NordForsk

Nordic Excellence

A Bibliometric Exploration of Common Nordic Research Funding Opportunities

NORDFORSK POLICY BRIEFS 2008-5

For NordForsk by
Technopolis Group

NordForsk

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A Bibliometric Exploration of Common Nordic Research Funding Opportunities

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Technopolis Group

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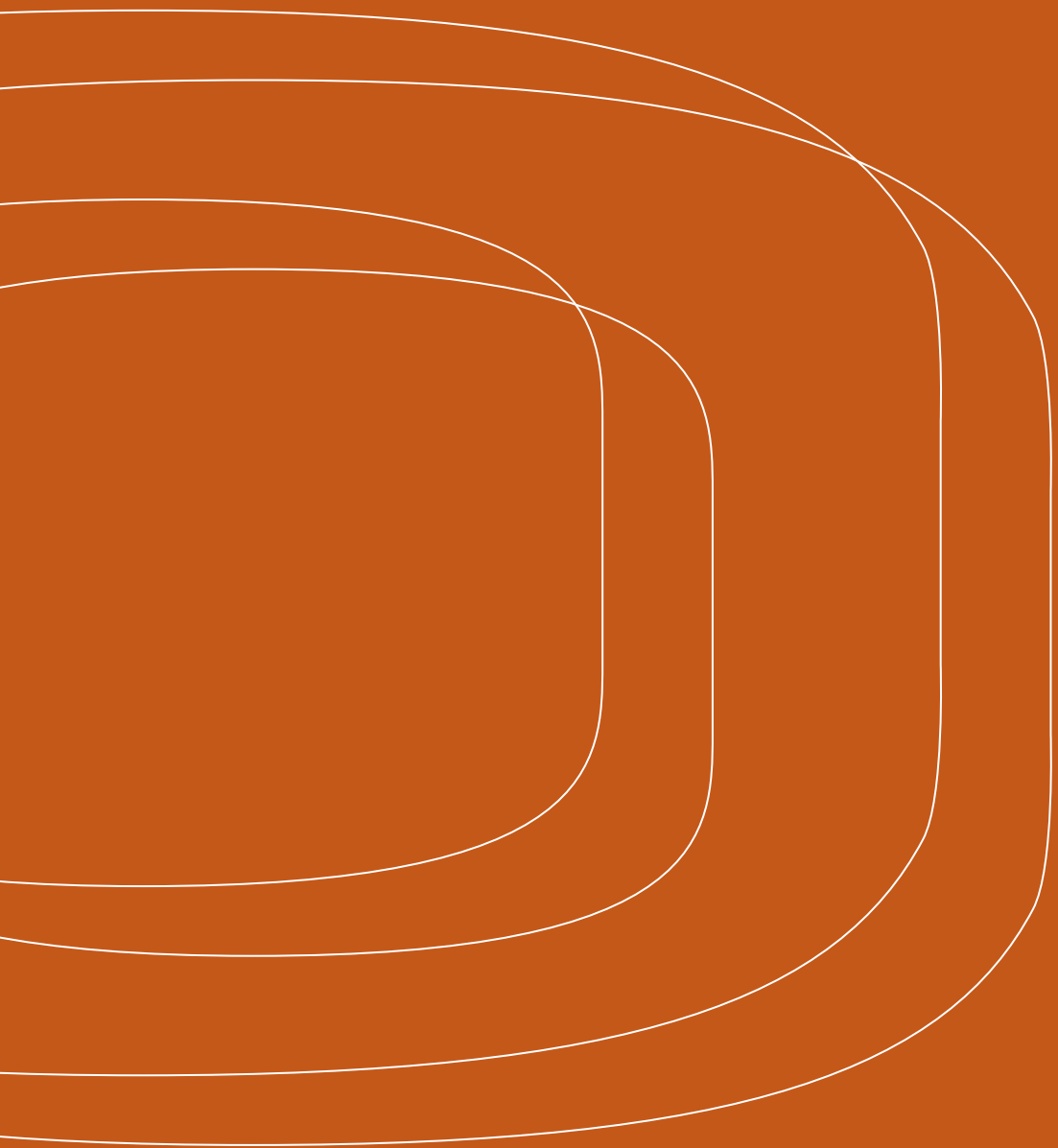

NordForsk Policy Briefs 5–2008

Nordic Excellence
A Bibliometric Exploration of Common Nordic
Research Funding Opportunities

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Sammanfattning

NordForsk

NordForsk är ett nordiskt forskningsråd under Nordiska ministerrådet som är ansvarigt för nordiskt samarbete inom forskning och forskarutbildning. NordForsk samordnar viktiga forskningsprioriteringar som har identifierats som lämpliga för en gemensam nordisk satsning och koncentrerar sina satsningar på områden där nordiska länder har en internationellt stark position. NordForsk har tre roller: samordning, finansiering och policyrådgivning. NordForsks mission är att befästa och vidareutveckla Norden som en av världens mest dynamiska regioner för forskning och innovation och därigenom förstärka de nordiska ländernas internationella konkurrenskraft samt befolkningens levnadsvillkor i regionen.

Studien

Målsättningen med denna studie är att identifiera sådana excellenta forskningsområden i Norden som har potential att ytterligare förstärkas genom användningen av gränsöverskridande finansieringsinstrument. Studien förser NordForsk med «strategisk kunskap» för verkställande av NordForsks vision.

Vi har identifierat såväl breda forskningsfält som mera specifika ämnesområden inom vilka nordisk forskning är stark. Därefter har vi föreslagit finansieringsprioriteringar. Vår studie baserar sig på bibliometriska analyser av publikationer under perioden 2001–04. Vi har kontrollerat att våra resultat inte motsägs av andra bibliometriska studier om Norden och att de är i samsvar med den erfarenhet som flertalet av de nordiska forskningsråden har. Bibliometriska studier har dock en del välkända begränsningar, speciellt gäller det bibliometriska indikatorer utanför det engelska språket inom samhällsvetenskap och humaniora. Bibliometri är också tillbakablickande och förmår inte att identifiera nyanser i utvecklingen av ett nytt forskningsfält. För att vara ett användbart bidrag till policyutvecklingen måste rapporten därför kompletteras med ytterligare kunskap och bedömningar. Rapporten ska ses som ett bidrag till debatten, snarare än ett definitivt policyuttalande.

Nordisk forskningsprestation mätt utifrån bibliometriska metoder

De nordiska länderna representerade 3.45 % av världens vetenskapliga produktion mellan 1999-2001, och 3.27 % mellan 2002–04. År 2004 stod Sverige för 1.38 %, medan Danmark och Finland vardera hade 0.71 %, Norge hade 0.44 % och Island 0.13 % av det totala antalet vetenskapliga publikationer på världsnivå. Med undantag av Island har de nordiska ländernas andelar minskat under perioden. Detta är inte förvånande eftersom antalet publicerande forskare i världen ökat.

På de åtta stora forskningsfält som har goda bibliometriska data är de nordiska publiceringsmönstren starkt orienterade mot biovetenskaperna. Medicin har flest publikationer. Samlat är de nordiska länderna mest specialiserade inom biologi; tillämpad biologi-ekologi; geovetenskap; rymdvetenskap och medicin. Specialiseringen ökar inom de tre första fälten, medan den minskar inom medicin. Faktum är att de nordiska ländernas världsandel av publikationer minskar snabbast inom medicin och kemi. Aggregerade publikationsdata kan inte avslöja eventuella enskilda nordiska exempel på briljans. Men dessa forskningsfält förefaller rätt mogna och de nordiska prestationerna verkar ha stagnerat.

NordForsk bad oss i denna studie identifiera de 10 starkaste ämnesområdena inom nordisk vetenskap från en förteckning över 170 ämneskategorier. Gallringen skedde genom att ämnesområdena rankades nationellt utgående från världsandel av publikationer. Därefter introducerade vi ett andra kriterium dvs att antalet publikationer måste överstiga 50 per år. Detta är inte endast ett konventionellt kriterium för att garantera kvaliteten på den bibliometriska analysen, utan även en metod för att utesluta mindre ämnesområden från analysen. (Island utgör här ett undantag, eftersom det totala antalet publikationer där är lågt.) Då ämnesområden med få publiceringar hade uteslutits, kunde vi se vilka de 20 största ämnesområdena i varje land var.

Genom en fyr-stegsmodell var det möjligt att identifiera de tio starkaste ämnesområdena för den nordiska regionen i sin helhet

- **Första steget:** ... filtrera ut ämnesområden med färre än tre nordiska länder: NordForsk ser samverkan som finansierbar om åtminstone tre av fem nordiska länder är inkluderade
- **Andra steget:** ... för att hitta de discipliner där Norden presterar bäst rankas disciplinerna baserat på genomslagsfaktorer - ett kriterium för att forskningen är framstående
- **Tredje steget:** ... ranka discipliner som passerat genom filtret, utgående från deras totala världsandel av publikationer, vilket är en indikator för kritisk massa
- **Fjärde steget:** ... kalkylera genomsnittet av dessa rankningar och identifiera de 10 högst rankade

Denna metod identifierar de tio största ämnesområden som är rimligt starka i åtminstone tre nordiska länder och har en god total kvalitet på forskningen och har en kritisk massa av forskare, vilket mätts med bibliometriska indikatorer. Vi har behandlat kvalitet och kritisk massa som lika viktiga indikatorer, istället för att ge den ena större vikt än den andra. Metoden är på vissa punkter rätt godtycklig (varför 10 fält, exempelvis, och inte 9 eller 11?), men dess fördel är dess enkelhet och den introducerar inte mer godtycklighet än nödvändigt. De 10 ämnesområden som identifierades genom denna analys är

- fiskeri
- obstetrik och gynekologi
- anestesiologi
- marin- och färskvattenbiologi
- ekologi
- idrottsvetenskap
- odontologi, oral kirurgi och medicin
- reumatologi
- offentlig-, miljö- och arbetshälsa
- miljövetenskap

Policyslutsatser

NordForsks målsättning är inte att upprätthålla den nordiska vetenskapens allmänna välfärd utan att investera i nordisk styrka. I denna studie har vi därför anlagt något av en investerares perspektiv med syftet att allokera resurser till utvalda områden med existerande eller sannolik styrka. Framtiden är naturligtvis oviss, vilket innebär att då NordForsk förverkligar sin övergripande finansieringsstrategi borde man använda en blandning av en toppstyrd finansieringsmetod som utgår ifrån strategisk kunskap, samt bottenstyrda instrument som tillåter områden med existerande eller framväxande styrka att uppdagas.

