A Macro-Study of Scientific Productivity and Publication Patterns Across All Scientific and Scholarly Disciplines

Dag W. Aksnes[1] and Gunnar Sivertsen[2]

[1] *dag.w.aksnes@nifustep.no;* [2]*gunnar.sivertsen@nifustep.no*
Norwegian Institute for Studies in Innovation, Research and Education (NIFU STEP),
Wergelandsveien 7, NO-0167, OSLO (Norway)

Abstract

The study includes all disciplines in the humanities, social sciences, health sciences, natural sciences and engineering at Norway's four major universities (Oslo, Bergen, Trondheim, and Tromsø). The study is based on a database containing complete data at the level of individuals for scientific/scholarly publishing at the higher education institutions in Norway in the three year period 2005-2007. The purpose of the study is to gain knowledge about differences between disciplines with regard to three parameters that are all known to be important when assessing and comparing publication output at universities:

1. The relative importance of publication types (articles in journals/series, articles in books, and books)
2. The degree of coverage of the publications output on ISI Web of Science
3. Average productivity and productivity differences among faculty staff

Introduction

In 2004, Norway became one of the few countries that have implemented a bibliometric model for performance based budgeting of research institutions. The model covers the total higher education sector with a total of 16,000 academic employees. The funding of these institutions is now partially based on the measurement of their scientific and scholarly publishing. All types of scholarly publications in all fields of research are included. Bibliographic data are collected through a common documentation system for all institutions in the sector. The system secures complete, verifiable and structured data for bibliometric analysis. The bibliometric indicator itself is built on a simple model for delimiting, weighting and counting publications in a way that balances between field specific publication patterns, thereby making them comparable.

The national data that have been processed for the Norwegian model now cover four years (2004-2007) with about 9,000 scholarly publications annually. These data can be analyzed by themselves. They can also be compared to a subset, namely the Norwegian journal articles that have been indexed for the *ISI Web of Science* (Thomson Reuters) in the same period.

The purpose of this study is to gain knowledge about differences between disciplines with regard to three parameters that are all known to be important when assessing and comparing publication output at universities:

1. The relative importance of publication types (articles in journals and series, articles in books, and books)
2. The degree of coverage of the publications output on *ISI Web of Science*
3. Average productivity and productivity differences among faculty staff

The study is limited to the four major research universities in Norway (Oslo, Bergen, Trondheim and Tromsø). They account for 76 per cent of the total national research output in the higher education sector.

The three parameters mentioned above have been measured and discussed in several bibliometric studies before, but on the basis of more limited datasets (e.g. Bourke & Butler, 1996; Hicks, 1999, 2004; Moed et al., 1985; Schoepflin, 1992). The novelty of our study is related to the completeness of the publication data in combination with detailed information about all academic employees in all disciplines at the four universities in focus.

Proceedings of ISSI 2009, pages 394–397.
Edited by B. Larsen and J. Leta.

Data

In the bibliometric database applied, the publication activity is reported by the institutions in a common documentation system as ordinary bibliographic references. But unlike normal publication lists in CV's or annual reports, the bibliographic references in the documentation system are standardized and analyzable by *publication channel* and *type of publication*, just as in professional bibliometric data sources. *Co-authored publications* can be identified and shared among the participating institutions; they are not double-counted.

A dynamic *authority record* of so far 19,000 controlled scientific and scholarly publication channels ensures that references to non-scientific publications are not entered into the system. *Publication channels* are defined as ISSN-*titles* (journals, e-journals and series) or *publishers* of ISBN-titles. It is required that all publication channels in the authority record make use of external peer review. They must also publish on a minimum national level, which means that not more than 2/3 of the authors that publish in the channel can be from the same institution.

Publication data from professional bibliographic data sources (e.g. *Web of Science*) are *imported* to the documentation system in order to facilitate the registration of publications by the employees. These data are supplemented by controlled bibliographic references for publications that have not been indexed in external databases.

Methods

We selected publication data from the four major Norwegian universities (University of Oslo, University of Bergen, The Norwegian University of Science and Technology in Trondheim, and the University of Tromsø) in the three year period 2005-2007.

The publications of each department were assigned to four broad fields (natural sciences, engineering, health sciences, social sciences and humanities) and to disciplines. The disciplines have been categorized in such a way that it is possible to assign all of a department's publications to one discipline based on their department name.

Many publications are multi-authored because they are the results of collaborative efforts involving more than one researcher. In such cases, different principles and counting methods may be applied in bibliometric studies. The most common is "whole" or "integer" counting, i.e. with no fractional attribution of credit (everyone gets full credit). Another alternative is "fractional counting" where the credit is divided equally between all the authors. For example, if an article has five authors, each person is credited one fifth of the article (0.2). The different results of the two methods are compared in our study. In order to make the research efforts behind different publication types comparable, a book counts as five articles.

