to knowledge” than just the publication count in itself. The citation signifies recognition

⁷ Van Raan 2006 a and b.

⁸ Moed et al (1985), p. 133 ff.

⁹ For an excellent review of this topic, see Borgmann & Furner (2002).

and typically bestows prestige, symbolizing influence and continuity.¹⁰ There is no doubt citations can be based on irrational criteria, and some citations may reflect poor judgment, rhetoric or friendship. Nevertheless, the frequency with which an article is cited would appear to establish a better approximation of “quality” than the sheer quantity of production.¹¹ Furthermore, citations may indicate an important sociological process: continuity of the discipline. From this perspective, a positive or a negative citation means that the authors citing and the author cited have formed a cognitive relationship.¹²

From the view of the pragmatist citation school, a discussion of the limits of citation counting is necessary. As stated above, not all works that “ought” to be cited are actually cited, and not all works that are cited “ought” to be. As a consequence, the validity of using citation counts in evaluative citation analysis is problematic. Even if the quality of the earlier document is the most significant factor affecting its citation counts, the combined effect of other variables is sufficiently powerful and much too complex to rule out positive correlations between citation count and cited-document quality.¹³

Moreover, citation practices can be described as results of stochastic processes with accidental effects (Nederhof, 1988:207). Many random factors contribute to the final outcome (e.g. structural factors such as publication time-lags etc.) and the situation can be described in terms of probability distributions: there are many potential citers, each with a small probability of actually giving a reference, but the chance gets higher with each former reference (Dieks & Chang, 1976: 250).

This also creates difficulties when it comes to levels of significance:¹⁴ “...when one paper is cited zero times, another paper, of the same age, has to be cited at least by five different authors or groups of authors, for the difference to be statistically significant. ...This implies that when small numbers of papers are involved, chance factors may obscure a real difference in impact. However, as the number of papers involved in comparisons increases, the relative contribution of chance factors is reduced, and that of real differences is increased” (Nederhof, 1988:207). Accordingly, we have to be very careful in citation analysis when comparing small research groups. Chance factors and technical problems with citations have too pronounced an influence.

Principle of anti-diagnostics

The type of insecurities involved in bibliometrics makes it necessary to underscore the **principle of anti-diagnostics**: “... while in medical diagnosis numerical laboratory results can indicate only pathological status but not health, in scientometrics, numerical indicators can reliably suggest only eminence but never worthlessness. The level of citedness,

¹⁰ Roche & Smith (1980), p. 344.

¹¹ Martin & Irvine, 1983; Cole and Cole, 1973..

¹² Cf. Small (1978) proposed the view that citations act as “concept symbols” for the ideas that are referenced in papers.

¹³ Borgmann & Furner (2002). In the words of Cole & Cole (1973) citations measures “socially defined quality”. Gronewegen (1989) finds that “irregularities, which show up in the patterns of citations towards the work of groups, can be understood as a *result of changes in the local context*” (p.421).

¹⁴ Cf. Schubert & Glänzel (1983).

for instance, may be affected by numerous factors other than inherent scientific merits, but without such merits no statistically significant eminence in citedness can be achieved.” (Braun & Schubert, 1997: 177).

The meaning of this principle is that it is easier with citation analysis to identify excellence than to diagnose low quality in research. The reasons for absence of citations may be manifold: the research community has not yet observed this line of research; publications might not be addressed to the research community but to society etc. Clearly, results for a unit of assessment that are above the international average (=1,0) – e.g. relative citation levels of 2,0–3,0 or higher – indicate a strong group and lively research, but citation levels below 1,0 do not necessarily indicate a poorly performing group.

Citation indicators

The above review of the literature reveals that there are limitations to all theories and all methods for finding excellence in research. According to Martin & Irvine (1983:70) we have to consider three related concepts: *Quality*, *Importance* and *Impact*. *Quality* refers to the inherent properties of the research itself, whilst the other two concepts are more external. *Importance* and *impact* are concepts that refer to relations between the research and other researchers/research areas. The latter also describes the strength of links to other research activities.

We can discuss the *quality* of a research paper without considering the number of times it has been cited by others or how many different researchers cited it. It is not an absolute, but a relative characteristic; it is socially as well as cognitively determined, and can, of course, be judged by many other individuals. *Importance* refers to the potential influence¹⁵ on surrounding research and should not be confused with “correct”, as an idea “must not be correct to be important” (Garfield et al. 1978: 182).¹⁶ Due to the inherent imperfections in the scientific communication system, the actual impact is not identical with the importance of a paper. Thus it is clear that *impact* describes the actual influence on surrounding research: “*while this will depend partly on its importance, it may also be affected by such factors as the location of the author, and the prestige, language, and availability, of the publishing journal*” (Martin & Irvine 1983: 70; cf. Dieks and Chang 1976). Hence, while impact is an imperfect measure, it is clearly linked to the scientific work process, and, used in a prudent and pragmatic approach; measures based on impact give important information on the performance of research groups.

¹⁵ Zuckerman (1987) . Of course, some of the influences (and even facts) may be embedded in the author's mind and not easily attributable.

¹⁶ Again, negative citations are also important: “The high negative citation rate to some of the polywater papers is testimony to the fundamental importance of this substance if it could have been shown to exist” (Garfield et al. 1978.). We assume that the same apply for negative citations to cold fusion papers.

Validation of bibliographic data

One of the practical problems is that of constructing the basic bibliography for each Unit of Assessment's production. This is not a trivial question as papers from one institution might be headed under several different names (de Bruin & Moed, 1990). The identification of papers included in the Aalto University RAE has been based on the individual. This was organized by the TKK library, and the bibliometric analysis was based on the data yielded in that process.

Coverage of scientific and technical publications

Explorations made by Carpenter & Narin (1981), and by Moed (2005), have shown that the Thomson Reuters database (sometimes still referred to as the ISI database or the Web of Science) is representative of scientific publishing activities for most major countries and fields, not counting soft social sciences and humanities: "In the total collection of cited references in 2002 ISI source journals items published during 1980–2002, it was found that about 9 out of 10 cited journal references were to ISI source journals" (Moed 2005:134). It should be emphasized that Thomson mainly covers *international* scientific journals, and that citation analysis is viable only in the context of international research communities. National journals and national monographs/anthologies cannot be accessed by international colleagues. Consequently, publications in these journals are of less interest in a citation exercise of the RAE-type. As long as we are calculating relative citation figures based on fields and sub-fields in the ISI database, the inclusion of national or low cited journals will have the effect of lowering the citation score.

In some studies it has been suggested that there are two distinct populations of highly cited scholars in social science subfields: one consisting of authors cited in the journal literature, the other of authors cited in the monographic literature (Butler, 2008). As the Web of Science has a limited coverage of monographic citing material, the latter population will hardly be recognized in the Web of Science database (Borgmann & Furner, 2002). Related to this question is the language-bias in the citation index. Several studies have evidenced that journal articles written in languages other than English reach a lower relative citation score than articles in English (van Leeuwen et al., 2000). This indicates a bias towards other languages and this should be accounted for in the analytical procedures.