Utgående från vår analys har vi identifierat tre alternativa toppstyrda finansieringsstrategier

1. Enbart finansiera det bästa, med fokus på områden med existerande eller växande styrka
2. Satsa på lovande områden i sina begynnelsestadier, genom att leta efter positioner där de nordiska länderna kanske inte är starkast, men redan är någorlunda starka och där signaler visar på förbättringar och det därför finns möjligheter för NordForsk att främja utvecklingen
3. Förstärka etablerade områden som stagnerat

Valmöjlighet 1 återspeglar klart NordForsks målsättning. Om de relevanta ämnesområdena i alternativ 3 tenderar att vara stora och etablerade innebär att de skulle behöva en mycket stor insats för att återetableras. Dels finns det troligen starka interna orsaker till stagnation inom dessa ämnesområden, och dels har NordForsk begränsade medel. Därför framstår denna valmöjlighet som oattraktiv och reflekterar endast i mindre grad NordForsks målsättning. Valmöjlighet 2 är mer förenlig med målsättningen, men medför också mer osäkra investeringar än valmöjlighet 1. Vi menar att en livskraftig strategi kombinerar valmöjlighet 1 med utvalda investeringar enligt valmöjlighet 2, där sådana antas ge hög återbäring.

Vår analys av aggregerade övergripande forskningsfält pekar på att de största nordiska finansieringsmöjligheterna finns inom

- **Tillämpad biologi** och **geovetenskap** samt **rymdforskning** - regionen har inom dessa områden starka och växande andelar av publikationer, specialiseringen ökar och en ökad finansiering borde ha gott «inflytande» (det vill säga varje ytterligare publikation skapar en förhållandevis stor ökning av den nordiska andelen av världspublikationer)
- **Biologi** - Norden har starka och växande andelar av världspublikationer och den nordiska specialiseringen ökar, även om det tillgängliga «inflytandet» är lågt
- **Matematik** – Nordens position är blygsam, men håller på att stärkas och finansieringsinflytandet är högt

Alla tio ämnesområden är intressanta och potentiella investeringsområden eftersom de har passerat igenom en rigorös urvalsprocess. Vi har också undersökt närmare deras prestationer och nätverkskaraktär och jämfört dem med varandra. Förutom idén om ”finansieringsinflytande” har vi tagit hänsyn till eventuellt redan existerande nätverksrelationer mellan forskarna som en nordisk finansiering kan bygga vidare på.

Utgående från vår analys kan vi för NordForsk föreslå och motivera prioriteringsområden bland de 10 högst rangerade ämnen. Vi kunde undersöka utsträckningen av nätverk bland nordiska forskare inom ämnesområden (genom att undersöka antalet gemensamma publikationer) och därmed beakta möjligheter för NordForsk att bygga vidare på existerande nordiska nätverk.

- **Fiskeri** är den starkaste kandidaten. Norden har en stark och växande position, finansieringsinflytandet skulle vara stort och det finns redan ett nätverk av sammankopplade nordiska institutioner att bygga vidare på
- **Ekologi** är ett mindre tydligt fall. Fastän ämnesområdet är starkt, börjar det visa tecken på stagnation. Ämnesområdet har starka samarbetsnätverk som erbjuder en god bas för vidare samverkan
- **Idrottsvetenskap** är ett ganska ungt ämnesområde, inom vilket Norden håller på att bygga upp en styrka och redan har etablerat små men sammankopplade nätverk
- **Marin- och färskvattenbiologi** är ett växande fält med väletablerade nordiska nätverk som även kunde vara ett attraktivt investeringsalternativ

Rådande status för bibliometrisk data gör det omöjligt att i denna studie meningsfullt konkludera om finansieringsprioriteringar inom humaniora och samhällsvetenskap. För tillfället innebär det att våra policyrekommendationer är att finansiera dessa genom bottenstyrda instrument eller att aktivera koordineringen mellan de nationella forskningsråden för att prioritera mellan ämnesområdena.

Målet med denna studie har varit att skapa ett grundlag för en nordisk diskussion kring prioriteringar för samverkan i forskardriven forskning via NordForsk och de nationella forskningsråden i Norden. Såsom vi har indikerat är en bibliometrisk studie i sig inget grundlag för att göra sådana prioriteringar. Men vi menar att den är ett mycket användbart bidrag till diskussionen om gemensamma prioriteringar hos nordiska finansiärer, eftersom den tillhandahåller ett antal hypoteser om potentiellt attraktiva områden för finansiering. Följande steg kunde nu vara:

- Att initiera en öppen diskussion om möjligheterna för riktade utlysningar för gemensamma nordiska forskningsaktiviteter inom de ämnesområden (och möjligtvis även inom de övergripande forskningsfälten) som identifierats i denna rapport
- Att i diskussionen inkludera (a) forskningsrådens och andra intressenters uppfattningar om utvecklingsområden som på grund av bristfälligheten i våra bibliometriska indikatorer inte är medtagna i denna rapport och (b) motförslag om prioriteringar inom «hård» vetenskap. – Dessa förslag och motförslag ska dock stödjas med belägg
- Att bjuda in till förslag på alternativa instrument till NCoE modellen, vilken annars kommer att bli det naturliga sättet att förverkliga nordiskt forskningssamarbete inom de identifierade ämnesområdena
- Att i samråd med nationella forskningsråd identifiera sätt för att säkra att riktade utlysningar kommer att samfinansieras (om nödvändigt) nationellt, i enlighet med de regler som de nationella råden följer

Summary

NordForsk

NordForsk is a Nordic research board operating under the Nordic Council of Ministers for Education and Research; responsible for Nordic collaboration in research and research training. NordForsk coordinates important research priorities that have been identified as suitable for joint Nordic efforts, concentrating its efforts on research areas where the Nordic countries have an international position of strength. NordForsk has three roles: co-ordination, financing and policy advice. The mission of NordForsk is to strengthen and further develop the Nordic region as one of the most dynamic regions in the world for research and innovation and, thereby, enhance the international competitiveness of the Nordic countries and the living conditions of the populations in the region.

This Study

This study aims to provide 'strategic intelligence' about areas of research excellence in the Nordic area, where it might be possible to add value through the use of cross-border funding instruments. In line with the NordForsk vision, we have identified areas of Nordic research strength, first at the level of fields of science and then at a much more specific, sub-field level and suggested funding priorities. Our study is based on bibliometric analysis of publications in the period 2001-04. We have checked that our findings are not contradicted by other bibliometric work in the Nordic area and that the bibliometric analysis accords with the knowledge of most of the Nordic research councils. However, the reliance on bibliometrics does involve a number of well-known limitations, notably the poverty of bibliometric indicators outside the English language and the 'hard' sciences. Bibliometrics is also backwards looking and poor at picking up the nuances of how scientific fields develop. The report must therefore be complemented with other knowledge and judgements, so that it can form a useful input to policymaking. It should be seen as a contribution to a debate rather than as a definitive policy statement.

Nordic Research Performance, as Measured via Bibliometrics

The Nordic countries represented 3.45% of World scientific production in 1999–2001, and 3.27% in 2002–2004. Sweden had the greatest share of world scientific publications in 2004 with 1.38%. Denmark and Finland each held 0.71%, Norway had 0.44% and Iceland 0.13%. With the exception of Iceland, the overall world share of each of the Nordic countries has fallen across the period. This is not surprising, since the world population of publishing scientists is growing.

At the level of the eight large fields of science for which there are good bibliometric data, the Nordic publication pattern is strongly oriented towards life sciences. Medicine is the field with the greatest number of publications. The Nordic Countries collectively are most specialised in: Fundamental Biology; Applied Biology-ecology; Earth and Space Science; and Medicine. Spe-

cialisation is growing in the first three fields but declining in Medicine. In fact, the Nordic countries are losing share of world publications fastest in medicine and in chemistry. Aggregate publication data cannot tell us whether there are individual Nordic acts of brilliance in these fields, but overall they appear rather mature and Nordic performance is stagnating.

NordForsk asked us in this study to identify the 10 strongest sub-fields of Nordic science from a list of more than 170 subject categories. To do this, we ranked the sub-fields in each country, based on World share of publications. We then applied a second criterion: the number of publications should be greater than 50 per year, which is not only a conventional criterion for assuring the quality of bibliometric analysis but also a way to take small fields out of the analysis. (In the case of Iceland, the small overall numbers of publications means that we have had to relax the minimum number criterion, otherwise Iceland would effectively have been excluded from the analysis). Once the fields with few publications were eliminated, we could see which were the Top-20 sub-fields for each country.

The next step was to identify the Top-10 sub-fields for the Nordic region as a whole, using four steps

- **First step:** ...filtered out the fields where fewer than 3 Nordic countries made it into the analysis: cooperation is regarded as viable and fundable if a minimum of 3 of the 5 Nordic states are involved
- **Second step:** ...ranked the disciplines that passed through the filter, based on impact factors, to find those where the Nordic area did best, based on this excellence criterion
- **Third step**: ...ranked disciplines passing through the filter, based on their total share of world publications - using this as an indicator of critical mass
- **Fourth step:** ...calculated the average of these rankings and identified the 10 highest ranking

The Top-10 sub-fields which were identified using this method are therefore the ones where at least three Nordic countries are reasonably strong and where the overall quality of the research is good and there is a critical mass of researchers – as measured by bibliometric indicators. Of course, there is some arbitrariness in the method (why 10 fields, for example, and not 9 or 11?). However, it has the virtue of simplicity and it does not introduce more arbitrariness than is needed. Thus, we have treated quality and critical mass as equally important rather than judging one to deserve higher weight than the other. The 10 sub-fields that emerge from this analysis are

- Fisheries
- Obstetrics and Gynaecology
- Anaesthesiology
- Marine and Freshwater Biology
- Ecology
- Sports Sciences
- Dentistry, Oral Surgery and Medicine
- Rheumatology
- Public, Environmental and Occupational Health
- Environmental Sciences

Policy Implications

NordForsk's mission is not to maintain the overall health of Nordic science but to invest in Nordic Strength. We have therefore taken something of an investor's perspective in this study, aiming to focus resources on selected areas of established or likely strength. Of course, one cannot know or plan everything, so in implementing its overall funding strategy NordForsk should use a mixture of top-down funding approaches, guided by strategic intelligence, and bottom-up instruments that allow areas of actual or developing strength to reveal themselves.

Based on our analysis, we have identified three alternative top-down funding strategies:

1. Only fund the best, focusing on areas of established and growing strength
2. Build on promising beginnings, looking for positions where the Nordic countries may not be the strongest but are already fairly strong, where the signals are that there is improvement and therefore that there are opportunities for NordForsk to accelerate that movement
3. Reinvigorate established but stagnating areas

Option 1 is clearly in line with NordForsk's mission. Option 3 is less clearly so, given that the relevant fields tend to be large and established and that it would therefore take a lot of effort to revive them. NordForsk has rather limited means, and there are likely to be strong internal reasons for the stagnation in these fields, so this appears to be an unattractive option. Option 2 is more consistent with the mission, but also involves placing less certain investment bets than Option 1. We suggest that a viable strategy is to combine Option 1 with making selected investments under Option 2 that appear likely to have high returns.

