Comparing Research at Nordic Universities using Bibliometric Indicators

A publication from the NORIA-net
«Bibliometric Indicators for the Nordic Universities»

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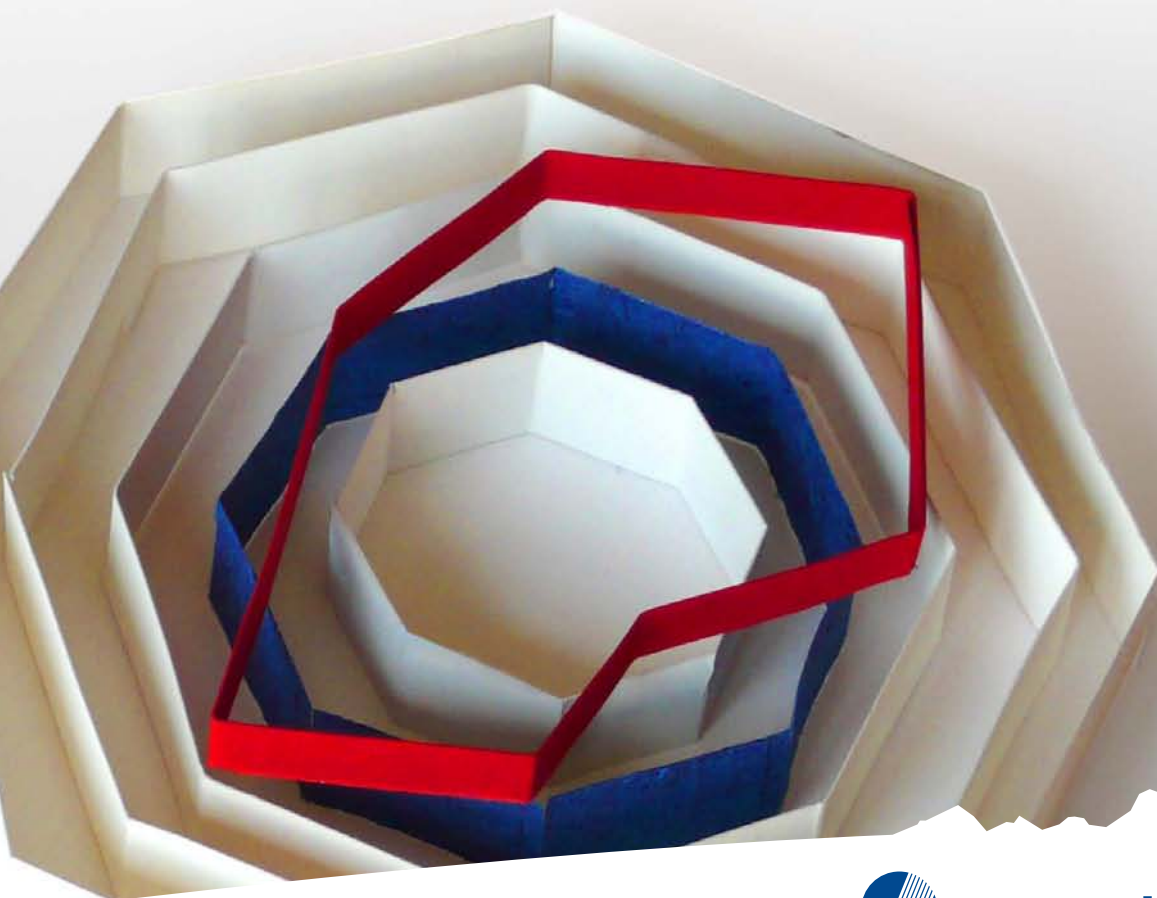NordForsk

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Preface

NordForsk is a platform for joint Nordic research and research policy development. The aim is to promote cooperation which adds value to national activity, and thereby contribute to the knowledge society through continuous efforts to improve the quality of Nordic research and innovation.

Within its policy role, NordForsk facilitates debate on important Nordic research and research policy issues. The basis for this is analyses of developments in the research community and how these might impact on NordForsk's advice to the Nordic Council of Ministers. NordForsk funds a number of NORIA networks with the goal of contributing to joint Nordic priorities on research and innovation policy issues, and as a consequence to sustainable collaboration and investments.

Early in 2008, a Nordic network on bibliometrics was established. It includes all those with special competence in this field who work for national research funding agencies in Denmark, Finland, Iceland, Norway and Sweden. The goal of the network was to facilitate cross-country comparisons of research performance, using a bibliometric approach. The network therefore concentrated on methodological and database issues, seeking to reach agreement on successful approaches and procedures in order to reach this goal.

This is the third in a series of three published reports from this NORIA-network in bibliometrics. The two earlier reports, *International Research Cooperation in the Nordic countries* and *Bibliometric Research Performance Indicators for the Nordic Countries*, were published by NordForsk in 2010. They reported on collaboration and performances in research at the national level, while this report also includes a comparative analysis of Nordic universities overall, using bibliometric indicators. NordForsk wants to thank the following NORIA-net participants for their valuable contribution:

Gunnel Gustafsson
Director of NordForsk

1. Introduction

1. Introduction

This report aims to demonstrate how state of the art bibliometric indicators can be used at the level of universities in the Nordic countries, in describing university performance in a more nuanced way than in the many international university rankings. In contrast to most such rankings, this report uses transparent methods and describes differences in university research profiles. Numbers are not used in this report to indicate rankings, but to represent real measurements and to give more specific information. We concentrate on providing reliable and recognisable descriptions of similarities and differences in the institutions' activities, profiles, and impacts of research.

Our network hopes to serve the needs of Nordic universities, the central research authorities in each country, as well as organisations for Nordic collaboration at both levels, by providing a better understanding of bibliometric indicators and university rankings. We also hope our report will inspire the development of more meaningful and transparent performance indicators for Nordic universities, that could provide the basis for annual comparisons in the future.

Our analysis is based on data covering the years 2000-2009, from the Science Citation Index Expanded and the Social Science Citation index, which combined to a large extent corresponds to *Web of Science*. These data have been processed in a database that is updated and maintained by the Swedish Research Council, under a license agreement with the producer of Web of Science, Thomson Reuters.

The publication database covers a core of about 11,500 international scientific journals, although these are known to be less representative of publication patterns in the humanities and social sciences. Other studies have shown that most scholarly publications from these fields are not covered by the Web of Science. The publications from these fields only make up less than seven per cent of all the Nordic articles in the Web of Science. In light of this, we decided to exclude the social sciences and humanities from the analysis in this report; otherwise this could have undermined the reliability and validity of indicators at the institutional level, where numbers of publications can be low. Based on our methods, the universities will still be comparable across different research profiles, but it is important to bear in mind that all comparisons are based on publications and citations in the following fields: Agriculture, Fisheries & Forestry; Biology; Biomedicine; Chemistry; Engineering & Materials Sciences; Geosciences; Health Sciences (including Psychology); and Physics & Mathematics.

Only universities with research activities above a minimum level, in one or more of the fields mentioned, are included in this study. In practice, this means that all general, technical and agricultural universities above a certain size in terms of publication output were included. Institutions that are specialized outside of these fields, such as *business schools*, are not included. All in all, the study covers 40 universities and 23 university hospitals. We specify the latter category to allow comparison between universities with and without university hospitals.

The methods and indicators used in this report were largely developed in the earlier report 'Bibliometric Performance Indicators for the Nordic Countries' (Schneider et al., 2010). A main task in this new study was to enrich the data with standardized institutional affiliations of authors of publications; in the original data from Thomson Reuters, the names of institutions are only partly standardized and therefore contain errors, while in this report, all addresses have been thoroughly checked to ensure that each publication is allocated to the right institution.

The report focuses on characterizing the publication activity and research impact of the Nordic universities, and on setting out research profiles for each university based on publication activity. All analyses are conducted at both the university and subject field levels, and measure the universities' performance over two time periods, 2000-2004 and 2005-2009. Overall, two types of measures are used in this report: measures of research activity (activity and profile), and measures of research impact.

We emphasize that citation-based performance indicators do not provide a clear measure of research quality. While they may reflect important aspects of quality, citations are primarily a formalised account of how the information is used and can thus be taken as an indicator of publications' reception at this level (Glänzel & Schoepflin, 1995).

1.1 Methods and indicators

The methods and indicators used in this report are described in detail in Appendix 1. In this appendix we also outline some of the methodological considerations behind our choice of data sources, methods and indicators. In summary, our report builds on the following *data material:*

- Data from the Thomson Reuters indices Science Citation Index Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index[1].
- Data from the time period 2000-2009.
- Covering publications defined by Thomson Reuters as research articles, letters or reviews.
- Covering 63 institutions (40 universities and 23 university hospitals).

In conducting the address matching, identifying addresses ten years back in time, we often faced the challenge of institutional mergers. Our approach to has been to treat all institutions as they were in 2009[2].

Methodologically our report is based on:

- Data cleaning techniques (i.e. address matching) developed at the Swedish Research Council[3].
- Measures of research activity based on fractionalized[4] publication counts, and impact measures based on fractionalized citation indicators. Self-citations are excluded.
- Data from two time periods: 2000-2004 and 2005-2009 (2005-2008 for citation statistics).
- Analyses of 8 main subject groups, based on the 248 journal subject classes used by Thomson Reuters during these periods: Agriculture, Fisheries & Forestry[5] (includes 14 subject classes), Biology (13 subjects), Biomedicine (17 subjects), Chemistry (10 subjects), Engineering & Materials Sciences (45 subjects), Geosciences (8 subjects), Health Sciences[6] (59 subjects), and Physics & Mathematics (17 subjects). All 65 subject classes from Social Sciences and Humanities, as well as some multidisciplinary subjects, have been left out of the report. See Appendix 2 for further details on these groupings.
- Analyses of citation statistics for universities, using a threshold of 50 fractionalized publications within each subject area in the time period 2005-2008 for inclusion[7].
- Normalization procedures relative to the 'world average', i.e. the average citation rate in Web of Science[8] for a given field or aggregation of fields.

In deciding which universities should be included in the report, the network agreed that universities should only be included when they had more than 200 fractionalized publication points from the 8 main subject fields, in the period 2005-2009. An exception was made for Icelandic institutions, where the minimum size was set at 25. The reason for this limitation is that low numbers may create unreliable results, especially in the measurement of citation impact. As a result of this limitation, several universities were excluded: the University of Vaasa (74 fractionalized publications in the period) and the University of Lapland (49 fractionalized publications) from Finland, the University of Agder

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1 Certain data included herein are derived from the Science Citation Index Expanded, Social Science Citation Index and Arts & Humanities Citation Index, prepared by Thomson Reuters®, Philadelphia, Pennsylvania, USA, © Copyright Thomson Reuters® 2010. All rights reserved.

2 With the exception of Aalto University (merger of Helsinki University of Technology, Helsinki School of Economics and School of Art and Design), the University of Eastern Finland (merger of University of Kuopio and University of Joensuu) in Finland and the Linnaeus University in Sweden, which was created by mergers of Kalmar University and Växjö University in 2010, but which are still treated as joint organizations in this study, and therefore have all publications created by their preceding organizations attributed to them.

3 A full documentation of the Swedish Research Council database, data cleaning procedures and indicator calculations can be found in Kronman et al. (2010).

4 Publications and citations are fractionalized based on each organization's share of the author addresses in the publication.

5 This category also includes Environmental Sciences, Plant Sciences, etc. See Appendix 2.

6 Health Sciences includes the subject area Psychology.

7 50 fractionalized publications equal 50 journal articles authored by one person. Alternatively: 100 journal articles with authors from two different universities.

8 The database at the Swedish Research Council used for this study corresponds closely to the contents of the Web of Science database except for proceedings that are lacking in the Research Council's database.

(108 fractionalized publications) from Norway, and IT University of Copenhagen (35 fractionalized publications) from Denmark.

The university hospitals that are included are described in Table A.2 in Appendix 1. The universities included in this report are listed in Table 1.1. Since scientific output is strongly dependent on size (e.g. staff size and investment in research), we present three key measures of institution size: the number of academic staff, the number of students and the student-staff ratio.

Table 1.1: Nordic universities: Scientific personnel and student teacher ratio 2008

	Academic staff 2008[9]	Number of students 2008[10]	Student-staff ratio 2008
Denmark	**13394**	**100202**	**7.5**
Aalborg University	1351	10439	7.7
Aarhus University	3486	29302	8.4
Roskilde University	553	7478	13.5
Technical University of Denmark	2245	6055	2.7
University of Copenhagen	4135	32860	7.9
University of Southern Denmark	1624	14068	8.7
Finland	**15424**	**129316**	**8.4**
Aalto University	2328	16472	7.1
Åbo Akademi University	659	5249	8.0
Lappeenranta University of Technology	562	5016	8.9
Tampere University of Technology	1154	9791	8.5
University of Eastern Finland	1386	11632	8.4
University of Helsinki	3807	30092	7.9
University of Jyväskylä	1407	11357	8.1
University of Oulu	1562	13597	8.7
University of Tampere	1082	12722	11.8
University of Turku	1477	13388	9.1
Iceland	**1181**	**15966**	**13.5**
Reykjavik University	143	2551	17.8
University of Akureyri	113	1432	12.7
University of Iceland	925	11983	13.0
Norway	**10305**	**78198**	**7.6**
Norwegian University of Life Sciences	509	3116	6.1
Norwegian University of Science and Technology	2686	20062	7.5
University of Bergen	2022	14208	7.0
University of Oslo	3354	27399	8.2
University of Stavanger	599	7872	13.1
University of Tromsø	1135	5541	4.9

9 All data have been collected in full-time equivalents, and refer to the whole calendar year of 2008. Counts of academic staff include all teaching and research personnel employed at the institution, including teaching/research assistants and PhD students.

10 Including all students at bachelor and master level, but not PhD students.

	Academic staff 2008	Number of students 2008	Student-staff ratio 2008
Sweden	**19027**	**233136**	**12.3**
Chalmers University of Technology	853	9430	11.1
Karlstad University	548	9660	17.6
Karolinska Institutet	1576	6416	4.1
Linköping University	1333	19095	14.3
Linnaeus University	834	8399	10.1
Luleå University of Technology	475	8028	16.9
Lund University	2205	29090	13.2
Mid Sweden University	395	10771	27.3
Royal Institute of Technology	1242	14120	11.4
Stockholm University	1878	32271	17.2
Swedish University of Agricultural Sciences	1286	4230	3.3
Umeå University	1607	19020	11.8
University of Gothenburg	2256	29257	13.0
Uppsala University	2036	23311	11.4
Örebro University	503	10038	20.0

Data sources: The Statistical Sources/Det Statistiske Beredskap (Denmark, data for Denmark are estimated values only), KOTA, Statistics Finland (Finland), DBH – Database for statistikk om høgre utdanning (Norway), Swedish National Agency for Higher Education (Sweden), RANNIS (Iceland).

As mentioned above, publications and citations in the social sciences and humanities are not included in this study (but Psychology is included under Health Sciences). Table 1.2 shows the share of the staff at the universities that are found in social sciences and humanities[11], which may to a certain degree give some indications about the proportion of research that is excluded from our analyses due to these limitations in the data. The shares vary from 0% at Technical University of Denmark and Karolinska Institutet, to 73% at Örebro University and 78% at Roskilde University. However, in light of our methods, these universities are still comparable within the subject areas that are in fact included in this study (i.e. our publication indicators are split into different subject categories and citations are field normalized).

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11   Data from Iceland was not available.

Table 1.2: Percentage of staff in Humanities and Social Sciences at Nordic universities

% of staff	Universities
70-80	Roskilde University, Örebro University
60-69	Karlstad University, University of Stavanger, Stockholm University, Mid Sweden University
50-59	University of Gothenburg, University of Jyväskylä, Linnaeus University
40-49	University of Tampere, Åbo Akademi University, Umeå University, University of Bergen, University of Oslo, Aarhus University, University of Southern Denmark, University of Tromsø
30-39	Uppsala University, University of Turku, Lund University, University of Helsinki, Linköping University
20-29	Norwegian University of Science and Technology, University of Eastern Finland, Aalborg University, Luleå University of Technology, University of Copenhagen, University of Oulu
10-19	Norwegian University of Life Sciences, Lappeenranta University of Technology
5-9	Tampere University of Technology, Aalto University, Royal Institute of Technology
0-4	Chalmers University of Technology, Swedish University of Agricultural Sciences, Technical University of Denmark, Karolinska Institutet

Data sources: The Statistical Sources/Det Statistiske Beredskap (Denmark, data for Denmark are estimated values only), KOTA, Statistics Finland (Finland), DBH – Database for statistikk om høgre utdanning (Norway), Swedish National Agency for Higher Education (Sweden).

The Thomson Reuters database also has some limitations in coverage of engineering and ICT, because these areas have conference proceedings as one of their main publication outlets. In light of this, results from these areas should be interpreted cautiously.

The universities and university hospitals in this report are compared in terms of the following *indicators*:
- Fractionalized number of publications
- Field normalized citation rates with a 3-year citation window[12]
- Normalized proportion of highly cited papers (among top 10% of world production)[13]
- Relative specialization index, indicating whether a university has a higher or lower than average activity in the world in a specific scientific field[14]

Our report is divided into five chapters: chapter 2 presents and discusses the most used university rankings; chapter 3 addresses the publication activity of the Nordic universities; chapter 4 describes the research publication profiles for the Nordic universities; and, chapter 5 addresses the citation impact of the Nordic universities.

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12 We report relative citation scores which are calculated in a way similar to the well-known 'Crown indicator'. In the 'Crown indicator' the normalization is performed at an aggregated level – the citation rate for a given university is divided by the citation average for the relevant fields (Moed et al., 1995, p. 399). In our calculations the normalization is performed at the item level – the citation for each paper from a given university is divided by the average citation for the field of that paper. These differences are described in detail in Lundberg (2007, p. 146-147).

13 A value of 1.0 equals the world average in the Thomson database. Average values less than 1 means a lower proportion than the world average, e.g. 0.8 means a 20% lower proportion of highly cited publications than the world average. Values over 1 means a higher proportion than the world average, e.g. 1.2 means a 20% higher proportion highly cited publications than the world average.

14 See chapter 3.3 for further explanation.

2 The University rankings

An important part of the background for the study presented in this report is the introduction of a large number of university rankings that have been established during the last decade, for example the Times Higher Education World University Rankings (since 2004), QS World University Ranking (since 2004), the Academic Ranking of World Universities by the Shanghai Jiao Tong University (since 2003) and The Performance Ranking of Scientific Papers for World Universities by the Higher Education Evaluation and Accreditation Council of Taiwan, HEEACT (since 2007).

These rankings have received a great deal of public attention. They aim to assess how well a particular university performs compared to others; high rankings are usually interpreted as showing that an institution belongs among the best universities in the world. While they have gained widespread attention, the rankings have also received extensive criticism, often concerning the validity and reliability of the indicators selected. The transparency and possible limitations of the methods and data sources have also been questioned, and the problems involved in comparing institutions with different research profiles, using the same scale, have been raised.

The rankings all focus on whole institutions, aggregating performance into composite indicators, a process which gives rise to several problems. First, the different scientific profiles of the universities are neglected, often resulting in bias against institutions focused on the humanities and social sciences (in addition to cultural and language bias, favoring American and English universities). Second, such general indicators do not tell us anything about the range of strengths and weaknesses within each university's scientific portfolio. The construction of 'league tables' prompts the question, how relevant are comparisons of a technological university to a university whose main activity is in medicine, or indeed the social sciences? The meaningful comparability of universities in these rankings can therefore be questioned. The added value of this report is that it compares universities that are all found within the same Nordic 'realm' and at the same time sets out to highlight their different research profiles.

Since the point of departure for our study is to provide Nordic research stakeholders with more adequate and transparent performance indicators than the university rankings do, these international rankings will also be described in the following subsections. These descriptions will focus on the methodology and indicators behind these rankings, and the ways in which they (inconsistently) rank the Nordic universities.

Five rankings are described. Perhaps the most well-known are the so-called Shanghai Ranking by the Shanghai Jiao Tong University and the former THE-QS ranking, which has now become two separate rankings; the Times Higher Education (THE) and QS (Quacquarelli Symonds). These three are regarded as the most influential and high-profile international university rankings. In addition to these, we also describe the HEEACT ranking (Taiwan) and the Leiden ranking (CWTS, Netherlands). The latter two are based on bibliometric indicators only, and are therefore more comparable to this report, whereas the former three are based on a broad range of performance categories, including teaching and innovation indicators, as well as more qualitative indicators based on perceived reputation from surveys. Finally, we present the U-Multirank (conducted by a European consortium), which is a new concept for a quite different kind of multi-dimensional, global comparison of universities, and which is being developed at present with funding from the European Commission.

2.1.1 The Shanghai Ranking (ARWU)

The Academic Ranking of World Universities (ARWU) by Shanghai Jiao Tong University was first performed in 2003. Only universities that have Nobel Laureates, Fields Medalists, Highly Cited Researchers, or papers published in Nature and Science are included in the ranking. In addition, universities with a significant amount of papers indexed by Science Citation Index-Expanded (SCIE) and Social Citation Index (SSCI) are included. In total, more than 1000 universities are ranked and the best 500 are published on the web.

The universities are compared and evaluated on the basis of six quantitative indicators:

Criterion	Indicators (2010)	Weight
Quality of education	Number of alumni who earned a Nobel Prize or Fields Medal since 1901.	10%
Quality of staff	Number of researchers who earned a Nobel Prize in physics, chemistry, medicine or economics and/or the Fields Medal in mathematics since 1911.	20%
	Number of highly cited researchers in the fields of life science, medicine, physics, engineeringand social sciences.	20%
Research output	Number of articles published in Nature and Science during the last five years. Number of articles listed in Thomson Reuters' Science Index Expanded and its Social Sciences Citation Index in 2009.	20% 20%
Size of the institution	The weighted score of the above five indicators divided by the number of full-time equivalent academic staff.	10%

30% of the score is based on prizes and awards, and 20% on articles published in Science and Nature. The ranking does not include a traditional citation analysis (as the ranking only considers the number of highly cited researchers), nor does it use fractionalized publication data. The universities are also grouped into five broad fields of research (with a few minor changes, the indicators used in these fields are similar to the ones used in the general ranking list): Natural sciences and mathematics; Engineering, technical sciences and information technology; Life sciences and agriculture; Clinical medicine and pharmacy; and Social sciences.

As in our study, the Arts & Humanities are not ranked because of the technical difficulties in finding internationally comparable indicators with reliable data. Contrary to our study, psychology and psychiatry are not included in the ranking because they are considered to be multidisciplinary.

2.1.2 Times Higher Education (THE) World University Ranking

The 2010 Times Higher Education ranking is the seventh produced, and yet it is considered the first, as until 2010 THE was a joint ranking with QS. However, in 2010 THE changed their database from QS to Thomson Reuters, while QS maintained their own ranking. Following this split, THE's methodology has been completely overhauled in order to "deliver their most rigorous, transparent and reliable rankings tables ever". THE considers their own ranking as the first of a new annual series.

Universities are excluded from the ranking tables if: they do not teach undergraduates; if their research output amounts to less than 50 articles per year; or, if they teach only a single narrow subject. The ranking uses 13 separate performance indicators designed to capture the full range of university activities, from teaching to research and knowledge transfer. These 13 elements are brought together into five headline categories, which are:

Criterion	Indicators (2010)	Weight
Teaching – the learning environment	Five indicators, the flagship of which is a reputation survey on teaching (carried out by Thomson Reuters).	30%
Research – volume, income and reputation	65% of this indicator is based on a reputation survey, 17.5% of the category is determined by a university's research income and 15% of the category is based on simple measures of research volume scaled against staff numbers. For this last measure, THE counts the number of papers published in academic journals indexed by Thomson Reuters per staff member.	30%
Citations – research influence	Unlike the approach employed by the old ranking system, all the citation impact data are normalized to reflect variations in citation volume between different subject areas.	32.5%
Industry income	Innovation indicator.	2.5%
International mix	Staff and students.	5%

The weights indicate that only 4.5% of the overall score and subsequent ranking is based on research volume (scaled against staff size), and with 32.5% based on field-normalized citations; 37% of the THE ranking is based on bibliometric measures. A worldwide academic reputation survey (with a total of 13,000 responses[15]) accounts for a total of 34.5% of the overall ranking score (15% for teaching and 19.5% for research). The ranking provides an overall top 200 list, and six tables showing the top 50-institutions for six subject areas: Engineering and technology; Life sciences; Clinical, pre-clinical & health, Physical sciences; Social sciences; and Arts & humanities.

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15   We do not know the response rate. THE states that: "The invitation-only survey was sent to tens of thousands of experienced academics, based on the United Nations' estimates of global academic researchers by geographical area".

2.1.3 QS World University Ranking

The 2010 ranking by QS (Quacquarelli Symonds) is the 7th edition of this ranking (which started in 2004) and which was part of the THE-QS ranking up to 2009. In this ranking, 20% of the overall result is based on bibliometric data, but the main indicator is based on the results from a reputation study, where some five thousand employers and over 15,000 academics and university administrators from around the world offer their opinion on the top universities. The survey seems to be biased towards US universities; the USA has the largest number of respondents to the survey, and the survey makes up half of a university's possible score in the ranking:

Criterion	Indicators (2010)	Weight
Reputation	In a reputation survey, academics and employers are asked to name up to 30 top universities in the subject they know about (excl. their own institution).	50%
Citations	Number of citations per person, based on Scopus data (5-year period), alongside data on the number of academic staff at each university.	20%
Teaching	Faculty/student ratio.	20%
Globalization	Percentage of international staff (5%) and international students at the university (5%), using data gathered from the universities.	10%

In addition to the scores above, the QS ranking provides the opportunity to rank universities under three separate categories, to make it possible to avoid universities of different sizes and types are being compared to each other. These three categories are:

- Size: based on the size of the degree-seeking student body (full time equivalents), covering both undergraduates and postgraduates. Institutions are classed as: extra large, large, medium or small.

- Focus: based on the range of subjects available in each institution. Focus is classed as: fully comprehensive (e.g. broad-based universities with a medical school), comprehensive (those operating in all five faculty areas without a medical school), focused (those operating in three or four faculty areas), and specialist (those operating in only one or two areas).

- Research activity: four levels of research activity are evaluated based on the number of academic papers recorded in the Scopus database over a five-year period. Specialist institutions are assessed on the mean levels of publication for the disciplines in which they are active. Research intensity is classed as: very high, high, moderate or limited/none.

Institutions that focus on only one of the five broad faculty areas are allowed to appear in faculty area and indicator tables but are excluded from the overall list; this means that Karolinska Institutet (ranked 23rd in Life sciences and medicine) is not in the overall list.

The main ranking is provided for five subject groupings: Arts and humanities; Engineering and technology; Life sciences and medicine; Natural sciences; and Social sciences and management. In the specific subject rankings, only the top-50 universities are shown in tables. These subfield rankings are only based on the reputation survey. In the top-50 lists by subject fields, only Karolinska Institutet (23rd in Life sciences and medicine) and the University of Copenhagen (47th in Natural sciences) are represented from the Nordic countries.

2.1.4 Higher Education Evaluation & Accreditation Council of Taiwan (HEEACT)

HEEACT's *Performance Ranking of Scientific Papers for World Universities* was first conducted in 2007. This ranking system employs bibliometric methods to analyze and rank the scientific paper performance of the 'top' 500 universities in the world. This ranking is based on several procedural steps, with the largest universities in the world (based on numbers of published journal articles and numbers of citations) being selected, to provide a list of 820 institutions that represent the HEEACT universe. HEEACT themselves distinguish their ranking from the others described here by stating that it is: "Different from ARWU focusing on academic ranking and THE-QS focusing on university ranking, this ranking system focuses on scientific paper performance ranking".