The Web of Science works well and covers most of the relevant information in a large majority of the natural sciences and medical fields, and also works quite well in applied research fields and behavioral sciences (CWTS, 2007:13). However, there are exceptions to that rule. Considerable parts of the social sciences and large parts of the humanities are either not very well covered in the Web of Science or have citations patterns that do not apply to studies based on advanced bibliometrics (Butler, 2008; Hicks, 1999; Hicks, 2004). The information on why this is the case is lacking, and there may be several explanations.

One explanation could be that there are severe lacunas in specific areas of the database, e.g. architecture, computer science, traditional engineering, humanities and soft social sciences. Another interpretation would be that there are areas of research where some of the Aalto University-groups fail to 'perform' in the internationally recognized journals, and instead choose to publish in other international and more national publication channels, e.g. chapters in books, books in national languages, national and local journals or local report series.

One problem with the citation index is that we tend to drop information in so far as we apply a restricted view of scientific communication. In some specialties of the engineering sciences (applied areas) there might be the same type of problem as discussed above. Traditional engineering sciences might have publication and citation patterns that deviate from scientific fields. This has been a theme in scientometrics studies ever since Derek J de Solla Price, the father of bibliometrics, started to investigate the relationship between science and technology. In summary Price found the following: "*To put it in a nutshell, albeit in exaggerated form, the scientist wants to write but not read, and the technologist wants to read but not write*".¹⁷ Price finds that while technologists are *papyrofobic*, scientists are *papyrocentric*. The way science works at research fronts cannot be found within many of the engineering sciences. Price extended his analysis in these words: "Less dramatically, I would like to split research activity into two sharply defined halves; the one part has papers as an end product, the other part turns away from them. The first part we have already identified with science; the second part should, I think, be called 'technology', though here there is more conflict with intuitive notions." Technology is here used in a wider meaning than just engineering; it includes some of the medical specialties, botany and several disciplines within the humanities. Using the concepts in this unorthodox way, Price is clear about the fact that large parts of the engineering sciences should be considered as science areas: "By this definition, it should be remembered there is a considerable part of such subjects as electronics, computer engineering, and industrial chemistry that must be classified as science in spite of the fact that they have products that are very useful to society."¹⁸

During the 1980s it was stated that several areas of technology were becoming *science-based technologies*.¹⁹ The dancing partners (in Toynbee's words) were coming closer to each other and the concept of *technoscience* was introduced by the influential French sociologist Latour.²⁰ The intermixing of both sides was further elaborated by SPRU researchers in the book *Knowledge Frontiers* (1995), a book based on case-studies in areas where the differences regarding ways of gathering, transforming and diffusing information were disappearing between science and technology. According to American information scientists, high-technology and science were analytically "indistinguishable".²¹

¹⁷ Price (1965), pp. 553-568.

¹⁸ The same idea is apparent in T. Allens *Managing the Flow of Technology*, MIT Press 1977.

¹⁹ Böhme et al (1978), pp. 219-250.

²⁰ Latour, Bruno (1987).

²¹ Narin & Toma (1985).

A completely opposite perspective has been cultivated by Dutch research managers.²² From a detailed case study of electron microscopy it was shown that some scientific advances were incorporated in scientific and technical instruments and therefore invisible. Although very important, these advances received few citations and therefore citation analyses were proven not comprehensible. The expression “citation gap” was coined. However, indicators are partial and need to be complemented by other methods. This is the basis for modern advanced bibliometrics and a theme throughout this report. Certainly there are citation gaps, but there is a problem of knowing what type of conclusions to draw from that. Instruments are developed in almost all fields of science and technology. So, even with severe differences between areas in this respect, the method of field normalization should take care of much of the disparity. Relative indicators were not developed at the time when the citation gap was discussed (1980s).²³

Still, there remain some differences between areas that should be accounted for. Detailed studies of engineering areas show that there are more citations to non-journals (text books and handbooks) and this contributes to a more insecure citation statistic for these fields. We should be observant of this before we draw any conclusions about UoAs in traditional engineering areas.

Another problem concerns the computer science areas and their habit of using conference proceedings in the same way as other areas use journals for the communication of results. 2008 the Web of Science included a number of serial proceedings: IEEE, LNCS, ACM etc. Moreover, the coverage of the new *Web of Science with Conference Proceedings* is even better than what is the case in ordinary WoS.²⁴ Because the TKK Library did not have a subscription to the ISI Proceedings, all the proceedings papers could not be included in the exercise. Another interesting comparison concerns the choice of database; in appendices No 1 there is a comparison of ISI and Scopus databases. In five out of the almost fifty cases there are great concerns due to coverage in the respective databases.

Matching of references to articles

The Thomson Reuters database consists of articles and their references. Citation indexing is the result of a linking between references and source (journals covered in the database). This linking is done with a citation algorithm, but the one used by Thomson Reuters is conservative and a consequence of this is non-matching between reference and article. Several of the non-matching problems relate to publications written by ‘consortia’ (large groups of authors), and to things such as variations and errors in author names; errors in initial page numbers; discrepancies arising from journals with dual volume-numbering systems or combined volumes; journals applying different article numbering systems; or multiple versions due to e-publishing.²⁵ Approximations indicate

²² Le Pair, C. (1988), van Els et.al. (1989).

²³ Relative indicators were introduced in 1988 by Schubert, Glänzel and Braun (1988).

²⁴ For further exploration see Moed & Visser (2007) which reports on an expanded version of WoS with IEEE, LNCS and ACM.

²⁵ Moed (2002) summarizes the major problems found with the citation algorithm, c.f. Moed (2005), ch. 14 “Accuracy of citation counts”.

that about seven per cent of citations are lost due to this conservative strategy. Thomson Reuters seem anxious not to over-credit authors with citations. In the Aalto University Bibliometric Analysis, we have used an alternative algorithm that addresses a larger number of the missing links. Additionally, we have corrected links to Aalto University using a manual double-check. This should take into account most of the 'missing' citations.

Self-citations

Self-citations can be defined in several ways, usually with a focus on co-occurrence of authors or institutions in the citing and cited publications. In this report we follow the recommendation to eliminate citations where the first-author coincides between citing and cited documents (Aksnes, 2003a). If an author's name can be found at other positions, as last author or middle author, it will not count as a self-citation. This more limited method is applied for one reason: if the whole list of authors is used, the risk for eliminating the wrong citations is increased. On the down-side, this method may result in a senior-bias. This will probably not affect Units of Assessment, but caution is needed when the analysis is aimed at the individual level (Adams, 2007: 23; Aksnes, 2003b; Glänzel et al., 2004; Thijs & Glänzel, 2005).

Time window for citations

An important factor that has to be accounted for is the time effect of citations. Citations accumulate over time, and citation data has to cover comparable time periods (and be within the same subfield or area of science, see below). However, in addition to that, the time patterns of citation are far from uniform, and any valid evaluative indicator must use a fixed window or a time frame that is equal for all papers. The reason for this is that citations have to be appropriately normalized. Most of our investigations use a decreasing time-window from the year of publication until December 31 2008. However, some of our indicators are used for time-series, and in these cases we apply a fixed two year citation window. Publications from the year 2003 receive citations until 2005; publications from 2006 receive citations until 2008 and so on.

Fractional counts and whole counts

In most fields of research, scientific work is done in a collaborative manner. Collaborations make it necessary to differentiate between whole counts and fractional counts of papers and citations. Fractional counts give a figure of weight for the contribution of the group to the quantitative indicators of all their papers. By dividing the number of authors from the group with the number of all authors on a paper we introduce a fractional counting procedure. Fractional counting is a way of controlling the effect of collaboration when measuring output and impact.