At the level of large scientific fields, our analysis suggests that the major Nordic funding opportunities are in

- **Applied Biology and Earth and Space Sciences**, where the region has strong and rising shares of world publications, Nordic specialisation is increasing and increased funding should have fairly good 'leverage' (in the sense that each additional publication produces a comparatively large increase in the Nordic share of world publications)
- **Fundamental Biology**, where the region also has strong and rising shares of world publications and Nordic specialisation is increasing, though the 'leverage' available is low
- **Mathematics**, where the region's position is modest but strengthening and the funding leverage available is high

All the ten sub-fields are interesting potential investments, in so far as they have passed a rather rigorous selection process. We have, however, also looked in more detail at performance and network characteristics of these 10 sub-fields, comparing them with each other. We have employed not only the idea of 'funding leverage' but also considered whether there already are network relationships in place among researchers on which Nordic funding could build.

On this basis, we can make some suggestions for where and why to prioritise among the Top-10 sub-fields. At the sub-field level we were able to explore the extent of networking among Nordic researchers (using the proxy of co-publication) and therefore to take into account the extent to which Nordic investments can build upon existing networks.

- **Fisheries** is the strongest candidate. The Nordic area has a strong and strengthening position, funding leverage would be high and there already exists a core network of interconnected Nordic institutions on which to build
- **Ecology** is less of a clear-cut case. While it is strong it also shows early signs of stagnation. It has strong collaboration networks that offer a good basis for further cooperation
- **Sports Science** is a rather young sub-field, where the Nordic area is building strength and has already established small but connected networks
- **Marine and Freshwater Biology** is a strengthening field with good established Nordic networks that could also be an attractive investment

Given the current state of the art in bibliometrics, it is not possible to say anything meaningful about funding priorities in the humanities and social sciences in this study. For the time being, at least, this means that our policy recommendation is to fund these through bottom-up instruments or to use more active coordination among the national research councils as a way to prioritise among sub-fields.

The objective of this study was to provide a basis for a Nordic discussion about priorities for cooperation in researcher-driven research via NordForsk and the Nordic research councils. As we indicate, a bibliometric study is, on its own, no basis for setting such policy priorities. However we suggest that it is very useful as a way to inform a discussion of common priorities among Nordic funders, providing a set of hypotheses about potentially attractive areas for funding. Next steps include:

- Launching an open discussion about the opportunities to direct calls for joint Nordic research activities at least in the sub-areas (and possibly also in the larger fields) identified in this report
- Including in that discussion: (a) the views of member research councils and other stakeholders on areas of opportunity excluded from this report because inadequate bibliometric indicators are available and (b) counter-proposals for the 'hard' science – but require that such proposals and counter-proposals be supported with evidence
- Inviting suggestions for alternative instruments to the NCoE model, which otherwise will be the natural way to implement Nordic research collaborations in the sub-fields identified
- Identifying, in discussion with member councils, means to ensure that directed calls will be co-funded (if necessary) at the national level, given the rules under which the national councils operate

1. Introduction

NordForsk (the Nordic Research Board) was established in 2005 as an independent Nordic body for research coordination under the Nordic Council of Ministers of Education and Research. It is financed by the Nordic countries via the budget of the Nordic Council of Ministers, has taken over the role of the former Nordic research policy council and runs the Nordic Centres of Excellence programme that was originally started by the three joint committees of the Nordic research councils (the so-called NOS committees).

The NordForsk mission is to

- Promote efficient cooperation among the Nordic countries in relation to research and researcher training of the highest international quality
- Contribute to continued development of excellent and relevant research and the exploitation of its results in society
- Increase the ability of the Nordic region to make a global contribution

Its vision is to combine Nordic position of national research strength, generating synergies that strengthen the combined global position of the Nordic nations, under the slogan '**Nordic strength**'.

NordForsk has identified three roles for itself in its strategy 2006–09[1]

- **Coordination**, by identifying important research priorities suitable for joint Nordic projects, focusing on international positions of strength in research and strategically important areas, participating in the planning of key infrastructures and working towards common Nordic calls and the partial opening of national research programmes
- **Funding** of a range of feasibility studies and joint programmes, including finding common-pot solutions co-funded with at least three national actors
- **Policy advice** to the Nordic Council of Ministers and the member states

It has a modest common budget that covers administration and allows it at the maximum to fund one third of the costs of collaborations among research performers in member states, but the bulk of its funding has to be agreed case by case by the member councils. It is expected to achieve some measure of policy coordination among its member councils. Its strategy says that it intends to coordinate also with the Nordic Innovation Centre (NICe) and with sectoral research activities under the auspices of the Nordic Council of Ministers.

NordForsk builds upon a long and strong tradition of Nordic cooperation in research. Familiarity with the Nordic neighbours and the habit of cooperation are important strengths in

the Nordic area. Variable geometry – the idea that not everyone has to join in all cooperations – is a long-established principle that has allowed the Nordic cooperation to be wide-ranging while still focusing on Nordic needs.

In addition to its policy coordination work, NordForsk has already established Nordic Centres of Excellence in

- Food, nutrition and health
- Welfare
- Global Change
- Molecular Medicine
- Humanities and Social Sciences

Each virtual centre brings together researchers in at least three of the five Nordic countries, with NordForsk funding being complemented by additional resources from the national research councils. NordForsk's other instruments include virtual graduate schools and 'seed financing' for establishing networks and planning, in addition to doing strategic studies where needed.

This study aims to provide NordForsk with 'strategic intelligence' about areas of research excellence in the Nordic area, where it might be able further to add value through the use of cross-border funding instruments. In line with the NordForsk strategy, we have identified areas of national research strength, first at the level of fields of science and then at a much more specific, sub-field level, and identified areas of potential Nordic strength – both in the sense of areas where there appear to be good numbers of researchers publishing and by identifying sub-areas where the quality (measured by conventional bibliometric indicators) also appears to be excellent. These provide important clues about areas where NordForsk might focus its funding to promote Nordic strength.

However, our study cannot provide all the answers. Our methods are primarily bibliometric, so they tell us about strengths in the (recent) past. Looking at the wake is one way to steer the boat, but looking ahead is also important, so our results need to be combined with the knowledge of NordForsk and its constituent research councils in order to become operative. Our work identifies points of established Nordic strength – not all of which NordForsk yet funds – but it cannot spot the small phenomena (such as a handful of people building a new approach) that could form the basis of future Nordic strengths. We will therefore suggest that NordForsk uses our findings in a mixed top-down and bottom-up policy that captures both what it is possible to see through analysis of past performance and the power of novelty and self-organisation.

The use of bibliometrics of course implies a number of other well-known limitations such as a bias towards English-language forms of communication (which are more appropriate in some disciplines than others), better ability to tackle fields where journal publication is the primary means of scientific communication (unlike, say, in parts of engineering) and an inability adequately to tackle the humanities and social sciences.

Remedying these deficiencies is a major project for the whole bibliometrics community; we will not be able to correct them in this small study. However, we have taken some steps to increase the robustness of our work. In addition to scrutinising and 'cleaning' the input data used in the bibliometric analyses, we have read the recent Nordic literature that tackles similar questions (this comprises entirely national studies) and cross checked our findings with theirs, as far as differences in timing, methods and definitions allow. We also asked the Nordic research councils to:

- Recommend any comparable studies of which they were aware, in an effort to make our coverage of the relevant literature as complete as possible
- Comment on a draft version of this report
- Provide any other complementary information they felt was relevant

This study is based on bibliometric analysis, covering the periods 1999–2001 and 2002–04. Up to Exhibit 32, we show annual averages for each of these periods. Subsequently, where we look at specific co-authorship patters, the analyses are confined to the single year 2004. Because the aim of the study is to inform pol-

EXHIBIT 1

BIBLIOMETRIC APPROACH

- **Step 1:** a 'classic' bibliometric analysis for each of the 5 countries and the Nordic area as a whole, covering
  - analysis per scientific field ('exact' sciences)
  - analysis per subject category and evolutions: activity/specialisation index, number of citations and world share, impact factor, structure of (co-)publications, share of publication in collaboration with the first 10 scientific partners
- **Step 2:** identification of the 10 sub-fields of excellence for each of the 5 countries
- **Step 3:** identification of the 10 most prolifically publishing institutions in each of these 10 fields for the 5 countries
- **Step 4:** provision, for each of these publishers/institutions, of their 5 main partners; as a result, identification for each country of a theoretical maximum of
  - the ten sub-fields in which each country is the strongest performer worldwide
  - within each sub-field, the ten institutions that have the strongest publication records
  - for each institution a list of their main (up to 5) publication partners
- **Step 5:** documentation of the analysis in a form that is readable and usable by a policy audience, identifying areas of excellence per country and the Nordic region as a whole and indicating areas of potential interest for Nordic-level funding, based on the extent to which areas of excellence coincide among the countries

icy, we chose as short and as recent a period as we believed would yield robust results, in order to explore trends. The study is focused on the following disciplines: Applied biology – ecology; Fundamental biology; Chemistry; Mathematics; Physics; Medical research; Earth and space sciences; and Engineering. Multidisciplinary journals cannot be aggregated in the same way as disciplines since, more or less by definition, they tackle fragmented phenomena and cannot be folded into analyses such as this one where critical mass is a key element. We therefore excluded them from this study.

The analysis focuses on Nordic countries' individual and collective shares of world scientific publications within individual fields and sub-fields, and on identification of main scientific institutions and partners in each of the five Nordic countries and in the partner countries. Exhibit 1 summarises our bibliometric approach. The Appendixes give more extensive information on the methodology and tools used.

We worked together with the French OST (Observatory of Science and Technology), our established partner in bibliometric work, which has access to the relevant data sets. We studied bibliometric indicators on all publications in journals covered by the Citation Index from Thomson Scientific, the former Institute for Scientific Information (ISI) in Philadelphia (Thomson Scientific is the producer and publisher of the Citation Index system used by the Web of Science).

During the study, we have been helped and encouraged by comments form NordForsk and from people in or suggested by several national Nordic research councils. We are grateful for their useful comments. The usual disclaimer of course applies.

2. Nordic Scientific Performance Broken Down by Scientific Field

This Chapter looks at Nordic scientific performance at a high level, focusing on the eight major fields of science for which there are good bibliometric data. This provides some context, especially by showing how – in broad terms – the Nordic scientific community specialises, compared with the rest of the world. If NordForsk is to build on demonstrated Nordic strength, then one of its options is to focus funding on those major fields where the Nordic research community is specialised. This would be a rather inclusive strategy, relying on the research community itself to identify the sub-fields that should be funded.

2.1 Performance

The following tables show the performance of each of the five Nordic countries and the Nordic region as a whole in the eight major scientific fields, using the following indicators

- Number of publications – which is an indicator of the absolute size of the effort in each field, and therefore of critical mass
- World shares of publications – indicating the relative competitiveness of the Nordic area in each field
- Scientific specialisation index – showing the degree to which the Nordic countries are more or less specialised in each field that the 'average' country

  In each case we show annual averages for 1999/2001 and 2002/04, and look at the changes between those two years, so we can see whether Nordic positions are strengthening or weakening.