As a subset of all publications we have identified the articles which were indexed in *ISI Web of Science* (WoS, covering the *Science Citation Index Expanded*, *Social Science Citation Index, Arts and Humanities Citation Index, but not the Proceedings Citation Index*).

In the last study focusing on productivity differences among faculty staff at discipline levels, we decided to make further limitation in terms of data included. Numerous previous studies have analyzed productivity at individual levels. It has been shown that the productivity of publications per person may depends on various factors such as age, gender, academic position and rank, availability of research funds, teaching loads, equipment, research assistants, workload policies, department culture and working conditions, size of department and organizational context (Dundar & Lewis, 1998; Kyvik, 1993; Ramesh & Singh, 1998). Within the context of this study, however, our ambitions were limited to assessing the extent the various disciplines at macro levels differ in terms of average productivity of publications per person. In order to compare "like with like" we limited the study to full-professors with 100% positions, using the reported data in the database. This means that adjunct professors and professors with part time positions were excluded. Full-professors at Norwegian research universities are expected to devote approximately 50 percent of their time to research.

Results and discussion

Figure 1 shows how the use of publication types varies across major scientific and scholarly areas. In the natural sciences, health sciences and engineering most of the publications appear in scientific journals or peer-reviewed conference series. In these fields, books and book chapters play a minor role. Within the social sciences and the humanities, on the other hand, the latter publication categories are much more important. These findings are not surprising as they correspond well previous studies on this issue (e.g. Bourke & Butler, 1996; Moed, 2005).

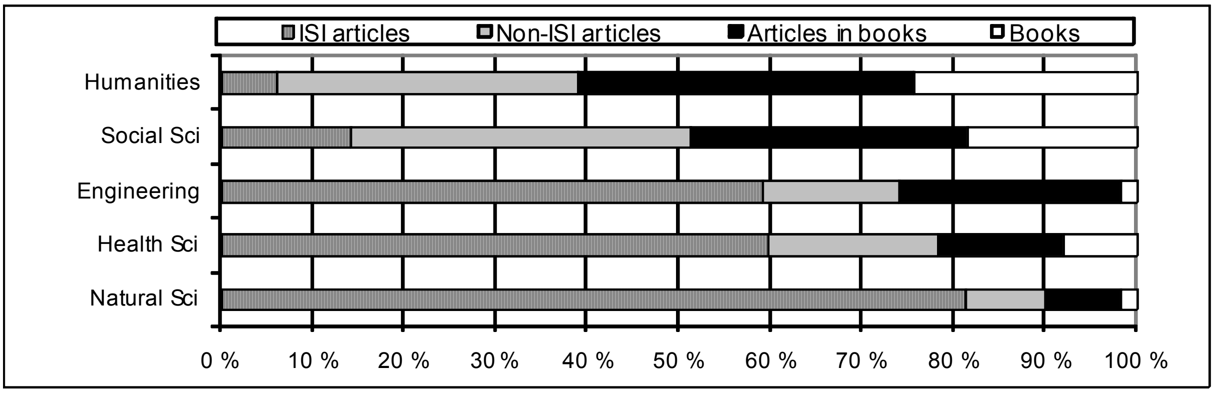

Figure 1. Publication types* in five major areas (N=24,154)

*) Fractionalized counts. One book is weighted as 5 articles.

In Figure 2, we have shown similar data on the level of disciplines within the social sciences. Here we find significant differences in the extent of journal publications. In economics, geography, and library and information science approximately 80% of the publications are published in journals – even when books are counted as five articles. At the other end we find sociology and education with approximately 40% of the publications appearing in journals.