Fields and sub-fields

In bibliometric studies, the definition of fields is generally based on the classification of scientific journals into the 250 or so categories developed by Thomson Reuters. Although this classification is not perfect, it provides a clear and consistent definition of fields suitable for automated procedures. However, this proposition has been challenged by several scholars (e.g. Leydesdorff, 2008; Bornmann et al. 2008). Two limitations have been pointed out: (1) multidisciplinary journals (e.g. *Nature*; *Science*); and (2) highly specialized fields of research.

The Thomson Reuters classification of journals includes one sub-field category named “Multidisciplinary Sciences” for journals like *PNAS*, *Nature and Science*. More than 50 journals are classified as multidisciplinary since they publish research reports in many different fields. Fortunately, each of the papers published in this category are subject-specific, and therefore it is possible to assign a subject category to these on the article level – what Glänzel et al. (1999) call “item by item reclassification”. We have followed that strategy in this report.

Normalized indicators

During recent decades, standardized bibliometric procedures have been developed to assess research performance.²⁶ Relative indicators or rebased citation counts, as an index of research impact, are widely-used by the scientometrics research community. They have been employed extensively for many years by Thomson Reuters in the Essential Science Indicators. The CHI research team in the United States and the ISSRU team in Budapest popularized the central concepts of normalization during the 1980s.²⁷ More recently, field normalized citations have been used, for example, the European science and technology indicators used by groups such as the CWTS bibliometrics research group at the University of Leiden (labeling it the “crown indicator”); the Evidence group in the U.K.²⁸; leading higher education analysts at the Norwegian institute NIFU/STEP²⁹; the analyst division at the Swedish Research Council/Vetenskapsrådet³⁰ and others. Field normalized citations can be considered as an **international standard** used by analysts and scientists with access to the Web of Science database.

In this report we follow the normalization procedures proposed by the Leiden group (van Raan 2004) with only two minor addendums: firstly, while the Leiden method gives higher weight to papers from normalization groups with higher reference values, we treat all papers alike; secondly, while the Leiden method is based on a “block indicators” covering four or five year period,³¹ our method rests on a statistic calculation year

²⁶ Schubert et al (1988), Glänzel (1996), Narin & Hamilton (1996), van Raan (1996), Zitt et al. (2005).

²⁷ Cf. Zitt (2005: 43).

²⁸ C.f. Adams et al. (2007).

²⁹ See, the biannual Norwegian Research Indicator Reports.

³⁰ Vetenskapsrådet Rapport 2006.

³¹ C.f. Visser and Nederhof (2007), p. 495 ff.

to year. Publications from 2003 are given an 6 year citation window (up to 2008) and so on. Due to these relatively small differences, we have chosen to name our indicator NCS (Normalized Citation Score), but, it should be emphasized that it is basically the same type of indicator.

The normalization procedure shown in Figure 1 can be further explained thus: The sub-field consists of five journals (A–E). For each of these journals, a journal-based reference value can be calculated. This is the journal mean citation level for the year and document type under investigation. A UoA might have a CPP above, below or on par with this mean level. All journals in the sub-field are taken together as the basis for the field reference value. A researcher publishing in journal A will probably find it easier to reach the mean than a researcher publishing in journal E.

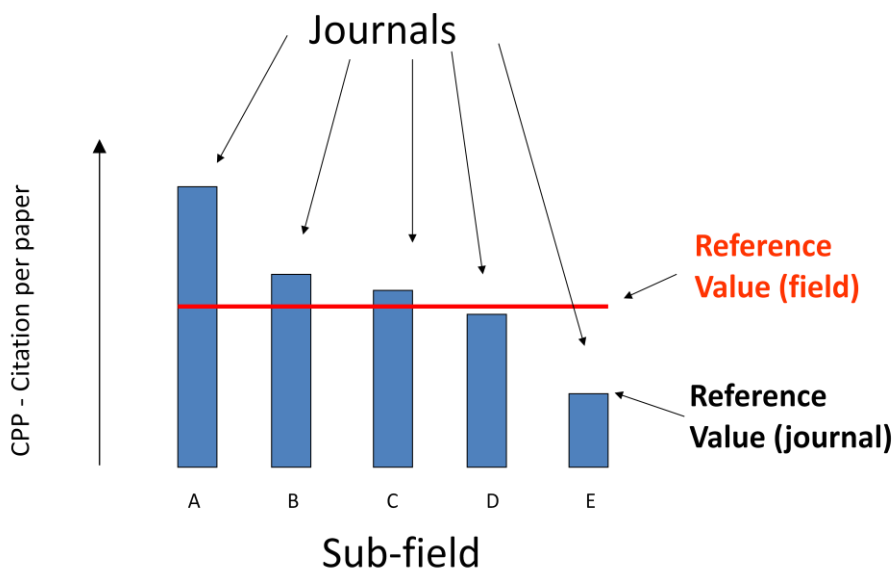


Figure 1. Normalization of reference values.

We consider the field citation score to be the most important indicator. The number of citations per paper is then compared with a sub-field reference value. With this indicator it is possible to classify UoA performances in five different classes:³²

³² This classification of performances is inspired from presentations made by Van Raan, but the levels are accommodated to the actual methods used for computation of citation scores. CWTS levels are higher as citations are not fractionalized. For further information, see U. Sandström "Peer Review and Bibliometrics", available at www.forskningspolitik.se.

A. $NCSf \leq 0.60$	significantly far below international average
B. $0.60 < NCSf \leq 1.20$	at international average
C. $1.20 < NCSf \leq 1.80$	significantly above international average
D. $1.80 < NCSf \leq 2.40$	from an international perspective very strong
E. $NCSf > 2.40$	global excellence

Standard Citation Score

The heterogeneity between research fields is a well-known fact and has been vigorously described by authors such as Whitley (2000) and Cole (1992). Z-score, which uses the standard deviation as a measure, has been used in bibliometric analyses from the beginning of the 1980s. However, skewing of citation distributions poses problems to this, and therefore McAllister et al. (1983) suggested that the logarithm of citations should be added as a methodological point of departure. We follow the method proposed by McAllister et al and use it as another partial indicator. Along with the NCSf indicator we assume that they together give a more complete picture of citation based impact.

Top 5 percent

The above Standard Citation Score gives a more complete picture, taking the skewed nature of citations into account. Still, we might need simple figures that indicate the excellence of the group in just one number and the *Top5%* is an indicator of that type. As an indicator it expresses the share of publications within the top 5% of the worldwide citation distribution of the fields concerned for the given research group. This approach provides a better statistical measure than those based on mean values. We suggest that this indicator is used together with other indicators and in this case as *“a powerful tool in monitoring trends in the position of research institutions and groups within the top of their field internationally”* (CWTS, 2007: 25). If the research group has a high proportion of articles in the Top5% they will probably have a large impact on their research field.

Vitality

Boyack and Börner (2003) established the term “vitality”, defining vital research with the following features:

1. A stable/increasing number of publications in prominent journals with high impact factors;
2. High *export* factors indicating that research is acknowledged and utilized in other domains;
3. A tightly knit co-authorship network leading to efficient diffusion of knowledge;
4. Funding resulting in larger numbers of high impact publications;
5. New emerging research fields.