EXHIBIT 2
SOME VOCABULARY

The sectoral specialisation index (the "activity index" for bibliometricians) relates the weight of a given country in a specific discipline to the country's weight in all disciplines combined, or the weight of a given discipline within the country to the discipline's weight world-wide. This probabilistic index is one that allows us to establish and compare the discipline-by-discipline profile of various countries. The dispersion observed in these index values for a given country provides an indication of the overall level of specialisation in the country's research strategy. When the specialisation index is higher than 1, then the country in question is more specialised in the specific discipline than the average of the other countries.

Exhibit 3 shows how the Nordic countries' overall shares of scientific publications changed between 1999–2001 and 2002–04. The Nordic countries represented 3.45% of World scientific production in 1999–2001, and 3.27% in 2002–04 (a reduction of 5.2%). With the exception of Iceland, the overall world share of each of the Nordic countries has fallen across the period. This is not surprising, since the world population of publishing scientists is growing – not least through a rising contribu-

tion from newly developing countries – but also because of the growing efforts of EU countries to raise their national spend on R&D towards 3% of GDP: a level that three of the five Nordic countries already exceed.

Sweden had the greatest share of world scientific publications in 2004 with 1.38%. Denmark and Finland each held 0.71%. Given that all the Nordic countries spend quite a lot on scientific research, the main driver of their world shares of publications is population[2]. Overall, in 2004, each million of population in the Nordic countries generated a world share of publications of some 0.13%. Swedes published more, getting about 0.15% world share per million of population. Norwegians and Icelanders got less: 0.09% and 0.1% respectively, while the Danes and Finns were close to the average. After population, the other main drivers of differences will be field specialisation (Sweden specialises in life sciences, which have a comparatively high propensity to publish) and national spending on comparatively fundamental research.

The simple fact that the Nordic countries are of different sizes means that in this study we have to take care that the large Swedish pattern does not overly dominate our conclusions.

Exhibit 4 looks at the absolute numbers of publications by the Nordic countries in each of the eight major fields for which there are good bibliometric data and the shares of world publications they generated. The number of publications is based on 'full counting'. This means, for example, that a joint publication by a Swedish, a Norwegian and a Thai author will count once as a Swedish publication and again as a Norwegian publication but only once as a Nordic publication. (In this analysis, the Thai gets no credit.) This is why the national numbers add up to more than the Nordic numbers. On the other hand, the world share numbers are based on 'fractional counting' so that our Swedish-Norwegian-Thai publication will count as one third of a publication for each of Sweden and Norway and as two thirds of a publication for the Nordic level. So the absolute publication numbers tell us about who is making inputs and the world share numbers give a sense of the outputs that result.

EXHIBIT 3

NORDIC COUNTRIES' WORLD SHARES OF PUBLICATIONS, ALL FIELDS, 1999/2001-2002/04

	WS publication (1999-2001)	WS publication (2002-2004)	WS publication (2004/2001)
Denmark	0,74 %	0,71 %	-4,1%
Finland	0,74 %	0,71 %	-4,1%
Iceland	0,02 %	0,03 %	50,0%
Norway	0,46 %	0,44 %	-4,3%
Sweden	1,49 %	1,38 %	-7,4%
Total	**3,45 %**	**3,27 %**	**-5,2%**

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.
Note : WS : World share of publication. Fractional counting.

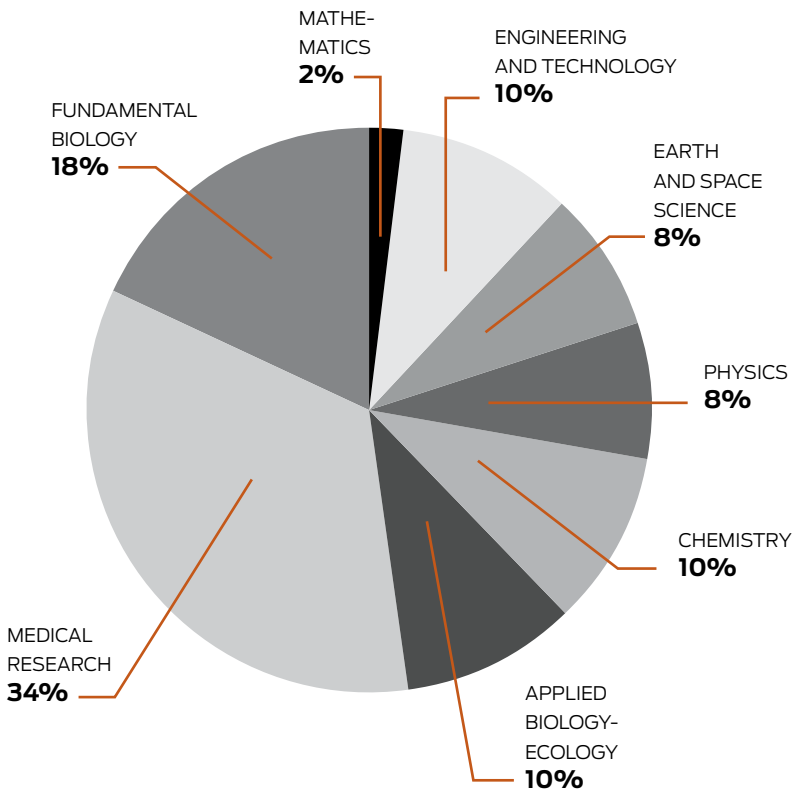
EXHIBIT 4 NORDIC COUNTRIES: NUMBER OF SCIENTIFIC PUBLICATIONS AND WORLD SHARES OF PUBLICATIONS

		Number of publications*						World shares of publications**					
		1999-01		2002-04		2004/01		1999-01		2002-04		2004/01	
		N	R	N	R	%	R	WS	R	WS	R	%	R
Denmark	Fundamental Biology	1933	2	1945	2	0,6%	5	0,91	3	0,89	3	-2,0%	4
	Medical research	2893	1	2984	1	3,1%	4	0,86	4	0,84	4	-1,9%	3
	Applied Biology - Ecology	936	4	927	3	-0,9%	6	1,11	1	1,08	1	-2,8%	5
	Chemistry	798	6	776	7	-2,8%	7	0,41	8	0,37	8	-11,1%	8
	Physics	964	3	874	4	-9,3%	8	0,55	5	0,50	6	-10,5%	7
	Earth and space sciences	822	5	862	5	4,9%	3	0,98	2	0,90	2	-8,7%	6
	Engineering and technology	673	7	793	6	17,9%	1	0,49	7	0,49	7	0,7%	2
	Mathematics	187	8	210	8	11,9%	2	0,49	6	0,51	5	3,5%	1
Finland	Fundamental Biology	1574	2	1571	2	-0,2%	7	0,78	3	0,76	4	-2,1%	5
	Medical research	2941	1	2724	1	-7,4%	8	0,95	2	0,83	2	-13,0%	8
	Applied Biology - Ecology	766	5	816	6	6,6%	4	1,02	1	1,06	1	3,9%	4
	Chemistry	831	4	916	4	10,3%	3	0,50	7	0,48	8	-4,4%	7
	Physics	849	3	875	5	3,1%	6	0,50	8	0,52	6	5,5%	2
	Earth and space sciences	614	7	701	7	14,2%	2	0,77	4	0,81	3	4,2%	3
	Engineering and technology	753	6	988	3	31,3%	1	0,60	5	0,71	5	17,4%	1
	Mathematics	181	8	189	8	4,2%	5	0,51	6	0,49	7	-3,6%	6
Iceland	Fundamental Biology	53	3	60	3	13,8%	6	0,02	4	0,02	4	24,5%	5
	Medical research	119	1	144	1	21,3%	5	0,03	3	0,03	3	15,3%	6
	Applied Biology - Ecology	42	4	58	4	39,2%	3	0,03	2	0,05	2	49,0%	1
	Chemistry	18	6	20	6	9,3%	7	0,01	8	0,01	8	-1,8%	7
	Physics	21	5	19	7	-6,5%	8	0,01	6	0,01	6	-3,2%	8
	Earth and space sciences	65	2	92	2	41,3%	2	0,07	1	0,09	1	29,2%	3
	Engineering and technology	15	7	23	5	52,2%	1	0,01	7	0,01	7	41,4%	2
	Mathematics	7	8	9	8	30,0%	4	0,01	5	0,02	5	26,0%	4
Norway	Fundamental Biology	883	2	918	2	4,0%	5	0,41	4	0,40	4	-2,6%	4
	Medical research	1783	1	1841	1	3,2%	6	0,55	3	0,52	3	-6,3%	7
	Applied Biology - Ecology	734	4	741	4	1,0%	7	0,87	2	0,84	2	-4,0%	5
	Chemistry	467	6	413	6	-11,6%	8	0,26	7	0,20	7	-22,7%	8
	Physics	354	7	372	7	5,0%	4	0,18	8	0,17	8	-5,9%	6
	Earth and space sciences	801	3	897	3	12,0%	2	0,97	1	0,99	1	1,3%	2
	Engineering and technology	490	5	568	5	15,8%	1	0,37	6	0,38	6	2,6%	1
	Mathematics	142	8	156	8	9,4%	3	0,39	5	0,39	5	0,5%	3
Sweden	Fundamental Biology	3550	2	3468	2	-2,3%	6	1,69	2	1,59	2	-5,8%	4
	Medical research	6035	1	5771	1	-4,4%	8	1,89	1	1,70	1	-9,8%	8
	Applied Biology - Ecology	1312	6	1256	6	-4,3%	7	1,54	3	1,40	3	-9,5%	7
	Chemistry	1945	3	1962	3	0,9%	5	1,10	7	1,04	7	-6,1%	6
	Physics	1881	4	1928	4	2,5%	4	1,18	5	1,13	6	-4,2%	3
	Earth and space sciences	1141	7	1209	7	6,0%	3	1,44	4	1,35	4	-6,0%	5
	Engineering and technology	1514	5	1686	5	11,3%	2	1,16	6	1,14	5	-2,1%	2
	Mathematics	306	8	361	8	17,9%	1	0,87	8	0,88	8	0,9%	1
5 countries together	Fundamental Biology	5654	2	5459	2	-3,5%	6	3,81	4	3,67	4	-3,6%	5
	Medical research	10849	1	10036	1	-7,5%	8	4,28	2	3,93	3	-8,3%	7
	Applied Biology - Ecology	2997	3	2838	5	-5,3%	7	4,58	1	4,42	1	-3,4%	4
	Chemistry	2966	4	2902	4	-2,2%	5	2,28	7	2,09	8	-8,5%	8
	Physics	2444	6	2483	6	1,6%	4	2,42	6	2,33	6	-3,8%	6
	Earth and space sciences	2266	7	2370	7	4,6%	3	4,23	3	4,13	2	-2,5%	3
	Engineering and technology	2679	5	3125	3	16,6%	1	2,63	5	2,73	5	3,7%	1
	Mathematics	596	8	651	8	9,2%	2	2,28	8	2,29	7	0,5%	2

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.
Note: *: Full counting. **: Fractional counting
N: Number of publications
R:Rank
%: Trend between 1999–2001 and 2002–04.