HEEACT uses information from Thomson Reuters' SCI, SSCI, and Journal Citation Report (JCR) (HEEACT considers the coverage of the database *Arts & Humanities Citation Index* too poor, thus leaving it out). The ranking is based on eight indicators:

Criterion	Indicators (2010)	Weight
Research productivity	Number of articles in the last 11 years (10%). Number of articles in the current year (10%).	20%
Research impact	Number of citations in the last 11 years (10%). Number of citations in the last 2 years (10%). Average number of citations in the last 11 years (10%).	30%
Research excellence	H-index for the last 2 years (20%). Number of highly cited papers (top 1%) in the last 11 years (15%). Number of articles in the current year in high impact journals (15%).	50%

HEEACT does not standardize or normalize their data across subject fields or based on university size. Neither publications nor citations are fractionalized. To neutralize size bias, they produce four of the indicators above, weighted by each university's number of full time faculty members (obtained from web sites), but these results are not part of the main ranking.

HEEACT calculates an overall composite score, in addition to ranking universities by six subject categories: Agriculture & environment sciences; Clinical medicine; Engineering, computing & technology; Life sciences; Natural sciences; and Social sciences.

2.1.5 The Leiden Ranking

Leiden University's Centre for Science and Technology Studies (CWTS) bases its ranking purely on bibliometric indicators. In early 2007, the CWTS presented its ranking results for the 100 European universities with the largest number of scientific publications for the first time. This ranking list has since been extended and it now focuses on all universities worldwide with more than 400 Web of Science indexed publications per year. This means that the 500 largest universities in the world (in terms of publication numbers) are covered. The ranking does not only make worldwide comparisons but also presents a European ranking, based on the largest 100 and largest 250 European universities. It is the worldwide comparison that is of interest in this report, as the other rankings presented here are all worldwide.

The universities are ranked on the basis of several different indicators, rather than one aggregate indicator. The four main indicators are: the number of publications, the number of citations per publication, the total number of publications multiplied by the relative impact in the given field, and the number of citations per publication divided by the average impact in the given field. Since this last indicator has been presented as the '*crown indicator*' in the Leiden ranking (on the basis that it enables comparison of research institutions with impact measures that take account of differences between disciplines), we use this indicator to show the rankings of Nordic universities in 2010, in Table 2.1.

Of all the rankings presented, the Leiden ranking has the most similar methods to those used in this report, and also draws on the same source of data in the Web of Science. However, our results may still differ from the results of the Leiden ranking. This is interesting as it builds on arguments that rankings of universities are highly dependent not only on indicators (and the weighting of these), but also on the many delimitations and methodological considerations that play a role in analysis, and which have an influence before the publication data are analysed. Methodological differences create several potential sources of variation between the results in this report and the Leiden ranking. This report is based on address matching that has been both manual and algorithmic, which has enabled up us to increase the percentage of addresses allocated to the correct institutions, while the Leiden ranking 'only' uses algorithmic address matching. Another variation is that this report is based on fractionalized counting of both publications and citations, whereas Leiden uses whole counts. We have excluded the Social Sciences and Humanities, while Leiden includes these areas. Further differences relate to time spans for publication counts (and citations), and whether university hospitals are included or not. All these issues (and many others) are potential causes of differences between the Leiden results and our own.

2.1.6 Comparing the Nordic universities in the international rankings

Table 2.1 summarizes the ranking of the Nordic universities in each of the rankings described above.

Table 2.1: The Nordic universities' positions in five university rankings in 2010

University	THE	QS	ARWU	HEEACT	Leiden[3]
Aalborg University	N/A	451-500	N/A	N/A	N/A
Aalto University[1]	N/A	250	401-500	466	289
Aarhus University	167	84	98	105	149
Chalmers University of Technology	N/A	204	201-300	371	300
Karolinska Institutet	43	N/A[2]	42	34	138
Linköping University	N/A	389	401-500	356	328
Lund University	89	72	101-150	73	183
Norwegian University of Science and Technology	N/A	237	201-300	296	243
Royal Institute of Technology	193	150	201-300	321	342
Stockholm University	129	168	79	192	79
Swedish University of Agricultural Sciences	199	N/A[2]	201-300	385	210
Technical University of Denmark	122	141	151-200	212	77
Umeå University	N/A	297	201-300	252	185
University of Bergen	135	133	201-300	243	178
University of Copenhagen	177	45	40	54	140
University of Eastern Finland[1]	N/A	308	401-500	292	200
University of Gothenburg	N/A	183	201-300	227	170
University of Helsinki	102	75	72	47	131
University of Jyväskylä	N/A	303	401-500	N/A	370
University of Oslo	186	100	75	153	162
University of Oulu	N/A	313	301-400	330	372
University of Southern Denmark	N/A	298	301-400	249	142
University of Tampere	N/A	369	N/A	366	268
University of Tromsø	N/A	293	301-400	454	284
University of Turku	N/A	211	301-400	290	361
Uppsala University	147	62	66	84	225

1. In the HEEACT and Leiden ranking, Aalto University and University of Eastern Finland are listed under the names: Helsinki University of Technology and University of Kuopio, respectively.

2. Karolinska Institutet and Swedish University of Agricultural Sciences were not included in the overall ranking of QS, since they are considered to be too specialized.

3. In the Leiden-ranking, we have used the old 'Crown indicator' (number of citations per publication divided by the average impact in the given field).

In general, according to Table 2.1, *Karolinska Institutet* is the highest ranked Nordic university, although it is not included in the QS' overall ranking and is only ranked 138th by the Leiden crown indicator. In the Leiden ranking, the Technical University of Denmark is ranked highest out of the Nordic universities, but this university's position is lower in the other rankings.

The differences between the rankings are sometimes fairly large. For example, Stockholm University is ranked as the 79th 'best' university in the world in the Shanghai ranking, but only the 192nd 'best' in HEEACT's ranking. The University of Oslo is the world's 75th 'best' university according to the Shanghai ranking, but only number 186 in the THE's ranking. The University of Copenhagen has three positions between 40th and 54th place, but is ranked 140th and 177th in the other two rankings. Perhaps unsurprisingly, these variations in university rankings appear to be highly dependent on the specific methods and indicators chosen in each ranking system.

This raises the tricky question, what is the difference between a university ranked 51st and a university ranked 71st? First of all, it is sometimes difficult to find out why two universities gain different positions. Secondly, although the two universities differ, the numerical values separating them may be very small, but nevertheless produce a gap of twenty positions between them. Ranking is different from measurement, and universities are complex organizations with performances in several dimensions, all of which are difficult to measure.

In light of this, we focus on measurements rather than rankings. We hope this report may provide more reliable and transparent measurements of research at the Nordic universities, which is only one of the dimensions typically considered. Rather than ranking the universities, we focus on describing their research profiles, thus making it possible to compare like-with-like via simple, non-aggregated indicators. The Leiden ranking serves the last point well. The universities are ranked by strict bibliometric indicators, and the rankings change from indicator to indicator. Although the Leiden ranking has had its 'crown indicator' for many years, the focus is less on 'rank winners' and rank positions, but more on the numerical values of the bibliometric indicators. However, The Leiden ranking does not separate the universities according to their research profiles. This last aspect is better taken into consideration in the upcoming U-Multirank project.

2.1.7 U-Multirank

U-Multirank is a feasibility project funded by the European Commission that aims at establishing indicators which take into account that universities are multidimensional in terms of their aims and activities, their different research profiles and roles in higher education, as well as their different funding conditions. The project started in June 2009 and will finish in June 2011, with a report on possible indicators that have been tested during the project. These indicators will attempt to take account of several dimensions, such as research, education, internationalization and knowledge transfer, all based on comparisons within each field or discipline.

A distinctive feature of U-Multirank is that scores on different indicators in different dimensions will *not* be aggregated into a single overall score or rank. The project thereby focuses more on in-depth information and understanding of the universities. Another distinctive feature is that the project is being carried out by experts at European institutions and organizations *within* the higher education sector.

Our project is similar to the U-Multirank project in its purpose, which is not to make a Nordic university ranking, but to increase transparency, recognize diversity and make field-based comparison while also serving the Nordic universities, the central research authorities in each country and the common Nordic bodies and organizations at the levels of governments, research councils and institutions for a better understanding of bibliometric indicators. However, our project is much more limited than U-Multirank, as it only studies research and only makes use of bibliometric data.

3 Publication activity
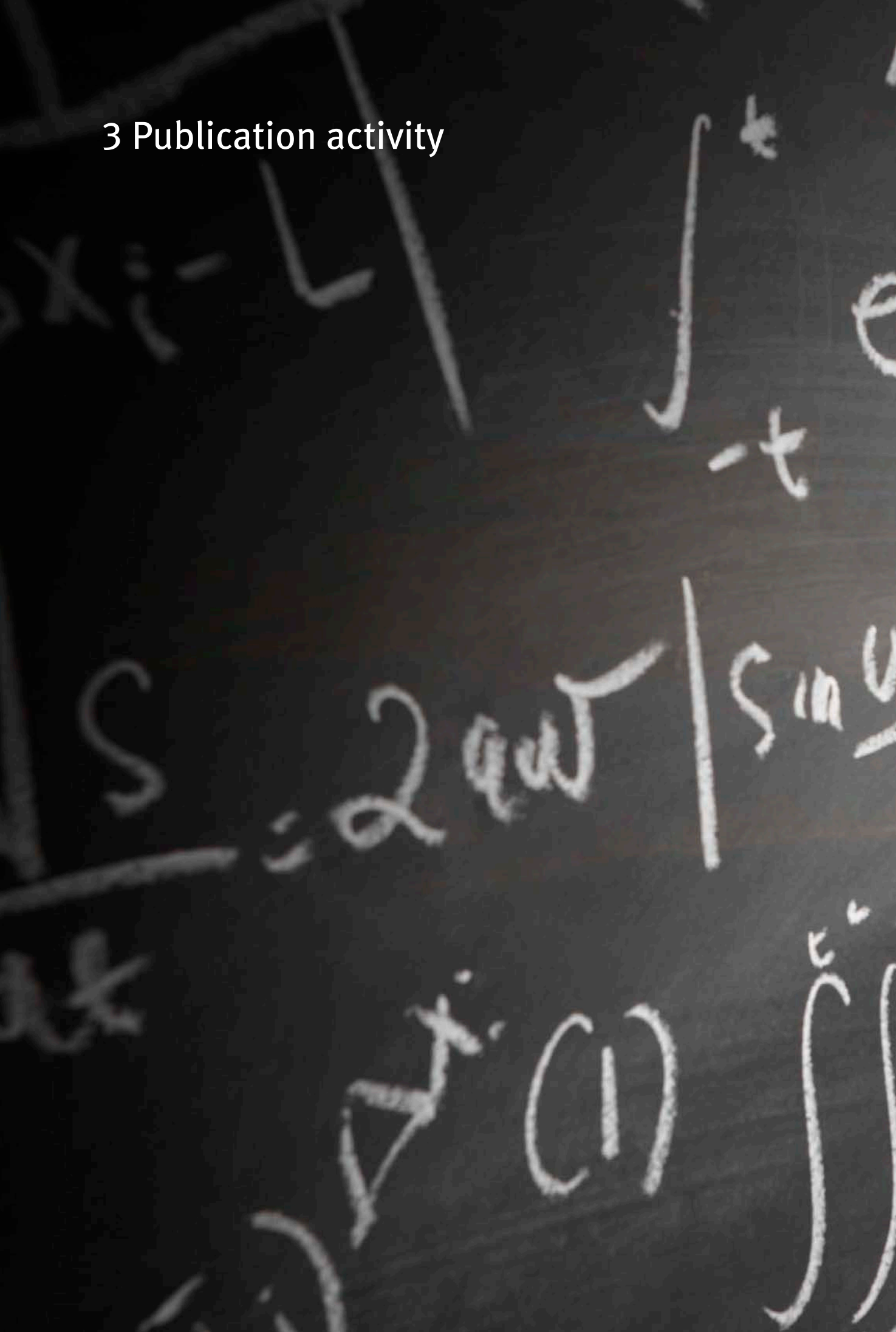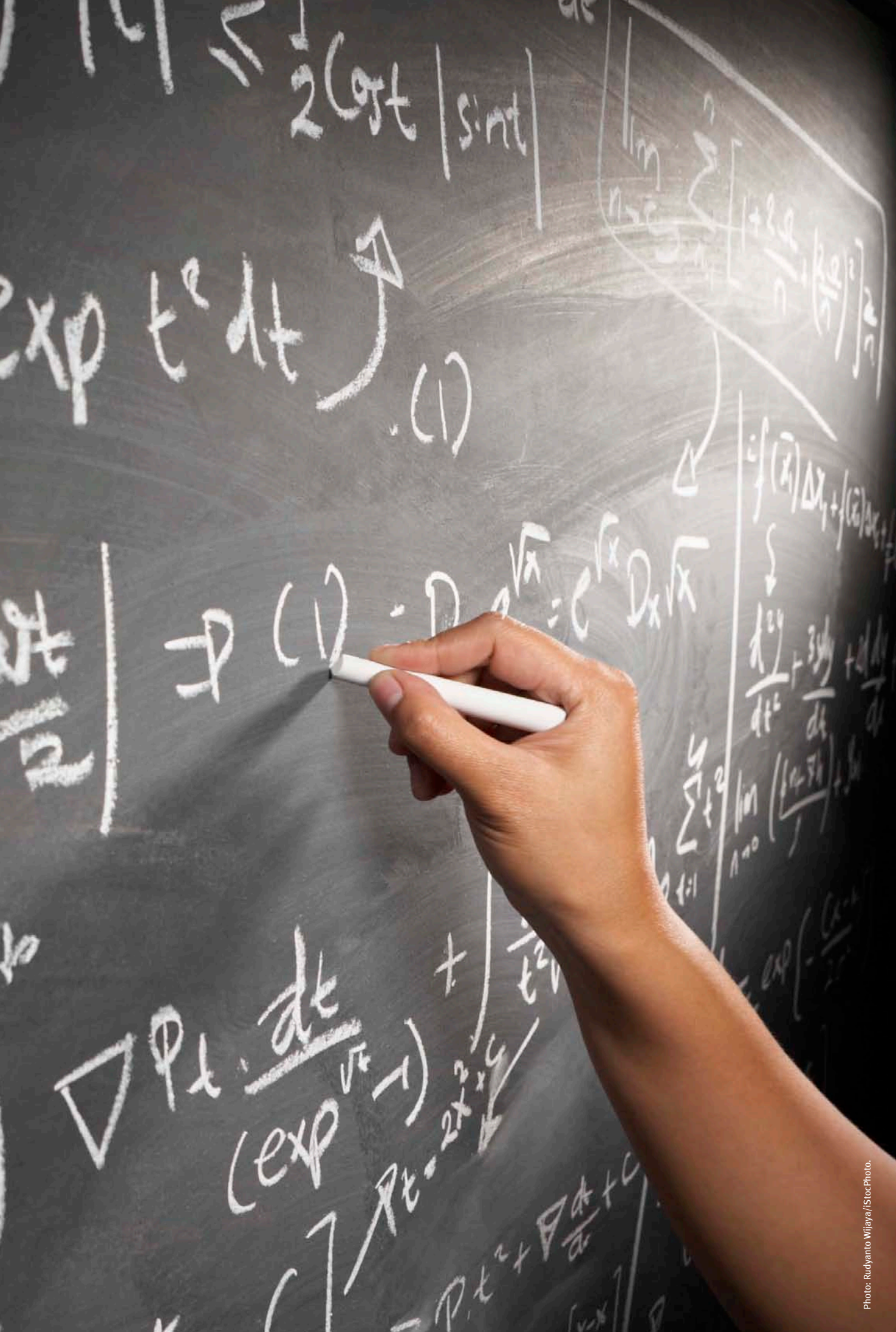
3 Publication activity

The aim of this chapter is to give an overview of the relative size of scientific publication output at the Nordic universities in the 10-year period 2000-2009 and the changes within that period.

All subject areas covered by this study are combined to produce aggregated 5-year interval publication numbers; covering 2000-2004 and 2005-2009. The results at the national level for the five countries are briefly presented, before focusing more closely on each university and university hospital, in each country.

3.1 Total scientific publication output – universities and university hospitals

The total scientific publication output in the Nordic countries was studied at the national level in our earlier report (Schneider et al., 2010). In the present study, the national totals are limited to publications from universities and university hospitals. The totals are calculated for two 5-year periods, using the sum of fractionalized number of publications, within eight subject fields: Agriculture, Fisheries & Forestry; Biology; Biomedicine; Chemistry; Engineering & Materials Sciences; Geosciences; Health Sciences (including Psychology); and Physics & Mathematics.

As shown in Table 3.1, the relative growth rate from 2000-2004 to 2005-2009 is especially strong among the universities in the two smallest countries, Norway and Iceland. This finding is consistent with findings for national totals in our earlier report.

Table 3.1: Publication activity growth in selected Nordic universities and university hospitals

	Volume 2000-2004	Volume 2005-2009	Percentage of world production 2005-2009	Relative growth rate[16]
Denmark	22915	25973	0.52 %	13 %
Finland	21812	23135	0.46 %	6 %
Iceland	721	1075	0.02 %	49 %
Norway	12485	16844	0.33 %	35 %
Sweden	47766	49548	0.98 %	4 %
Total	**105699**	**116575**	**2.32 %**	**10 %**

Sweden has the greatest publication activity among the Nordic countries, with its universities and university hospitals contributing to 42.5% of the overall publication output from Nordic universities and university hospitals, in the period 2005-2009. The equivalent shares for Finland (19.8%) and Denmark (22.3%) are fairly similar, while those for Norway (14.4%) and Iceland (0.9%) are much smaller. In total, the universities and university hospitals included in this report, contributed to 2.3% of the world production of publications in the period 2005-2009.

The universities and university hospitals in Sweden and Finland have seen relatively low growth rates in publications, while the growth is relatively high in Iceland and Norway. The differences in sizes and growth rates correspond relatively well with our earlier findings about national level performance as set out in the NORIA-net report *'Bibliometric Research Performance Indicators in the Nordic Countries'*.

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16   Relative growth rate = (Volume 2005-2009 – Volume 2000-2004) / Volume 2000-2004.

As discussed in this report, the increases in numbers of publications from institutions in all countries may be explained by the growth of the Thomson Reuters' database[17] and in the science system itself (Schneider et al., 2010). However, the differences in growth rates between the Nordic countries cannot be explained in the same way. In line with the growth rates in Table 3.1, Table 3.2 shows that the increase in R&D expenditures has been greater in Denmark, Iceland and Norway and was more modest in Finland and Sweden. There are changes that have taken place at the national level that are likely to be of significance here. Norway implemented a new funding model for the higher education sector in 2004 and the funding scheme for these institutions is now partially based on the measurement of their scientific and scholarly publishing. It is likely that this model has contributed to part of the increase in Norway, via the new incentives created, although the actual contribution of this effect is hard to establish[18]. In recent years, Iceland has seen the establishment of many new biotechnology companies working in close cooperation with the universities and the university hospital, but again, the effect of this on publication output is difficult to measure.

Table 3.2: R&D expenditures on natural sciences, engineering and technology, medical and health sciences, and agricultural sciences in the higher education sector 1999-2007 – Millions of Euro in current prices.

	1999	2001	2003	2005	2007
Denmark	455	533	791	880	1181
Finland	563	616	690	745	822
Iceland	30	36	40	20	87
Norway	489	525	630	789	1021
Sweden	1536	1630	1805	1842	2009

Source: Eurostat.

When comparing growth in university publications, it is important to bear in mind that R&D expenditures in the higher education sector is dependent on the size of several different sectors. For example, Finland and Norway have large institute sectors (comprising independent research institutions not part of the higher education system) that are not included in these figures, whereas most research in Sweden is conducted by the universities. This means that some of the national growth in R&D expenditures in the natural sciences, engineering and technology, medical and health sciences, and agricultural sciences in Finland and Norway is not visible in statistics for the higher education sector. Table 3.1 shows that the Swedish growth rate in number of publications was the lowest among the Nordic countries, which is concomitant with a relatively low increase in research funding (Table 3.2).

Table 3.3 gives a more detailed picture of these issues by presenting relative publication activity at the national level (for the universities and university hospitals included in our report) across subject fields for the period 2005-2009, and alongside the growth rates from 2000-2004 to 2005-2009. This table also shows the category 'Other Areas', representing the Humanities and the Social Sciences (see Appendix 2) and indicating that we have only excluded 6% of the overall publication data from Web of Science in this study by leaving out these subject areas. However, based on Norwegian data, we know that approximately 50% of the total publication output of the universities is missing in the Web of Science data. Most of this is of course due to publications from the Humanities and Social Sciences that are not included (Sivertsen, 2009).

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17 A more thorough discussion of this is given in Schneider et al. (2010). It is argued that it is reasonable to assume that the growth in database coverage affects all the Nordic countries in the same way.

18 See http://nifu.pdc.no/index.php?seks_id=12474.

Table 3.3: Relative publication activity in different subject fields for selected universities and university hospitals (percentages of fractionalized number of publications), 2005-2009, and growth rate of the production of fractionalized publications from 2000-2004 to 2005-2009 for each field. Blue color = share 20 per cent above the Nordic average; red color = share 20 per cent below the Nordic average

Subject field	Denmark	Finland	Iceland	Norway	Sweden	All Nordic countries	Growth rate
Agriculture, Fisheries & Forestry	9.2%	6.5%	4.7%	5.9%	5.8%	6.7%	6.6%
Biology	5.1%	5.2%	4.1%	5.8%	4.8%	5.1%	10.9%
Biomedicine	18.0%	15.1%	13.8%	13.7%	17.4%	16.5%	3.3%
Chemistry	6.3%	7.4%	3.2%	5.2%	7.1%	6.7%	5.1%
Engineering & Materials Sciences	10.1%	14.7%	7.2%	10.3%	11.3%	11.5%	23.4%
Geosciences	2.5%	1.8%	11.7%	5.0%	2.3%	2.7%	20.3%
Health Sciences	33.1%	30.5%	37.4%	37.0%	34.1%	33.6%	12.0%
Physics & Mathematics	10.0%	12.2%	9.2%	8.5%	11.5%	10.8%	7.3%
Other Areas*	5.8%	6.7%	8.6%	8.8%	5.8%	6.4%	61.8%
(Sum)	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**13.0%**

*Other Areas include Social Sciences and Arts & Humanities (see Appendix 2).

In total, the number of fractionalized publications (including Other Areas) for all selected universities and university hospitals in the Nordic countries, grew by 13% between 2000-2004 and 2005-2009. Sweden is responsible for just over two-fifths of the total publication volume of the Nordic countries. Thus, the relative publication activity of the Nordic countries, in different fields, i.e., the Nordic averages by subject field is quite similar to the Swedish numbers. As Sweden's activity is distributed this way, there are no subject fields where Sweden diverges by 20% or more from the Nordic average. In contrast, results for Iceland and Norway show large fluctuations from the Nordic average. In Denmark, the publication activity in Agriculture, Fisheries & Forestry (which includes Environmental Sciences and Food Science & Technology) is much higher than the Nordic average, while Finland's publication activity in Engineering & Materials Sciences is 20% higher than the Nordic average. Finnish production in Geosciences shows the opposite tendency, being well below the Nordic average.

As expected from our previous study focusing on country level (Schneider et al., 2010), we find somewhat different *research publication profiles* among the Nordic countries. These kinds of research profiles are investigated further, at the institutional level, in Chapter 4. Health Sciences and Biomedicine constitute around 50% of the research publication production at *Danish* universities and university hospitals (i.e. not including production in scholarly fields such as Humanities and Social Sciences). In Biomedicine, Denmark's output is slightly above the average for the Nordic countries, whereas the Health Sciences output is slightly below the average. Danish production in Engineering & Materials Science is some 1.4 percentage points lower than the Nordic average, yet the numbers vary considerably.

For *Finland*, substantial deviations from the average Nordic profile can be observed in Physics & Mathematics (12%) and especially in Engineering & Materials Sciences (15%), where Finland stands out with the highest proportion of publications among the Nordic countries. Finland's relative publication activity in Geosciences (1.8%) is below the Nordic average, but this field is represented very unevenly in different countries, with Iceland and Norway clearly above the average, and the other three countries forming a group with a comparable and low share.

In *Iceland*, Health Sciences and Biomedicine make up for 51% of the Icelandic production. Geosciences is the subject field that stands out in a Nordic context, making up almost 12% of Iceland's production (based on a rather long history of research in this field), which is much higher than in any other Nordic country. All other sciences are showing lower relative activity than in the other Nordic countries.

In *Norway* Geosciences also represent a relative large share of all publications. Biology and Health Sciences also have relatively high shares in Norway, while Biomedicine and Physics & Mathematics in particular have lower relative publication activity.

In *Sweden,* Health Sciences and Biomedicine together makes up 51% of the publication volume. As in the case of Finland, Sweden has a large proportion of publications in Physics & Mathematics.

In Table 3.4 we have calculated the Relative Specialization Index (RSI) for each country, which shows whether the universities and university hospitals of that country have a relatively higher or lower share of world publications in particular fields of science than their overall share of total world production (a more detailed presentation is given in Chapter 4.3). The RSI has its value between -1 and 1, by dividing the specific share for each country by the general share in the database. When RSI is zero it reflects a proportion equal to that of the field in the world. As shown in Table 3.4, compared to the world, the universities and university hospitals in the Nordic countries have a relatively high research publication production in Agriculture, Fisheries & Forestry, and the bio-related subject fields (Biology, Biomedicine and Health Sciences). Compared to the world, the Nordic institutions have a smaller proportion of production in Chemistry; Engineering & Materials Sciences, Geosciences (except in Iceland and Norway) and Physics & Mathematics.

Table 3.4: Relative specialization indexes for the country totals of Nordic universities and university hospitals 2005-2009

	Agriculture, Fisheries & Forestry	Biology	Bio-medicine	Chemistry	Engineering & Materials Sciences	Geo-sciences	Health Sciences	Physics & Mathematics
Denmark	0.16	0.14	0.12	-0.25	-0.19	-0.07	0.10	-0.17
Finland	-0.01	0.15	0.03	-0.17	0.00	-0.21	0.06	-0.07
Iceland	-0.15	0.05	0.00	-0.53	-0.33	0.62	0.17	-0.20
Norway	-0.04	0.22	0.00	-0.32	-0.17	0.29	0.17	-0.24
Sweden	-0.06	0.11	0.10	-0.19	-0.14	-0.11	0.11	-0.11
Total	**0.01**	**0.14**	**0.08**	**-0.22**	**-0.12**	**-0.02**	**0.11**	**-0.13**

3.2 Publication activity and growth of the universities

In this section we describe the publication activity of each Nordic university and university hospital included in the study. We present the number of fractionalized publications for two time periods (2000-2004 and 2005-2009) and the growth rate between these periods. As expected, the largest growth rates are found amongst the smaller and the younger universities. We also show the percentage distributions for each country based on the output of the universities, and of the university hospitals, respectively.