Later Boyack (2007) and Klavans & Boyack (2008) operationalized the concept of vitality as field normalized *reference age* of articles. Even if there is a lack of consensus in the field of bibliometrics on how to measure reference age, there are not that many options. Price defines the so-called *Price Index* as “the proportion of the references that are from the last five years of literature” (Price, 1979; Egghe, 1997). Klavans and Boyack (2008) suggest the use of the mean age of references with normalization to the field, and we follow their recommendations.

Vitality – recency of cited literature – is an interesting factor in assessments of research performance. It rests on the hypothesis that researchers at the front use the most recent references and that they “are committed to participating at the forefront of science rather than on older science” (ibid.). Typically, they are willing to shift their emphasis from older ideas to newer ideas when warranted. Researchers with an older average reference age are far less committed to focusing on new science. Remember that there are differences between fields of science³³ that have to be accounted for and, therefore, the proposed method uses normalization in relation to WoS sub-fields. Nevertheless, vitality is, as an index, very simple, and hence the sociological interpretation is rather ambiguous.

³³ Originally, the motive for Price’s research on this was to demonstrate these differences between areas. Moed (1989) has showed that Price’s statement might be an oversimplification.

RESULTS FROM THE BIBLIOMETRIC STUDY

Information gathered and analyzed includes the following indicators:

Table 1: Indicators used in the report

P	NUMBER OF PAPERS	Number of papers (articles, proceedings papers and reviews) published by UoA "NN" during 2003–2007.
Frac P	NUMBER OF FRACTIONALIZED PAPERS	Sum of author fractionalized papers (articles, proceedings papers and reviews) published by UoA "NN" during 2003–2007.
CPP	CITATIONS PER PAPER	Number of citations per paper (31 December 2008).
C2YR	CPP 2 YEAR	Citations per paper with a 2-year citation window
NCSj	JOURNAL NORMALIZED CITATION SCORE	CPP normalized in relation to the UoA "NN" journal set (average=1.00).
NJCS	NORMALIZED JOURNAL CITATION SCORE	The impact of the journal set normalized in relation to its sub-fields (average=1.00).
NCSf	FIELD NORMALIZED CITATION SCORE	CPP normalized in relation to the UoA "NN" sub-field set (average=1.00).
SCSf	STANDARD FIELD CITATION SCORE	Z-score standardized citation score in relation to the UoA "NN" sub-field set (N.B! average=0.00).
TOP5%	SHARE OF PAPERS WITHIN TOP 5%	Percentage of papers above the 95th citation percentile.
VITALITY	VITALITY	Recency of references.
IntCOLLm	INTERNATIONAL COLLABORATION	Mean number of countries per paper from the UoA "NN".
AUm	AUTHOR MEAN	Mean number of Authors per paper
SCIT	PERCENTAGE SELF-CITATIONS	Percentage self-citations.
PNC	PERCENTAGE NOT CITED PAPERS	Percentage of not cited papers during the period.

Journal Normalized Citation Score (NCSj): Citations per publication related to the reference value, which in this case is the average number of citations per publication in the journals in which the UoA appears, taking document type and year of publication into account.

[This indicator is almost identical to the CPP/JCS indicator developed by the Leiden group]

Normalized Journal Citation Score (NJCS): This measure is used in order to estimate the average journal impact in relation to other journals in the same sub-field(s).

[This indicator is almost identical to the JCS/FCS indicator developed by the Leiden group]

Field Normalized Citation Score (NCSf): Citation per publication related to a reference value built on the global averages for all articles in the sub-fields to which the UoA papers are assigned.

[This indicator is almost identical to the CPP/FCS indicator developed by the Leiden group]

Major differences between areas of science call for an alternative measure that takes the deviation of citations into account. Since citation data are skewed we use the logarithm of citations before calculating the standard deviation. This measure is called *Standardized Citation Score, field, SCSf*, and measures the number of standard deviations from the average. This indicator is used as complementary to the NCSf.

Top 5% is another measure that takes the citation skews into account. More precisely, this indicator shows how many of the UoA papers that are above the 95th percentile regarding citations in their sub-fields.

Table 2: Aalto results 2003 – 2007 (all units)

Symbol	Indicator	Score 2003–2007
PERS	NUMBER OF PERSONNEL	2 192
P	NUMBER OF PAPERS	4 451
Frac P	NUMBER OF FRACTIONALIZED PAPERS	1992
CPP	CITATIONS PER PAPER	4.68
C2YR	CPP WITH A 2-YEAR WINDOW	2.77
NCS _j	JOURNAL NORMALIZED CITATION SCORE	1.25
NJCS	NORMALIZED JOURNAL CITATION SCORE	1.12
NCS _f	FIELD NORMALIZED CITATION SCORE (Crown Indicator)	1.23
SCS _f	STANDARD FIELD CITATION SCORE	0.21
TOP5%	SHARE OF PAPERS WITHIN TOP 5%	6.5 %
VITALITY	VITALITY	1.11
IntCOLLm	INTERNATIONAL COLLABORATION	1.7
AUm	AUTHOR MEAN	5.6
SCIT	PERCENTAGE SELF-CITATION	13.4 %
PNC	PERCENTAGE NOT CITED PAPERS	31 %

Table 2 B shows the bibliometric results for TKK research units.

Table 2B: TKK results 2003 – 2007

Symbol	Indicator	Score 2003–2007
PERS	NUMBER OF PERSONNEL	1 817
P	NUMBER OF PAPERS	4 262
Frac P	NUMBER OF FRACTIONALIZED PAPERS	1880.3
CPP	CITATIONS PER PAPER	4.80
C2YR	CPP WITH A 2-YEAR WINDOW	2.86
NCS _j	JOURNAL NORMALIZED CITATION SCORE	1.28
NJCS	NORMALIZED JOURNAL CITATION SCORE	1.11
NCS _f	FIELD NORMALIZED CITATION SCORE (Crown Indicator)	1.23
SCS _f	STANDARD FIELD CITATION SCORE	0.22
TOP5%	SHARE OF PAPERS WITHIN TOP 5%	6.74 %
VITALITY	VITALITY	1.11
IntCOLL _m	INTERNATIONAL COLLABORATION	1.7
AU _m	AUTHOR MEAN	5.7
SCIT	PERCENTAGE SELF-CITATION	12.6 %
PNC	PERCENTAGE NOT CITED PAPERS	22.7 %

Table 3: Bibliometric Results 2003–2007 per Unit of Assessment (table contd. for two more pages)