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

EXHIBIT 5 NORDIC PUBLICATIONS BY FIELD, 2002/04



These data show that the Nordic countries' greatest absolute volumes of publications are in Medicine (nearly 10 000 publications in 2004; 6 000 publications for Sweden) and Fundamental biology (nearly 6 000 publications 2004; 4 000 publications for Sweden). However, the Nordic countries collectively have the highest share of world publications (almost 4%) in applied biology – ecology, earth, space and science, physics, and fundamental biology. In seven fields, Sweden has a share of over 1% of world publications. In all other cases, the individual Nordic countries' shares of publications are below 1%.

The overall pattern of publication is strongly oriented towards life sciences, as Exhibit 5 shows, with one third of the publication effort coming from medicine. Exhibit 4 shows that at the Nordic level the publication effort in life sciences is tapering off, except in Iceland where the percentage growth is big but the absolute numbers of publications remain small. The biggest fall in publications is in medicine (driven by declines in Finland and Sweden).

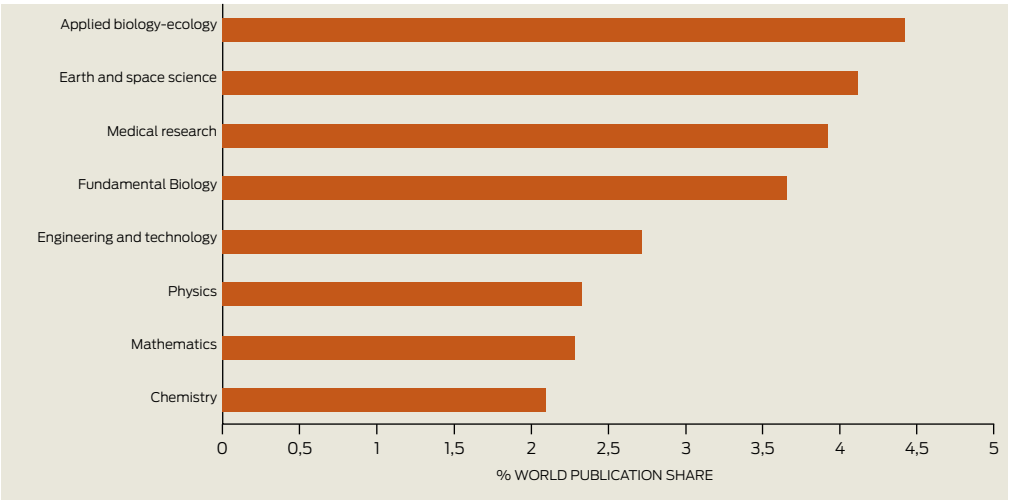
Exhibit 6 compares the national publication patterns with the Nordic one, indicating, for example, that comparing the Danish publication pattern with the Nordic one shown in Exhibit 5, Denmark has two percentage points more of its publications in Fundamental Biology than does the Nordic region. (In fact, a little over 20% of Denmark's publications are in Fundamental Biology, compared with a little over 18% for the Nordic region.) These data are a little approximate because they are based on 'full counting'. However, they suggest that there are surprisingly few big differences in the pattern of publication among the Nordic countries. The one striking divergence is in Earth and Space Science, presumably owing to the Icelanders' and Norwegians' rather different interests in geology.

EXHIBIT 6 VARIATIONS IN NATIONAL PUBLICATION PATTERNS FROM THE NORDIC PATTERN, 2002/04 (IN % POINTS)

	Denmark	Finland	Iceland	Norway	Sweden
Fundamental Biology	2%	0%	-4%	-3%	1%
Medical research	-2%	-3%	0%	-2%	-1%
Applied biology-ecology	0%	0%	4%	3%	-2%
Chemistry	-1%	1%	-5%	-3%	1%
Physics	1%	2%	-4%	-2%	3%
Earth and space science	1%	0%	14%	7%	-1%
Engineering and technology	-2%	1%	-5%	-1%	-1%
Mathematics	0%	0%	0%	0%	0%

Source: Calculated from Exhibit 4

EXHIBIT 7
NORDIC SHARES OF WORLD PUBLICATIONS, 2002/04 (%)

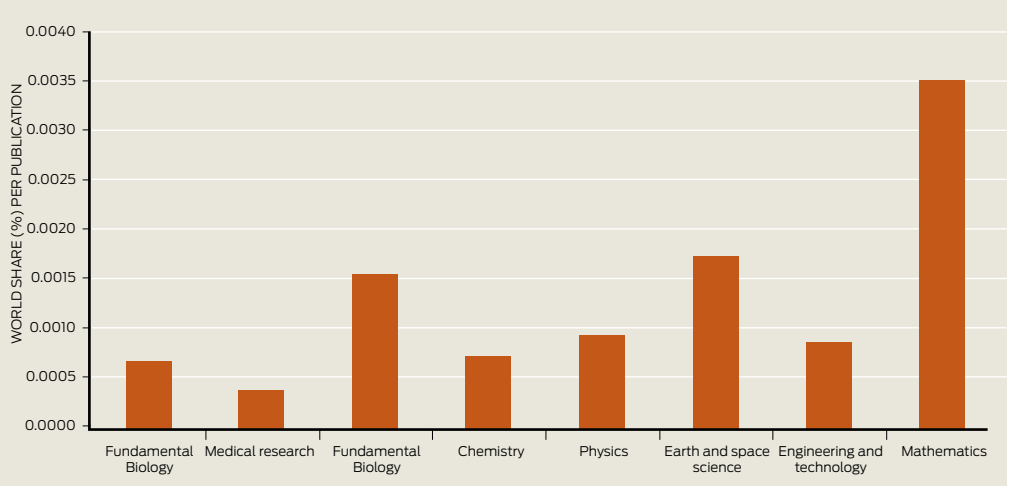


Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group. Fractional counting.

While the number of publications gives a crude sense of the amount of publication effort involved, it does not translate directly into success. Exhibit 7 shows Nordic shares of world publications in 2002/04. Thus, while over one third of the Nordic area's publications are in Medicine, the smaller numbers of publications in Applied Biology-Ecology and in Earth and Space Science yield stronger competitive positions in world science (measured in terms of shares of world publications).

A crude comparison (Exhibit 8) between the absolute numbers of Nordic publications per field and Nordic shares of world publication illustrates[3] that there are large differences among the world share represented by a single publication in different disciplines. While the Nordic medics publish a lot, so do those in the rest of the world. A publication in mathematics generates nearly10 times as much world share as one in medicine. Building Nordic strength by increasing the level of publication in Mathematics, Earth and Space Science and Applied Biology-Ecology could therefore be an attractive strategy for NordForsk.

EXHIBIT 8 WORLD PUBLICATION SHARE GENERATED PER PUBLICATION, 2002/04



Source: Calculated from Exhibit 4

Exhibit 9 shows the changes in the Nordic countries' world shares of publications at the field level between 1999–2001 and 2002–04. Overall, the Nordic countries' share of publications in Engineering and Technology and in Mathematics has increased, but fallen in other fields. This has to be read against the background of a growing global scientific community, so it is not in itself a problem.

Within this overall pattern, Iceland has made progress from a low base and Finland has increased its share in engineering and technology, physics, earth, space, and science, and applied biology-ecology. These developments presumably reflect the great increases in funding in those two countries over recent years and remind us that if you want to improve your national research position, you have to invest.

EXHIBIT 9 FIVE NORDIC COUNTRIES: WORLD SHARES OF PUBLICATIONS (CHANGE BETWEEN 1999/2001 AND 2002/04) – BREAKDOWN BY SCIENTIFIC FIELD

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group. Fractional counting.

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

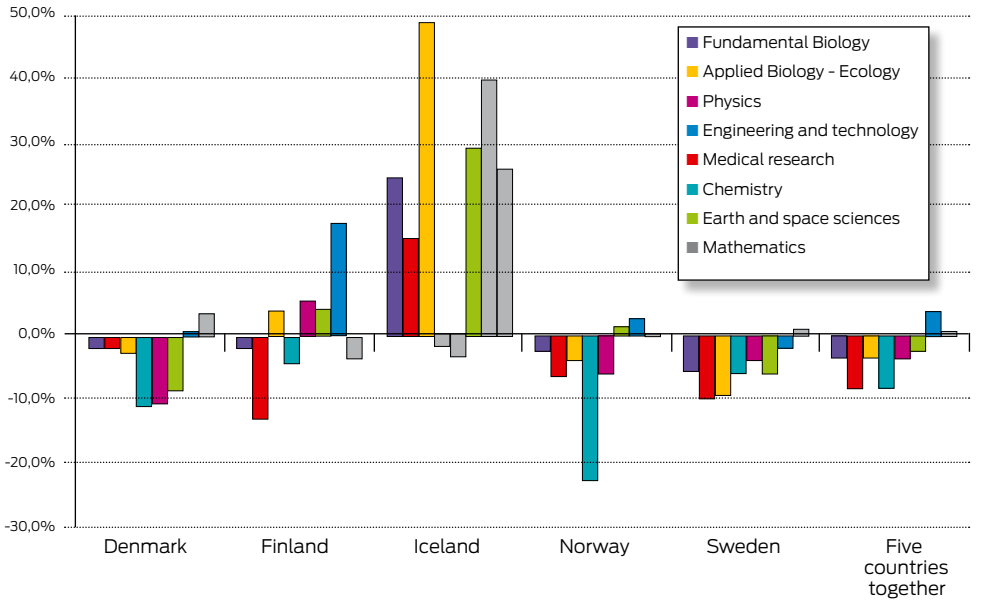


Exhibit 10 shows scientific specialisation indices for the Nordic countries in 1999/2001 and 2002/4 for each of the 8 fields.

EXHIBIT 10

FIVE NORDIC COUNTRIES: SPECIALISATION INDEX - BREAKDOWN BY SCIENTIFIC FIELD

	Denmark			Finland			Iceland		
	1999-01	2002-04	2004/01	1999-01	2002-04	2004/01	1999-01	2002-04	2004/01
Fundamental Biology	1,23	1,26	2,2%	1,05	1,07	1,7%	0,86	0,89	3,7%
Medical research	1,17	1,20	2,3%	1,28	1,16	-9,6%	1,28	1,23	-4,0%
Applied Biology - Ecology	1,50	1,52	1,5%	1,37	1,48	8,0%	1,44	1,79	24,1%
Chemistry	0,56	0,52	-7,2%	0,67	0,67	-0,7%	0,35	0,29	-18,2%
Physics	0,75	0,70	-6,6%	0,67	0,73	9,6%	0,60	0,49	-19,4%
Earth and space sciences	1,33	1,27	-4,7%	1,04	1,13	8,3%	3,03	3,26	7,6%
Engineering and technology	0,67	0,70	5,1%	0,81	0,99	22,0%	0,36	0,43	17,7%
Mathematics	0,67	0,72	8,0%	0,69	0,69	0,2%	0,60	0,63	5,0%
All fields together	1,00	1,00	-	1,00	1,00	-	1,00	1,00	-

	Norway			Sweden			5 countries together		
	1999-01	2002-04	2004/01	1999-01	2002-04	2004/01	1999-01	2002-04	2004/01
Fundamental Biology	0,88	0,90	2,6%	1,14	1,15	1,6%	1,10	1,12	1,8%
Medical research	1,19	1,17	-1,3%	1,27	1,23	-2,7%	1,24	1,20	-3,1%
Applied Biology - Ecology	1,89	1,91	1,1%	1,04	1,01	-2,4%	1,32	1,35	2,0%
Chemistry	0,56	0,45	-18,6%	0,74	0,75	1,2%	0,66	0,64	-3,3%
Physics	0,40	0,39	-0,8%	0,79	0,82	3,3%	0,70	0,71	1,7%
Earth and space sciences	2,10	2,24	6,7%	0,96	0,98	1,4%	1,23	1,26	3,0%
Engineering and technology	0,79	0,85	8,1%	0,78	0,82	5,6%	0,76	0,83	9,6%
Mathematics	0,85	0,90	5,8%	0,58	0,64	8,8%	0,66	0,70	6,2%
All fields together	1,00	1,00	-	1,00	1,00	-	1,00	1,00	-

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group. Fractional counting.