Table 3.5: Number of fractionalized publications in Denmark

Denmark	Volume 2000-2004	Volume 2005-2009	Growth rate	Per cent of output 2005-2009
Aalborg University	1089	1422	31 %	7.4 %
Aarhus University	4071	4403	8 %	22.9 %
Roskilde University	219	262	19 %	1.4 %
Technical University of Denmark	3859	4554	18 %	23.6 %
University of Copenhagen	6584	6895	5 %	35.8 %
University of Southern Denmark	1395	1713	23 %	8.9 %
				(100 %)
Aarhus University Hospitals	1793	2163	21 %	32.2 %
Copenhagen University Hospitals	3399	4000	18 %	59.5 %
University of Southern Denmark Hospitals	504	560	11 %	8.3 %
				(100 %)
Total	**22915**	**25973**	**13 %**	

Among the universities and university hospitals included in this report, and within the areas of research covered, Denmark has both the largest university (University of Copenhagen) and the largest hospital (Copenhagen University Hospitals) in the Nordic countries. It is important to note, however, that Danish research institutions in the entire period investigated here are treated according to their more recent status following widespread mergers of higher education institutions in Denmark. Two of the largest Danish universities (Copenhagen and Aarhus) have had the lowest publication growth rates, while the growth rates are highest in the smaller universities.

Table 3.6: Number of fractionalized publications in Finland

Finland	Volume 2000-2004	Volume 2005-2009	Growth rate	Per cent of output 2005-2009
Aalto University	2240	2605	16 %	13.7 %
Åbo Akademi University	788	895	14 %	4.7 %
Lappeenranta University of Technology	213	357	68 %	1.9 %
Tampere University of Technology	756	917	21 %	4.8 %
University of Eastern Finland	1907	2081	9 %	10.9 %
University of Helsinki	5108	5624	10 %	29.5 %
University of Jyväskylä	1147	1374	20 %	7.2 %
University of Oulu	2029	2007	-1 %	10.5 %
University of Tampere	730	866	19 %	4.5 %
University of Turku	2448	2328	-5 %	12.2 %
				(100 %)
Helsinki University Central Hospital	2152	1991	-7 %	48.8 %
Kuopio University Hospital	783	605	-23 %	14.8 %
Oulu University Hospital	357	406	14 %	9.9 %
Tampere University Hospital	721	637	-12 %	15.6 %
Turku University Hospital	436	443	2 %	10.8 %
				(100 %)
Total	**21812**	**23135**	**6 %**	

Finland is represented by ten universities, five of which have a medical faculty and a university hospital (Helsinki, Turku, Tampere, Oulu and Eastern Finland). Of the other five, two are technical universities (Tampere University of Technology and Lappeenranta University of Technology), while Aalto University was formed by the recent merger between Helsinki University of Technology, Helsinki School of Economics and School of Art and Design.

The University of Helsinki is in a class of its own in Finland, when it comes to the number of fractionalized publications for the research areas covered here. Growth rates in the number of publications vary a great deal between the Finnish universities. Overall there is a clear trend that publication activity in larger universities grew more slowly than in smaller universities. The significant increase in the number of publications coming from Lappeenranta University of Technology cannot however, be considered as only a consequence of the university's small size, but must also reflect the university's active policy of encouraging researchers to publish their results more in internationally renowned journals.

Table 3.7: Number of fractionalized publications in Iceland

Iceland	Volume 2000-2004	Volume 2005-2009	Growth rate	Per cent of output 2005-2009
Reykjavik University	4	48	982 %	5.9 %
University of Akureyri	12	28	138 %	3.5 %
University of Iceland	503	735	46 %	90.6 %
				(100 %)
Landspitali University hospital	202	264	30 %	100 %
				(100 %)
Total	**721**	**1075**	**49 %**	

The universities of Reykjavik and Akureyri are both relatively young organizations in the process of building up their research capacity. The percentage increase between the two periods in Table 3.7 for these universities is considerable, even though the numbers of publications involved are extremely small. However, both the University of Iceland and Landspitali University Hospital show a large increase between the periods, compared to the larger universities and university hospitals in other Nordic countries.

Table 3.8: Number of fractionalized publications in Norway

Norway	Volume 2000-2004	Volume 2005-2009	Growth rate	Per cent of output 2005-2009
Norwegian University of Life Sciences	653	880	35 %	6.7 %
Norwegian University of Science and Technology	2076	3320	60 %	25.4 %
University of Bergen	2139	2815	32 %	21.6 %
University of Oslo	3479	4573	31 %	35.0 %
University of Stavanger	123	256	109 %	2.0 %
University of Tromsø	957	1205	26 %	9.2 %
				(100 %)
St. Olavs Hospital	306	430	41 %	11.3 %
University Hospital North Norway	220	283	28 %	7.4 %
University of Bergen Hospitals	651	877	35 %	23.1 %
University of Oslo Hospitals	1881	2205	17 %	58.1 %
				(100 %)
Total	**12485**	**16844**	**35 %**	

Norway is represented by four broad universities (in Oslo, Bergen and Tromsø, and the Norwegian University of Science and Technology in Trondheim), one agricultural university and one ex-university college, that recently acquired university status (University of Stavanger). All the four broad universities have medical faculties and close cooperation with university hospitals. For the universities in Oslo and Bergen, this cooperation involves several hospitals, while the universities in Tromsø and Trondheim each have their 'own' university hospital. Similarly to Denmark and Iceland, we can see an increase in publication activity for *all* Norwegian universities and university hospitals included here from the first to the second period. The growth has been especially marked at the smallest university (in Stavanger). The Norwegian University of Science and Technology, however, also stands out with a growth rate that is twice as high as that found for the universities of Bergen and Oslo.

Table 3.9: Number of fractionalized publications in Sweden

Sweden	Volume 2000-2004	Volume 2005-2009	Growth rate	Per cent of output 2005-2009
Chalmers University of Technology	2630	2628	0 %	6.3 %
Karlstad University	167	293	75 %	0.7 %
Karolinska Institutet	5547	6200	12 %	15.0 %
Linköping University	2282	2421	6 %	5.8 %
Linnaeus University	228	476	109 %	1.1 %
Luleå University of Technology	627	697	11 %	1.7 %
Lund University	6106	6493	6 %	15.7 %
Mid Sweden University	221	303	37 %	0.7 %
Royal Institute of Technology	3397	3985	17 %	9.6 %
Stockholm University	2695	3069	14 %	7.4 %
Swedish University of Agricultural Sciences	2578	2456	-5 %	5.9 %
Umeå University	2202	2594	18 %	6.2 %
University of Gothenburg	3700	3701	0 %	8.9 %
Uppsala University	5545	5746	4 %	13.9 %
Örebro University	171	373	118 %	0.9 %
				(100 %)
Karolinska University Hospital	3142	2609	-17 %	32.2 %
Linköping University Hospital	561	522	-7 %	6.4 %
Norrland's University Hospital	540	433	-20 %	5.3 %
Sahlgrenska University Hospital	1794	1493	-17 %	18.4 %
Skåne University Hospital	2330	1918	-18 %	23.6 %
Uppsala University Hospital	1302	1140	-12 %	14.0 %
				(100 %)
Total	**47766**	**49548**	**4 %**	

As shown in Table 3.9, the Swedish institutions overall have the lowest growth rates in publications between the two periods studied. There are large variations between Swedish institutions, with several universities demonstrating falling publication rates (negative growth figures) between the two time periods. In addition, the output from Swedish university hospitals seems to have decreased markedly, with all university hospitals showing negative growth rates. Looking at the statistics behind these numbers, most of the decreases are found in Biomedicine and in Health Sciences (about two thirds), which remained stable or slightly increased at the universities. This may be an effect of changing habits in how to write the author addresses.

The four small and young universities (Karlstad, Linnaeus, Mid Sweden and Örebro) show higher growth rates (between 37-118%)[19], while the four older, broad universities (Gothenburg, Lund, Stockholm and Uppsala) have increased their publication activity much less (0-14%). This pattern may reflect funding schemes; using a one-year lag between funding (in constant prices) and output, the four small universities' funding increased by 28% between the two periods while their publication output increased by 84%. The publication output of the four large universities increased by 5% during the same period, while their funding increased by just 3% (with a one year time lag).

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19 A fifth university, Luleå University of Technology, shows a more modest growth of 11%.
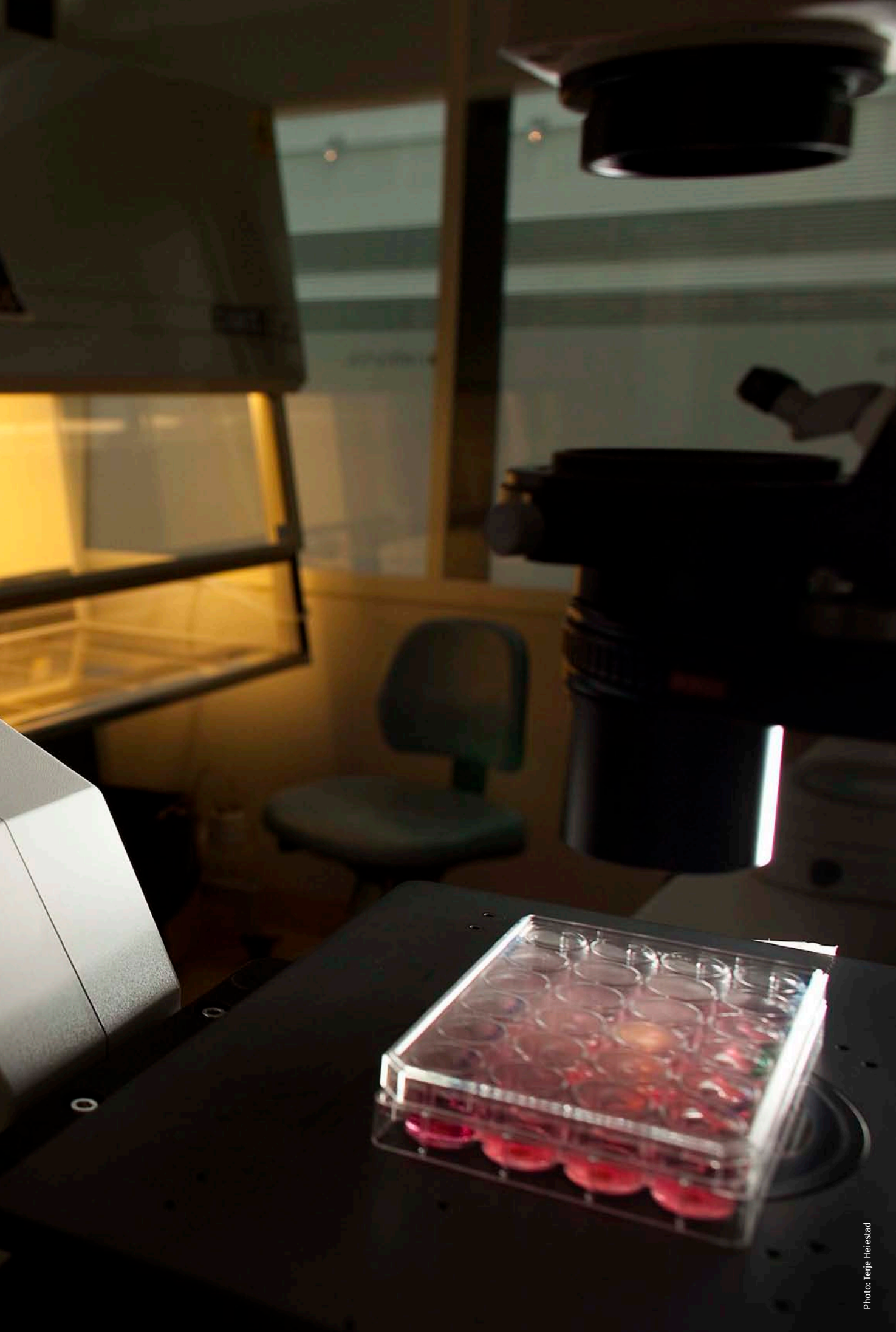
4 Research Profiles

The aim of this chapter is to demonstrate differences and similarities in the science research profiles of the Nordic universities, by measuring their relative publication activities in the main scientific subject areas. We have restricted the presentation of research profiles to the last 5-year period only (2005-2009). We present the percentages of fractionalized publication counts, distributed among the eight major subject areas for each university and university hospital (Tables 4.1 to 4.5). In Appendix 3, we set out the relative contribution of each university or university hospital to the overall national output within each subject field. However, the focus of Chapter 4 is the research profiles of the universities. Based on factor analysis we show how the universities group around three major domains, creating a figure that maps the universities' overall profiles (Figures 4.1 and 4.2). We then use octagons to visualize which subject fields the universities are specialized in (Figures 4.3 to 4.7).

4.1 Publications per research field for each Nordic University

Tables 4.1 to 4.5 present the percentage share of fractionalized publication counts distributed among major subject areas for each Nordic university and university hospital. We use colours to describe the size of the publication output in each area of research relative to the size in the overall output of all the universities in a country, i.e. whether or not a university or a university hospital has a share equal to or above the national level. This national comparison of research profiles is supplemented with comparisons with base-lines for the Nordic countries and for the world in later sections of the report. The publication numbers constituting the percentages in Tables 4.1 – 4.5 are listed in Appendix 4.

Table 4.1: Different subject areas' share of the publication volume (ISI, fractionalized) in Denmark during 2005-2009, within each university and university hospital (green colour = equal to or above the national level)

Danish universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	10 %	5 %	19 %	7 %	11 %	3 %	35 %	11 %	100 %
Aalborg University	13 %	1 %	15 %	3 %	43 %	1 %	12 %	12 %	100 %
Aarhus University	16 %	10 %	18 %	10 %	6 %	4 %	22 %	15 %	100 %
Roskilde University	11 %	10 %	17 %	16 %	15 %	3 %	9 %	18 %	100 %
Technical University of Denmark	11 %	3 %	13 %	13 %	31 %	3 %	5 %	20 %	100 %
University of Copenhagen	15 %	9 %	26 %	6 %	4 %	5 %	25 %	10 %	100 %
University of Southern Denmark	3 %	5 %	25 %	12 %	7 %	2 %	35 %	11 %	100 %
Aarhus University Hospitals	1 %	1 %	14 %	0 %	2 %	0 %	82 %	0 %	100 %
Copenhagen University Hospitals	0 %	2 %	17 %	0 %	1 %	0 %	80 %	0 %	100 %
University of Southern Denmark Hospitals	0 %	1 %	17 %	0 %	1 %	0 %	81 %	0 %	100 %

The *Danish* universities seem to be 'clustered' in two groups. The first is a group of technically and natural science oriented universities: Aalborg University, whose main research field is Engineering & Materials Sciences, and Technical University of Denmark, whose main research fields are Engineering & Materials Sciences and Physics & Mathematics. The other universities can be considered as a group with broader portfolios, although Roskilde University has a considerably lower activity in the Health Sciences, compared to the other universities in this group.

Table 4.2: Different subject areas' share of the publication volume (ISI, fractionalized) in Finland during 2005-2009, within each university and university hospital (green colour = equal to or above the national level)

Finnish universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	7 %	6 %	16 %	8 %	16 %	2 %	33 %	13 %	100 %
Aalto University	2 %	0 %	4 %	11 %	47 %	1 %	3 %	31 %	100 %
Åbo Akademi University	6 %	4 %	15 %	26 %	32 %	1 %	9 %	8 %	100 %
Lappeenranta University of Technology	6 %	0 %	2 %	11 %	66 %	0 %	1 %	13 %	100 %
Tampere University of Technology	2 %	0 %	6 %	9 %	54 %	1 %	4 %	25 %	100 %
University of Eastern Finland	15 %	5 %	21 %	10 %	11 %	2 %	27 %	9 %	100 %
University of Helsinki	14 %	10 %	23 %	8 %	5 %	4 %	24 %	11 %	100 %
University of Jyväskylä	7 %	10 %	9 %	14 %	10 %	0 %	21 %	29 %	100 %
University of Oulu	6 %	7 %	14 %	6 %	19 %	6 %	28 %	15 %	100 %
University of Tampere	1 %	1 %	18 %	1 %	12 %	0 %	63 %	3 %	100 %
University of Turku	5 %	9 %	20 %	8 %	9 %	1 %	34 %	13 %	100 %
Helsinki University Central Hospital	0 %	1 %	16 %	0 %	1 %	0 %	81 %	0 %	100 %
Kuopio University Hospital	1 %	1 %	18 %	0 %	2 %	0 %	77 %	1 %	100 %
Oulu University Hospital	0 %	1 %	8 %	0 %	2 %	0 %	88 %	1 %	100 %
Tampere University Hospital	0 %	1 %	22 %	0 %	2 %	0 %	74 %	0 %	100 %
Turku University Hospital	0 %	0 %	14 %	0 %	1 %	0 %	83 %	0 %	100 %

The *Finnish* universities seem to divide into three groups. In the first group, the University of Tampere and University of Turku are strongly focused on life sciences (over half of their publications come from Health Sciences and Biomedicine), but it should be noted that Social Sciences and Humanities (excluded in our analysis) are important subject fields in these universities. The second group is formed by Aalto University and the technological universities in Tampere and Lappeenranta, which mainly publish in Engineering & Material Sciences and to some extent in Physics and Mathematics. The rest of the universities have a more even distribution of publication activity across the different subject fields.

Table 4.3: Different subject areas' share of the publication volume (ISI, fractionalized) in Iceland during 2005-2009, within each university and university hospital (green colour = equal to or above the national level)

Icelandic universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	5 %	5 %	15 %	3 %	8 %	13 %	41 %	10 %	100 %
Reykjavik University	2 %	0 %	4 %	1 %	55 %	0 %	12 %	25 %	100 %
University of Akureyri	7 %	3 %	6 %	9 %	9 %	18 %	47 %	1 %	100 %
University of Iceland	7 %	6 %	16 %	4 %	7 %	18 %	28 %	13 %	100 %
Landspitali University hospital	1 %	1 %	15 %	0 %	1 %	0 %	82 %	0 %	100 %

In *Iceland*, the University of Akureyri and University of Iceland have broad, general profiles including activity in Health Sciences and fairly high activity in the Geosciences. Reykjavik University stands out as a more specialized technical university in our analysis.

Table 4.4: Different subject areas' share of the publication volume (ISI, fractionalized) in Norway during 2005-2009, within each university and university hospital (green colour = equal to or above the national level)

Norwegian universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	6 %	6 %	15 %	6 %	11 %	5 %	41 %	9 %	100 %
Norwegian University of Life Sciences	51 %	17 %	15 %	3 %	5 %	3 %	3 %	2 %	100 %
Norwegian University of Science and Technology	5 %	6 %	9 %	10 %	33 %	3 %	19 %	15 %	100 %
University of Bergen	5 %	9 %	15 %	4 %	9 %	13 %	36 %	9 %	100 %
University of Oslo	4 %	6 %	18 %	8 %	8 %	7 %	36 %	15 %	100 %
University of Stavanger	7 %	2 %	6 %	7 %	40 %	6 %	23 %	9 %	100 %
University of Tromsø	10 %	13 %	19 %	7 %	3 %	9 %	34 %	7 %	100 %
St.Olavs Hospital	0 %	1 %	13 %	1 %	1 %	0 %	82 %	1 %	100 %
University Hospital North Norway	0 %	1 %	13 %	0 %	0 %	0 %	85 %	0 %	100 %
University of Bergen Hospitals	0 %	1 %	16 %	0 %	0 %	0 %	82 %	0 %	100 %
University of Oslo Hospitals	0 %	1 %	18 %	1 %	1 %	0 %	80 %	0 %	100 %

The *Norwegian* universities can be divided in three groups. The first group contains the three universities of Bergen, Oslo and Tromsø, all of which have broad research profiles. The more technically oriented University of Stavanger and Norwegian University of Science and Technology in Trondheim make up a second group. The Norwegian University of Life Sciences stands apart from these first two groups, as it has a specialized profile corresponding closely to its origins as an agricultural university college.

Table 4.5: Different subject areas' share of the publication volume (ISI, fractionalized) in Sweden during 2005-2009, within each university and university hospital (green colour = equal to or above the national level)

Swedish universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	6 %	5 %	19 %	8 %	12 %	2 %	36 %	12 %	100 %
Chalmers University of Technology	3 %	1 %	5 %	15 %	42 %	2 %	2 %	30 %	100 %
Karlstad University	7 %	3 %	6 %	8 %	35 %	3 %	20 %	19 %	100 %
Karolinska Institutet	1 %	2 %	33 %	1 %	1 %	0 %	62 %	0 %	100 %
Linköping University	3 %	2 %	12 %	7 %	23 %	0 %	32 %	21 %	100 %
Linnaeus University	10 %	10 %	16 %	4 %	15 %	4 %	16 %	24 %	100 %
Luleå University of Technology	8 %	0 %	1 %	9 %	51 %	5 %	7 %	18 %	100 %
Lund University	6 %	7 %	21 %	10 %	12 %	3 %	27 %	13 %	100 %
Mid Sweden University	13 %	4 %	4 %	7 %	34 %	2 %	21 %	16 %	100 %
Royal Institute of Technology	3 %	1 %	6 %	16 %	36 %	2 %	3 %	33 %	100 %
Stockholm University	8 %	10 %	19 %	17 %	6 %	10 %	13 %	17 %	100 %
Swedish University of Agricultural Sciences	53 %	17 %	14 %	4 %	4 %	2 %	4 %	1 %	100 %
Umeå University	6 %	8 %	21 %	6 %	7 %	2 %	38 %	12 %	100 %
University of Gothenburg	5 %	9 %	21 %	5 %	5 %	4 %	43 %	8 %	100 %
Uppsala University	4 %	7 %	24 %	10 %	11 %	4 %	23 %	17 %	100 %
Örebro University	10 %	2 %	9 %	10 %	14 %	1 %	48 %	5 %	100 %
Karolinska University Hospital	0 %	1 %	21 %	1 %	0 %	0 %	76 %	0 %	100 %
Linköping University Hospital	0 %	1 %	13 %	1 %	1 %	0 %	83 %	0 %	100 %
Norrland's University Hospital	0 %	1 %	13 %	1 %	2 %	0 %	84 %	0 %	100 %
Sahlgrenska University Hospital	1 %	1 %	13 %	0 %	1 %	0 %	84 %	0 %	100 %
Skåne University Hospital	1 %	1 %	14 %	1 %	1 %	0 %	82 %	1 %	100 %
Uppsala University Hospital	1 %	1 %	15 %	0 %	1 %	0 %	82 %	0 %	100 %

Sweden is the only Nordic country to have a specialized medical university, Karolinska Institutet, where 95% of the output is in the Biomedicine and Health Sciences fields. The Swedish University of Agricultural Sciences has about half (53%) of its total output in Agriculture, Fisheries & Forestry, but still retains a relatively broad profile. The three technical universities also have relatively broad subject profiles, with no more than half of their output in technical fields. Karlstad University and Mid Sweden University also have a large proportion of technical sciences in their portfolios (35-36%). The remaining universities have broader subject profiles, including life and health sciences.

4.2 University profiles according to their publication output

In order to investigate similarities in scientific research profiles between universities in the Nordic countries more systematically than would be possible based on a qualitative assessment of the results in Tables 4.1 to 4.5, we performed a factor analysis to identify how universities cluster together (based on correlating subject profiles). Factor analysis is a dimensionality reduction technique. Its purpose is to identify a relatively small number of latent themes, dimensions or factors underlying a larger set of variables. This is done by distinguishing sets of variables that have more in common with each other than with the other variables in the analysis. What the subsets of variables have in common is the underlying dimension or factors. In the present analysis, the eight research fields are the initial (subject) dimensions which are targeted for reduction. After reduction, the universities will be clustered in relation to the reduced number of subject dimensions. The analysis is based on the universities' research profiles for the second period (2005-2009), as shown in Tables 4.1 to 4.5. The results of the factor analysis are shown in Figure 4.1; each country's universities are highlighted with different colors and the size of the circles indicate the size of each university's total research publication activity. The university hospitals are not included in the factor analysis as they are too specialized.

Figure 4.1 can be interpreted in the following way: the universities are positioned in the figure according to how similar their research profiles are. The closer they are positioned to each other, the more similar their research profiles. Conversely, the longer the distance between two universities (or groups of universities), the less comparable they are. This is an important perspective to offer the ranking-oriented area of university performance indicators, as most international rankings do not take into consideration that the universities have very different profiles.

The factor analysis 'reduces' the initial eight research fields to three latent main dimensions. These main dimensions are visualized in Figure 4.1, as the three clustered areas. The three main dimensions that emerge from the analysis are the 'applied technical sciences' (to the north in the map); 'medical sciences' (to the east in the map), and 'agricultural' sciences (to the south-west in the map). The results show that the specialized technical and agricultural science universities are clustered in two distinct factors, whereas universities that include medical faculties are clustered together in one large factor that includes both the clinically oriented universities and those with more emphasis on Biomedicine. The institutions in this large cluster are typically the older, more traditional universities that include a variety of faculties, but as the publication production of medical fields typically comprises about 40% of the total annual research output of these universities, these have a powerful influence on the overall calculation. Stockholm University stands out as an exception among these general universities, as it has no medical faculty.