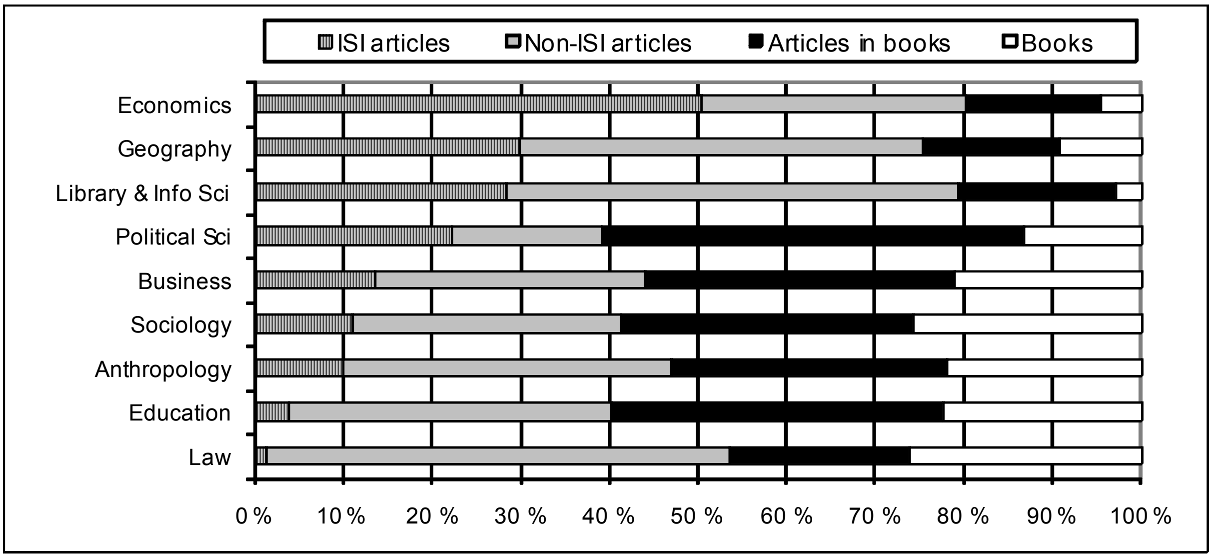

Figure 2. Publication types* in social science disciplines (N=5,616)

*) Fractionalized counts. One book is weighted as 5 articles.

Figure 2 is meant as a preliminary example of differences at the level of disciplines within all major areas of research. We will study such differences extensively.

In terms of ISI-coverage, there are also large differences between the natural sciences, health sciences and engineering on the one hand, and social sciences and humanities on the other. Again, there are large variations on the level of disciplines within one area of research with the socials sciences as an example (cf. Figure 2).
Figure 3 shows the average annual number of publication [ii] per full time professor for the period 2005-2007 for disciplines within the natural sciences and medicine. For the time being we have only analysed the data for three of the four Norwegian universities (not for The Norwegian University of Science and Technology) and only for the faculties of mathematics and natural sciences and medicine. All disciplines in all areas of research at all four universities will be included in our final results.
A first observation is that the extent of multiple co-authorship is significant in all these fields. That is, the fractionalized publication counts are much lower than the whole counts. The difference is particularly large in physics, due to the effect of the so-called "CERN-papers" which often have several hundred authors. At the other end we find mathematics and informatics with the lowest differences between the two measures. These differences correspond with differences in the average number of authors per publication.