Note:
The sectoral specialisation index relates the weight of a given country (or zone) in a specific scientific field to the country's weight in all fields combined, or the weight of a given discipline within the country to the discipline's weight world-wide. This probabilistic index is one that enables establishing and comparing the discipline-by-discipline profile of various countries. The dispersion observed in these index values for a given country provides a perception of the overall level of specialisation in the country's research strategy.
When the specialisation index is higher than 1, it means that the country is more specialised in the considered field than the average of the other zones.
The red colour indicates high specialisation (the specialisation index is higher than 1.2) and blue colour low specialisation (the specialisation index is lower than 0.8).

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

EXHIBIT 11 NORDIC COUNTRIES' SCIENTIFIC SPECIALISATION 2002-04 AND TREND IN SPECIALISATION 1999/2001 – 2002/04

	Denmark	Finland	Iceland	Norway	Sweden	All
Fundamental Biology	+	+	+	+	+	+
Medical research	+					
Applied biology-ecology	+	+	+	+		+
Chemistry					+	
Physics		+			+	+
Earth and space science		+		+	+	+
Engineering and technology	+	+	+	+	+	+
Mathematics	+	+	+	+	+	+

Key: Shading indicates a specialisation index above 1 in 2002/04; a "+" indicates increasing specialisation in the period 1999/2001 - 2002/04

It appears therefore that the five Nordic countries as a whole are strongly specialised in three scientific fields: Applied Biology-Ecology (specialisation index SI=1.4), earth, space and science (SI=1.3), and Medical Research (SI=1.2). This specialisation is relatively stable over time in the Nordic area as a whole, though there is increasing specialisation in Applied Biology-Ecology (specialisation index SI=+2%) and earth, space and science (SI=+3%). Specialisation indexes have only decreased in two fields: medical research (-3.1%), and chemistry (-3.3%).

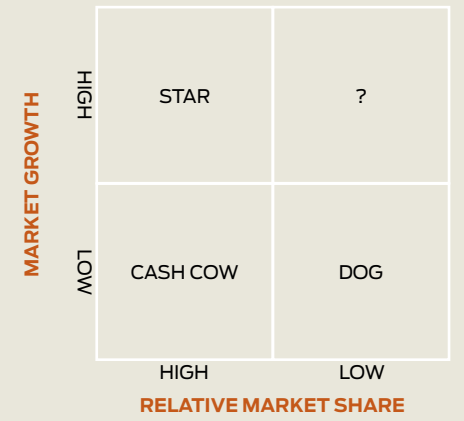
Exhibit 11 summarises the data about specialisation and the changes in specialisation over time. Using a wider definition of specialisation (index > 1) it shows the Nordic area is specialised in four of the eight major scientific fields, and that it is increasing its specialisation in three of them (Fundamental Biology, Applied Biology-Ecology and Earth and Space Science) while in fact its existing specialisation in Medicine is declining. However, specialisation in Engineering and Technology and in Mathematics is consistently increasing, while two of the countries are increasing their specialisation in Physics.

2.2 Policy Implications

What can we conclude about NordForsk funding policy the level of the eight large fields? Of course, the bibliometric evidence should not be the only input to policy, so the following analysis should be complemented with a more qualitative discussion of strategy, based on types of understanding of the research communities, opportunities and relevance issues that are not visible through bibliometrics.

A strategy based on Nordic strength needs to incorporate at least a dimension of existing strength and a dynamic component. The 'Boston Boxes' developed by the Boston Consulting Group (BCG) for analysing market strategies provide a useful point of departure. They were originally designed in order to help analyse and strategise about conglomerate companies' strategic business units.

EXHIBIT 12
THE 'BOSTON BOXES'



The 'relative market share' dimension is a measure of the extent to which the firm has an established and exploitable position in an industry, while the 'market growth' dimension relates to the ease with which it is likely to be possible to expand the business. It is usually

easier to build strong business positions in growing markets than in declining ones. The Boston Boxes provide a basis for a strategic positioning matrix (Exhibit 13) for Nordic science, which NordForsk can use to think about where it should invest. (We have reversed BCG's rather eccentric ordering of the high and low positions on the horizontal axis.)

We would hesitate to use such a logic in the case of a national research council, which has responsibilities that tend to include the maintenance and development of scientific capabilities and careers, gender balance and diversity, timely diversification into new fields and in some countries in practice (though it is not always stated) maintenance of a minimum of capability across most disciplines. However, NordForsk's 'Nordic strength' mission allows it to take a more focused perspective of its investment role, concentrating on strengthening strength. The investment perspective is therefore more appropriate.

Exhibit 14 is based upon analyses earlier in this Chapter and provides a basis for (subjectively) locating fields within the positioning matrix. We regard the first three columns as indicators of present position and the next two as indicators of the extent to which the Nordic countries are building strength. The final column – 'Leverage' – indicates the extent to which increasing the number of publications increases world share, and is therefore a direct indicator of investment attractiveness for building Nordic strength.

The low degree of variation in the publication patterns of the Nordic countries, coupled with the fact that multiple countries are strong in each field means that we can treat the Nordic area as a whole in this discussion.

On this analysis, the biggest producer of publications – medicine – is in the 'cash cow' box. The Nordic area has a solid share of publications but development and growth would be hard won. There is every reason to carry on funding the area but little investment justification for increasing funding in terms of strengthening the Nordic position[4]. Chemistry is a 'dog'. It is fairly important in the total volume of publications but generates only a modest share of world publications, the Nordic share of publications is declining and it is not

EXHIBIT 13 STRATEGIC POSITIONING MATRIX

EXHIBIT 14 ASSESSING NORDIC STRENGTH IN EIGHT FIELDS

	% of Nordic Publications, 2002/04	Nordic World Share, 2002/04	Current Specialisation	Growth of Nordic Share	Trend in Specialisation	Leverage*
Fundamental Biology	13%	3.7%	Yes	-	+	Low
Medical research	34%	3.9%	Yes	-	-	Very Low
Applied biology-ecology	10%	4.4%	Yes	-	+	Medium
Chemistry	10%	2.1%		-	-	Low
Physics	8%	2.3%		-	+	Low
Earth and space science	8%	4.1%	Yes	-	+	Medium
Engineering and technology	10%	2.7%		+	+	Low
Mathematics	2%	2.3%		small +	+	High

* A qualitative assessment of the extent to which adding a marginal publication increases world share (see Exhibit 8)

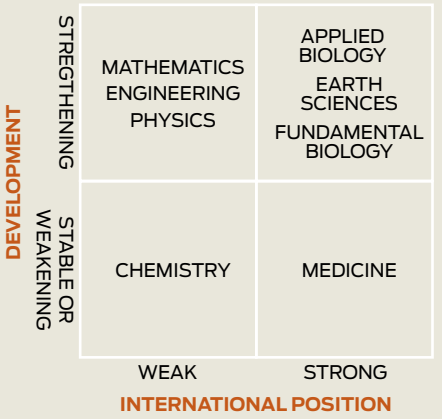
an area in which the Nordic area is specialised. Further, the marginal return to increased publications is low, so investing to build Nordic strength is not very attractive.

The 'stars' are Applied Biology-Ecology, Earth Sciences and Fundamental Biology. The Nordic countries are strong in these fields and are becoming stronger. The former two fields are especially interesting, because they offer high leverage.

The 'question marks' are Mathematics, Engineering and Technology and Physics. Here the Nordic region does not have especially strong positions but there are signs of strengthening. NordForsk money could reinforce this upward movement – to what extent is a matter of judgement and not something that he bibliometric indicators can foretell. Mathematics may be especially interesting because of the very high leverage to additional publications. In physics, the differences in performance among the Nordic nations are big, so action at the national level is probably preferable to the Nordic level.

EXHIBIT 15

STRATEGIC POSITIONING MATRIX: FIELDS



Note: Medium and high leverage fields are italicised

Based on the bibliometric evidence, therefore, our suggestion would be that – if it wants to fund at the field level – NordForsk should direct calls towards the stars (Applied Biology-Ecology, Earth Sciences and Fundamental Biology) and Mathematics.

3. Nordic Excellence

In the previous Chapter, we discussed the level of large fields of science and a 'macro-strategy' that NordForsk could pursue. Here, we use the fact that the available bibliometric data are classified into 170 sub-fields (definitions are in Appendix D) to select ten promising sub-fields on which NordForsk might consider focusing some calls for proposals. This results in a suggested 'micro-strategy' that would complement the macro-strategy. The choice of ten and not, say, nine or twenty sub-fields is inevitably arbitrary, conditioned by the amount of time we could spend 'cleaning' the relevant data for this study and the fact that ten sub-fields are enough to provide some variety of funding opportunities.

Having shown how we chose the sub-fields, we then analyse them more closely. First, we look at the way the Nordic countries have performed, in terms of conventional indicators, notably numbers of publications, the world shares achieved as a result and two indicators of quality: world citation shares and the impact factors of the journals in which they are published. Then we show how some aspects of international collaboration work in these sub-fields, looking at both the level of collaborations among Nordic countries and at the wider international collaboration patterns of leading Nordic institutions in each sub-field. This reveals interesting differences between the national and institutional patterns, which suggest policy alternatives for NordForsk.

3.1 How We Selected the Top-10 Subject Categories

In order to find the Top-10 sub-field categories for the Nordic area, we first identified the 20 top sub-fields for each country, within a list of more than 170 subject categories, in decreasing order of World share of publications. We then applied a second criterion: the number of publications should be greater than 50 per year, which is a conventional criterion for assuring the quality of bibliometric analysis. (In the case of Iceland, the small absolute numbers of publications means that we have had to relax the minimum number criterion, otherwise Iceland would effectively have been excluded from the analysis).

For each country, we developed the following indicators for 2001, 2004 and the percentage changes between these years

- Number of publications
- World shares of publications
- Specialisation index of publications
- World shares of citations
- Relative impact index

Exhibit 16 shows the Swedish tables, by way of example. The full set of tables is shown in Appendix F.