The universities are identified using the following acronyms in the figure:

Aalborg University	**DEN**	**AAU**
Aarhus University	**DEN**	**AU**
Roskilde University	**DEN**	**RUC**
Technical University of Denmark	**DEN**	**DTU**
University of Copenhagen	**DEN**	**KU**
University of Southern Denmark	**DEN**	**SDU**
Aalto University	**FIN**	**AALTO**
Åbo Akademi University	**FIN**	**ÅA**
Lappeenranta University of Technology	**FIN**	**LUT**
Tampere University of Technology	**FIN**	**TUT**
University of Eastern Finland	**FIN**	**UEF**
University of Helsinki	**FIN**	**UH**
University of Jyväskylä	**FIN**	**JyU**
University of Oulu	**FIN**	**OULU**
University of Tampere	**FIN**	**UTA**
University of Turku	**FIN**	**UTU**
Reykjavik University	**ICE**	**RU**
University of Akureyri	**ICE**	**UNAK**
University of Iceland	**ICE**	**UI**
Norwegian University of Life Sciences	**NOR**	**UMB**
Norwegian University of Science and Technology	**NOR**	**NTNU**
University of Bergen	**NOR**	**UiB**
University of Oslo	**NOR**	**UiO**
University of Stavanger	**NOR**	**UiS**
University of Tromsø	**NOR**	**UiT**
Chalmers University of Technology	**SWE**	**CTH**
Karlstad University	**SWE**	**KaU**
Karolinska Institutet	**SWE**	**KI**
Linköping University	**SWE**	**LiU**
Linnaeus University	**SWE**	**LnU**
Luleå University of Technology	**SWE**	**LTU**
Lund University	**SWE**	**LU**
Mid Sweden University	**SWE**	**MiU**
Royal Institute of Technology	**SWE**	**KTH**
Stockholm University	**SWE**	**SU**
Swedish University of Agricultural Sciences	**SWE**	**SLU**
Umeå University	**SWE**	**UmU**
University of Gothenburg	**SWE**	**GU**
Uppsala University	**SWE**	**UU**
Örebro University	**SWE**	**ØU**

Figure 4.1: Factor Analysis grouping Nordic universities by bibliometric research profiles. The symbol size is proportional to total research publication activity.
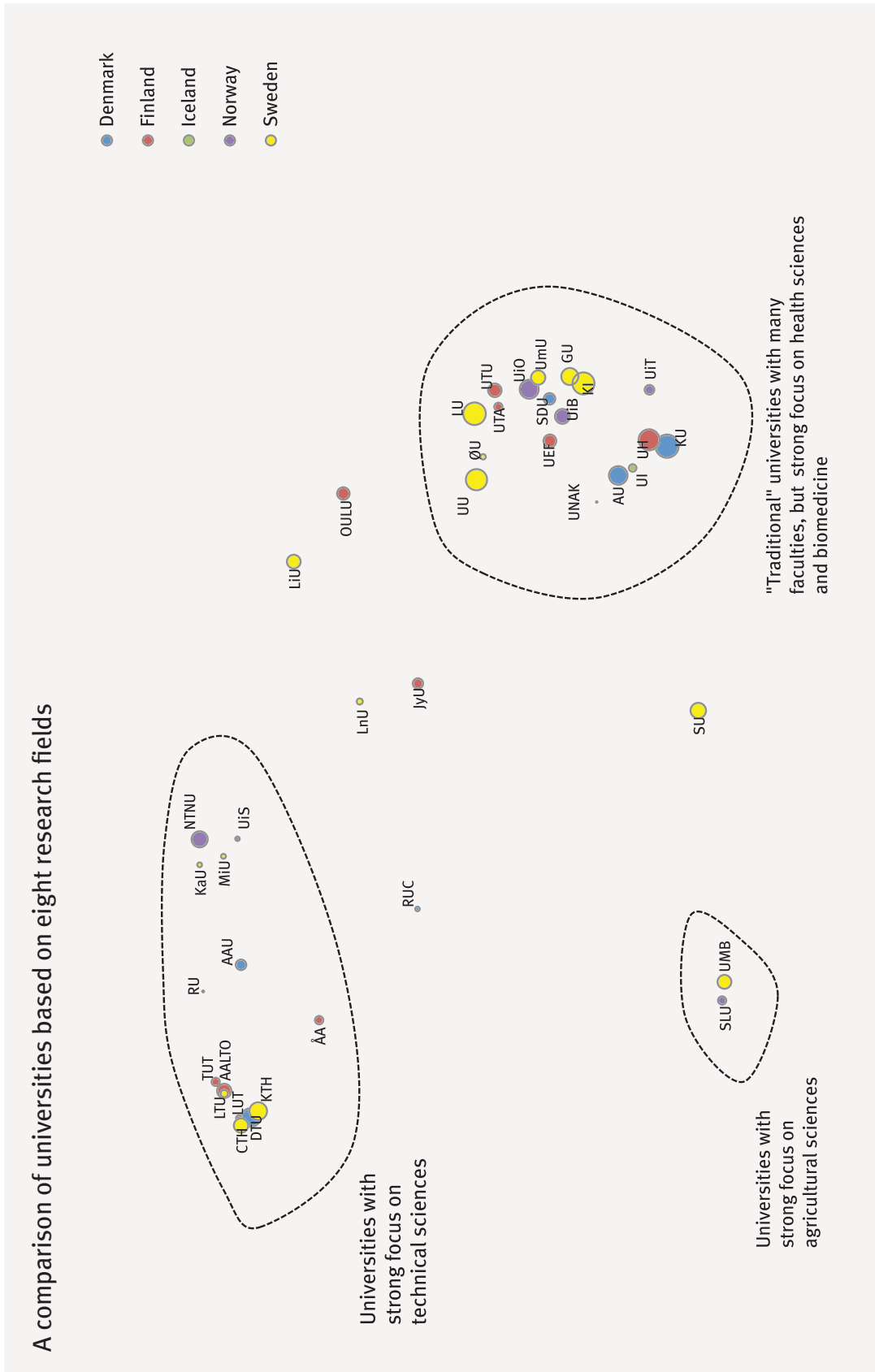
Figure 4.2: Factor Analysis grouping Nordic universities by bibliometric research profiles (excl. Health Sciences and Biomedicine). The symbol size is proportional to total research publication activity.

A comparison of universities based on six research areas (excluding Health Sciences and Biomedicine)

Legend:
- Denmark
- Finland
- Iceland
- Norway
- Sweden

Universities with strong focus on technical sciences

Universities with several faculties, but focus on chemistry, physics and mathematics

University with strong focus on geosciences

Universities with several faculties, but strong focus on agriculture, biology and chemistry

The universities that have medical faculties tend to cluster towards the bottom right of the quadrant, mostly due to the powerful influence of the Health Sciences which may 'override' other research areas. We therefore produced an alternative quadrant based on a factor analysis where Health Sciences and Biomedicine were removed (Figure 4.2). Biomedicine was left out as there is a very high correlation between these two subject fields. The scaling of university size, represented by the colored circles, has been adjusted for the removal of these two research areas.

The consequence of excluding Health Sciences and Biomedicine is a dispersion of universities into four clusters, three large and one small. As before, technical sciences represent one domain and the universities of Oulu and Linköping are now more clearly positioned in this group, while Örebro University has changed cluster, moving from the general cluster to the technical one.

The 'general' universities in Figure 4.1 have for the most part been divided between the two clusters in the bottom of Figure 4.2, with several of them joining the agricultural universities in Norway and Sweden, to form a group of universities with a strong focus on Agriculture, Fisheries & Forestry; Biology and Chemistry. Interestingly, three universities which were among the general universities in Figure 4.1 (the universities of Bergen, Tromsø and Iceland), end up positioned outside of the three large clusters in this second analysis. The University of Tampere is positioned in the group of technical universities mainly because of its publication activity in computer science. In addition, the University of Akureyri is shown on its own, in a Geosciences cluster, positioned fairly near to the University of Bergen and University of Iceland.

4.3 Relative specialization index (RSI)

We have now described the distribution of subject fields at the Nordic universities and grouped them along three major dimensions. In this section, we will elaborate on these findings by calculating the Relative Specialization Index (RSI) for each university (defined in *REIST-2*, 1997). The RSI gives an overview of a university's research profile (or specialization) by comparing the shares of fields of science among the university's total publications to the overall shares of each field among the world's total publications.

The symmetric RSI is a relative indicator which is based upon the Activity Index (AI). The Activity Index is defined as:

$$AI = \frac{\text{the share of the given field in the publications of the given university}}{\text{the share of the given field in the world total of publications}}$$

The RSI is then defined as:

$$RSI = \frac{AI - 1}{AI + 1}$$

RSI will take its values in the range -1 to < 1. The value indicates whether a university has a higher-than-average activity in the world in a scientific field (RSI >0) or a lower-than-average activity (RSI <0). RSI = 0 reflects a completely balanced situation.

It is important to note that RSI reflects a certain internal balance among the fields at the given university; positive RSI values must always be balanced by negative ones, as no university can have only positive RSI values (or only negative values for that matter). As a benchmark an RSI = 0 value is used for all research fields, which corresponds to the 'world standard case', as graphically presented by a regular octagon in the following figures. The numbers behind the graphical presentation of RSIs in this section are presented in detail in Appendix 5.

In this chapter we present the RSIs using octagonal diagrams, offering a visual presentation of each university's research publication activity in eight subject fields. Figure 4.3 shows that, when we consider all the Nordic universities and university hospitals together in comparison to the world, they appear to have a specialization profile that favors the life and health sciences. Agricultural sciences (including fisheries and forestry) are also shown as being relatively high activity areas in the profile, while other natural sciences and engineering are less active, compared to world averages.

Figure 4.3: Nordic universities' (excluding university hospitals) Relative Specialization Index (RSI) compared to the world (2005-2009)
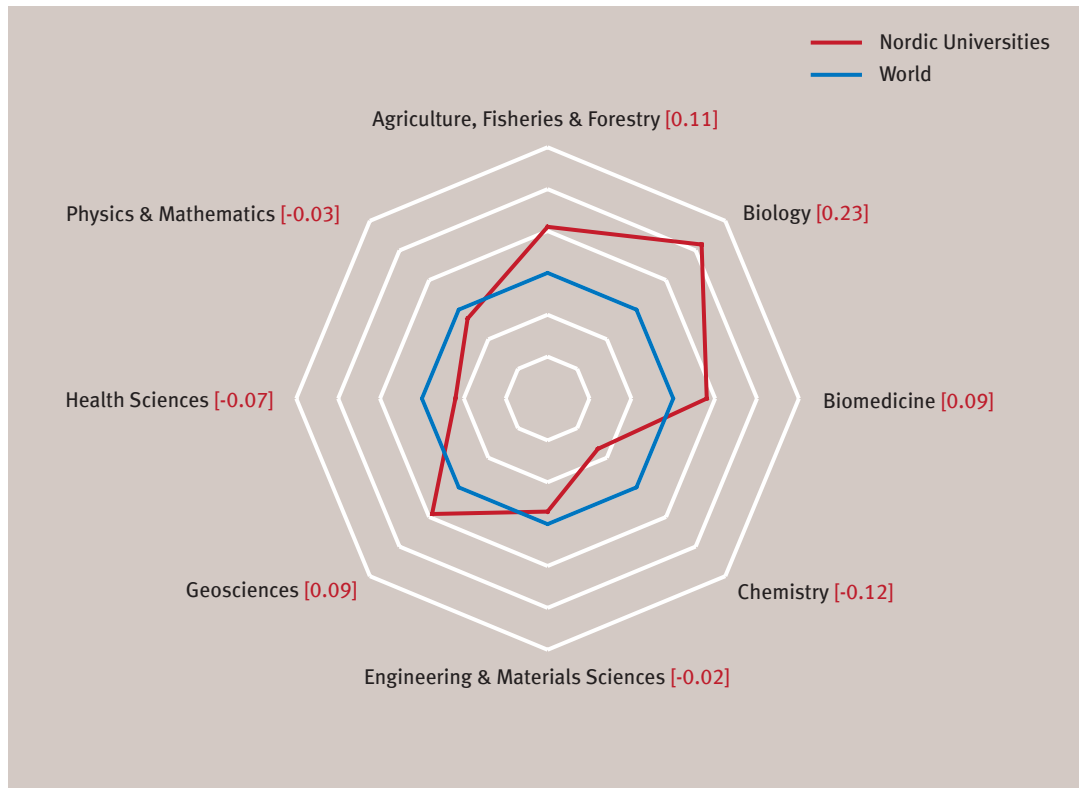
Similar specialization diagrams (based on RSI) for each of the Nordic universities are presented in the following section, where the universities are grouped not by country, but according to the results of the first factor analysis (see Figure 4.1). This makes it easier to compare between universities that have already been shown to have similar profiles on a more general level, thus offering a more detailed picture of variations between institutions, than simply comparing across countries.

Figure 4.4 shows the specialization profiles of the universities classified as technical universities in the factor analysis (universities found in the upper left quadrant). Figure 4.5 shows the agricultural universities (bottom left). Figure 4.6 shows the universities classified as 'general', with a broad profile including Health sciences. Figure 4.7 shows the universities that do not belong to any particular cluster group. RSI numbers for all universities (and subject fields) are found in Appendix 5.

**Figure 4.4: Relative Specialization Index for technical universities
(blue line equals the world average, red line equals the Nordic university analyzed)**
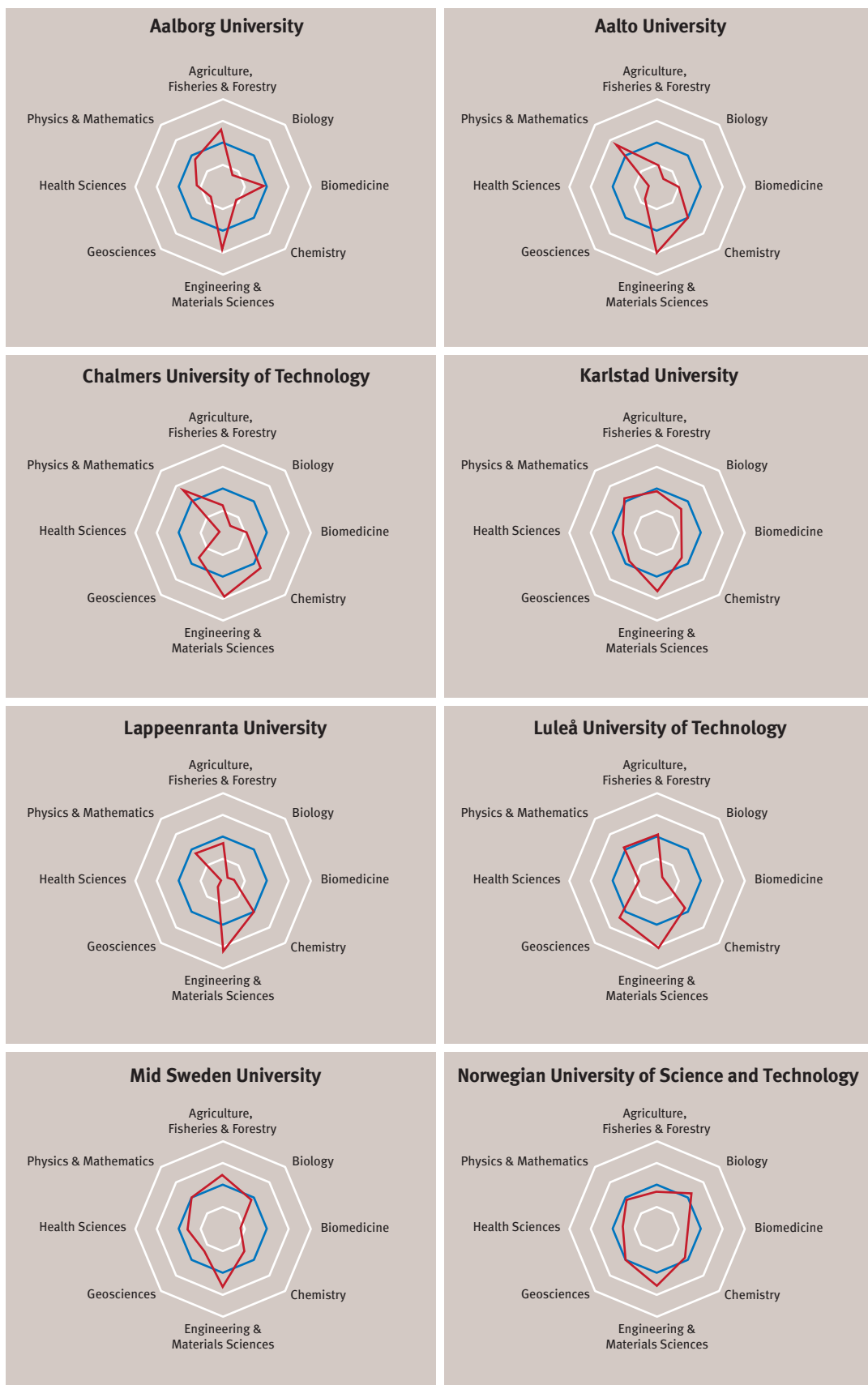
**Figure 4.4 (continue): Relative Specialization Index for technical universities
(blue line equals the world average, red line equals the Nordic university analyzed)**

Reykjavik University

Royal Institute of Technology

Tampere University of Technology

Technical University of Denmark

University of Stavanger

Åbo Akademi University
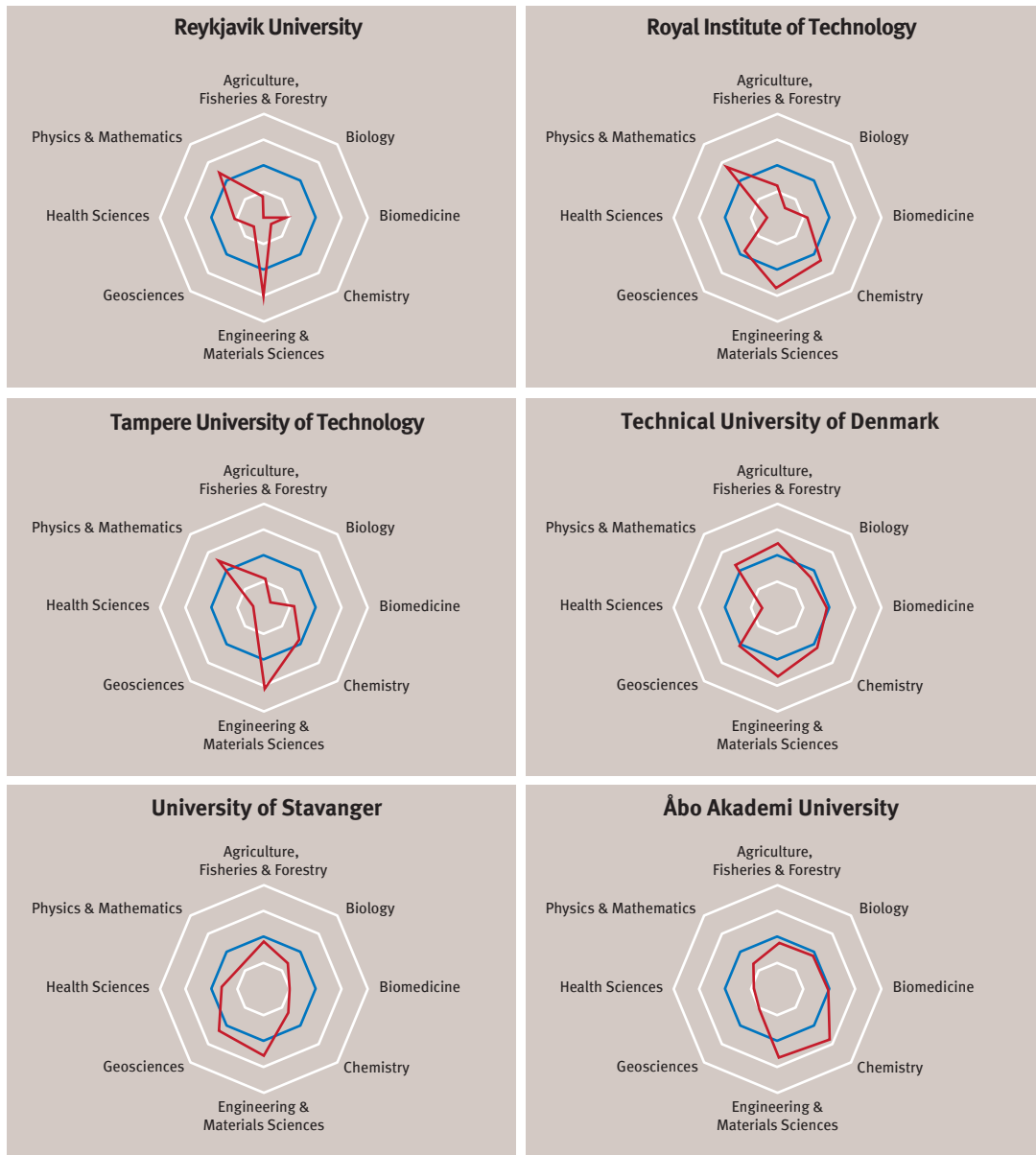
**Figure 4.5: Relative Specialization Index for agricultural universities
(blue line equals the world average, red line equals the Nordic university analyzed)**

Norwegian University of Life Sciences

Swedish University of Agricultural Sciences
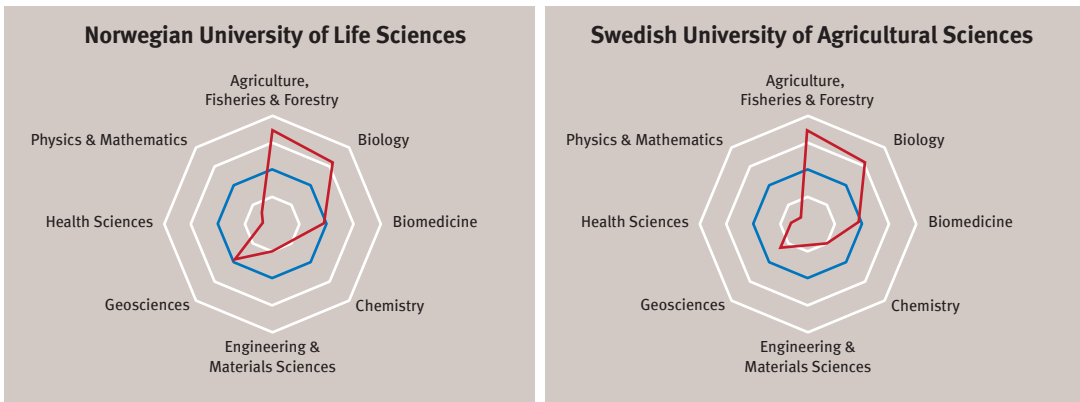
Figure 4.6 (continue): Relative Specialization Index for 'traditional' universities (blue line equals the world average, red line equals the Nordic university analyzed)

Figure 4.6: Relative Specialization Index for 'traditional' universities (blue line equals the world average, red line equals the Nordic university analyzed)
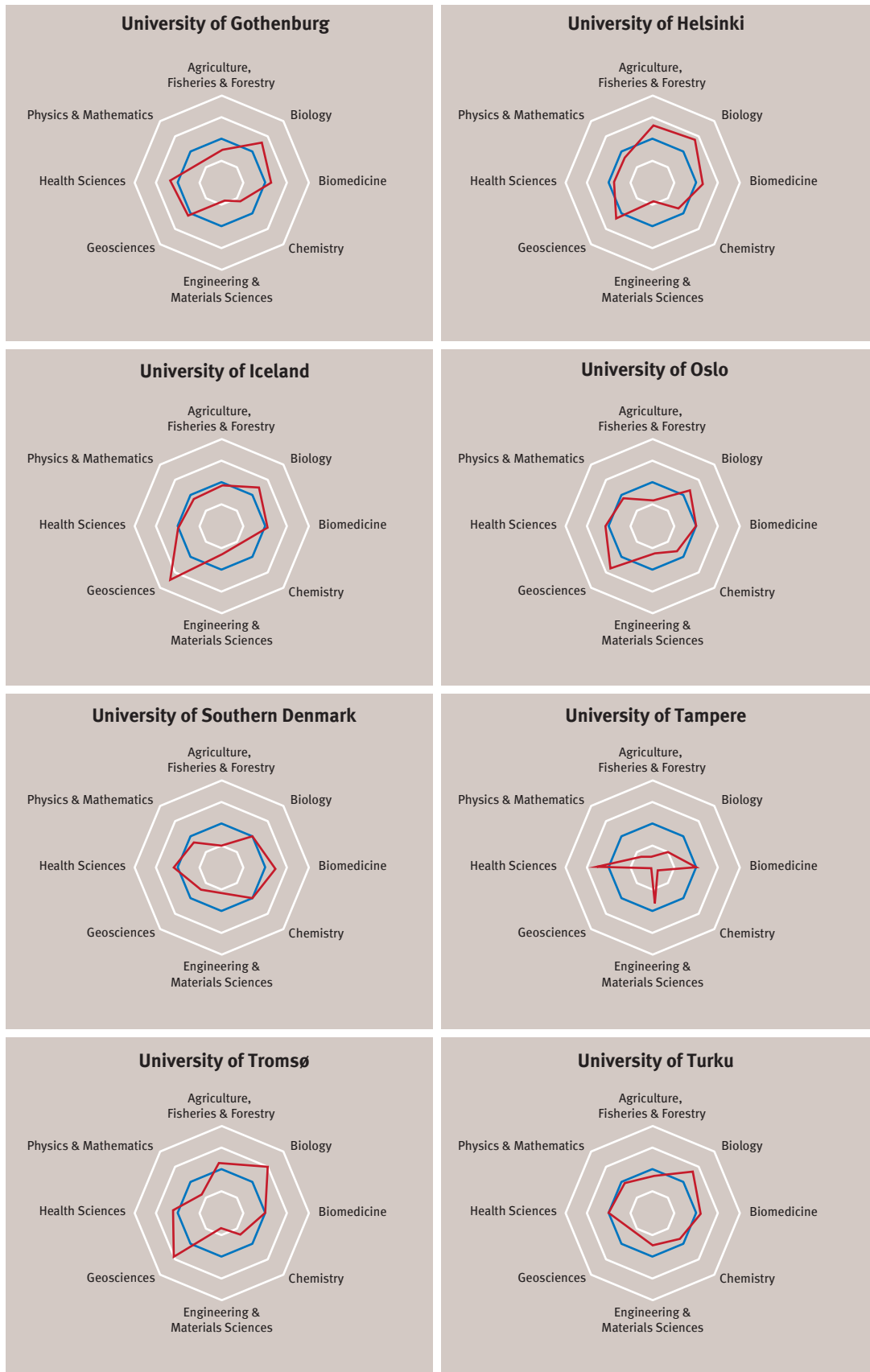
Figure 4.6 (continue): Relative Specialization Index for 'traditional' unclassified' universities (blue line equals the world average, red line equals the Nordic university analyzed)

Uppsala University

Örebro University
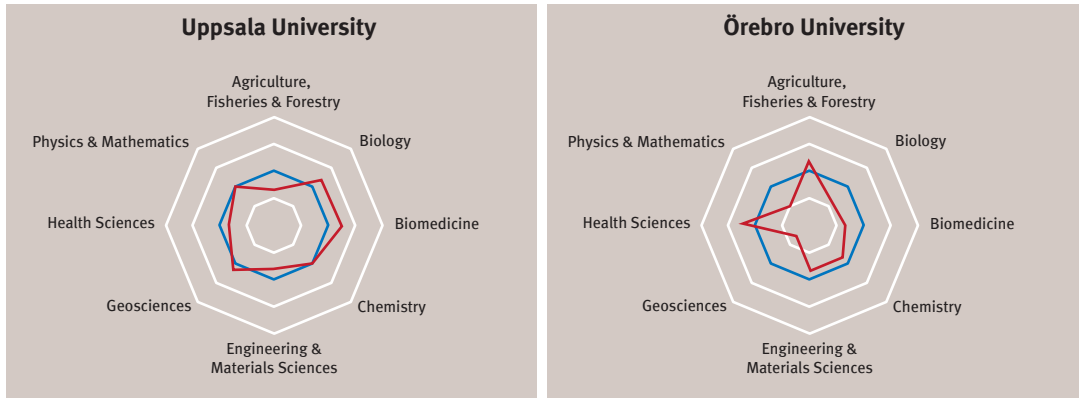
Figure 4.7: Relative Specialization Index for 'unclassified' universities (blue line equals the world average, red line equals the Nordic university analyzed)

Linköping University

Linnaeus University

Roskilde University

Stockholm University

University of Jyväskylä

University of Oulu
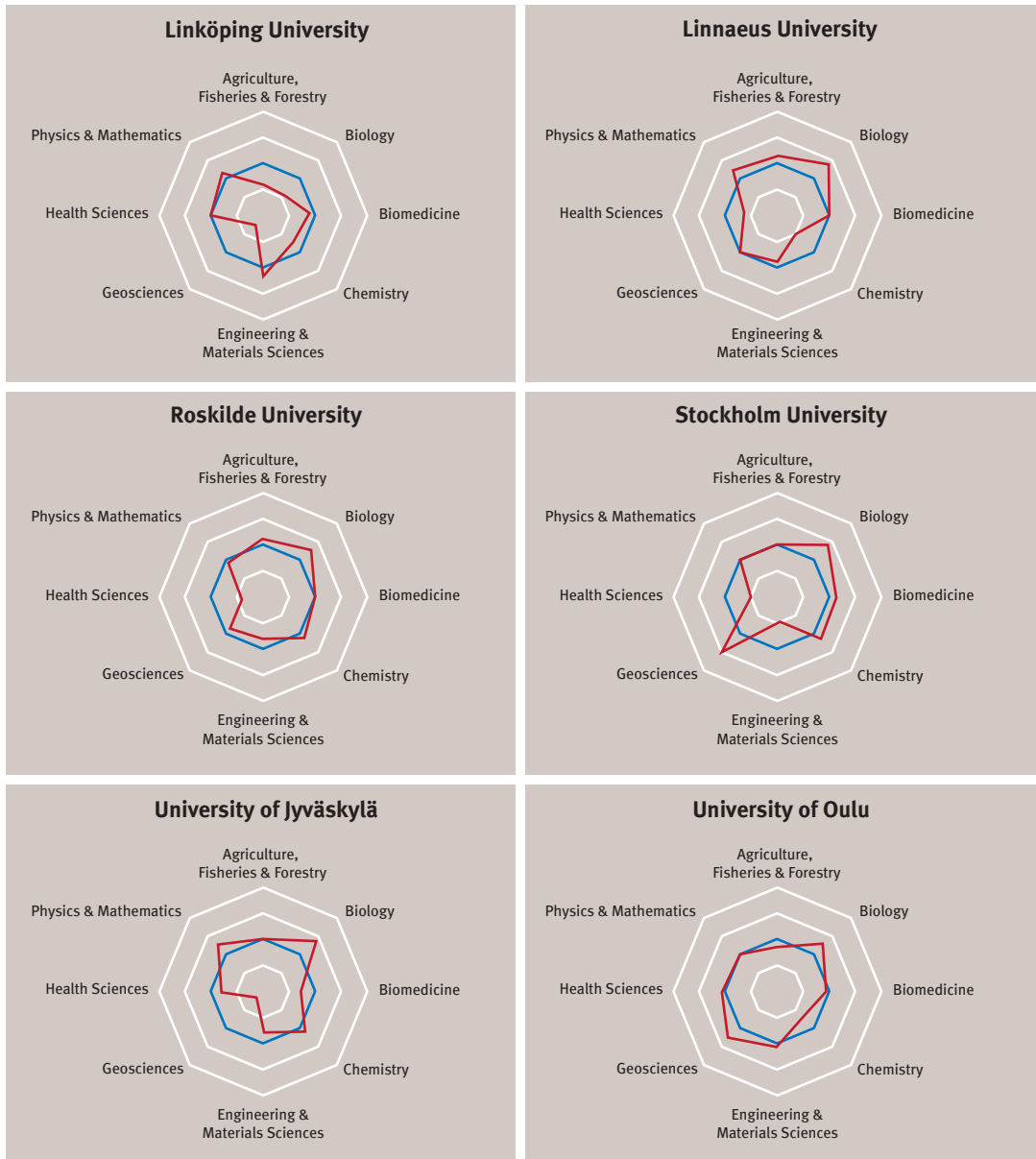
In this chapter we have shown the research publication profiles of the Nordic universities, clearly illustrating the diversity that exists both within each country and within clusters of similar universities, across countries. Even within clusters of more alike universities, based on overall publication activity, the universities have different research profiles. This variation is usually hidden in aggregated university rankings. The aim of this chapter has thus been to highlight the diversity of the Nordic universities, and the need to specify profiles and subject fields when comparing them. The methods we have presented can also be used by the universities themselves, to get a clearer overview of their activities and profiles, in comparison with other universities.