Panel and Unit of Assessment	P	Frac P	CPP	C2YR	NCSj	NJCS	NCSf	SCSF	TOP5%	VITALITY	In-tCOLLm	AUm	SCIT	PNC
Panel 1: Chemical Technology and Materials														
T1010 Dept of Biotechnology and Chemical Tech	252	108,3	3,97	2,14	0,82	1,06	0,82	0,01	2,0%	1,03	1,1	4,4	13,0%	24,0%
T1020 Dept of Chemistry	300	89,1	10,77	6,13	1,43	1,31	1,60	0,31	9,7%	1,06	1,6	5,1	10,6%	15,1%
T1030 Dept of Materials Science and Eng	177	78,3	3,12	1,66	1,10	0,76	0,79	-0,06	1,4%	1,05	1,4	4,2	19,6%	35,3%
T1040 Dept of Forest Products Technology	226	81,8	3,33	1,89	2,01	1,05	1,47	0,28	4,4%	1,14	1,5	4,3	16,3%	30,4%
Panel 2: Electronics and Electrical Engineering														
T4020 Dept of Electronics	67	31,9	4,47	2,51	2,60	0,63	0,91	-0,02	0,0%	1,19	1,3	3,7	5,6%	50,3%
T4040 Dept of Radio Science and Eng	312	169,0	4,63	2,66	1,96	1,11	1,62	0,46	11,4%	1,09	1,5	5,1	14,7%	27,1%
T4050 Dept of Signal Proc and Acoustics,	173	73,7	3,10	1,71	1,32	0,91	1,02	0,15	5,5%	1,05	1,5	3,9	16,8%	35,6%
T4060 Dept of Electrical Engineering	89	46,5	1,87	1,02	1,25	0,72	0,81	0,02	0,5%	0,91	1,5	3,1	21,2%	43,0%
T4080 Metsähovi Radio Observatory	68	9,3	6,77	5,42	0,81	1,03	0,90	0,17	1,5%	1,06	6,4	43,6	10,6%	14,6%
Panel 3: Mathematics and Physics														
T3010 Dept of Biomedical Eng & Comp Sci	239	79,1	6,41	3,89	1,21	1,14	1,25	0,25	6,5%	1,14	1,5	4,8	9,7%	21,9%
T3020 Dept of Mathematics and Syst Analysis	144	78,5	2,59	1,41	1,44	1,17	1,57	0,32	11,4%	1,10	1,5	2,9	20,8%	44,6%
T3040 Dept of Applied Physics	996	341,9	8,42	5,05	1,37	1,38	1,76	0,52	13,2%	1,22	2,1	8,3	11,8%	16,6%
T4030 Dept of Micro and Nanosciences	253	93,9	3,57	2,35	0,91	1,09	0,96	0,02	5,2%	1,12	1,4	6,0	17,1%	33,6%
T5300 Low Temperature Laboratory	367	157,8	6,65	4,46	1,05	1,41	1,18	0,32	4,2%	1,10	1,8	4,6	11,0%	14,1%

Table 3 contd.

Panel and Unit of Assessment	P	Frac P	CPP	C2YR	NCSj	NJCS	NCSf	SCSf	TOP5%	VITALITY	Int-COLLm	AUm	SCIT	PNC
Panel 4: Computer Science and Information Technology														
T3030 Dept of Media Technology,	36	15,6	1,01	0,55	0,39	1,05	0,52	-0,20	0,0%	1,21	1,1	3,3	6,9%	69,1%
T3050 Dept of Computer Science and Eng	51	28,6	0,63	0,46	0,74	0,68	0,45	-0,17	0,0%	1,09	1,2	2,9	10,5%	62,7%
T3060 Dept of Information and Comp Sci	234	123,2	2,18	1,49	1,51	1,03	1,28	0,30	6,3%	1,13	1,4	3,6	7,9%	43,1%
T4070 Dept of Communications and Networking	111	58,4	1,03	0,67	0,68	0,99	0,65	-0,15	3,6%	1,09	1,4	2,9	11,9%	60,0%
T6300 Helsinki Institute for Information Tech	35	14,5	2,27	1,44	1,24	0,84	0,94	0,20	6,9%	1,28	1,3	3,4	10,6%	41,7%
Panel 5: Mechanical Engineering and Automation														
T2020 Dept of Energy Technology	71	43,7	1,68	0,84	0,60	0,88	0,54	-0,21	2,3%	1,01	1,1	2,9	13,7%	41,5%
T2030 Dept of Engineering Design and Prod	66	30,1	4,42	1,56	1,32	0,73	0,94	0,04	3,3%	1,26	1,2	4,3	21,1%	35,8%
T2040 Dept of Applied Mechanics	34	24,6	0,99	0,34	0,66	0,86	0,57	-0,23	0,0%	0,95	1,1	2,4	17,2%	55,9%
T4010 Dept of Automation and Systems Tech	26	13,2	0,76	0,58	0,41	1,11	0,38	-0,37	0,0%	0,98	1,2	3,2	10,4%	57,1%
Panel 6: Civil Engineering and Urban Regional														
T2050 Dept of Surveying	7	2,6	2,04	0,74	0,30	0,53	0,29	-0,78	0,0%	0,96	2,0	4,0	1,6%	72,5%
T2060 Dept of Structural Eng and Build Tech	41	19,0	1,16	0,72	0,54	0,96	0,48	-0,25	0,0%	1,05	1,3	3,2	26,4%	46,9%
T2070 Dept of Civil and Environ Eng	51	24,3	2,86	1,89	1,09	0,82	1,05	0,02	6,2%	1,39	1,3	3,5	11,7%	34,4%
T2080 Lahti Center	2	1,5	0	0	0	0,55	0	-0,96	0,0%	0,94	1,0	1,5	0,0%	100,0%
T2090 Centre for Urban and Regional Stud YTK	7	5,4	1,60	0,86	0,27	0,76	0,36	-0,70	0,0%	1,19	1,0	1,9	18,5%	69,2%

Table 3 contd.

Panel and Unit of Assessment	P	Frac P	CPP	C2YR	NCSj	NJCS	NCSf	SCSf	TOP5%	VITALITY	Int-COLLm	AUm	SCIT	PNC
Panel 7: Business Technology, Econ & Finance														
E1 Dept of Accounting and Finance, HSE	12	8,2	2,35	1,16	0,50	1,53	0,63	0,04	0,0%	1,17	1,3	1,9	2,4%	36,7%
E2 Dept of Business Technology, HSE	54	24,3	3,09	1,29	0,96	1,19	1,15	0,21	4,5%	0,97	1,6	2,9	12,6%	35,5%
E5 Dept of Economics, HSE	36	19,3	1,97	0,72	0,74	1,24	0,74	0,03	0,0%	1,08	1,5	2,1	13,0%	37,1%
Panel 8: Marketing, Management and Applied Business Research														
E3 Ctr for Markets in Transition (CEMAT), HSE	1	1,0	2,00	1,00	1,09	0,84	0,91	0,36	0,0%	0,58	1,0	1,0	0,0%	0,0%
E4 Ctr for Knowl and Innovation Res (CKIR)	31	18,0	2,52	1,45	1,02	1,51	2,95	0,28	0,0%	1,01	1,2	3,6	40,4%	33,5%
E6 Dept Languages and Communication, HSE	2	1,3	1,75	1,00	1,40	0,65	0,70	0,10	0,0%	0,97	1,5	3,0	0,0%	0,0%
E7 Dept Marketing and Management, HSE	53	30,8	3,42	1,60	1,04	0,89	0,98	0,08	3,8%	0,99	1,4	2,6	7,6%	34,4%
T3070 Dept Ind Engineering and Management	44	22,2	4,14	2,07	1,03	1,34	1,53	0,42	9,7%	0,99	1,5	2,7	6,3%	27,4%
T3080 BIT Research Centre	26	14,6	1,49	0,93	0,79	0,86	0,57	-0,10	1,4%	1,02	1,1	2,8	6,0%	49,5%
Panel 9: Architecture, Design, Media and Art														
A1 Designium, TaiK	1	0,3	0	0	0	0,43	0	-0,96	0,0%	1,16	4,0	4,0	0,0%	100,0%
A2 Motion Pict, Television and Prod Design	1	1,0	0	0	0	1,28	0	-0,22	0,0%	0,81	1,0	1,0	0,0%	100,0%
A3 Future Home Institute, TaiK	0	0,0	0	0	0	0	0	0	0,0%	0	0,0	0,0	0,0%	0,0%
A4 Medialab, TaiK	8	5,4	0,07	0,04	0,02	1,10	0,03	-0,32	0,0%	1,84	1,4	2,1	0,0%	96,3%
A5 School of Design, TaiK	1	1,0	0	0	0	7,76	0	-0,14	0,0%	2,73	1,0	1,0	0,0%	100,0%
A6 School of Art and Media, Pori, TaiK	0	0	0	0	0	0	0	0	0,0%	0	0,0	0,0	0,0%	0,0%
A7 School of Art Education, TaiK	1	0,5	2,00	1,00	1,14	0,54	0,61	0,13	0,0%	0,86	1,0	2,0	0,0%	0,0%
A8 School of Visual Culture, TaiK	0	0	0	0	0	0	0	0	0,0%	0	0,0	0,0	0,0%	0,0%
T2010 Dept of Architecture,	0	0	0	0	0	0	0	0	0,0%	0	0,0	0,0	0,0%	0,0%
Total	4451	1992	4,68	2,77	1,25	1,12	1,23	0,21	6,5%	1,11	1,7	5,6	13,4%	31,0%