EXHIBIT 16 MAIN TABLES FOR SWEDEN

Number of publications	1999-01		2002-04		Trend	
	N	R	N	R	%	R
Engineering, Environmental	117	15	161	13	36,9%	1
Energy & Fuels	91	19	121	16	33,1%	2
Rheumatology	82	20	106	18	29,7%	3
Environmental Sciences	364	4	430	3	18,2%	4
Biochemical Research Methods	219	9	243	7	10,8%	5
Ecology	294	6	317	5	7,7%	6
Oncology	521	2	550	1	5,6%	7
Public, Environmental & Occupational Health	300	5	316	6	5,1%	8
Obstetrics & Gynecology	193	12	194	11	0,7%	9
Endocrinology & Metabolism	384	3	382	4	-0,7%	10
Anesthesiology	111	16	110	17	-0,9%	11
Infectious Diseases	198	11	194	11	-1,9%	12
Peripheral Vascular Diseases	229	8	220	8	-4,2%	13
Materials Science, Paper & Wood	106	18	98	19	-7,5%	14
Dentistry, Oral Surgery & Medicine	217	10	195	10	-10,3%	15
Physiology	237	7	211	9	-10,8%	16
Forestry	143	14	126	15	-11,9%	17
Immunology	585	1	506	2	-13,4%	18
Allergy	107	17	91	20	-15,5%	19
Orthopedics	171	13	131	14	-23,2%	20

World shares (%) of publications	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Energy & Fuels	1,71	20	2,13	15	24,7%	1
Rheumatology	2,22	15	2,53	7	14,2%	2
Materials Science, Paper & Wood	8,22	1	9,27	1	12,8%	3
Engineering, Environmental	2,74	8	2,99	6	8,8%	4
Anesthesiology	2,04	19	2,01	18	-1,6%	5
Obstetrics & Gynecology	2,28	14	2,22	13	-2,6%	6
Environmental Sciences	2,14	18	2,07	17	-3,3%	7
Public, Environmental & Occupational Health	3,21	6	3,01	5	-6,2%	8
Biochemical Research Methods	2,45	12	2,27	11	-7,3%	9
Peripheral Vascular Diseases	2,31	13	2,11	16	-8,7%	10
Endocrinology & Metabolism	2,66	9	2,43	9	-8,7%	11
Oncology	2,20	17	1,99	20	-9,5%	12
Infectious Diseases	2,20	16	1,99	19	-9,5%	13
Physiology	2,46	11	2,19	14	-10,7%	14
Allergy	3,59	4	3,17	4	-11,7%	15
Immunology	2,54	10	2,23	12	-12,3%	16
Ecology	2,84	7	2,47	8	-13,3%	17
Dentistry, Oral Surgery & Medicine	4,35	3	3,61	3	-17,0%	18
Forestry	6,06	2	4,45	2	-26,5%	19
Orthopedics	3,40	5	2,28	10	-32,9%	20

Specialisation index	1999-01		2002-04		Trend	
	SI	R	SI	R	%	R
Energy & Fuels	1,15	20	1,54	15	34,6%	1
Rheumatology	1,49	15	1,84	7	23,2%	2
Materials Science, Paper & Wood	5,52	1	6,72	1	21,6%	3
Engineering, Environmental	1,84	8	2,16	6	17,3%	4
Anesthesiology	1,37	19	1,46	18	6,2%	5
Obstetrics & Gynecology	1,53	14	1,61	13	5,1%	6
Environmental Sciences	1,44	18	1,50	17	4,3%	7
Public, Environmental & Occupational Health	2,15	6	2,18	5	1,2%	8
Biochemical Research Methods	1,64	12	1,64	11	0,0%	9
Peripheral Vascular Diseases	1,55	13	1,52	16	-1,5%	10
Endocrinology & Metabolism	1,79	9	1,76	9	-1,5%	11
Oncology	1,48	17	1,44	20	-2,3%	12
Infectious Diseases	1,48	16	1,44	19	-2,4%	13
Physiology	1,65	11	1,59	14	-3,7%	14
Allergy	2,41	4	2,30	4	-4,8%	15
Immunology	1,71	10	1,61	12	-5,4%	16
Ecology	1,91	7	1,79	8	-6,4%	17
Dentistry, Oral Surgery & Medicine	2,92	3	2,62	3	-10,4%	18
Forestry	4,07	2	3,23	2	-20,8%	19
Orthopedics	2,28	5	1,65	10	-27,7%	20

World shares (%) of citations (2 years)	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Rheumatology	2,28	15	3,36	5	47,2%	1
Materials Science, Paper & Wood	16,45	1	19,19	1	16,7%	2
Environmental Sciences	2,72	12	2,77	8	1,9%	3
Endocrinology & Metabolism	2,62	13	2,58	11	-1,4%	4
Anesthesiology	2,58	14	2,53	12	-1,9%	5
Immunology	1,69	20	1,60	19	-5,5%	6
Obstetrics & Gynecology	2,88	10	2,72	9	-5,5%	7
Peripheral Vascular Diseases	2,15	16	2,02	16	-6,0%	8
Infectious Diseases	1,86	19	1,72	17	-7,4%	9
Biochemical Research Methods	2,78	11	2,46	15	-11,5%	10
Energy & Fuels	3,08	8	2,62	10	-15,0%	11
Public, Environmental & Occupational Health	2,95	9	2,50	14	-15,2%	12
Allergy	4,69	5	3,96	3	-15,4%	13
Oncology	1,98	17	1,67	18	-15,6%	14
Forestry	5,70	3	4,39	2	-23,0%	15
Ecology	3,70	7	2,81	7	-24,1%	16
Physiology	1,96	18	1,46	20	-25,5%	17
Dentistry, Oral Surgery & Medicine	5,38	4	3,87	4	-28,1%	18
Engineering, Environmental	3,82	6	2,52	13	-33,9%	19
Orthopedics	5,70	2	3,02	6	-47,1%	20

Impact factors	1999-01		2002-04		Trend	
	IF	R	IF	R	%	R
Rheumatology	1,03	12	1,32	3	28,9%	1
Endocrinology & Metabolism	0,99	13	1,06	12	8,0%	2
Immunology	0,67	20	0,72	19	7,7%	3
Environmental Sciences	1,27	7	1,34	2	5,4%	4
Forestry	0,94	14	0,99	13	4,9%	5
Materials Science, Paper & Wood	2,00	1	2,07	1	3,4%	6
Peripheral Vascular Diseases	0,93	15	0,96	14	2,9%	7
Infectious Diseases	0,85	18	0,87	15	2,3%	8
Anesthesiology	1,26	9	1,26	5	-0,4%	9
Obstetrics & Gynecology	1,27	8	1,23	8	-3,0%	10
Allergy	1,30	5	1,25	6	-4,2%	11
Biochemical Research Methods	1,14	11	1,08	10	-4,5%	12
Oncology	0,90	17	0,84	17	-6,8%	13
Public, Environmental & Occupational Health	0,92	16	0,83	18	-9,6%	14
Ecology	1,30	6	1,14	9	-12,5%	15
Dentistry, Oral Surgery & Medicine	1,24	10	1,07	11	-13,4%	16
Physiology	0,80	19	0,67	20	-16,5%	17
Orthopedics	1,68	3	1,32	4	-21,2%	18
Energy & Fuels	1,80	2	1,23	7	-31,8%	19
Engineering, Environmental	1,39	4	0,84	16	-39,2%	20

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.
Note: selection of the 20 first subject categories: decreasing order of World share and N > 50.

EXHIBIT 17 RESULTS OF THE SELECTION PROCESS FOR TOP-10 SUB-FIELDS

Fields	Number of countries	Impact Factor Mean	Rank	Fields	Number of countries	World share of publications	Rank	Joint
Fisheries	4	1,30	4	Fisheries	4	6,47	4	4
Obstetrics & Gynecology	4	1,30	5	Obstetrics & Gynecology	4	4,30	8	6,5
Anesthegiology	3	1,39	2	Anesthegiology	3	4,36	12	7
Marine & Freshwater Biology	3	1,34	3	Marine & Freshwater Biology	3	4,65	11	7
Ecology	5	1,13	11	Ecology	5	6,98	3	7
Sports Sciences	3	1,60	1	Sports Sciences	3	3,37	13	7
Dentistry, Oral Surgery & Medicine	5	1,05	12	Dentistry, Oral Surgery & Medicine	5	7,68	2	7
Rheumatology	4	1,21	7	Rheumatology	4	5,37	7	7
Public, Environmental & Occupational Health	5	1,01	13	Public, Environmental & Occupational Health	5	7,83	1	7
Environmental sciences	4	1,21	8	Environmental sciences	4	5,72	6	7
Endocrinology & Metabolism	3	1,16	9	Endocrinology & Metabolism	3	5,94	10	9,5
Engineering, Environmental	4	0,97	15	Engineering, Environmental	4	6,39	5	10
Nutrition & Dietetics	3	1,27	6	Nutrition & Dietetics	3	2,87	15	10,5
Forestry	3	0,99	14	Forestry	3	10,88	9	11,5
Food Science & Technology	3	1,13	10	Food Science & Technology	3	2,47	16	13
Infectious Diseases	3	0,85	16	Infectious Diseases	3	3,20	14	15

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.

In the context of the NordForsk (and more general Nordic) practice of working with 'variable geometry' where there is a minimum of three Nordic states involved in Nordic-funded projects, we then selected the Top-10 sub-fields using four steps

- First step: ...filtered out the fields where fewer than 3 Nordic countries made it into the analysis: cooperation is regarded as viable and fundable if a minimum of 3 of the 5 Nordic states are involved
- Second step: ...ranked the disciplines that passed through the filter, based on impact factors, to find those where the Nordic area did best, based on this excellence criterion
- Third step: ...ranked disciplines passing through the filter, based on their total share of world publications - using this as an indicator of critical mass
- Fourth step: ...calculated the average of these rankings

Exhibit 17 shows the main results of the selection process and the Top-10 ranked fields. We chose not to weight the quality and critical mass criteria, since both appear necessary. At the left is the ranking based on impact factors (Step 2). In the middle is the ranking based on share of world publications (Step 3). The small column at the right shows the joint ranking. We have used that to order the table, so that the first 10 rows make up the Top-10 sub-fields.

3.2 How the Nordic Countries Performed in the 10 Sub-fields

This section gives more detail about the ten sub-fields selected, based on the following indicators

- Number of publications
- World shares of publications
- World shares of citations
- Relative impact index

3.2.1 Number of publications

Exhibit 18 below presents the data regarding the number of publications for each of the Top-10. It confirms at the sub-field level the tendency towards stagnation in medical fields that we observed at the overall level, but there are differences among sub-fields and countries. Obstetrics and Gynaecology is fairly stable, whereas Anaesthesiology and Rheumatology show very different growth rates among countries.