5 Citation impact of the Nordic universities
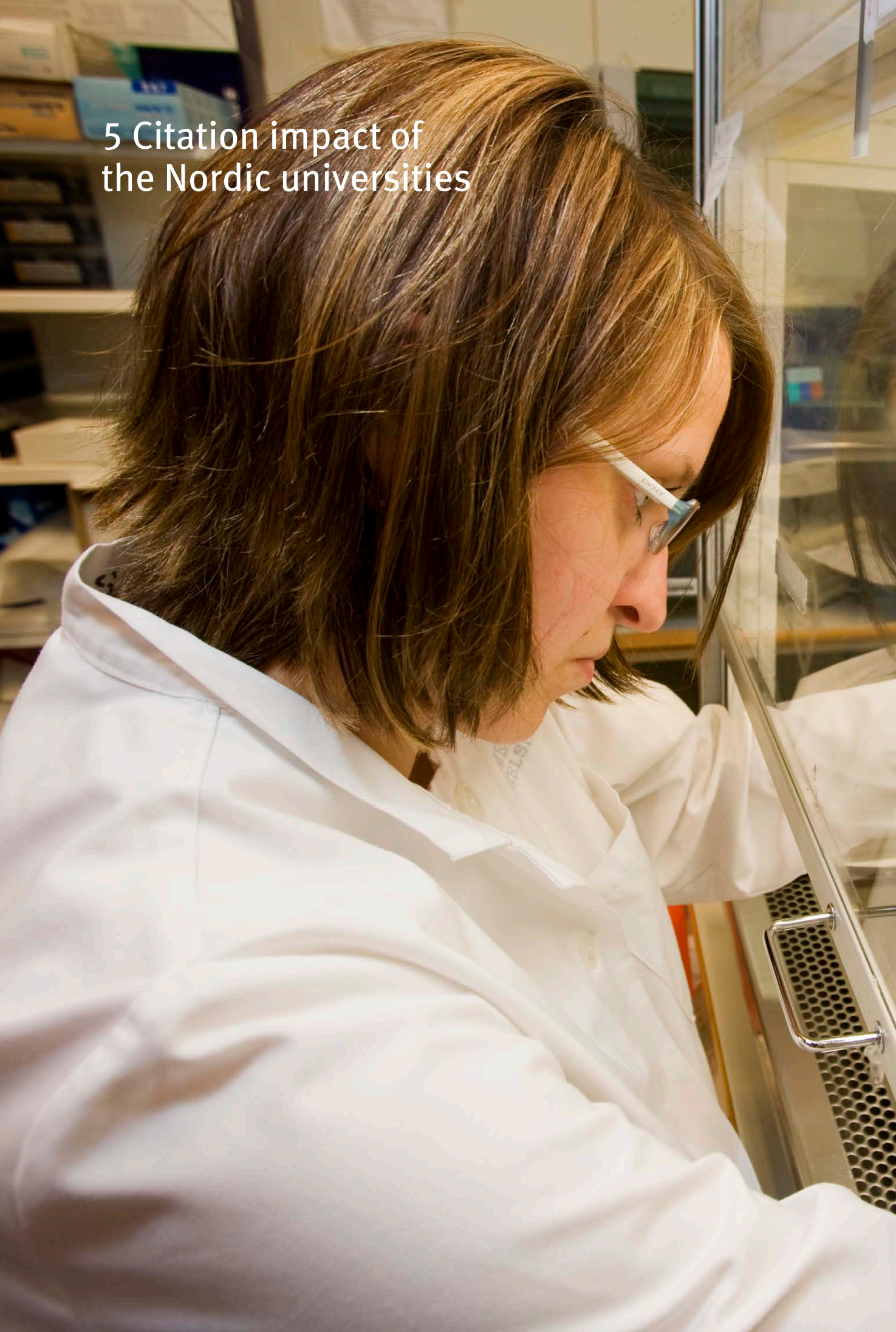
5 Citation impact of the Nordic universities

The aim of this chapter is to compare the citation impact of the Nordic universities over two 5-year periods. The chapter contains two parts: first, we analyze citation impact at an aggregated university level (Chapter 5.1). We then analyze citation impact, broken down by subject field, for each university (Chapter 5.2).

All citation analyses presented in this report are carried out according to the following procedures and calculations:

- Field normalized (fractionalized) citation rates,
- Excluding self-citations,
- Three year citation window.

We report relative citation rates as index values, where an index value of 1.00 is the 'world average' for the aggregated field. An index value of 1.10 represents citation rates ten per cent above the world average and an index value of 0.90 represents citation rates ten per cent below world average. Citation rates are item-normalized according to publication type, publication year, and field specific citation rates. This means that citation rates per publication are compared to the average citation rates for the same type of publications, in the same years, for the specific research field, before they are aggregated to provide totals. This enables the comparison of so-called *relative* citation indicators across research fields, publication types and publication years. Such relative indicators are needed here because the typical number of citations is highly dependent on research field, publication type and the time allowed before citations are counted.

Please note that for the citation statistics presented in this study, the later period is based on publications from 2005-2008, providing a period one year shorter than the period used in our analysis of publication activity (see Chapter 3). The publications from 2009 are left out from the calculation because otherwise the citation window would have been too short to provide reliable results.

Another phenomenon that affects the reliability of citation indicators is the skewness of citation distributions; while a few publications get cited heavily, most publications are seldom or never cited (although recent studies suggest that the share of publications that do get cited is increasing[20]). The calculation of an average (normalized) citation rate for any number of publications is therefore highly dependent on the presence and citation rates of a relatively small portion of highly cited publications. In light of this, a rule of thumb is that a minimum of fifty publications per unit should be used to produce reliable citation indicators in professional bibliometrics. We have followed this rule in this report. Nonetheless, we need to point out that the citation indicator for any given university, in any given field of research, may still be highly dependent on the presence or absence of just a few highly cited publications. We give special attention to highly cited publications in a more focused analysis in section 5.2.2 below.

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20 See e.g. Vetenskapsrådet (2010).

5.1 Overall citation impact (all subjects)

First we investigate the overall field normalized (fractionalized) citation rates for the universities and university hospitals for the periods 2000-2004 and 2005-2008, and how they have changed between these periods (Tables 5.1 to 5.5, and at the national level in Table 5.6). This analysis aggregates all research fields into one overall citation score, which is then weighted according to research profiles, based on field normalized citation scores. The aggregated indicator is reasonably comparable across different research profiles and types of universities (the numbers behind the citations, i.e. number of fractionalized field normalized citations, are found in Appendix 6). We also investigate whether citation rates vary between publications that are nationally and internationally co-authored (Table 5.7).

Table 5.1: Field normalized citation rates (fractionalized), Denmark

Denmark	Citation rate 2000-2004	Citation rate 2005-2008	Citation rate change	Number of field normalized citations 2005-2008
Aalborg University	1.04	1.03	-0.02	1192
Aarhus University	1.34	1.38	0.04	4834
Roskilde University	0.84	1.12	0.28	236
Technical University of Denmark	1.51	1.40	-0.11	5133
University of Copenhagen	1.16	1.23	0.07	6578
University of Southern Denmark	1.48	1.22	-0.26	1653
				(19626)
Aarhus University Hospitals	1.01	1.07	0.06	1822
Copenhagen University Hospitals	1.17	1.33	0.16	4226
University of Southern Denmark Hospitals	1.06	0.97	-0.09	433
				(6481)
Averages and total for Denmark	**1.25**	**1.27**	**0.02**	**26106**

Almost all Danish universities have relative citation impacts that are clearly above the world average. The Technical University of Denmark and Aarhus University have the highest impact when we consider the overall impact over both time periods measured (2000-2008). If these results are contrary to those found in other studies of citation impact, we must bear in mind that we have conducted a separate analysis for the university hospitals in this study (who are not directly visible in most rankings). We must also consider that changes from one period to the next might be due to the presence of a few highly cited articles.

Table 5.2: Field normalized citation rates (fractionalized), Finland

Finland	Citation rate 2000-2004	Citation rate 2005-2008	Citation rate change	Number of field normalized citations 2005-2008
Aalto University	1.14	1.10	-0.04	2280
Åbo Akademi University	1.09	1.09	0.01	785
Lappeenranta University of Technology	0.68	0.84	0.16	239
Tampere University of Technology	0.78	0.84	0.06	619
University of Eastern Finland	1.02	0.98	-0.05	1626
University of Helsinki	1.21	1.18	-0.03	5311
University of Jyväskylä	0.96	1.08	0.12	1147
University of Oulu	0.88	0.87	-0.01	1374
University of Tampere	0.97	0.96	-0.01	658
University of Turku	0.96	0.96	0.00	1795
				(15834)
Helsinki University Central Hospital	1.13	1.14	0.01	1861
Kuopio University Hospital	1.11	1.05	-0.06	517
Oulu University Hospital	0.95	0.89	-0.06	285
Tampere University Hospital	0.95	0.92	-0.04	464
Turku University Hospital	0.97	1.03	0.06	363
				(3490)
Averages and total for Finland	**1.05**	**1.05**	**-0.01**	**19326**

The Finnish universities have weighted relative citation impacts that fall both below and above the world average. Finland's two largest universities, in terms of publication output (Helsinki and Aalto), and the largest university hospital (Helsinki University Central Hospital) are all well above the world average for citation rates.

Table 5.3: Field normalized citation rates (fractionalized), Iceland

Iceland	Citation rate 2000-2004	Citation rate 2005-2008	Citation rate change	Number of field normalized citations 2005-2008
Reykjavik University	-	-	-	18
University of Akureyri	-	-	-	12
University of Iceland	0.87	1.05	0.18	596
				(626)
Landspitali University hospital	1.23	1.38	0.15	285
				(285)
Averages and total for Iceland[1]	**0.96**	**1.11**	**0.15**	**911**

[1] Includes the publications/citations from Reykjavik University and University of Akureyri.

Landspitali University Hospital has the highest relative citation impact of all the university hospitals included in this study, and stands in contrast to the typical case of a smaller institution, where the total research output is strongly influenced by a few highly cited papers; instead Landspitali has a reasonably high number of highly cited papers. The University of Iceland shows an increased impact between the two periods. The smaller universities are not shown in the table as their output is too small to produce a reliable citation indicator.

Table 5.4: Field normalized citation rates (fractionalized), Norway

Norway	Citation rate 2000-2004	Citation rate 2005-2008	Citation rate change	Number of field normalized citations 2005-2008
Norwegian University of Life Sciences	1.00	1.09	0.09	766
Norwegian University of Science and Technology	1.05	1.07	0.03	2773
University of Bergen	1.01	1.11	0.10	2444
University of Oslo	1.09	1.11	0.02	3952
University of Stavanger	0.68	0.75	0.07	139
University of Tromsø	0.95	1.04	0.09	974
				(11048)
St. Olavs Hospital	1.01	1.07	0.06	364
University Hospital North Norway	0.82	1.02	0.19	223
University of Bergen Hospitals	0.99	1.04	0.06	709
University of Oslo Hospitals	1.07	1.11	0.04	1996
				(3292)
Averages and total for Norway	**1.03**	**1.08**	**0.05**	**14340**

With the exception of the University of Stavanger, which has a small output in this context, all Norwegian institutions have citation impacts of around the same level; above the world average, but not very high. There is a slight overall increase in impact from the first period to the second.

Table 5.5: Field normalized citation rates (fractionalized), Sweden

Sweden	Citation rate 2000-2004	Citation rate 2005-2008	Citation rate change	Number of field normalized citations 2005-2008
Chalmers University of Technology	1.16	1.10	-0.06	2339
Karlstad University	0.98	0.73	-0.25	173
Karolinska Institutet	1.17	1.21	0.04	5966
Linköping University	1.07	1.02	-0.05	1968
Linnaeus University	0.89	0.81	-0.08	301
Luleå University of Technology	1.00	0.81	-0.19	454
Lund University	1.13	1.18	0.05	6185
Mid Sweden University	0.99	0.81	-0.18	199
Royal Institute of Technology	1.17	1.08	-0.08	3454
Stockholm University	1.27	1.36	0.10	3314
Swedish University of Agricultural Sciences	1.15	1.21	0.06	2367
Umeå University	1.19	1.11	-0.08	2293
University of Gothenburg	1.08	1.11	0.03	3261
Uppsala University	1.18	1.08	-0.10	4959
Örebro University	1.08	1.14	0.06	332
				(37565)
Karolinska University Hospital	1.12	1.19	0.07	2572
Linköping University Hospital	1.01	1.03	0.02	440
Norrland's University Hospital	0.90	1.07	0.17	372
Sahlgrenska University Hospital	1.12	1.19	0.08	1468
Skåne University Hospital	0.96	1.04	0.08	1645
Uppsala University Hospital	0.97	1.09	0.12	980
				(7477)
Averages and total for Sweden	**1.13**	**1.13**	**0.01**	**45044**

All of the larger Swedish institutions and some of the smaller ones, have citation rates well above the average in both periods. Indeed, Stockholm University is one of the most highly cited universities in the Nordic countries.

Table 5.6: Field normalized citation rates (fractionalized),
Nordic countries (selected universities and university hospitals)

All Nordic countries	Citation rate 2000-2004	Citation rate 2005-2008	Number of field normalized citations 2005-2008
Denmark	1.25	1.27	26106
Finland	1.05	1.05	19326
Iceland	0.96	1.11	911
Norway	1.03	1.08	14330
Sweden	1.13	1.13	45044
Averages and total for the Nordic countries	**1.13**	**1.14**	**105717**

Denmark stands out among the Nordic countries with a substantially higher citation impact. The other countries are all above the world average and are about the same level as each other. Norway and Iceland have increased their citation impact between the two periods. All of these findings are consistent with our earlier report (Schneider et al., 2010) which covered all publications from each country, not only those from the institutions that are included here.

5.1.1 Citation rates in publications with and without international co-authorship

In our earlier NORIA-net report on international research cooperation in the Nordic countries it was shown that much of the increase in citation rates for Denmark and Norway, identified at the national level, could be attributed to increased citation rates for national publications, i.e. publications where all authors represent the same country (Schneider et al. 2010). In contrast, Iceland's increased citation rate was due to citation rates for international publications, i.e. publications where more than one country is represented among the authors. Finland and Sweden both saw their national-level citation rates decrease for international publications, while remaining constant rates for national publications. Although, international cooperation is not the focus of this report, it is nevertheless worthwhile looking at how field normalized citation rates vary between national and international publications, in the period 2005-2008, for the universities and university hospitals in this report.

Table 5.7: Average field normalized citation rates (fractionalized) in nationally and internationally co-authored publications, Nordic countries (selected universities and university hospitals)

	Citations to publications without international co-authorship	Citations to publications with international co-authorship	Proportion of publications with international co-authorship[A]
Denmark	1.19	1.43	33 %
Finland	0.97	1.23	29 %
Iceland	0.77	1.53	44 %
Norway	0.98	1.30	32 %
Sweden	1.05	1.31	32 %
All Nordic countries	**1.05**	**1.32**	**32 %**

[A] These are proportions based on fractional counts. See Figure 2.6 in Gunnarsson et al. (2010) for whole counts statistics of international collaboration.

Table 5.7 shows that national publications generally receive lower citation rates than publications involving international collaboration. This is particularly the case in Iceland, where a large proportion of international publications are found within Biomedicine and Health Sciences. A full list of the universities and university hospitals' citation rates for national and international publications is found in Appendix 7.

5.2 Citation impact in subject areas

Chapter 5.1 focused on citation rates at the aggregated university level only. In this section, we turn our attention to the eight subject fields. We show the average field normalized citation rates over a 4-year period (2005-2008) broken down at field level (Table 5.8). The citation rates are based on fractionalized publications. In Chapter 5.2.1 we present Citation-Publication Matrixes, showing how citation rates are associated with number of publications (Figures 5.1 and 5.2). Chapter 5.2.2 shows the universities' share of highly cited papers across the eight subject fields (Table 5.9).

It often becomes clear that we are dealing with a very limited number of publications when we study each field of research at the individual institutions. As already mentioned, citation indicators may become unreliable when they are based on small numbers. We therefore applied a minimum threshold of 50 fractionalized publications within a subject field, over a 4-year period, in our analyses. Citation rates based on publication data below this threshold are not presented. This is in line with common practice in bibliometrics (see Moed et al., 1995, who suggested 50 publications as a minimum "in an oeuvre"). The result of applying this threshold is that about 45% of the cells in Table 5.8 are empty. However, the 'Total' cells still represent the total for each university, regardless of whether a given subject field at that university has more or less than 50 fractionalized publications required to produce subject-field specific results.

Table 5.8: Field normalized citation rates of universities and university hospitals (2005-2008) across subject fields[21] (high scores are indicated by darkness of colour)

University	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Denmark	1.36	1.34	1.07	1.46	1.31	1.30	1.24	1.43	**1.27**
Aalborg University	1.23		0.70		1.01		0.86	1.45	**1.03**
Aarhus University	1.32	1.50	0.95	2.22	1.60	1.22	1.22	1.48	**1.38**
Roskilde University									**1.12**
Technical University of Denmark	1.51	1.54	1.24	1.44	1.42	1.16	1.11	1.49	**1.40**
University of Copenhagen	1.35	1.20	1.12	1.00	1.42	1.33	1.24	1.33	**1.23**
University of Southern Denmark		1.14	1.48	1.10	0.77		1.12	1.08	**1.22**
Aarhus University Hospitals			0.77				1.11		**1.07**
Copenhagen University Hospitals			0.98				1.40		**1.33**
University of Southern Denmark Hospitals			0.84				0.98		**0.97**
Finland	1.10	1.19	0.92	0.99	1.00	1.06	1.09	1.08	1.05
Aalto University			0.84	1.21	1.13		0.92	1.11	**1.10**
Åbo Akademi University			0.81	0.90	1.29		0.99	1.19	**1.09**
Lappeenranta University of Technology					0.93				**0.84**
Tampere University of Technology				0.94	0.80			0.85	**0.84**
University of Eastern Finland	1.06	1.01	0.86	0.65	0.94		1.16	0.89	**0.98**
University of Helsinki	1.17	1.26	1.05	1.22	1.30	1.14	1.18	1.33	**1.18**
University of Jyväskylä	0.91	1.12	0.57	1.00	0.95		0.95	1.43	**1.08**
University of Oulu	0.81	1.17	0.85	0.52	0.81	0.83	1.05	0.66	**0.87**
University of Tampere			0.78		0.69		1.11		**0.96**
University of Turku	1.23	1.15	0.81	0.85	0.76		1.09	0.83	**0.96**
Helsinki University Central Hospital			1.05				1.16		**1.14**
Kuopio University Hospital			0.89				1.06		**1.05**
Oulu University Hospital							0.91		**0.89**
Tampere University Hospital			0.82				0.94		**0.92**
Turku University Hospital							1.05		**1.03**
Iceland				1.31	1.44	1.04	1.06	0.75	1.11
Reykjavik University									
University of Akureyri									
University of Iceland			0.99			1.02	0.93	0.74	**1.05**
Landspitali University hospital							1.22		**1.38**

21 Empty cells have less than 50 fractionalized publications. Total is the weighted average of all fields, i.e. includes the values of the empty cells as well.

University	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Norway	**1.22**	**1.17**	**0.96**	**0.93**	**1.05**	**1.12**	**1.09**	**1.23**	**1.08**
Norwegian University of Science and Technology	1.16	1.05	1.13	0.87	1.02	0.51	1.03	1.42	**1.07**
University of Bergen	1.11	1.11	0.94	0.97	1.27	1.38	1.08	1.03	**1.11**
University of Oslo	1.14	1.32	1.00	0.95	1.07	1.12	1.12	1.20	**1.11**
University of Stavanger					0.69				**0.75**
University of Tromsø	1.54	1.28	0.79	1.16		1.01	0.94	0.92	**1.04**
St. Olavs Hospital							1.08		**1.07**
University Hospital North Norway							1.05		**1.02**
University of Bergen Hospitals			0.67				1.12		**1.04**
University of Oslo Hospitals			1.02				1.13		**1.11**
Sweden	**1.28**	**1.32**	**1.00**	**1.32**	**1.14**	**1.10**	**1.14**	**1.06**	**1.13**
Chalmers University of Technology	1.16		0.85	1.11	1.18			1.03	**1.10**
Karlstad University					0.77				**0.73**
Karolinska Institutet		1.58	1.15	0.97			1.22		**1.21**
Linköping University	1.01		0.75	1.26	1.04		0.95	1.15	**1.02**
Linnaeus University			0.80		0.90		0.87	0.55	**0.81**
Luleå University of Technology				0.77	0.91			0.58	**0.81**
Lund University	1.18	1.33	1.00	1.31	1.40	1.20	1.00	1.39	**1.18**
Mid Sweden University					0.69				**0.81**
Royal Institute of Technology	1.02		0.88	1.24	1.12	0.64	0.79	1.06	**1.08**
Stockholm University	1.54	1.32	1.15	1.98	1.43	1.40	1.02	1.13	**1.36**
Swedish University of Agricultural Sciences	1.31	1.35	0.80	1.14	1.14		0.85		**1.21**
Umeå University	1.60	1.22	0.98	1.09	1.14		1.10	0.94	**1.11**
University of Gothenburg	1.18	1.27	0.97	0.97	1.26	0.97	1.17	0.97	**1.11**
Uppsala University	1.03	1.35	1.01	1.40	1.06	0.84	1.14	0.91	**1.08**
Örebro University							1.11		**1.14**
Karolinska University Hospital			0.98				1.24		**1.19**
Linköping University Hospital			0.63				1.11		**1.03**
Norrland's University Hospital							1.14		**1.07**
Sahlgrenska University Hospital			0.87				1.25		**1.19**
Skåne University Hospital			0.91				1.05		**1.04**
Uppsala University Hospital			0.81				1.12		**1.09**
Nordic total	**1.27**	**1.27**	**1.00**	**1.23**	**1.13**	**1.14**	**1.14**	**1.16**	**1.14**

The citation rates vary a great deal between the universities, but just as importantly, they also vary *within* the universities, depending on field. This underlines the suggestion that, to get a better understanding of a university's performance, detailed analysis is needed alongside composite measures. However, as the aggregated university citation scores are broken down into the eight research fields, we also see more variations and uncertainties emerging in these specific indicators. Each subset will contain fewer publications upon which indicators are calculated, thus creating larger variation due to highly cited articles, which will tend to have disproportionate influence in smaller data sets. For this reason, one should be careful in interpreting the meaning of these differences.

Table 5.8 illustrates some of the difficulties that can emerge when combining high citation rates with low publication volumes; four out of the ten values of 1.5 or above in the table are found at universities with less than 200 publications in the field, i.e. less than 40 papers published on average per year. Furthermore, no university exceeds a value of 1.5 in the larger, medical related fields, while the smaller field of Agriculture, Fisheries & Forestry have four universities with a value above 1.5. Biology has three universities exceeding this value, Chemistry has two universities and Engineering & Materials Sciences has one university with a value above 1.5.

5.2.1 Citation-publication matrix

The relationship between publication activity and citation impact can be studied via geographical presentations of a Citation-publication matrix. The figures below present a plot of relative citation impact, as a function of the volume of publications for each university (Figure 5.1) and university hospital (Figure 5.2). Compared to a one-dimensional ranking based on citation scores, a two-dimensional plot of this kind provides vital additional information concerning publication volume. Due to the intrinsic and distributional nature of relative citation indicators, small (i.e. low number of publications) units of analyses can have a very high citation impact, due to a few highly cited articles in the nominator and only a few articles in the denominator to be divided with. As the size of the units grow, a considerable number of articles that have zero or only few citations will count in the denominator, making it considerably harder to sustain a relatively high citation impact.

In the present analysis (Figure 5.2), we can see that some institutions, such as the Landspitali University hospital in Iceland, have a high citation impact, but a correspondingly low publication volume, whereas others, such as Copenhagen University Hospitals, have both a high impact and a high publication volume, making their relative citation score much more robust. It is interesting to note that these results show that almost all of the university hospitals have impact values above the world average.

Looking at the universities (Figure 5.1), we can see that they present a more differentiated picture than the university hospitals. Most notably, Figure 5.1 shows that the largest universities in the research areas included here (i.e. the universities with the highest number of publications) have relative citation impacts above the world average. All universities that have over 3000 fractionalized publication points also have impact values above the world average. The highest impact values are found for three universities that are all in the range of 3000-5000 fractionalized publications: the Technical University of Denmark, Aarhus University and Stockholm University.