Table 4: Bibliometric Results 2003–2007 per Panel

PANEL	P	Frac P	CPP	C2YR	NCSj	NJCS	NCSf	SCSf	TOP5%	VITALITY	Int-COLLm	AUm	SCIT	PNC
Panel1	939	357,5	5,33	2,97	1,30	1,05	1,16	0,13	0,04	1,07	1,41	4,53	0,15	0,26
Panel2	703	330,4	3,95	2,28	1,75	0,96	1,29	0,28	0,07	1,06	1,89	7,51	0,15	0,33
Panel3	1947	751,1	6,62	4,09	1,24	1,30	1,47	0,36	0,09	1,16	1,84	6,55	0,13	0,22
Panel4	453	240,3	1,65	1,11	1,13	0,97	0,96	0,10	0,05	1,13	1,36	3,33	0,09	0,51
Panel5	197	111,6	2,16	0,89	0,78	0,86	0,63	-0,17	0,02	1,06	1,18	3,32	0,16	0,45
Panel6	108	52,9	2,00	1,25	0,74	0,84	0,71	-0,22	0,03	1,21	1,31	3,29	0,17	0,46
Panel7	102	51,8	2,55	1,06	0,81	1,26	0,91	0,12	0,02	1,04	1,53	2,51	0,11	0,36
Panel8	145	88,1	3,06	1,56	1,00	1,12	1,45	0,18	0,04	1,00	1,34	2,81	0,14	0,34
Panel9	12	8,1	0,17	0,09	0,08	1,89	0,06	-0,28	0,00	1,74	1,50	2,08	0,00	0,91
Total	4451	1991,8	4,68	2,77	1,25	1,12	1,23	0,21	0,06	1,11	1,66	5,56	0,13	0,31

CONCLUSIONS AND DISCUSSION

Results indicate that Aalto University has research personnel with high capacity for internationally competitive research. The citation impact is well above global average (23 per cent above global average) and several UoA:s have a record of strong performances from an international perspective.

The main field indicator, NCSf, is a bit lower than the journal normalized indicator, NCSj. Although Aalto University is publishing in rather good journals, 12 per cent above world average, the difference between NCSf and NCSj indicates that too many papers in the better journals have not yet received citations. The data here is limited to a period of five years and a large part of the papers are of recent origin. This might affect the results as relatively more papers are not cited. This should be remembered for any comparison with other universities, e.g. Royal Institute of Technology in Stockholm, which had data from a longer time period, 2000–2006. Accordingly, there were in that case a higher portion of the total papers which were given the possibility of a longer citation window.

Bibliometric indicators should be treated with caution and cannot be interpreted without detailed knowledge of the research units under assessment and the context of their research. Is it a group that was recently started? Has there been a lot of mobility or fluctuations in the support of research students or research income? These are questions that cannot be answered without additional information.

If the bibliometric analysis indicates a low correlation with the peer ratings there are several possible explanations. Firstly, the peers might not see the scientific potentials of the group. Secondly, and probably more common, there might be flaws in the bibliometric data. Imperfections and limitations of bibliometric analysis can be sorted under two headings:

- 1) ISI classification of journals into sub-fields is a powerful instrument for normalization procedures, but the categorization has to be stable over time. For areas under fast transformation this might lead to inconsistencies, and new areas in between sub-fields, or old areas where two disciplines are collaborating, may not receive optimal attention in all actual cases. In such cases, if the NCSj figures (Normalized Citations Score, journal) deviates from the NCSf, the former might give a more appropriate description of performances.

- 2) Coverage issues in the Web of Science selection of journals and serials is an important problem, and this could be a more pertinent problem especially in the applied engineering areas than for other fields. The investigations reported here cannot discount this, as ICT units (computer and media science) do seem to be disadvantaged by the bibliometric analysis. ICT consists of several areas with a typically high number of specialized conference proceedings which were not retrievable from the database. These areas are often better covered in the proceedings databases, e.g. the ISI proceedings database included in the Web of Science in 2008. Appendices No 1 shows data for dif-

ferent coverage in the ISI and Scopus databases. This indicates that this is an issue to consider when interpreting the analysis.

Beside the coverage issue, there are no obvious tendencies in the results pointing to severe problems with the underlying data. However, units with a small international exposure, many of them within typical engineering areas (e.g. civil engineering), do show results with an undersized number of papers. To draw general conclusions from this would be unwarranted; instead, we should use the information for further investigation of publication strategies from those units and examine the different possibilities and options for the researchers with the objective of international competitiveness in mind.

A low number of publications in the Web of Science database can also indicate a different type of focus for the research of a UoA. There are many different stakeholders at a technical/economic/design university and certainly not all of them are content with international publications as the main result of academic research. Nevertheless, such UoA:s might need advice from the point of view of advanced research, thus increasing international publications in refereed journals as a visible sign of competence which could eventually act as a vehicle for getting even more out of the consulting and commissioned projects that are their specialty.

Researchers in the UoA:s of the present study need not have been at Aalto University for the whole period. In essence, this is the method of prescriptive “brain power” analysis. With this method we are looking towards the future, since the personnel currently employed are likely to remain at Aalto University for the immediate future. The downside of this method is that we cannot relate personnel structure, research income or any other structural indicators to the bibliometric indicators. Unfortunately, this is the main limitation of the applied method, but on the plus side we have relevant information to use for future knowledge assessment strategies.

To conclude, a bibliometric analysis can hardly account for all the manifold activities of a diverse modern university. Many other methods have to be applied in order to capture the variety of functions performed by academic researchers in society. In this context we emphasize that the bibliometric methods used here are geared towards an international comparison, and it is important that any conclusions drawn consider this limitation.