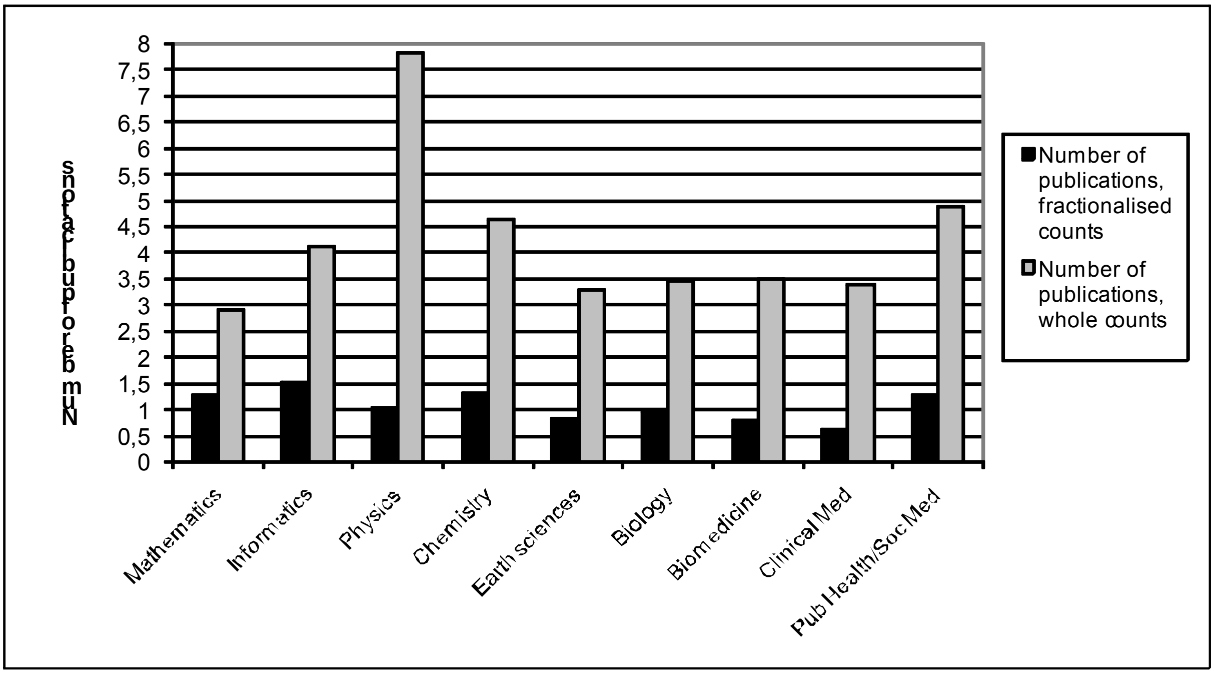

Figure 3. Annual number of publications per person (full-time professors) at three Norwegian universities, 2005-2007, natural sciences and medicine

A second observation is that the difference among the disciplines in the number of fractionalized publications per person is much less than for the whole count measure. In some fields the professors publish more publications, but these publications have more co-authors. The mean number of publications according to fractionalized counts varies from 0.61 to 1.54.

Table 1 gives further details on the fractionalized publication measures. On average, each professor publishes one fractionalized publication per year. There are, however, differences among the disciplines. The lowest productivity levels are found for clinical medicine (0.61) and biomedicine (0.80). This is perhaps somewhat surprising considering previous studies which have found the highest productivity levels in the medical fields (Kyvik, 1991). We will analyze this issue further, but one explanation may be that some of the professors also work as doctors in hospitals and have limited time for doing research. Our primary hypothesis is that the productivity across disciplines will be about the same if the research conditions are the same and fractional counts are applied. This hypothesis also extends to the social sciences and the humanities.

Table 1. Average number of fractionalized publications per person (full-time professors) per year at three Norwegian universities, 2005-2007, Natural sciences and medicine

Discipline	Avg no of pub per person per year	St deviation	Max-value	Coeff of variation	N*
Mathematics	1.28	1.04	6.4	0.81	104
Informatics	1.54	1.25	5.8	0.81	111
Physics	1.05	0.97	5.9	0.93	179
Chemistry	1.32	1.07	5.0	0.81	141
Earth Sciences	0.83	0.77	4.5	0.92	172
Biology	0.98	0.85	4.7	0.87	172
Biomedicine	0.80	0.74	3.9	0.93	425
Clinical Medicine	0.61	0.62	6.0	1.02	389
Public Health/Soc Med	1.27	1.06	7.5	0.84	198

*) N: Total number of observations, where each person is counted one time per year included.

In all disciplines, the productivity at individual level is very skewed. As can be seen, the mean and the standard deviation are closely related and do not differ much from each other in terms of numerical values. This indicates that the differences in the average productivity across the disciplines reflect differences in the rate of productivity rather than differences in equality.

References

Bourke, P., & Butler, L. (1996). Publication types, citation rates and evaluation. *Scientometrics,* 37(3), 437-494.

Dundar, H., & Lewis, D.R. (1998). Determinants of researh productivity in higher education. *Research in Higher Education*.

Hicks, D. (1999). The difficulty of achieving full coverage of international social science literature and the bibliometric consequences. *Scientometrics,* 44(2), 193-215.

Hicks, D. (2004). The four literatures of social science. In H.F. Moed, W. Glänzel & U. Schmoch (Eds.), *Handbook of Quantitative Science and Technology* research (pp. 473-496). Dordrecht: Kluwer Academic Publisheres.

Kyvik, S. (1991). *Productiviy in Academia. Scientific publishing at Norwegian universities*. Oslo: Universitetsforlaget.

Kyvik, S. (1993). Academic staff and scientific production. *Higher Education,* 5, 191-202.

Moed, H.F. (2005). *Citation Analysis in Research Evaluation*. Dordrecht: Springer.

Moed, H.F., Burger, W.J.M., Frankfurt, J.G., & van Raan, A.F.J. (1985). The use of bibliometric data for the measurement of university research performance. *Research Policy,* 14, 131-149.

Ramesh, B.A., & Singh, Y.P. (1998). Determinants of research productivity. *Scientometrics,* 43(3), 309-329.

Schoepflin, U. (1992). Problems of Representativity in the Social Sciences Citation Index. In P. Weingart, R. Sehringer & M. Winterhager (Eds.), *Representation of Science and Technology.* Proceedings of the International Conference on Science and Technology Indicators, Bielefeld, Germany, 10-12 June 1990. DSWO Press.

[ii] For these faculties only 0.2% of the total number publications were books, and we have not made any weighting according to publication type.