Figure 5.1: Citation-publication matrix for Nordic universities 2005-2008[22]
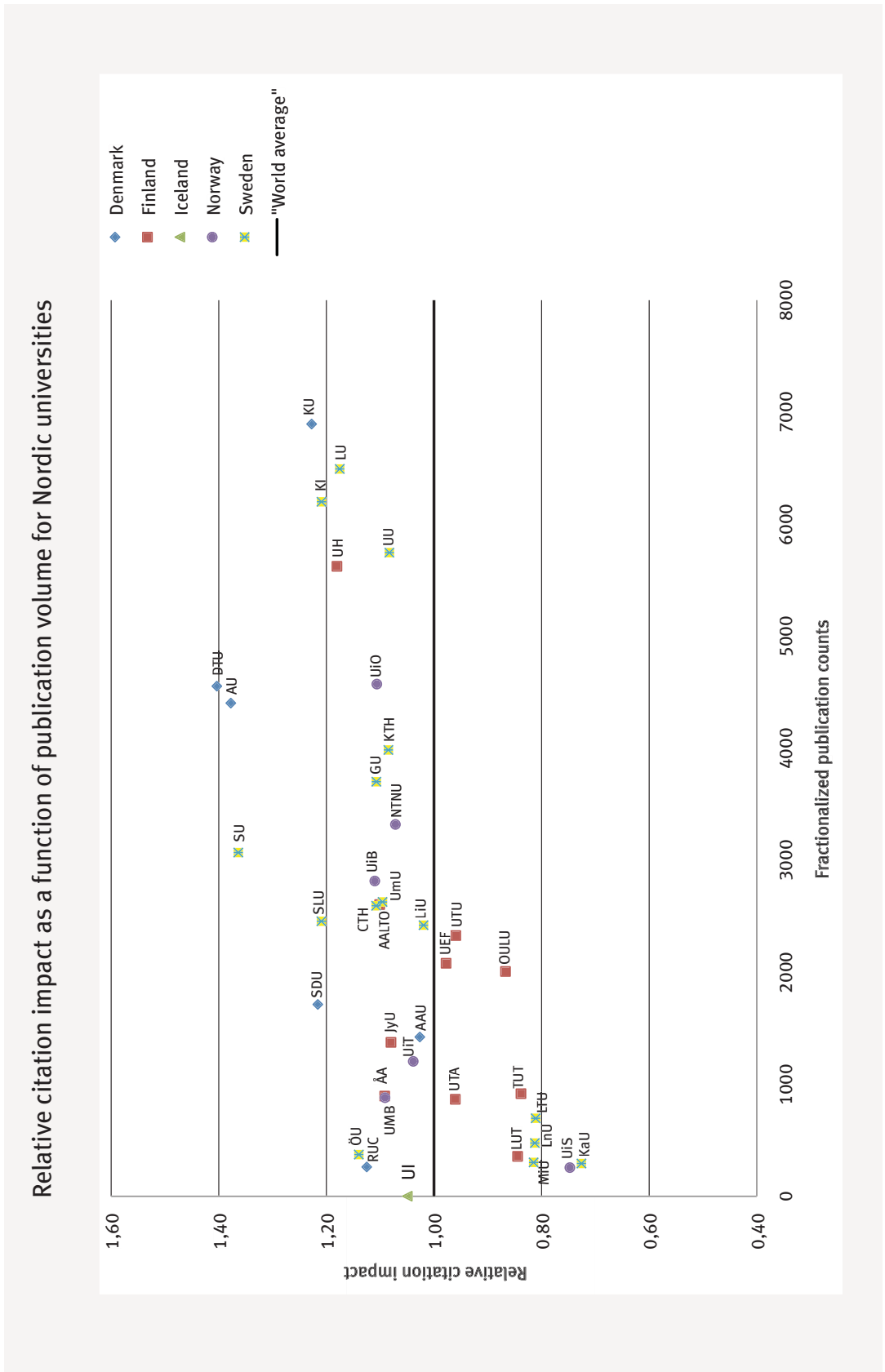
22   Publication counts on the x-axis are data for 2005-2009.

Figure 5.2: Citation-publication matrix for Nordic university hospitals 2005-2008[23]
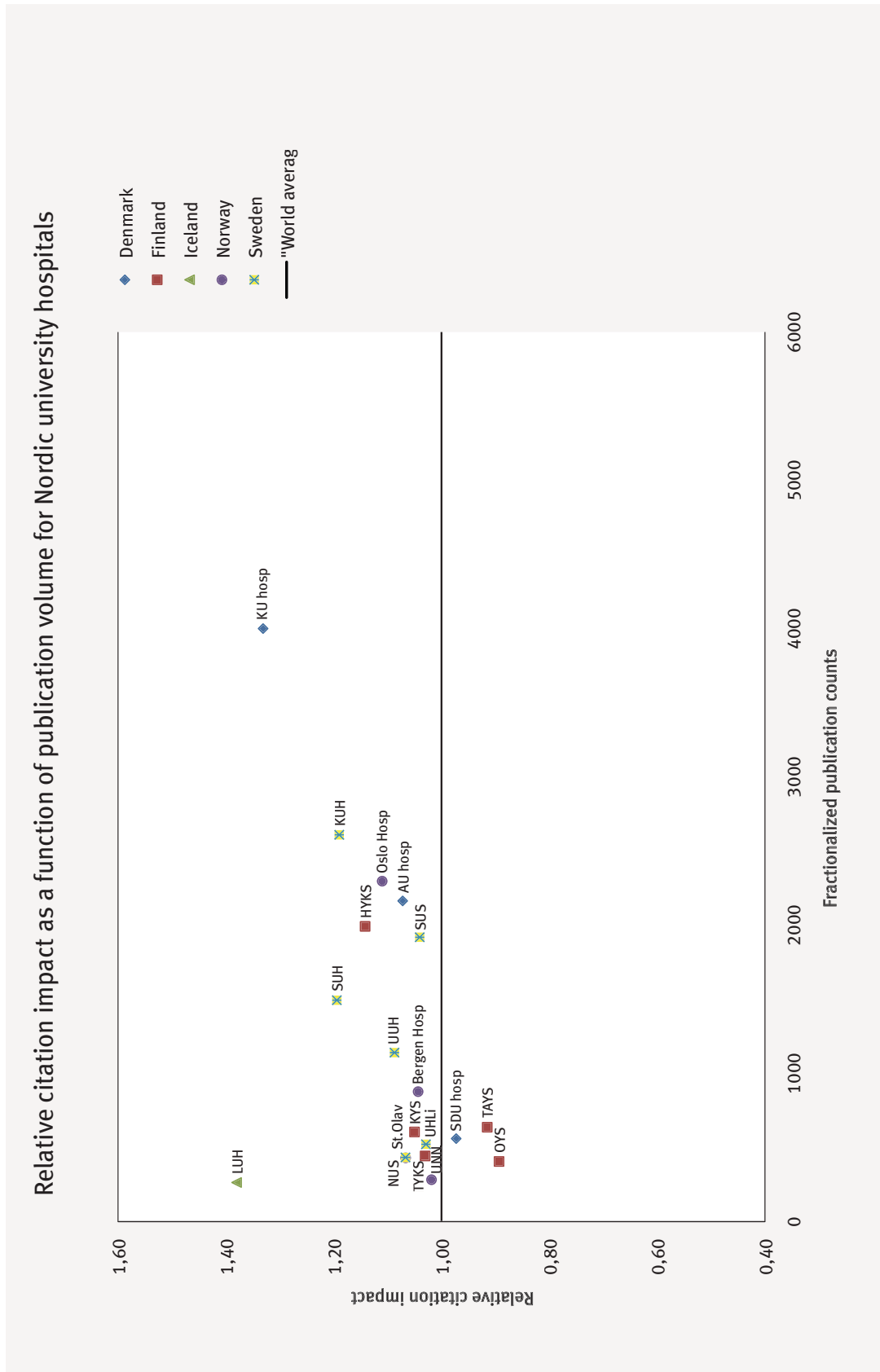
23   Publication counts on the x-axis are data for 2005-2009.

5.2.2 Share of highly cited papers

As mentioned above, citation distributions are easily skewed. A few publications tend to receive most of the citations. The issue of contribution to highly cited papers is therefore interesting to investigate, in addition to field normalized average scores. The final topic of Chapter 5 is our investigation of the Nordic universities' shares of highly cited papers. We concentrate on the period 2005-2008 and consider these shares across the eight subject fields. The indicator is calculated based on the share each Nordic university has of the 10% most highly cited papers, in each subject field, divided by the world share of the 10% most highly cited papers in the same subject field. The world average therefore corresponds with a value of 1.00. Table 5.9 only includes universities with publications above the minimum threshold of 50 per subject field. Two Icelandic universities are left out, due to their low numbers of publications in general.

Table 5.9 exhibits similar patterns of differences found in Table 5.8, although interestingly, these differences are more marked in this case, even in the case of country totals. Since this indicator to a higher degree is dependent on the relatively small number of highly cited publications, this 'satellite picture' of Nordic research might – be an aid to focus more closely on the organizations where we can find researchers who fulfill an ambition to contribute substantially to research of wide interest and consequences.

Table 5.9 Universities' and university hospitals' normalized proportion of highly cited publications across subject field among top 10% in world production (2005-2008) (1.00 equals the world average) (size level reflected by darkness of colour)

University	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Denmark	**1.38**	**1.46**	**1.06**	**1.49**	**1.37**	**1.41**	**1.23**	**1.57**	**1.30**
Aalborg University	1.15		0.63		0.92		0.53	1.31	0.85
Aarhus University	1.28	1.73	0.95	2.45	1.81	1.36	1.17	1.67	1.45
Roskilde University									1.13
Technical University of Denmark	1.60	1.62	1.28	1.63	1.56	1.20	1.11	1.62	1.47
University of Copenhagen	1.40	1.25	1.12	0.84	1.36	1.43	1.27	1.53	1.27
University of Southern Denmark		1.24	1.52	0.85	0.42		1.00	1.14	1.05
Aarhus University Hospitals			0.62				1.06		1.43
Copenhagen University Hospitals		1.95	0.93				1.48		1.17
University of Southern Denmark Hospitals			0.88				0.80		0.89
Finland	**0.93**	**1.04**	**0.83**	**0.89**	**0.96**	**1.11**	**1.04**	**1.05**	**0.98**
Aalto University	0.42		0.66	1.10	1.12		0.62	1.24	1.05
Åbo Akademi University	1.76		0.76	0.76	1.25		1.25	0.93	1.01
Lappeenranta University of Technology					0.86				0.66
Tampere University of Technology			0.87	0.60	0.70			0.84	0.71
University of Eastern Finland	0.94	0.45	0.71	0.61	0.90		1.19	0.83	0.89
University of Helsinki	0.95	1.25	1.01	1.19	1.26	1.20	1.16	1.09	1.12
University of Jyväskylä	0.82	0.94	0.23	0.88	1.21		0.64	1.63	1.01
University of Oulu	0.52	1.05	0.74	0.34	0.84	0.71	0.94	0.51	0.76
University of Tampere			0.70		0.39		1.05		0.88
University of Turku	1.22	0.90	0.66	0.77	0.50		1.02	0.76	0.87
Helsinki University Central Hospital			1.02				1.17		1.18
Kuopio University Hospital			0.70				0.99		0.99
Oulu University Hospital							0.79		0.86
Tampere University Hospital			0.72				0.83		0.84
Turku University Hospital			0.99				0.97		1.00
Iceland	**1.07**	**0.79**	**0.97**	**0.55**	**1.28**	**0.75**	**0.80**	**0.74**	**0.86**
Reykjavik University									
University of Akureyri									
University of Iceland			0.68		1.59	0.74	0.69	0.77	0.79
Landspitali University hospital							0.95		1.12

University	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Norway	**1.15**	**1.12**	**0.86**	**0.84**	**0.95**	**1.16**	**0.96**	**1.20**	**1.00**
Norwegian University of Life Sciences	1.08	0.90	0.74						0.97
Norwegian University of Science and Technology	1.18	1.02	1.05	0.84	0.89	0.32	0.93	1.44	0.97
University of Bergen	1.09	1.00	0.97	0.63	1.16	1.54	0.98	0.87	1.05
University of Oslo	1.24	1.34	0.88	0.90	1.07	1.26	1.01	1.21	1.06
University of Stavanger						0.52	0.52		0.51
University of Tromsø	1.31	1.30	0.55	1.12		0.80	0.70	0.84	0.87
St. Olavs Hospital			0.72				1.10		1.10
University Hospital North Norway							0.96		0.98
University of Bergen Hospitals			0.58				1.06		1.01
University of Oslo Hospitals			0.90				0.94		0.97
Sweden	**1.24**	**1.29**	**0.95**	**1.36**	**1.09**	**1.12**	**1.06**	**1.03**	**1.10**
Chalmers University of Technology	1.00		0.70	1.11	1.10	0.83		0.96	0.97
Karlstad University					0.73		0.56	0.81	0.54
Karolinska Institutet		1.38	1.13	0.79	1.18		1.28		1.28
Linköping University	0.86		0.61	1.40	1.06		0.82	1.32	1.00
Linnaeus University			0.68		0.69		0.60	0.59	0.77
Luleå University of Technology	0.76			0.51	0.67		0.87	0.42	0.60
Lund University	1.21	1.38	0.92	1.26	1.40	1.39	0.82	1.26	1.10
Mid Sweden University					0.76		0.38		0.77
Royal Institute of Technology	1.13		0.86	1.37	1.08	0.72	0.53	1.03	1.03
Stockholm University	1.55	1.24	1.14	2.31	1.63	1.31	0.87	1.15	1.41
Swedish University of Agricultural Sciences	1.17	1.18	0.69	0.72	0.83		0.51		1.02
Umeå University	1.83	1.18	1.07	1.09	1.29	1.55	1.12	1.01	1.18
University of Gothenburg	1.06	1.19	0.86	0.93	1.22	0.89	1.12	0.92	1.05
Uppsala University	0.98	1.46	0.95	1.42	1.01	0.90	1.09	0.85	1.06
Örebro University						1.02	1.09		1.18
Karolinska University Hospital			0.97				1.17		1.17
Linköping University Hospital			0.37				0.87		0.84
Norrland's University Hospital			0.90				0.91		0.96
Sahlgrenska University Hospital			0.82				1.14		1.13
Skåne University Hospital			0.36				1.13		1.03
Uppsala University Hospital			0.66				1.04		1.04
All Nordic countries	**1.21**	**1.25**	**0.94**	**1.22**	**1.10**	**1.17**	**1.08**	**1.16**	**1.10**
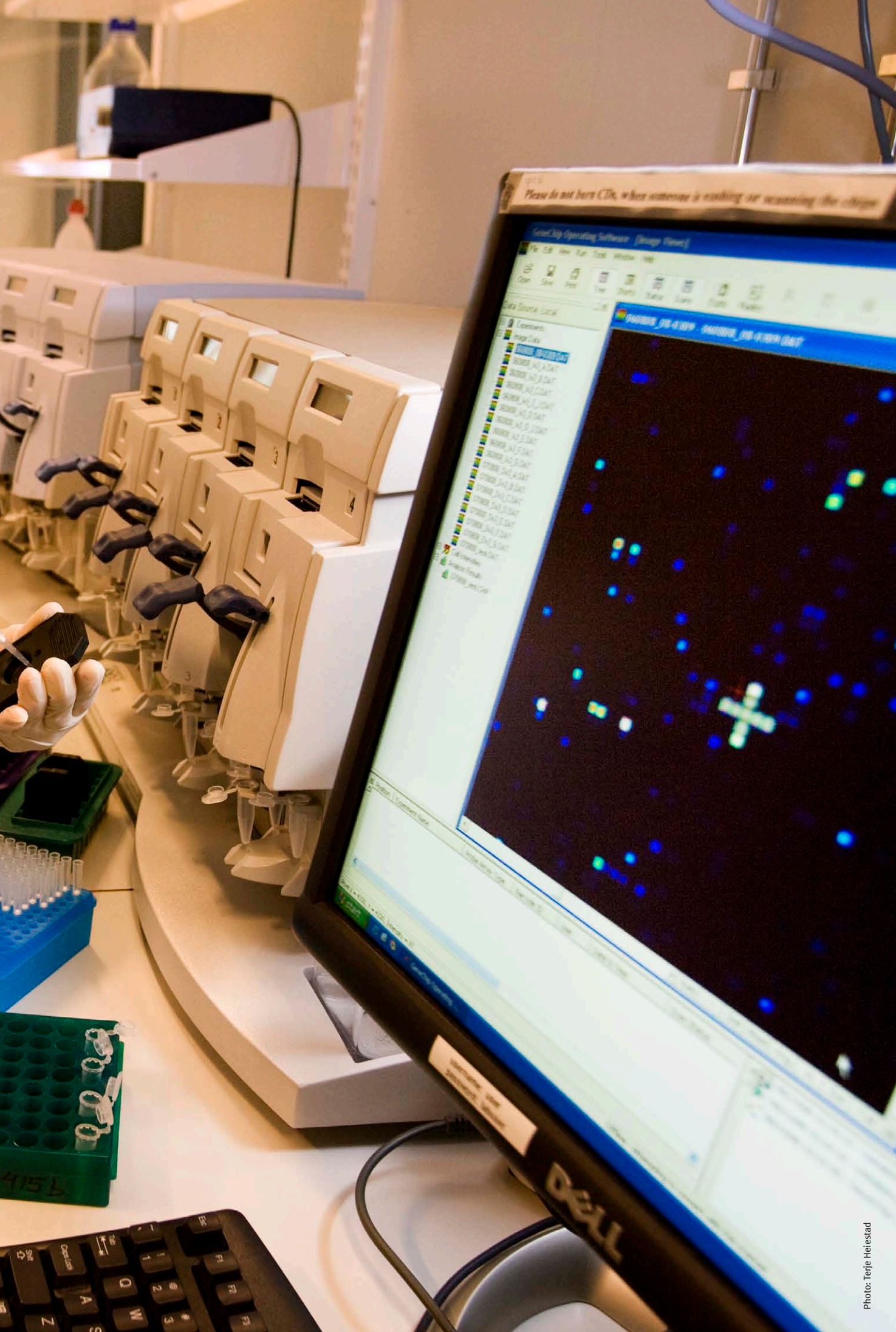
6 Conclusions

Contrary to university rankings of all kinds, we will not end this report by presenting a 'league table' of the Nordic universities or make statements about which university is the 'best' in the Nordic countries. We hope instead to have shown that advanced bibliometric indicators can offer a more detailed overview and provide more insight than rankings, not only by allowing us to measure (instead of rank) features of performance, but also by showing variations within and between institutions that are otherwise lost in composite scores. By offering transparent and reproducible methods, bibliometrics may be able to play a part in providing the information needed to start a benchmarking process within a specific organization. Rankings are less suitable for this.

We have also emphasized the importance of describing the universities' research profiles, so that comparisons can be based on the like-with-like principle, another feature that is rarely focused on in university rankings. At the same time, we have demonstrated methods of weighting and field normalization that allow for more meaningful and fair comparison between institutions with different research profiles.

It is possible to identify the research profile of individual universities and thereby observe variations between them. It is also possible to group universities in terms of their research profiles and thereby help them to identify potential 'partners' or comparator institutions. We hope this will prove useful both for those who wish to compare the research performance of the Nordic universities in general, or wish to compare their own universities to others.

This report should be read as supplement to the current rankings that receive so much attention. We do not suggest that our way of measuring or comparing the Nordic universities is the only or best approach to take. Indeed, our work has been experimental and was developed within a time-limited project for Nordic collaboration in bibliometrics. If the indicators we present here are found to be useful, and if there is interest in having them updated from year to year, we are certain that further work could be done to develop and improve these indicators.

One of the issues that we would like to see improvement in, is the representation of the Social Sciences and Humanities in the data sources for this type of analysis. We have omitted these areas of research from our study only because our data, so far, have proved too limited to produce reliable and valid indicators; we do not wish to neglect them. There are signs, however, of an increased international focus on developing data sources covering these fields, and we have also been discussing how contributing to this process could be the next step for a Nordic network of our kind.

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Appendixes

Appendix 1: Methodological considerations

The data source for the present report is the bibliometric database at the Swedish Research Council, which contains data from the Thomson Reuters indices Science Citation Index Expanded, Social Sciences Citation Index and Arts & Humanities Citation Index[24]. The analyses cover a 10-year time period from 2000-2009. Publications have been restricted to include only research articles, letters and reviews, as defined by Thomson Reuters. At the Swedish Research Council, the Thomson Reuters' publication type *letter* is re-classified and grouped, and normalized together with the original research articles, since letters can contain significant findings and can be well cited in some scientific areas. We use the data cleaning techniques developed at the Swedish Research Council[25].

Bibliometric indicators play a crucial role in most rankings; and especially the Leiden Ranking, which is entirely based on publication and citation indicators. A main challenge when constructing these rankings, however, involves the allocation of publications at institution levels. The allocation is based on the information given in the author addresses in each publication. In these addresses, a particular institution name may be spelled in a variety of different ways or it may be lacking entirely. In consequence, it is difficult to provide a correct and reliable allocation of articles at the institution level. Knowledge of countries' research systems is required in order to do this in a satisfactory way. All the examples below are addresses that belong to the University of Oslo (Norway) but would most likely not have been picked up by outsiders:

- Arne Naess Ctr Ecol & Philosophy, Oslo, Norway
- IASAM, Inst Gen Practice & Prevent Med, Oslo, Norway
- Fredrik Holsts Hus, Sect Med Eth, N-0318 Oslo, Norway
- Akershus Fac Div, Akershus, Norway
- Hlth Econ Res Programme Oslo, Ctr Hlth Adm, NO-0027 Oslo, Norway

The data cleaning method developed in Sweden has been an important asset to this report, and offers a good approach to handling the address difficulties seen above. Network members from each country have manually checked all addresses from their respective countries and assigned them to the relevant universities and university hospitals, according to a set of rules developed in Sweden. This has enabled the network to get a complete picture of the universities' research than would have been possible if data were retrieved by researchers from outside the Nordic countries, as they would not have similar knowledge of the institutions and 'hidden content' in many of the hard-to-identify addresses, used by the universities over a ten-year period.

The 248 journal subject classes used by Thomson Reuters have been grouped into 8 main subject groups (see Appendix 2): Agriculture, Fisheries & Forestry (includes 14 subject classes), Biology (13 subjects), Biomedicine (17 subjects), Chemistry (10 subjects), Engineering & Materials Sciences (45 subjects), Geosciences (8 subjects), Health Sciences[26] (59 subjects), and Physics & Mathematics (17 subjects). There are also 65 subject classes from Social Sciences and Humanities, as well as some multidisciplinary subjects that have been left out of the report. One methodological difficulty of comparing countries by the eight subject fields used here, or indeed by using any such grouping of subjects, is that there may be large variations within each subject field. This is particularly significant in the subject field *Agriculture, Fisheries & Forestry,* which has different meaning for the Nordic countries.

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24 Certain data included herein are derived from the Science Citation Index Expanded, Social Science Citation Index and Arts & Humanities Citation Index, prepared by Thomson Reuters®, Philadelphia, Pennsylvania, USA, © Copyright Thomson Reuters® 2010. All rights reserved.

25 A full documentation of the Swedish Research Council database, data cleaning procedures and indicator calculations can be found in Kronman et al. (2010).

26 Health Sciences includes the subject area Psychology.

Table A.1: Proportion of Agriculture, Fisheries & Forestry fields in the Nordic countries

Agriculture, Fisheries & Forestry	Denmark	Finland	Iceland	Norway	Sweden
Agricultural Economics & Policy	0.2 %	0.2 %	0.6 %	0.4 %	0.2 %
Agricultural Engineering	1.8 %	1.1 %	0.0 %	0.6 %	1.5 %
Agriculture, Dairy & Animal Science	10.2 %	4.4 %	5.1 %	7.3 %	5.5 %
Agriculture, Multidisciplinary	3.3 %	4.2 %	3.3 %	1.9 %	1.9 %
Agronomy	3.7 %	1.9 %	0.7 %	2.3 %	3.0 %
Environmental Sciences	19.5 %	26.7 %	14.8 %	23.1 %	29.6 %
Fisheries	4.2 %	3.3 %	26.5 %	19.5 %	2.2 %
Food Science & Technology	17.2 %	12.0 %	16.6 %	11.9 %	7.2 %
Forestry	2.8 %	22.0 %	5.7 %	4.6 %	10.6 %
Horticulture	1.7 %	0.9 %	0.0 %	1.5 %	0.9 %
Plant Sciences	11.0 %	10.7 %	6.0 %	9.7 %	16.2 %
Soil Science	5.7 %	3.8 %	2.8 %	3.3 %	4.5 %
Veterinary Sciences	14.5 %	6.1 %	13.0 %	10.0 %	11.9 %
Water Resources	4.0 %	2.7 %	5.0 %	4.0 %	4.8 %
Total	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**	**100.0 %**

Table A.1 illustrates how the dominant themes in Agriculture, Fisheries & Forestry differ in the Nordic countries. As expected, Fisheries is Iceland's largest sub-field (26%) and Norway's second largest (19%), but is of limited importance in Denmark, Finland and Sweden. Similarly, Forestry is an important sub-field in Finland (22%) and Sweden (11%), but is less so in the other countries. Environmental Sciences; Food Science and Technology; Plant Sciences and Veterinary Sciences all make large contributions to this broad area in all Nordic countries, although to varying degree. To very roughly summarize the key differences within Agriculture, Fisheries & Forestry, it can be said that Denmark is more focused on food; Finland on forestry, Iceland and Norway on fish, and Sweden on plant sciences, while all countries share an interest in Environmental Sciences.

Many publications are nationally or internationally co-authored, and are the results of collaborative efforts involving more than one university. Different principles and counting methods can be applied in bibliometric studies to deal with this. The most common is 'whole' counting, i.e. with no fractional attribution of credit (every university gets full credit for all papers co-authored with another institution). An alternative is fractionalized counting where the credit is divided equally between all the contributing author addresses. For example, if an article has one author address from Aarhus University and one from Aalborg University, each university will receive a value of 0.5 papers. One can argue that these counting methods are complementary: the whole or integer count gives the number of papers in which the university 'participated'. We apply a fractionalized counting scheme where all the basic units (addresses) in a publication share 1 credit, and where a university gets 1 fraction each time it appears in the address list. For example, in an article with 3 addresses from the University of Helsinki, 1 from Lund University and 1 from Harvard University, the University of Helsinki receives 3/5, Lund University 1/5 and Harvard 1/5 of the credit for the article. Citations to the articles are allocated in the same way.

A fractional count gives a sense of the number of papers 'creditable' to the university, assuming that all authors made equal contributions to a co-authored paper, and that all contributions add up to one (Moed, 2005). Contrary to most large-scale national bibliometric analyses, we apply fractionalized counting. The figures in our report will therefore deviate from some other published indicators, such as those presented in institutional reports, which are often based on whole counts of each university's contributions to nationally and internationally co-authored articles. The number of publications is much lower when each university only receives its fractionalized share of each publication[27]. This also holds for the citation indicators (Chapter 5).

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27   When whole counts are used, a university with a high share of national or international co-publications will have a higher publication count than a university with a low share of external co-publications, all other things being equal.

Another note of caution relates to small data sets, which are more vulnerable to fluctuations due to larger variability. Highly skewed distributions, which are common in bibliometrics, influence relative citation rates, meaning that a few highly cited papers can influence average citation rates considerably, especially when the data set is small. Changes in small research areas or at small universities may be more visible, but less important. Increases and decreases in publication and citation patterns may also be influenced by changes in the selection of journals indexed in the citation databases, which determines the 'world size' of the research area.

University hospitals

During the address matching, we decided to include the university hospitals, but kept separate tags for them. Many medical doctors have dual positions; they carry out research both in the hospital and at the university. However, university hospitals are separate units, often with different funding systems, and should be kept apart as far from analysis of standard universities as possible. Some of the university hospitals were aggregated into groups according to Table A.2.