International collaboration is a main method for maintaining and for extending the citation impact. Aalto University researchers collaborate on approximately half of their papers. Obviously, as is apparent from Table 5 that there is a correlation between number of international addresses and impact:

Table 5: Collaboration (No of Addresses) and Indicators for Aalto University

NrOfCountries	P	%	CPP	NCSj	NJCS	NCSf	SCSf	Top5%
1	2706	60,8%	4,72	1,21	1,07	1,13	0,17	5%
2	1152	25,9%	6,36	1,33	1,27	1,50	0,40	10%
3	379	8,5%	6,24	1,43	1,25	1,60	0,45	10%
4	116	2,6%	6,69	1,22	1,43	1,80	0,39	7%
>4	98	2,2%	10,65	1,84	1,33	2,01	0,70	18%

Taking all the mentioned caveats into account we can summarize this report with a few notes on the excellence issue. Are there excellent research groups at Aalto University? As indicated in the report there are rules of thumb for identifying excellent groups using bibliometric measures. The field normalized citation score (the so called crown indicator) is one necessary ingredient for the analysis. If a group is found to have a citation performance around 100 per cent or higher above the international average this is an indication of outstanding excellence. But, and this is important, it also depends on the number of papers. With few papers the reliability of measures is weakened; also we might expect an excellent group to perform a number of papers that is close to the normal productivity per researcher within that specific field. A further development of this analysis could be to include a study of the field adjusted production factor per group.³⁴

Finally, there is room to discuss the relation between bibliometrics and peer review. General bibliometric indicators provide useful information that can be used by peers or in a prudent process initiated by university management. Several studies have shown that usually there is a good correspondence between peer ratings and bibliometrics. Let us investigate this question. How is the relation between grades given in the Research Assessment Exercise and bibliometric indicators?

We have 46 empirical observations, which are a bit too few for statistical significance, but the question can at least be illustrated with descriptive statistics. Two box-plot diagrams are given in Figure 2 and 3. The first, to the left, is concerned with the field normalized citation score and shows a rather nice picture with a covariance between grades and bibliometric values. Although there are few observations the results indicate that there is a significant difference between grade 2 and 5 also in bibliometric impact. Lines in the boxes show the mean value. Boxes cover from first to third quartile.

³⁴ Cf. Sandström, U & Sandström, E (2009). The Field Factor: towards a metric for Academic Institutions. *Research Evaluation*, 18(3), September 2009, pages 243–250.

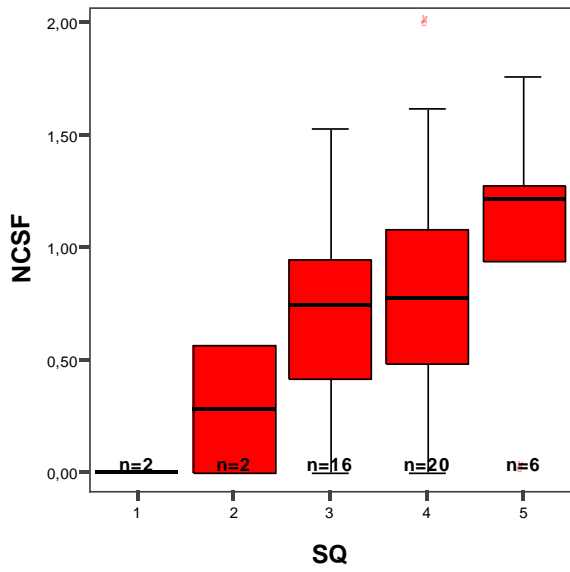


Figure 2. Sci Quality and NCSf (Aalto)

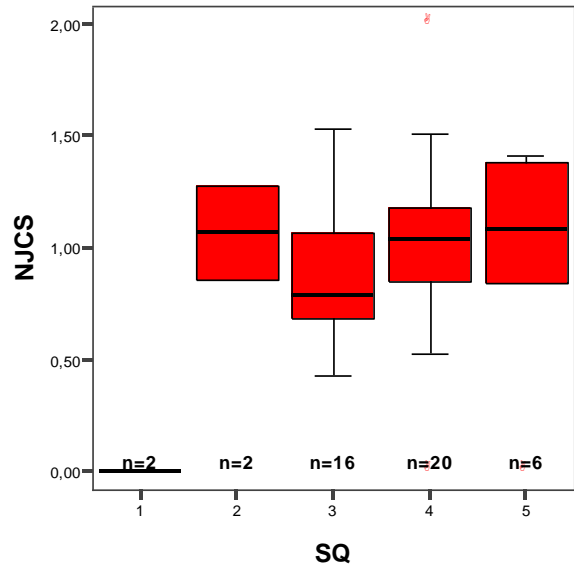


Figure 3. Quality and NJCS (Aalto)
NB! Extreme values are hidden.

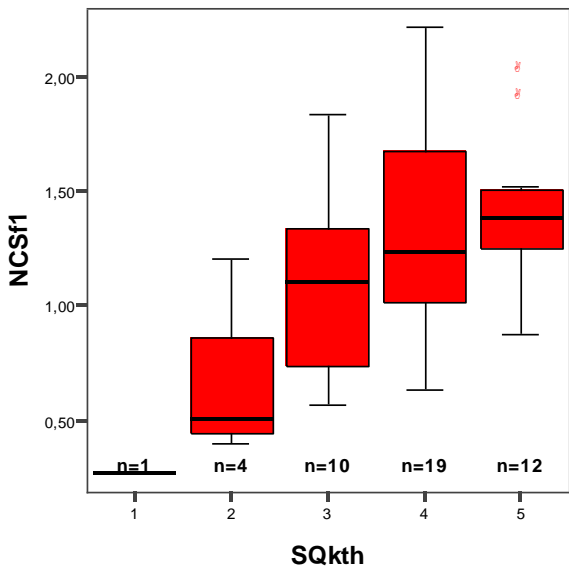


Figure 4. "Sci Quality" and NCSf (KTH)

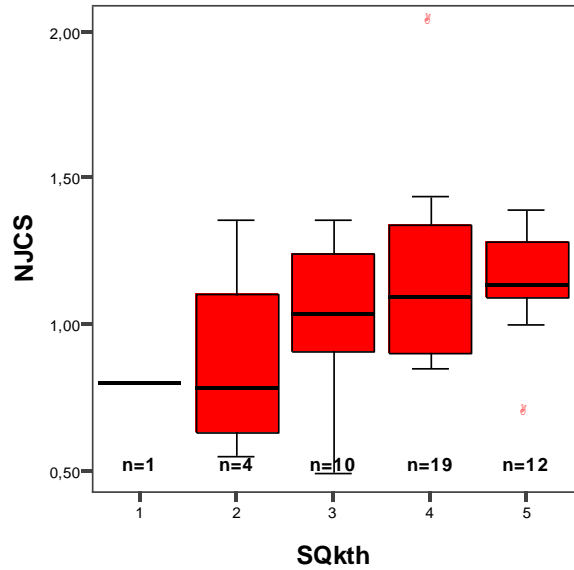


Figure 5. Quality and NJCS (KTH)
NB! Extreme values are hidden.

From other investigations we would expect that reviewers guide their grading based on the journal impact, i.e. the quality of the journals in which the units have been publishing. Therefore, it seems untypical that Figure 3 shows quite the opposite result. There are no significant differences regarding normalized journal impact in relation to grades. This might be an effect of specific features of the engineering area. If we compare with the recent Royal Institute of Technology RAE from last year we find the same pattern (see Figure 4 and 5).³⁵ Quite another pattern is found when looking at the Swedish University for the Agricultural Sciences and the results from its research assessment exercise performed in 2009.³⁶ There it seems to be the case that NJCS (journal impact) has the best fit with grades given by reviewers (data not shown here).