Table A.2: University hospitals included in the report

Country	University	Affiliated hospitals
Denmark	Aarhus University	Aarhus University Hospitals[1]
	University of Copenhagen	Copenhagen University Hospitals[2]
	University of Southern Denmark	Odense University Hospitals[3]
Finland	University of Helsinki	Helsinki University Central Hospital[4]
	University of Kuopio	Kuopio University Hospital[5]
	University of Oulu	Oulu University Hospital
	University of Tampere	Tampere University Hospital[6]
	University of Turku	Turku University Hospital[7]
Iceland	University of Iceland	Landspitali University Hospital
Norway	Norwegian University of Science and Technology	St. Olavs Hospital
	University of Bergen	Haukeland University Hospital
		Stavanger University Hospital
	University of Oslo	Akershus University Hospital
		Diakonhjemmet Hospital
		Oslo University Hospital
	University of Tromsø	University Hospital North Norway
Sweden	Karolinska Institutet	Karolinska University Hospital
	Linköping University	Linköping University Hospital
	Lund University	Skåne University Hospital
		Malmö University Hospital
	Sahlgrenska University	Sahlgrenska University Hospital
	Umeå University	Norrland's University Hospital
	Uppsala University	Uppsala University Hospital

[1] Aarhus University Hospitals include: Amtssygehuset, Børne- og Ungdomspsykiatrisk Hospital, Kommunehospitalet, Marselisborg Hospital, Psykiatrisk Hospital Risskov, Skejby Sygehus, Århus Sygehus, Aalborg Psykiatriske Sygehus, Aalborg Sygehus.
[2] Copenhagen University Hospitals include: Amager, Bispebjerg, Frederiksberg, Gentofte, Glostrup, Herlev, Hillerød (Hørsholm), Holbæk, Hovedstaden Psykiatri, Hvidovre, Kommunehospitalet, Køge, Næstved, Rigshospitalet, Roskilde, Sct. Hans.
[3] Odense University Hospitals include: Odense Universitetshospital, Svenborg sygehus.
[4] Helsinki University Central Hospital includes: Aurora Hospital, Children's Castle, Children's Hospital, Department of Oncology, Eye and Ear Hospital, Hospital for Children and Adolescents, Jorvi Hospital, Kätilöopisto Maternity Hospital, Meilahti Tower Hospital, Peijas Hospital, Psychiatrycenter, Skin and Allergy Hospital, Surgical Hospital, Töölö Hospital and Women's Hospital.
[5] Kuopio University Hospital includes: Puijo Hospital, Alava Hospital, Julkula Hospital and Tarina Hospital.
[6] Tampere University Hospital includes: Tampere University Central Hospital, Pitkäniemi Hospital, Lahti Radiotherapy Unit, and Heart Center.
[7] Turku University Hospital includes: Surgical Hospital in Turku, Raisio Hospital and Paimio Hospital.

Self-citations

The citation analyses in this report are based on citation data where self-citations have been excluded. Author names in the citing and the cited publications are compared and a citation is considered a self-citation and excluded if any of the names are the same in the publication (see Kronman et al., 2010, for more details).

There are large differences in (field normalized) self-citations for some universities, but overall the difference is relatively small for the whole Nordic dataset (1.8%). It seems Nordic researchers have a stronger tendency to cite themselves compared to the world average self-citation rate. In Table A.3 we describe the differences in mean citation rates with and without self-citations. As can be seen in the Table A.3, most universities have citation rates that increase slightly when self-citations are included, but only a few universities have a large increase in their citation rates due to self-citations. This is particularly evident in some of the smaller universities; and less so in the larger universities.

Table A.3: Mean citation rates in universities and university hospitals with and without self-citations

	Citation rate incl. self-citation	Citation rate excl. self-citation	Difference
Denmark	**1.28**	**1.27**	**0.01**
Aalborg University	1.10	1.03	0.07
Aarhus University	1.37	1.38	-0.01
Roskilde University	1.17	1.12	0.05
Technical University of Denmark	1.40	1.40	0.00
University of Copenhagen	1.24	1.23	0.01
University of Southern Denmark	1.25	1.22	0.03
Aarhus University Hospitals	1.09	1.07	0.02
Copenhagen University Hospitals	1.36	1.33	0.03
University of Southern Denmark Hospitals	0.97	0.97	0.00
Finland	**1.08**	**1.05**	**0.03**
Aalto University	1.11	1.10	0.01
Åbo Akademi University	1.13	1.09	0.04
Lappeenranta University of Technology	0.87	0.84	0.03
Tampere University of Technology	0.90	0.84	0.06
University of Eastern Finland	1.06	0.98	0.08
University of Helsinki	1.22	1.18	0.04
University of Jyväskylä	1.13	1.08	0.05
University of Oulu	0.91	0.87	0.04
University of Tampere	1.00	0.96	0.04
University of Turku	1.04	0.96	0.08
Helsinki University Central Hospital	1.15	1.14	0.01
Kuopio University Hospital	1.07	1.05	0.02
Oulu University Hospital	0.88	0.89	-0.01
Tampere University Hospital	0.93	0.92	0.01
Turku University Hospital	1.01	1.03	-0.02
Iceland[1]	**1.12**	**1.11**	**0.01**
Reykjavik University[2]	-	-	-
University of Akureyri[2]	-	-	-
University of Iceland	1.07	1.05	0.02
Landspitali University hospital	1.31	1.38	-0.07

[1] Includes the publications/citations from Reykjavik University and University of Akureyri.
[2] Citation statistics not calculated because of too few publications/citations.

	Citation rate incl. self-citation	Citation rate excl. self-citation	Difference
Norway	**1.12**	**1.08**	**0.04**
Norwegian University of Life Sciences	1.12	1.09	0.03
Norwegian University of Science and Technology	1.09	1.07	0.02
University of Bergen	1.16	1.11	0.05
University of Oslo	1.13	1.11	0.02
University of Stavanger	1.02	0.75	0.27
University of Tromsø	1.09	1.04	0.05
St. Olavs Hospital	1.06	1.07	-0.01
University Hospital North Norway	1.02	1.02	0.00
University of Bergen Hospitals	1.11	1.04	0.07
University of Oslo Hospitals	1.13	1.11	0.02
Sweden	**1.14**	**1.13**	**0.01**
Chalmers University of Technology	1.12	1.10	0.02
Karlstad University	0.76	0.73	0.03
Karolinska Institutet	1.21	1.21	0.00
Linköping University	1.03	1.02	0.01
Linnaeus University	0.83	0.81	0.02
Luleå University of Technology	0.83	0.81	0.02
Lund University	1.19	1.18	0.01
Mid Sweden University	0.88	0.81	0.07
Royal Institute of Technology	1.09	1.08	0.01
Stockholm University	1.35	1.36	-0.01
Swedish University of Agricultural Sciences	1.20	1.21	-0.01
Umeå University	1.16	1.11	0.05
University of Gothenburg	1.11	1.11	0.00
Uppsala University	1.12	1.08	0.04
Örebro University	1.14	1.14	0.00
Karolinska University Hospital	1.18	1.19	-0.01
Linköping University Hospital	1.00	1.03	-0.03
Norrland's University Hospital	1.04	1.07	-0.03
Sahlgrenska University Hospital	1.20	1.19	0.01
Skåne University Hospital	1.06	1.04	0.02
Uppsala University Hospital	1.10	1.09	-0.01
Total all countries	**1.16**	**1.14**	**0.02**

Appendix 2: Main Subject Areas

Among 248 subject classes used by Thomson Reuters, 183 were grouped into 8 main groupings for our analyses. The remaining 65 subject classes were not used, as they are within Social Sciences and Humanities (see: http://science.thomsonreuters.com/mjl/scope/)

Code	Thomson name	NORIA subject
AD	Agriculture, Dairy & Animal Science	AGRICULTURE, FISHERIES & FORESTRY
AE	Agricultural Engineering	AGRICULTURE, FISHERIES & FORESTRY
AF	Agricultural Economics & Policy	AGRICULTURE, FISHERIES & FORESTRY
AH	Agriculture, Multidisciplinary	AGRICULTURE, FISHERIES & FORESTRY
AM	Agronomy	AGRICULTURE, FISHERIES & FORESTRY
DE	Plant Sciences	AGRICULTURE, FISHERIES & FORESTRY
JA	Environmental Sciences	AGRICULTURE, FISHERIES & FORESTRY
JU	Fisheries	AGRICULTURE, FISHERIES & FORESTRY
JY	Food Science & Technology	AGRICULTURE, FISHERIES & FORESTRY
KA	Forestry	AGRICULTURE, FISHERIES & FORESTRY
MU	Horticulture	AGRICULTURE, FISHERIES & FORESTRY
XE	Soil Science	AGRICULTURE, FISHERIES & FORESTRY
ZC	Veterinary Sciences	AGRICULTURE, FISHERIES & FORESTRY
ZR	Water Resources	AGRICULTURE, FISHERIES & FORESTRY
BD	Biodiversity Conservation	BIOLOGY
CU	Biology	BIOLOGY
CX	Biology, miscellaneous	BIOLOGY
GU	Ecology	BIOLOGY
HT	Evolutionary Biology	BIOLOGY
HY	Developmental Biology	BIOLOGY
IY	Entomology	BIOLOGY
OU	Limnology	BIOLOGY
PI	Marine & Freshwater Biology	BIOLOGY
RQ	Mycology	BIOLOGY
TA	Ornithology	BIOLOGY
WF	Reproductive Biology	BIOLOGY
ZM	Zoology	BIOLOGY
AY	Anatomy & Morphology	BIOMEDICINE
CO	Biochemical Research Methods	BIOMEDICINE
CQ	Biochemistry & Molecular Biology	BIOMEDICINE
CT	Cell & Tissue Engineering	BIOMEDICINE
DA	Biophysics	BIOMEDICINE
DB	Biotechnology & Applied Microbiology	BIOMEDICINE
DR	Cell Biology	BIOMEDICINE
DX	Chemistry, Medicinal	BIOMEDICINE
FQ	Cytology & Histology	BIOMEDICINE
KM	Genetics & Heredity	BIOMEDICINE
MC	Mathematical & Computational Biology	BIOMEDICINE
NI	Immunology	BIOMEDICINE

QU	Microbiology	BIOMEDICINE
RA	Microscopy	BIOMEDICINE
RU	Neurosciences	BIOMEDICINE
TI	Parasitiology	BIOMEDICINE
TU	Pharmacology & Pharmacy	BIOMEDICINE
UM	Physiology	BIOMEDICINE
DW	Chemistry, Applied	CHEMISTRY
DY	Chemistry, Multidisciplinary	CHEMISTRY
EA	Chemistry, Analytical	CHEMISTRY
EC	Chemistry, Inorganic & Nuclear	CHEMISTRY
EE	Chemistry, Organic	CHEMISTRY
EI	Chemistry, Physical	CHEMISTRY
FI	Crystallography	CHEMISTRY
HQ	Electrochemistry	CHEMISTRY
UY	Polymer Science	CHEMISTRY
XQ	Spectroscopy	CHEMISTRY
AC	Automation & Control Systems	ENGINEERING & MATERIALS SCI.
AI	Engineering, Aerospace	ENGINEERING & MATERIALS SCI.
EP	Computer Science, Artificial Intelligence	ENGINEERING & MATERIALS SCI.
ER	Computer Science, Cybernetics	ENGINEERING & MATERIALS SCI.
ES	Computer Science, Hardware & Architecture	ENGINEERING & MATERIALS SCI.
ET	Computer Science, Information Systems	ENGINEERING & MATERIALS SCI.
EV	Computer Science, Interdisciplinary Applications	ENGINEERING & MATERIALS SCI.
EW	Computer Science, Software Engineering	ENGINEERING & MATERIALS SCI.
EX	Computer Science, Theory & Methods	ENGINEERING & MATERIALS SCI.
FA	Construction & Building Technology	ENGINEERING & MATERIALS SCI.
ID	Energy & Fuels	ENGINEERING & MATERIALS SCI.
IF	Engineering, Multidisciplinary	ENGINEERING & MATERIALS SCI.
IG	Engineering, Biomedical	ENGINEERING & MATERIALS SCI.
IH	Engineering, Environmental	ENGINEERING & MATERIALS SCI.
II	Engineering, Chemical	ENGINEERING & MATERIALS SCI.
IJ	Engineering, Industrial	ENGINEERING & MATERIALS SCI.
IK	Engineering, Manufacturing	ENGINEERING & MATERIALS SCI.
IL	Engineering, Marine	ENGINEERING & MATERIALS SCI.
IM	Engineering, Civil	ENGINEERING & MATERIALS SCI.
IO	Engineering, Ocean	ENGINEERING & MATERIALS SCI.
IP	Engineering, Petroleum	ENGINEERING & MATERIALS SCI.
IQ	Engineering, Electrical & Electronic	ENGINEERING & MATERIALS SCI.
IU	Engineering, Mechanical	ENGINEERING & MATERIALS SCI.
IX	Engineering, Geological	ENGINEERING & MATERIALS SCI.
JI	Ergonomics	ENGINEERING & MATERIALS SCI.
NS	Nanoscience & Nanotechnology	ENGINEERING & MATERIALS SCI.
OA	Instruments & Instrumentation	ENGINEERING & MATERIALS SCI.
PE	Operations Research & Management Science	ENGINEERING & MATERIALS SCI.
PJ	Materials Science, Paper & Wood	ENGINEERING & MATERIALS SCI.
PK	Materials Science, Ceramics	ENGINEERING & MATERIALS SCI.
PM	Materials Science, Multidisciplinary	ENGINEERING & MATERIALS SCI.
PU	Mechanics	ENGINEERING & MATERIALS SCI.
PZ	Metallurgy & Metallurgical Engineering	ENGINEERING & MATERIALS SCI.

QE	Materials Science, Biomaterials	ENGINEERING & MATERIALS SCI.
QF	Materials Science, Characterization, Testing	ENGINEERING & MATERIALS SCI.
QG	Materials Science, Coatings & Films	ENGINEERING & MATERIALS SCI.
QH	Materials Science, Composites	ENGINEERING & MATERIALS SCI.
QJ	Materials Science, Textiles	ENGINEERING & MATERIALS SCI.
QM	Metallurgy & Mining	ENGINEERING & MATERIALS SCI.
RB	Robotics	ENGINEERING & MATERIALS SCI.
SR	Remote Sensing	ENGINEERING & MATERIALS SCI.
UE	Imaging Science & Photographic Technology	ENGINEERING & MATERIALS SCI.
YE	Telecommunications	ENGINEERING & MATERIALS SCI.
YQ	Transportation	ENGINEERING & MATERIALS SCI.
YR	Transportation Science & Technology	ENGINEERING & MATERIALS SCI.
ZQ	Mining & Mineral Processing	ENGINEERING & MATERIALS SCI.
GC	Geochemistry & Geophysics	GEOSCIENCES
KV	Geography, Physical	GEOSCIENCES
KY	Geology	GEOSCIENCES
LE	Geosciences, Multidisciplinary	GEOSCIENCES
QQ	Meteorology & Atmospheric Sciences	GEOSCIENCES
RE	Mineralogy	GEOSCIENCES
SI	Oceanography	GEOSCIENCES
TE	Paleontology	GEOSCIENCES
AQ	Allergy	HEALTH SCIENCES
AZ	Andrology	HEALTH SCIENCES
BA	Anesthesiology	HEALTH SCIENCES
BV	Psychology, Biological	HEALTH SCIENCES
DM	Oncology	HEALTH SCIENCES
DQ	Cardiac & Cardiovascular System	HEALTH SCIENCES
DS	Critical Care Medicine	HEALTH SCIENCES
EQ	Psychology, Clinical	HEALTH SCIENCES
FF	Emergency Medicine	HEALTH SCIENCES
FY	Dentistry, Oral Surgery & Medicine	HEALTH SCIENCES
GA	Dermatology	HEALTH SCIENCES
GM	Substance Abuse	HEALTH SCIENCES
HI	Psychology, Educational	HEALTH SCIENCES
HL	Health Care Sciences & Services	HEALTH SCIENCES
IA	Endocrinology & Metabolism	HEALTH SCIENCES
KI	Gastroenterology & Hepatology	HEALTH SCIENCES
LI	Geriatrics & Gerontology	HEALTH SCIENCES
LJ	Gerontology	HEALTH SCIENCES
MA	Hematology	HEALTH SCIENCES
MY	Psychology, Developmental	HEALTH SCIENCES
NE	Public, Environmental & Occupational Health	HEALTH SCIENCES
NN	Infectious Diseases	HEALTH SCIENCES
NQ	Psychology, Applied	HEALTH SCIENCES
OI	Integrative & Complementary Medicine	HEALTH SCIENCES
OO	Medical Ethics	HEALTH SCIENCES
OP	Medicine, Legal	HEALTH SCIENCES
PT	Medical Informatics	HEALTH SCIENCES
PW	Medical Laboratory Technology	HEALTH SCIENCES

PY	Medicine, General & Internal	HEALTH SCIENCES
QA	Medicine, Research & Experimental	HEALTH SCIENCES
RT	Clinical Neurology	HEALTH SCIENCES
RX	Neuroimaging	HEALTH SCIENCES
RZ	Nursing	HEALTH SCIENCES
SA	Nutrition & Dietetics	HEALTH SCIENCES
SD	Obstetrics & Gynecology	HEALTH SCIENCES
SU	Ophthalmology	HEALTH SCIENCES
TC	Orthopedics	HEALTH SCIENCES
TD	Otorhinolaryngology	HEALTH SCIENCES
TM	Pathology	HEALTH SCIENCES
TQ	Pediatrics	HEALTH SCIENCES
WC	Rehabilitation	HEALTH SCIENCES
VE	Psychiatry	HEALTH SCIENCES
WE	Respiratory System	HEALTH SCIENCES
WH	Rheumatology	HEALTH SCIENCES
VI	Psychology	HEALTH SCIENCES
VJ	Psychology, Multidisciplinary	HEALTH SCIENCES
VP	Psychology, Psychoanalysis	HEALTH SCIENCES
WQ	Psychology, Social	HEALTH SCIENCES
VS	Psychology, Mathematical	HEALTH SCIENCES
VX	Psychology, Experimental	HEALTH SCIENCES
VY	Radiology, Nuclear Medicine & Medical Imaging	HEALTH SCIENCES
XW	Sport Sciences	HEALTH SCIENCES
YA	Surgery	HEALTH SCIENCES
YO	Toxicology	HEALTH SCIENCES
YP	Transplantation	HEALTH SCIENCES
YU	Tropical Medicine	HEALTH SCIENCES
ZA	Urology & Nephrology	HEALTH SCIENCES
ZD	Peripheral Vascular Disease	HEALTH SCIENCES
ZE	Virology	HEALTH SCIENCES
AA	Acoustics	PHYSICS & MATH
BU	Astronomy & Astrophysics	PHYSICS & MATH
DT	Thermodynamics	PHYSICS & MATH
PN	Mathematics, Applied	PHYSICS & MATH
PO	Mathematics, Interdisciplinary Applications	PHYSICS & MATH
PQ	Mathematics	PHYSICS & MATH
RY	Nuclear Science & Technology	PHYSICS & MATH
SY	Optics	PHYSICS & MATH
UB	Physics, Applied	PHYSICS & MATH
UF	Physics, Fluids & Plasmas	PHYSICS & MATH
UH	Physics, Atomic, Molecular & Chemical	PHYSICS & MATH
UI	Physics, Multidisciplinary	PHYSICS & MATH
UK	Physics, Condensed Matter	PHYSICS & MATH
UN	Physics, Nuclear	PHYSICS & MATH
UP	Physics, Particles & Fields	PHYSICS & MATH
UR	Physics, Mathematical	PHYSICS & MATH
XY	Statistics & Probability	PHYSICS & MATH

Appendix 3: The universities contribution to the national level

Table A.4 – A.8 provides two types of information at the national level. First, it shows each university/university hospital's contribution to the scientific output within the eight subject fields; second, it shows each university/university hospital's contribution to the total publication output for their respective country (in the column Total). The darker the color, the larger is the contribution of each university (or hospital) to the national publication output, both within each subject area, and in terms of the national level output in total.

Table A.4: Danish universities and university hospitals' share of the publication volume (fractionalized) in 2005-2009 within each subject area (size level reflected by darkness of colour)

Danish universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
Aalborg University	7 %	1 %	4 %	3 %	22 %	1 %	2 %	6 %	5 %
Aarhus University	28 %	30 %	16 %	24 %	10 %	23 %	10 %	24 %	17 %
Roskilde University	1 %	2 %	1 %	2 %	1 %	1 %	0 %	2 %	1 %
Technical University of Denmark	20 %	10 %	12 %	33 %	51 %	22 %	2 %	34 %	18 %
University of Copenhagen	40 %	44 %	36 %	24 %	9 %	48 %	19 %	26 %	27 %
University of Southern Denmark	2 %	6 %	9 %	12 %	4 %	4 %	7 %	7 %	7 %
Aarhus University Hospitals	0 %	1 %	6 %	0 %	2 %	0 %	19 %	0 %	8 %
Copenhagen University Hospitals	1 %	4 %	14 %	1 %	1 %	0 %	35 %	1 %	15 %
University of Southern Denmark Hospitals	0 %	0 %	2 %	0 %	0 %	0 %	5 %	0 %	2 %

The University of Copenhagen is the largest university in *Denmark* with 27% of the research output in the second period. The Technical University of Denmark and Aarhus University are the second and third largest universities with 18% and 17% respectively. In fourth place comes the conglomerate of Copenhagen University Hospitals, with 15% of the national production. Here, Rigshospitalet in Copenhagen emerges as by far the most significant institution in terms of output. The universities in Copenhagen and Aarhus have comparable profiles based on research output. They have a relatively high share of the national output in most fields indicating the diversity, size and also reflecting the age and status of these 'old' universities. On the surface the Technical University can be considered a specialized institution with a very strong emphasis on Engineering & Materials Sciences. However, as Table A.4 demonstrates, the Technical University actually has the largest research output in Denmark in Physics & Mathematics as well as Chemistry, making the university profile more complex. The 'youngest' universities in Denmark; Aalborg, Southern Denmark and Roskilde, have a low share of the overall research production. Please note that the present analysis is based on bibliographic data from the life, medical and natural sciences. These 'young' universities are characterized by a strong focus on the Social Sciences and Humanities. Nevertheless, these institutions, and Aalborg University in particular, have a strong research output in Engineering & Materials Sciences.

Table A.5: Finnish universities and university hospitals' share of the publication volume (fractionalized) in 2005-2009 within each subject area (size level reflected by darkness of colour)

Finnish universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%
Aalto University	4 %	1 %	3 %	16 %	34 %	4 %	1 %	27 %	11 %
Åbo Akademi University	3 %	3 %	4 %	13 %	8 %	2 %	1 %	2 %	4 %
Lappeenranta University of Technology	1 %	0 %	0 %	2 %	6 %	0 %	0 %	2 %	2 %
Tampere University of Technology	1 %	0 %	1 %	4 %	14 %	1 %	0 %	7 %	4 %
University of Eastern Finland	20 %	9 %	12 %	11 %	6 %	8 %	7 %	6 %	9 %
University of Helsinki	49 %	45 %	35 %	26 %	8 %	52 %	18 %	21 %	24 %
University of Jyväskylä	6 %	11 %	3 %	10 %	4 %	1 %	4 %	13 %	6 %
University of Oulu	7 %	11 %	8 %	7 %	10 %	25 %	7 %	10 %	9 %
University of Tampere	1 %	1 %	4 %	0 %	3 %	0 %	7 %	1 %	4 %
University of Turku	8 %	16 %	12 %	10 %	6 %	7 %	10 %	10 %	10 %
Helsinki University Central Hospital	0 %	2 %	8 %	0 %	1 %	0 %	21 %	0 %	9 %
Kuopio University Hospital	0 %	0 %	3 %	0 %	0 %	0 %	6 %	0 %	3 %
Oulu University Hospital	0 %	0 %	1 %	0 %	0 %	0 %	5 %	0 %	2 %
Tampere University Hospital	0 %	1 %	4 %	0 %	0 %	0 %	6 %	0 %	3 %
Turku University Hospital	0 %	0 %	2 %	0 %	0 %	0 %	5 %	0 %	2 %

The dominant position of the University of Helsinki in *Finnish* research is clearly demonstrated in Table A.5. In five of the eight subject fields under consideration, University of Helsinki holds the top position in terms of research output in Finland. In Geosciences, the University of Helsinki produces over half of all publications in Finland, and almost half in Agriculture, Fisheries & Forestry and Biology. Helsinki University Central Hospital is, by a narrow margin, the largest contributor to Health Sciences, just ahead of the University of Helsinki. The only other university that stands out as the most prolific in any particular fields is Aalto University, with its strong output in Engineering & Materials Sciences and Physics & Mathematics. The University of Turku show double digit figures in five subjects, reflecting its versatility.

Table A.6: Icelandic universities and university hospitals' share of the publication volume (fractionalized) in 2005-2009 within each subject area (size level reflected by darkness of colour)

Icelandic universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%
Reykjavik University	2 %	0 %	1 %	2 %	31 %	0 %	1 %	11 %	5 %
University of Akureyri	4 %	2 %	1 %	7 %	3 %	4 %	3 %	0 %	3 %
University of Iceland	89 %	95 %	73 %	88 %	63 %	96 %	47 %	88 %	68 %
Landspitali University hospital	6 %	3 %	24 %	3 %	2 %	0 %	49 %	1 %	25 %

In *Iceland,* there are two organizations responsible for producing over 90% of all publications in the table; the University of Iceland (with almost 70%) and the university hospital (with 25%). This indicates the importance of health research in this comparison. The university hospital has produced about one fourth of all the Biomedicine publications and about half of the publications related to Health Sciences in Iceland. The publication output of the other two universities is fairly low in most research areas, although the University of Reykjavik is visible in Engineering & Materials Sciences, and to a lesser extent, in Physics & Mathematics.

Table A.7: Norwegian universities and university hospitals' share of the publication volume (fractionalized) in 2005-2009 within each subject area (size level reflected by darkness of colour)

Norwegian universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%
Norwegian University of Life Sciences	42 %	14 %	5 %	3 %	2 %	3 %	0 %	1 %	5 %
Norwegian University of Science and Technology	17 %	18 %	12 %	35 %	57 %	12 %	9 %	32 %	20 %
University of Bergen	13 %	24 %	17 %	12 %	13 %	39 %	15 %	16 %	17 %
University of Oslo	15 %	26 %	32 %	38 %	18 %	33 %	24 %	43 %	27 %
University of Stavanger	2 %	1 %	1 %	2 %	5 %	2 %	1 %	1 %	2 %
University of Tromsø	11 %	15 %	9 %	8 %	2 %	11 %	6 %	5 %	7 %
St. Olavs Hospital	0 %	0 %	2 %	0 %	0 %	0 %	5 %	0 %	3 %
University Hospital North Norway	0 %	0 %	1 %	0 %	0 %	0 %	4 %	0 %	2 %
University of Bergen Hospitals	0 %	0 %	6 %	0 %	0 %	0 %	11 %	0 %	5 %
University of Oslo Hospitals	1 %	1 %	16 %	1 %	1 %	0 %	26 %	1 %	13 %

In *Norway*, the university hospitals contribute to 23% of the total production. Within Health Sciences they contribute to 46% and in Biomedicine 25%. Three universities (those in Oslo, Bergen, and the Norwegian University of Science and Technology) make a strong contribution to all subject areas, whereas the Norwegian University of Life Sciences has strong contributions concentrated in Agriculture, Fisheries & Forestry and Biology. The largest single contributor to a subject area is the Norwegian University of Science and Technology, which dominates publication output in Engineering & Materials Sciences (57%). In terms of overall size (measured by fractionalized publications), the University of Oslo is Norway's largest university (27% of all publications), followed by the Norwegian University of Science and Technology (20%) and the University of Bergen (17%).

Table A.8: Swedish universities and university hospitals' share of the publication volume (fractionalized) in 2005-2009 within each subject area (size level reflected by darkness of colour)

Swedish universities and university hospitals	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%
Chalmers University of Technology	2 %	1 %	2 %	11 %	19 %	4 %	0 %	13 %	5 %
Karlstad University	1 %	0 %	0 %	1 %	2 %	1 %	0 %	1 %	1 %
Karolinska Institutet	1 %	6 %	22 %	2 %	1 %	0 %	21 %	0 %	13 %
Linköping University	2 %	2 %	3 %	5 %	10 %	1 %	4 %	8 %	5 %
Linnaeus University	2 %	2 %	1 %	1 %	1 %	1 %	0 %	2 %	1 %
Luleå University of Technology	2 %	0 %	0 %	2 %	6 %	3 %	0 %	2 %	1 %
Lund University	13 %	19 %	15 %	18 %	13 %	17 %	10 %	14 %	13 %
Mid Sweden University	1 %	0 %	0 %	1 %	2 %	0 %	0 %	1 %	1 %
Royal Institute of Technology	4 %	1 %	3 %	17 %	24 %	7 %	1 %	22 %	8 %
Stockholm University	8 %	13 %	6 %	14 %	3 %	25 %	2 %	9 %	6 %
Swedish University of Agricultural Sciences	43 %	17 %	4 %	3 %	2 %	3 %	1 %	0 %	5 %
Umeå University	5 %	8 %	6 %	4 %	3 %	4 %	6 %	5 %	5 %
University of Gothenburg	6 %	13 %	9 %	5 %	3 %	12 %	9 %	5 %	7 %
Uppsala University	7 %	16 %	15 %	15 %	11 %	20 %	7 %	16 %	12 %
Örebro University	1 %	0 %	0 %	1 %	1 %	0 %	1 %	0 %	1 %
Karolinska University Hospital	0 %	1 %	6 %	0 %	0 %	0 %	11 %	0 %	5 %
Linköping University Hospital	0 %	0 %	1 %	0 %	0 %	0 %	2 %	0 %	1 %
Norrland's University Hospital	0 %	0 %	1 %	0 %	0 %	0 %	2 %	0 %	1 %
Sahlgrenska University Hospital	0 %	0 %	2 %	0 %	0 %	0 %	7 %	0 %	3 %
Skåne University Hospital	1 %	1 %	3 %	0 %	0 %	0 %	9 %	0 %	4 %
Uppsala University Hospital	0 %	0 %	2 %	0 %	0 %	0 %	5 %	0 %	2 %

In *Sweden,* the universities with an image of focusing on technology and a comprehensive engineering education (Chalmers University of Technology, Royal Institute of Technology, Linköping University and Luleå University of Technology) clearly dominate the subject fields related to engineering and natural sciences. There has, however, been a broadening of their publishing output in terms of subject fields, following a change of focus among these institutions. Similarly, Sweden's only exclusively medical university, Karolinska Institutet, is primarily publishing within the fields Biomedicine and Health Sciences, as would be expected. The more general universities, which tend to be larger institutions, have a distributed profile with publications within all fields. The largest relative contribution to the subject fields is made by the Swedish University of Agricultural Sciences in the Agriculture, Fisheries & Forestry field, with 43% of all Swedish output. The second largest percentage in the Swedish section of Table A.8 is the 25% contribution made to Geosciences from Stockholm University. There are also a number of universities contributing to 20-25% of the national output in different fields.

Appendix 4: Number of fractionalized publications (2005-2009)

Country, university	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Denmark	**2530.1**	**1406.7**	**4955.1**	**1742.9**	**2791.6**	**676.5**	**9114.8**	**2755**	**25973**
Aalborg University	189.6	13.5	211.1	49.7	607.1	9.8	164.7	176.8	1422
Aarhus University	702.2	429.1	795.7	426.0	271.7	158.2	953.3	667.1	4403
Roskilde University	29.4	26.8	45.8	42.9	38.4	7.9	24.6	46.3	262
Technical University of Denmark	514.3	145.6	595.7	574.2	1432.2	146.5	213.3	932.6	4554
University of Copenhagen	1016.0	615.4	1791.6	417.1	259.2	326.3	1749.4	719.4	6895
University of Southern Denmark	49.4	90.1	435.5	209.3	113.9	26.6	598.7	189.7	1713
Aarhus University Hospitals	12.0	20.8	296.8	7.9	44.6	0.5	1773.4	7.1	2163
Copenhagen University Hospitals	14.9	62.1	687.7	13.8	21.2	0.7	3184.2	15.6	4000
University of Southern Denmark Hospitals	2.3	3.3	95.2	2.0	3.3	0.0	453.2	0.4	560
Finland	**1602.8**	**1281.0**	**3734.7**	**1835.0**	**3645.9**	**452.3**	**7562.2**	**3020.8**	**23135**
Aalto University	56.7	12.1	115.1	290.3	1223.9	19.8	85.9	800.6	2605
Åbo Akademi University	52.2	32.9	131.4	232.9	284.8	10.5	80.3	70.0	895
Lappeenranta University of Technology	20.7	1.1	7.5	40.8	236.4	1.1	2.3	46.8	357
Tampere University of Technology	22.7	2.7	51.6	80.9	494.3	4.8	33.6	226.0	917
University of Eastern Finland	316.0	109.1	443.6	203.6	222.4	35.5	560.8	189.6	2081
University of Helsinki	781.6	581.7	1306.2	468.8	280.8	236.1	1325.7	643.4	5624
University of Jyväskylä	96.7	139.0	123.3	192.6	141.0	3.0	284.8	394.1	1374
University of Oulu	111.0	142.6	280.3	120.7	378.0	110.8	565.1	298.7	2007
University of Tampere	10.6	12.5	158.9	5.7	106.4	0.4	541.3	30.3	866
University of Turku	121.8	205.4	459.1	192.2	219.0	30.1	792.9	307.4	2328
Helsinki University Central Hospital	4.7	22.1	316.2	1.9	21.5	0.1	1621.0	4.0	1991
Kuopio University Hospital	3.3	5.3	109.8	1.6	12.0	0.0	468.5	4.3	605
Oulu University Hospital	0.6	5.1	31.6	0.6	6.9	0.1	358.3	2.4	406
Tampere University Hospital	2.3	7.4	137.8	1.9	13.0	0.0	472.5	1.8	637
Turku University Hospital	1.9	2.0	62.3	0.5	5.5	0.0	369.2	1.4	443
Iceland	**55.8**	**48.8**	**162.6**	**37.0**	**85.0**	**137.1**	**440.9**	**108.5**	**1075**
Reykjavik University	1.0	0.0	2.1	0.7	26.6	0.2	5.8	12.1	48
University of Akureyri	2.1	0.8	1.8	2.6	2.5	4.9	13.1	0.3	28
University of Iceland	49.4	46.4	118.9	32.6	53.9	131.8	206.8	95.4	735
Landspitali University hospital	3.3	1.6	39.8	1.1	2.0	0.2	215.2	0.7	264

Country, university	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Norway	**1083.3**	**1066.5**	**2532.5**	**955.4**	**1897.8**	**920.8**	**6822.6**	**1565.6**	**16844**
Norwegian University of Life Sciences	450.9	149.6	133.5	29.2	47.3	24.5	23.8	21.7	880
Norwegian University of Science and Technology	179.1	187.6	293.0	334.2	1081.3	109.9	634.7	500.0	3320
University of Bergen	144.0	255.3	432.0	112.4	250.2	359.6	1012.4	249.2	2815
University of Oslo	162.5	281.5	806.2	363.9	347.1	308.4	1629.3	673.9	4573
University of Stavanger	18.5	6.1	16.1	17.1	102.0	14.2	60.2	22.1	256
University of Tromsø	116.4	159.3	224.2	78.6	37.5	104.0	404.2	80.6	1205
St. Olavs Hospital	1.7	4.6	57.7	2.8	5.4	0.1	353.2	4.8	430
University Hospital North Norway	1.0	2.9	35.8	0.7	1.1	0.0	240.0	1.2	283
University of Bergen Hospitals	2.1	5.1	140.1	2.9	4.3	0.0	718.4	3.7	877
University of Oslo Hospitals	7.1	14.5	393.9	13.6	21.6	0.1	1746.4	8.4	2205
Sweden	**3058.0**	**2523.6**	**9166.7**	**3718.5**	**5958.8**	**1185.4**	**17910.5**	**6026.3**	**49548**
Chalmers University of Technology	76.0	14.9	140.3	400.7	1110.4	53.0	41.6	790.9	2628
Karlstad University	20.7	8.2	17.2	23.0	102.5	8.1	58.0	55.3	293
Karolinska Institutet	41.7	139.4	2029.4	85.9	60.4	0.8	3813.8	29.0	6200
Linköping University	68.8	40.3	291.3	170.0	568.0	10.6	767.3	504.4	2421
Linnaeus University	48.7	48.9	74.8	21.0	73.6	17.4	76.3	115.0	476
Luleå University of Technology	57.2	2.4	9.9	61.9	355.2	31.6	52.0	126.6	697
Lund University	394.4	480.7	1364.4	659.6	756.9	198.5	1770.4	868.3	6493
Mid Sweden University	37.9	12.2	13.0	20.4	102.7	4.7	63.2	48.5	303
Royal Institute of Technology	126.6	24.6	244.9	648.0	1436.4	87.9	110.2	1306.0	3985
Stockholm University	251.5	320.2	571.2	528.8	172.8	301.4	405.0	518.0	3069
Swedish University of Agricultural Sciences	1309.0	420.9	354.9	95.1	106.9	39.0	103.7	26.1	2456
Umeå University	163.7	205.9	537.2	158.2	174.6	51.0	996.7	306.3	2594
University of Gothenburg	176.5	317.5	729.1	193.4	166.9	141.1	1609.1	304.5	3701
Uppsala University	203.1	399.6	1396.1	570.4	646.1	237.6	1310.0	983.5	5746
Örebro University	38.7	8.5	32.6	37.7	53.4	2.2	179.8	19.8	373
Karolinska University Hospital	5.7	35.9	550.3	14.2	11.7	0.0	1987.9	3.1	2609
Linköping University Hospital	1.2	3.6	69.2	5.5	7.6	0.0	432.7	1.9	522
Norrland's University Hospital	1.0	2.2	55.2	2.4	8.6	0.1	363.3	0.1	433
Sahlgrenska University Hospital	9.8	9.9	191.8	6.8	11.5	0.4	1257.7	5.5	1493
Skåne University Hospital	18.2	19.8	261.5	10.6	22.7	0.0	1572.6	12.8	1918
Uppsala University Hospital	7.6	8.0	169.7	4.9	9.9	0.0	939.2	0.7	1140
Total	**8330.0**	**6326.6**	**20552.8**	**8288.8**	**14379.1**	**3372.1**	**41851.0**	**13476.2**	**116575**

Appendix 5: Relative Specialization Index (RSI) in 2005-2009
(Size level reflected by darkness of colour)

Country, university	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics
Denmark								
Aalborg University	0.31	-0.62	-0.01	-0.52	0.46	-0.63	-0.43	-0.10
Aarhus University	0.39	0.41	0.09	-0.07	-0.44	0.09	-0.14	0.00
Roskilde University	0.23	0.43	0.07	0.19	-0.04	0.01	-0.51	0.08
Technical University of Denmark	0.23	-0.12	-0.07	0.06	0.33	0.04	-0.72	0.15
University of Copenhagen	0.36	0.37	0.26	-0.30	-0.62	0.23	-0.06	-0.18
University of Southern Denmark	-0.42	0.13	0.25	0.05	-0.41	-0.32	0.10	-0.15
Aarhus University Hospitals	-0.85	-0.62	-0.05	-0.94	-0.77	-0.98	0.48	-0.96
Copenhagen University Hospitals	-0.90	-0.45	0.06	-0.94	-0.94	-0.99	0.47	-0.95
University of Southern Denmark Hospitals	-0.89	-0.72	0.06	-0.94	-0.93		0.48	-0.99
Finland								
Aalto University	-0.53	-0.79	-0.55	0.00	0.50	-0.59	-0.79	0.34
Åbo Akademi University	-0.09	-0.05	-0.02	0.40	0.34	-0.44	-0.52	-0.32
Lappeenranta University of Technology	-0.48	-0.86	-0.76	0.01	0.62	-0.81	-0.96	-0.07
Tampere University of Technology	0.37	-0.87	-0.46	-0.12	0.55	-0.70	-0.77	0.24
University of Eastern Finland	0.37	0.13	0.17	-0.06	-0.19	-0.27	-0.03	-0.25
University of Helsinki	0.33	0.43	0.21	-0.14	-0.52	0.17	-0.10	-0.14
University of Jyväskylä	0.00	0.43	-0.26	0.11	-0.21	-0.86	-0.16	0.31
University of Oulu	-0.12	0.27	-0.04	-0.30	0.09	0.30	-0.01	-0.01
University of Tampere	-0.70	-0.48	0.10	-0.89	-0.13	-0.97	0.37	-0.62
University of Turku	-0.14	0.37	0.13	-0.15	-0.25	-0.40	0.08	-0.07
Helsinki University Central Hospital	-0.94	-0.57	0.02	-0.98	-0.87	-1.00	0.48	-0.97
Kuopio University Hospital	-0.86	-0.65	0.09	-0.95	-0.78		0.46	-0.91
Oulu University Hospital	-0.96	-0.53	-0.32	-0.97	-0.80	-0.99	0.51	-0.92
Tampere University Hospital	-0.90	-0.55	0.18	-0.95	-0.77		0.44	-0.96
Turku University Hospital	-0.88	-0.80	-0.04	-0.98	-0.85		0.49	-0.96
Iceland								
Reykjavik University	-0.54		-0.56	-0.77	0.55	-0.75	-0.42	0.25
University of Akureyri	0.03	-0.20	-0.41	-0.08	-0.28	0.71	0.24	-0.89
University of Iceland	-0.02	0.21	0.03	-0.43	-0.37	0.71	-0.01	-0.08
Landspitali University hospital	-0.70	-0.74	0.00	-0.93	-0.91	-0.95	0.48	-0.97

Country, university	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics
Norway								
Norwegian University of Life Sciences	0.76	0.61	0.00	-0.54	-0.49	-0.03	-0.83	-0.72
Norwegian University of Science and Technology	-0.13	0.16	-0.26	-0.05	0.35	0.05	-0.20	0.00
University of Bergen	-0.16	0.38	0.01	-0.47	-0.28	0.62	0.11	-0.26
University of Oslo	-0.33	0.20	0.08	-0.17	-0.35	0.39	0.11	-0.01
University of Stavanger	0.02	-0.26	-0.41	-0.25	0.43	0.30	-0.10	-0.27
University of Tromsø	0.16	0.53	0.10	-0.26	-0.67	0.49	0.08	-0.39
St. Olavs Hospital	-0.90	-0.59	-0.06	-0.89	-0.85	-0.99	0.48	-0.86
University Hospital North Norway	-0.91	-0.59	-0.09	-0.95	-0.95		0.49	-0.95
University of Bergen Hospitals	-0.93	-0.75	0.03	-0.94	-0.94		0.48	-0.95
University of Oslo Hospitals	-0.91	-0.72	0.08	-0.90	-0.88	-1.00	0.47	-0.95
Sweden								
Chalmers University of Technology	-0.42	-0.76	-0.48	0.16	0.46	-0.19	-0.90	0.33
Karlstad University	0.00	-0.19	-0.44	-0.17	0.38	-0.04	-0.18	0.11
Karolinska Institutet	-0.82	-0.29	0.37	-0.78	-0.88	-0.99	0.36	-0.94
Linköping University	-0.42	-0.42	-0.11	-0.23	0.20	-0.74	0.05	0.16
Linnaeus University	0.19	0.43	0.02	-0.43	-0.01	0.10	-0.28	0.23
Luleå University of Technology	0.08	-0.84	-0.83	-0.11	0.53	0.21	-0.59	0.09
Lund University	-0.07	0.29	0.16	-0.05	-0.15	0.01	-0.03	-0.06
Mid Sweden University	0.28	-0.01	-0.56	-0.25	0.36	-0.31	-0.16	0.03
Royal Institute of Technology	-0.38	-0.74	-0.42	0.19	0.39	-0.15	-0.82	0.37
Stockholm University	0.08	0.44	0.10	0.22	-0.47	0.53	-0.37	0.06
Swedish University of Agricultural Sciences	0.77	0.62	-0.02	-0.48	-0.57	-0.31	-0.74	-0.87
Umeå University	-0.05	0.32	0.16	-0.29	-0.40	-0.21	0.14	-0.12
University of Gothenburg	-0.19	0.36	0.17	-0.36	-0.56	0.12	0.20	-0.29
Uppsala University	-0.33	0.26	0.23	-0.06	-0.17	0.16	-0.12	0.06
Örebro University	0.20	-0.28	-0.27	-0.05	-0.05	-0.66	0.25	-0.48
Karolinska University Hospital	-0.94	-0.50	0.16	-0.91	-0.94		0.45	-0.98
Linköping University Hospital	-0.93	-0.71	-0.07	-0.83	-0.83		0.48	-0.95
Norrland's University Hospital	-0.94	-0.78	-0.09	-0.90	-0.78	-0.98	0.49	-1.00
Sahlgrenska University Hospital	-0.83	-0.72	-0.08	-0.92	-0.91	-0.98	0.49	-0.95
Skåne University Hospital	-0.76	-0.60	-0.05	-0.91	-0.86		0.48	-0.92
Uppsala University Hospital	-0.83	-0.71	-0.01	-0.93	-0.90	-1.00	0.48	-0.99

The higher activity (compared to the world average) a university or university hospital has, the greener the color. The lower activity (compared to the world average), the more yellow the color is.

Appendix 6: Number of field normalized citations 2005-2008

Country, university	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Denmark	**2772**	**1493**	**4223**	**2010**	**2946**	**702**	**8857**	**3103**	**26106**
Aalborg University	203	14	121	30	494	4	110	215	1192
Aarhus University	745	511	598	756	365	149	914	796	4834
Roskilde University	32	20	33	28	30	12	22	60	236
Technical University of Denmark	615	174	614	676	1616	137	189	1111	5133
University of Copenhagen	1094	587	1552	312	311	347	1644	731	6578
University of Southern Denmark	52	85	532	181	70	53	525	156	1653
Aarhus University Hospitals	11	19	175	9	33	0	1561	15	1822
Copenhagen University Hospitals	18	79	540	13	21	0	3536	19	4226
University of Southern Denmark Hospitals	2	4	59	6	6	0	356	0	433
Finland	**1393**	**1177**	**2781**	**1425**	**2945**	**383**	**6617**	**2606**	**19326**
Aalto University	34	9	77	284	1104	14	61	697	2280
Åbo Akademi University	67	29	88	163	292	13	66	69	785
Lappeenranta University of Technology	10	1	4	30	177	1	1	17	239
Tampere University of Technology	23	2	34	56	326	3	18	155	619
University of Eastern Finland	254	89	311	108	168	38	526	132	1626
University of Helsinki	714	578	1105	456	292	212	1254	701	5311
University of Jyväskylä	73	114	55	145	105	2	199	452	1147
University of Oulu	73	121	195	48	235	76	471	156	1374
University of Tampere	7	9	96	2	67	0	467	10	658
University of Turku	122	186	306	130	138	24	692	197	1795
Helsinki University Central Hospital	6	22	279	0	12	0	1536	6	1861
Kuopio University Hospital	5	4	78	2	15	0	406	8	517
Oulu University Hospital	0	5	18	0	2	0	257	2	285
Tampere University Hospital	2	7	91	1	9	0	352	2	464
Turku University Hospital	2	2	44	0	2	0	311	1	363
Iceland	**65**	**36**	**171**	**22**	**87**	**122**	**350**	**58**	**911**
Reykjavik University			1	1	3	1	5	6	18
University of Akureyri	2	1	1	0	0	5	3	0	12
University of Iceland	60	34	92	21	82	114	141	52	596
Landspitali University hospital	4	1	76	0	1	1	201	0	285

Country, university	Agriculture, Fisheries & Forestry	Biology	Biomedicine	Chemistry	Engineering & Materials Sciences	Geosciences	Health Sciences	Physics & Mathematics	Total
Norway	**1049**	**976**	**1898**	**731**	**1537**	**786**	**5833**	**1530**	**14339**
Norwegian University of Life Sciences	433	125	91	22	47	14	15	19	766
Norwegian University of Science and Technology	154	160	269	237	840	42	510	560	2773
University of Bergen	127	217	326	88	262	376	846	202	2444
University of Oslo	146	297	618	288	287	268	1399	649	3952
University of Stavanger	18	3	10	4	51	3	40	9	139
University of Tromsø	147	157	137	77	31	82	280	63	974
St. Olavs Hospital	1	1	40	5	3	0	302	11	364
University Hospital North Norway	1	0	22	0	1	0	196	2	223
University of Bergen Hospitals	2	4	73	1	1	0	623	5	709
University of Oslo Hospitals	18	12	312	10	14	0	1620	10	1996
Sweden	**3164**	**2582**	**7424**	**3987**	**5473**	**1038**	**16211**	**5165**	**45044**
Chalmers University of Technology	71	10	85	361	1058	37	31	686	2339
Karlstad University	12	6	5	16	64	7	31	32	173
Karolinska Institutet	66	163	1903	62	67	1	3667	37	5966
Linköping University	59	40	179	166	479	10	562	472	1968
Linnaeus University	34	45	48	11	50	12	49	52	301
Luleå University of Technology	40	1	4	38	255	17	38	60	454
Lund University	393	482	1124	724	868	190	1399	1006	6185
Mid Sweden University	34	12	7	12	58	2	40	36	199
Royal Institute of Technology	101	16	171	670	1289	41	68	1099	3454
Stockholm University	306	333	537	838	196	340	336	429	3314
Swedish University of Agricultural Sciences	1369	445	229	88	103	53	69	11	2367
Umeå University	208	197	420	139	164	59	871	234	2293
University of Gothenburg	164	324	615	151	173	108	1488	237	3261
Uppsala University	174	414	1116	644	556	157	1162	735	4959
Örebro University	71	17	20	25	35	1	151	12	332
Karolinska University Hospital	13	33	448	17	5	0	2051	4	2572
Linköping University Hospital	1	6	39	2	3	0	387	2	440
Norrland's University Hospital	1	1	33	2	4	0	331	0	372
Sahlgrenska University Hospital	6	11	137	7	12	0	1291	4	1468
Skåne University Hospital	37	20	194	9	15	0	1355	16	1645
Uppsala University Hospital	6	6	110	5	19	0	833	1	980
Total	**8443**	**6263**	**16496**	**8175**	**12988**	**3031**	**37868**	**12462**	**105726**

Appendix 7: Field normalized citation rates (2005-2008) from national and international publications

Some numbers (from Iceland) have been excluded (due to small publication counts below the minimum threshold).

Country, university	Volume		Proportion international publications	Citation rate	
	Publications without international co-authors	Publications with international co-authors		Publications without international co-authors	Publications with international co-authors
Denmark	**13845**	**6731**	**33 %**	**1.19**	**1.43**
Aalborg University	768	394	34 %	0.93	1.22
Aarhus University	2175	1334	38 %	1.35	1.42
Roskilde University	150	59	28 %	1.11	1.17
Technical University of Denmark	2454	1203	33 %	1.38	1.45
University of Copenhagen	3334	2024	38 %	1.14	1.38
University of Southern Denmark	832	528	39 %	1.06	1.46
Aarhus University Hospitals	1293	407	24 %	0.97	1.39
Copenhagen University Hospitals	2473	702	22 %	1.22	1.73
University of Southern Denmark Hospitals	366	79	18 %	0.86	1.50
Finland	**13100**	**5380**	**29 %**	**0.97**	**1.23**
Aalto University	1494	578	28 %	1.01	1.33
Åbo Akademi University	496	224	31 %	1.06	1.16
Lappeenranta University of Technology	207	76	27 %	0.79	0.98
Tampere University of Technology	575	163	22 %	0.77	1.07
University of Eastern Finland	1237	427	26 %	0.93	1.12
University of Helsinki	2927	1573	35 %	1.10	1.32
University of Jyväskylä	707	355	33 %	1.03	1.18
University of Oulu	1086	498	31 %	0.81	0.98
University of Tampere	517	169	25 %	0.84	1.33
University of Turku	1240	630	34 %	0.91	1.06
Helsinki University Central Hospital	1260	370	23 %	1.03	1.52
Kuopio University Hospital	403	89	18 %	0.96	1.45
Oulu University Hospital	265	54	17 %	0.83	1.21
Tampere University Hospital	397	110	22 %	0.83	1.22
Turku University Hospital	288	65	18 %	0.93	1.47
Iceland	**459**	**365**	**44 %**	**0.77**	**1.53**
Reykjavik University	9	20	68 %	N/A	N/A
University of Akureyri	12	8	40 %	N/A	N/A
University of Iceland	311	256	45 %	0.81	1.34
Landspitali University hospital	126	81	39 %	0.72	2.40

Country, university	Volume		Proportion international publications	Citation rate	
	Publications without international co-authors	Publications with international co-authors		Publications without international co-authors	Publications with international co-authors
Norway	**8974**	**4252**	**32 %**	**0.98**	**1.30**
Norwegian University of Life Sciences	464	238	34 %	1.05	1.16
Norwegian University of Science and Technology	1842	746	29 %	0.94	1.40
University of Bergen	1340	862	39 %	0.99	1.30
University of Oslo	2270	1302	36 %	1.01	1.28
University of Stavanger	137	49	26 %	0.66	0.99
University of Tromsø	619	319	34 %	1.02	1.07
St. Olavs Hospital	264	78	23 %	0.89	1.67
University Hospital North Norway	166	52	24 %	0.97	1.19
University of Bergen Hospitals	493	187	28 %	0.94	1.32
University of Oslo Hospitals	1379	419	23 %	1.01	1.44
Sweden	**27200**	**12586**	**32 %**	**1.05**	**1.31**
Chalmers University of Technology	1483	651	31 %	1.05	1.21
Karlstad University	184	53	22 %	0.71	0.77
Karolinska Institutet	3065	1870	38 %	1.11	1.37
Linköping University	1437	493	26 %	0.98	1.13
Linnaeus University	281	90	24 %	0.78	0.93
Luleå University of Technology	396	164	29 %	0.76	0.92
Lund University	3452	1812	34 %	1.10	1.32
Mid Sweden University	198	46	19 %	0.74	1.13
Royal Institute of Technology	2149	1035	33 %	1.02	1.22
Stockholm University	1524	907	37 %	1.31	1.45
Swedish University of Agricultural Sciences	1266	691	35 %	1.18	1.27
Umeå University	1458	612	30 %	1.01	1.33
University of Gothenburg	2036	910	31 %	1.02	1.31
Uppsala University	3025	1555	34 %	1.03	1.19
Örebro University	211	80	28 %	0.99	1.52
Karolinska University Hospital	1530	632	29 %	1.08	1.46
Linköping University Hospital	368	60	14 %	0.98	1.34
Norrland's University Hospital	270	78	23 %	0.98	1.38
Sahlgrenska University Hospital	947	283	23 %	1.03	1.76
Skåne University Hospital	1196	385	24 %	0.94	1.36
Uppsala University Hospital	722	179	20 %	0.99	1.49
Total	**63577**	**29313**	**32 %**	**1.05**	**1.32**

Comparing Research at Nordic Universities using Bibliometric Indicators
A publication from the NORIA-net «Bibliometric Indicators for the Nordic Universities»

This report aims to demonstrate how bibliometric indicators can be used at the level of universities in the Nordic countries, in describing university performance in a more nuanced way than in the many international university rankings. In contrast to most such rankings, this report uses transparent methods and describes differences in university research profiles. Numbers are not used in this report to indicate rankings, but to represent real measurements and to give more specific information. The focus is on providing reliable and recognisable descriptions of similarities and differences in the institutions' activities, profiles, and impacts of research.

40 Nordic universities and 23 university hospitals are analysed in the period 2000-2009, making this report the most comprehensive and detailed bibliometric description of Nordic university research ever to be produced