Whether this should be explained by differences between fields (on the one hand there are the natural sciences and medicine and on the other hand engineering sciences), is an open question that needs more of research to be decided upon. If engineering researchers relate to journals in a different way so that a reviewer will not use a publication list in the same way as a natural scientist or medical reviewer, i.e. as a proxy for the quality of different areas of research. Engineering science might be motivated in a different way and therefore cannot be compared with natural or medical science without taking these differences into account.

The correlation between the peer-review grades and the NCS f is rather good. Still, we haven't found the perfect match between bibliometric indicators and peer review. As mentioned in many other reports by several social scientist this is nothing but expected. Especially, in this case with a short time period for the bibliometrics, we cannot expect to be able to account for significant work done by the units of assessment before 2003. Peers have a detailed insight into content and nature of research at the research front and are able to compare on a more direct way taking several factors into consideration.

³⁵ More information on the KTH RAE can be found at <http://www.kth.se/2.1705/rae>.

³⁶ More information on SLU RAE can be found at <http://www.slu.se/?id=1411>

APPENDICES

NO 1: COMPARISON OF ISI AND SCOPUS DATABASES

There are differences in the number of publications retrieved from ISI and Scopus, the latter database is noted for its wider coverage of conference papers. In five panels there are significant differences between the units of assessment in their publication distribution between ISI and Scopus databases (marked with bold)

Panel and Unit of Assessment	Publications	
	ISI	Scopus
Panel 1: Chemical Technology and Materials		
T1010 Department of Biotechnology and Chemical Technology, TKK	252	280
T1020 Department of Chemistry, TKK	300	319
T1030 Department of Materials Science and Engineering, TKK	177	206
T1040 Department of Forest Products Technology, TKK	226	320
Panel 2: Electronics and Electronical Engineering		
T4020 Department of Electronics, TKK	67	104
T4040 Department of Radio Science and Engineering, TKK	312	546
T4050 Department of Signal Processing and Acoustics, TKK	173	332
T4060 Department of Electrical Engineering, TKK	89	221
T4080 Metsähovi Radio Observatory, TKK	68	88
Panel 3: Mathematics and Physics		
T3010 Department of Biomedical Engineering and Computational Science	239	294
T3020 Department of Mathematics and Systems Analysis, TKK	144	178
T3040 Department of Applied Physics, TKK	996	1138
T4030 Department of Micro and Nanosciences, TKK	253	427
T5300 Low Temperature Laboratory, TKK	367	395

Panel 4: Computer Science and Information Technology

T3030 Department of Media Technology, TKK	36	87
T3050 Department of Computer Science and Engineering, TKK	51	168
T3060 Department of Information and Computer Science, TKK	234	398
T4070 Department of Communications and Networking, TKK	111	271
T6300 Helsinki Institute for Information Technology HIIT, TKK	35	87

Panel 5: Mechanical Engineering and Automation

T2020 Department of Energy Technology, TKK	71	90
T2030 Department of Engineering Design and Production, TKK	66	92
T2040 Department of Applied Mechanics, TKK	34	51
T4010 Department of Automation and Systems Technology, TKK	26	137

Panel 6: Civil Engineering and Urban Regional Studies

T2050 Department of Surveying, TKK	7	17
T2060 Department of Structural Engineering and Building Technology, TKK	41	57
T2070 Department of Civil and Environmental Engineering, TKK	51	78
T2080 TKK Lahti Center, TKK	2	4
T2090 Centre for Urban and Regional Studies YTK, TKK	7	15

Panel 7: Business Technology, Economics and Finance

E1 Department of Accounting and Finance, HSE	12	17
E2 Department of Business Technology, HSE	54	133
E5 Department of Economics, HSE	36	44

Panel 8: Marketing, Management and Applied Business Research

E3 Center for Markets in Transition (CEMAT), HSE	1	2
E4 Center for Knowledge and Innovation Research (CKIR), HSE	31	35
E6 Department of Languages and Communication, HSE	2	7
E7 Department of Marketing and Management, HSE	53	93
T3070 Department of Industrial Engineering and Management, TKK	44	73
T3080 BIT Research Centre, TKK	26	58

Panel 9: Architecture, Design, Media and Art Research

A1 Designium, TaiK	1	4
A2 School of Motion Picture, Television and Production Design, TaiK	1	0
A3 Future Home Institute, TaiK	0	0
A4 Medialab, TaiK	8	12
A5 School of Design, TaiK	1	5
A6 School of Art and Media, Pori, TaiK	0	1
A7 School of Art Education, TaiK	1	1
A8 School of Visual Culture, TaiK	0	0
T2010 Department of Architecture, TKK	0	2

Note: Data compiled by TKK Library

NO 2: TECHNICAL APPENDIX

Citation normalization

In this report normalization of citations is performed with reference to two different normalization groups: WoS sub-fields and journals. When normalizing, we also take into account the publication year and publication type. A normalization group might then look as follows: papers of the type “review” within the sub-field “Metallurgy & Metallurgical Engineering” published in 2003.

The most commonly used normalization type was developed by Schubert, Glänzel and Braun during the 1980s (1988). Simultaneously the Leiden group (Moed et al. 1988) developed a variant methodology with the well known “crown indicator”. These normalized indicators are typically named CPP/JCS or CPP/FCS depending on whether the normalization is carried out in relation to journals or sub-fields. The Leiden indicator is defined as follows:

$$\frac{\sum_{i=1}^P c_i}{\sum_{i=1}^P [\mu_f]_i}$$

where c is the number of citations to a paper i and $[\mu_f]_i$ is the average number of citations received by papers in the normalization group of paper i . In our calculations of “Field normalized citation score” and “Journal normalized citation score” we have chosen to adjust this as follows:

$$\frac{1}{P} \sum_{i=1}^P \frac{c_i}{[\mu_f]_i}$$

The difference is that our calculation treats all papers as equal, while the Leiden version gives higher weight to papers in normalization groups with higher reference values, cf. Lundberg (2006), pp. III:3; cf. Visser et al, (2007).

When calculating the “Normalized journal citation score” (similar to the Leiden-measure JCS/FCS), we use the following formula:

$$\frac{1}{P} \sum_{i=1}^P \frac{[\mu_j]_i}{[\mu_f]_i}$$

where $[\mu_j]_i$ is the average number of citations received by papers in the journal of paper i and $[\mu_f]_i$ is the average number of citations received by papers in the sub-field of paper i .

Another citation indicator that is used in the report is the “Standard citation score”. This indicator is defined as follows:

$$\sum_{i=1}^P \frac{\ln(c + 0,5) - [\mu_{f[\ln]}]_i}{[\sigma_{f[\ln]}]_i}$$

where $[\mu_{f[\ln]}]_i$ is the average value of the logarithmic number of citations (plus 0.5) in the normalization group and $[\sigma_{f[\ln]}]_i$ is the standard deviation of the $[\mu_{f[\ln]}]_i$ distribution (based on McAllister, PR, Narin, F, Corrigan, JG. 1983).

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