Exhibit 19 shows the 2004 publication numbers in graphical terms, illustrating both the differences between the amounts of activity in the sub-fields and the relative activity of the 5 countries. Sweden naturally dominates, since it has a much bigger population than the other Nordic countries. Environmental Sciences, Ecology and Public, Environmental and Occupational Health stand out as absolutely big sub-fields of Nordic importance.

EXHIBIT 18 FIVE NORDIC COUNTRIES: NUMBERS OF SCIENTIFIC PUBLICATIONS) – THE 10 SELECTED SUBJECT CATEGORIES

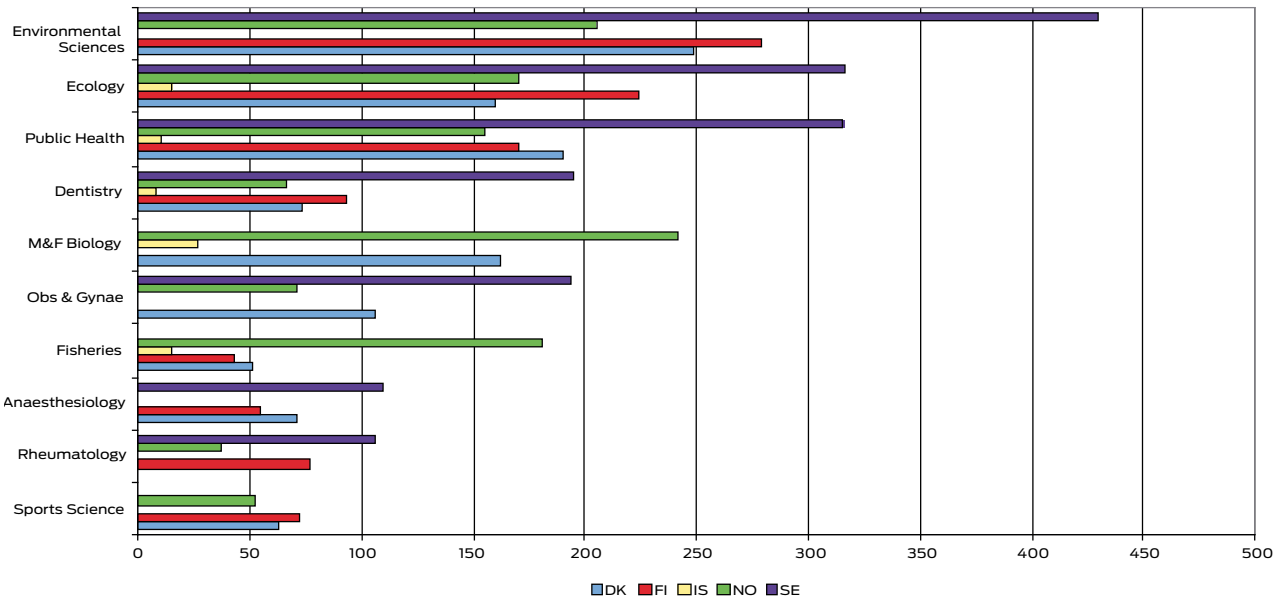
Sources:
OST – ISI-Thomson, Calculations OST and Technopolis Group.

Note:
N: Number of publications (Full counting)
R: Rank;
%
Trend between 2001 and 2004.
Selection of the 10 first subject categories: see § 3.2.
No aggregate data (Full counting).

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

		1999-2001		2002-04		2004/01	
Subject category	**Country**	**N**	**R**	**N**	**R**	**%**	**R**
Fisheries	Denmark	62	20	52	20	-15,6%	20
	Finland	38	19	43	18	13,0%	9
	Iceland	12	5	16	5	33,3%	12
	Norway	160	5	181	4	13,1%	10
Obstetrics & Gynecology	Denmark	107	11	106	13	-1,2%	18
	Norway	69	10	71	10	3,4%	13
	Sweden	193	12	194	11	0,7%	9
Anesthesiology	Denmark	65	18	71	18	9,3%	9
	Finland	72	12	55	15	-23,6%	18
	Sweden	111	16	110	17	-0,9%	11
Marine & Freshwater Biology	Denmark	164	5	162	8	-1,2%	17
	Iceland	16	3	27	2	70,2%	8
	Norway	191	2	242	1	26,3%	6
Ecology	Denmark	148	9	160	9	8,1%	11
	Finland	156	4	224	2	44,1%	2
	Iceland	6	10	16	6	147,4%	4
	Norway	168	4	171	5	2,2%	14
	Sweden	294	6	317	5	7,7%	6
Sport Sciences	Denmark	63	19	63	19	0,5%	15
	Finland	69	15	73	13	6,3%	11
	Norway	33	16	53	12	58,0%	2
Dentistry, Oral Surgery & Medicine	Denmark	70	16	74	16	6,2%	13
	Finland	81	11	94	9	16,9%	6
	Iceland	2	18	9	11	420,0%	1
	Norway	76	9	67	11	-11,8%	16
	Sweden	217	10	195	10	-10,3%	15
Rheumatology	Finland	81	10	77	12	-5,3%	16
	Norway	45	12	38	15	-16,3%	19
	Sweden	82	20	106	18	29,7%	3
Public, Environmental & Occupational Health	Denmark	154	6	191	6	23,5%	4
	Finland	166	3	171	4	2,6%	13
	Iceland	5	13	11	8	100,0%	6
	Norway	107	7	155	6	45,0%	3
	Sweden	300	5	316	6	5,1%	8
Environmental Sciences	Denmark	213	3	249	3	17,1%	6
	Finland	244	1	280	1	14,8%	8
	Norway	191	3	206	3	8,2%	11
	Sweden	364	4	430	3	18,2%	4

EXHIBIT 19 FIVE NORDIC COUNTRIES: NUMBERS OF SCIENTIFIC PUBLICATIONS (2002/04) – THE 10 SELECTED SUB-FIELD CATEGORIES



Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: Selection of the 10 first subject categories: see § 3.2.
No aggregate data (Full counting).

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

3.2.2 World shares of publications

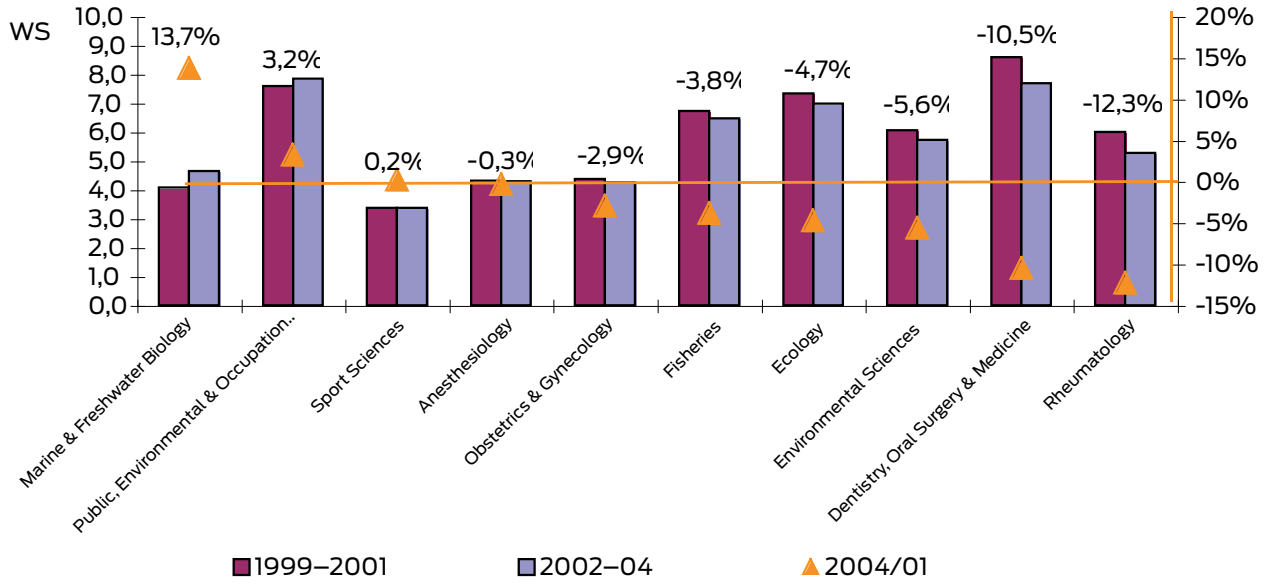
Exhibit 20 below presents data showing the world shares of Nordic scientific publications in the Top-10 sub-fields. Sub-fields are in decreasing order of the total rank in 2002/04. Public Health, Dentistry, Ecology and Fisheries have the largest world shares in 2002/04.

EXHIBIT 20 FIVE NORDIC COUNTRIES: WORLD SHARES OF SCIENTIFIC PUBLICATIONS (2001, 2004, AND CHANGE BETWEEN 2001 AND 2004) – BREAKDOWN BY SUBJECT CATEGORIES

Presentation based on 2004 ranking	1999–2001		2002–04		2004/01	
Subject category	WS	R	WS	R	%	R
Public, Environmental & Occupational Health	7,59	4	7,83	3	3%	19
Dentistry, Oral Surgery & Medicine	8,58	3	7,68	4	-10%	38
Ecology	7,32	5	6,98	5	-5%	29
Fisheries	6,73	6	6,47	6	-4%	28
Environmental Sciences	6,06	8	5,72	9	-6%	31
Rheumatology	6,01	9	5,27	10	-12%	40
Marine & Freshwater Biology	4,09	15	4,65	11	14%	13
Anesthesiology	4,31	14	4,30	12	0%	22
Obstetrics & Gynecology	4,37	13	4,25	14	-3%	26
Sport Sciences	3,36	18	3,37	16	0%	21

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note:
R: Rank,
WS: World share.
Selection of the 10 first subject categories: see § 3.2.

EXHIBIT 21 FIVE NORDIC COUNTRIES: WORLD SHARES OF SCIENTIFIC PUBLICATIONS - THE 10 SELECTED SUB-FIELDS



Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. Note: Selection of the 10 first subject categories: see § 3.2.

Exhibit 21 presents these data in graphical terms (ordered by growth rate) and illustrates that only Marine and Freshwater Biology and Public, Environmental and Occupational Health have grown between in terms of world shares of scientific publications. Dentistry, Oral Surgery and Medicine, although in first (1999/2001) or second place (2002/04) for world shares of scientific publications, has one of the most negative growth rates of the 10 scientific fields (-10%) in the period.

Exhibit 22 shows the breakdown by country and sub-fields of the world shares of Nordic scientific publications, in rank order. The Top-10 sub-fields we selected are shown in boxed text. It is worth noting that our approach therefore omits some traditional areas of Nordic collaboration. Materials Science, Paper and Wood are strong only in two of the five countries, so this sub-field does not make it into the final list. Nordic work in Forestry has too low an impact factor to appear on the list. Environmental engineering, which presumably has a close relationship with Environmental Science, also does not appear on our list but is a productive area, that NordForsk might consider for funding together with Environmental Science. Some of the prolific sub-fields that for various reasons did not make it into our Top-10 might nonetheless be regarded as candidates for funding because they relate to areas of Nordic need and capability.

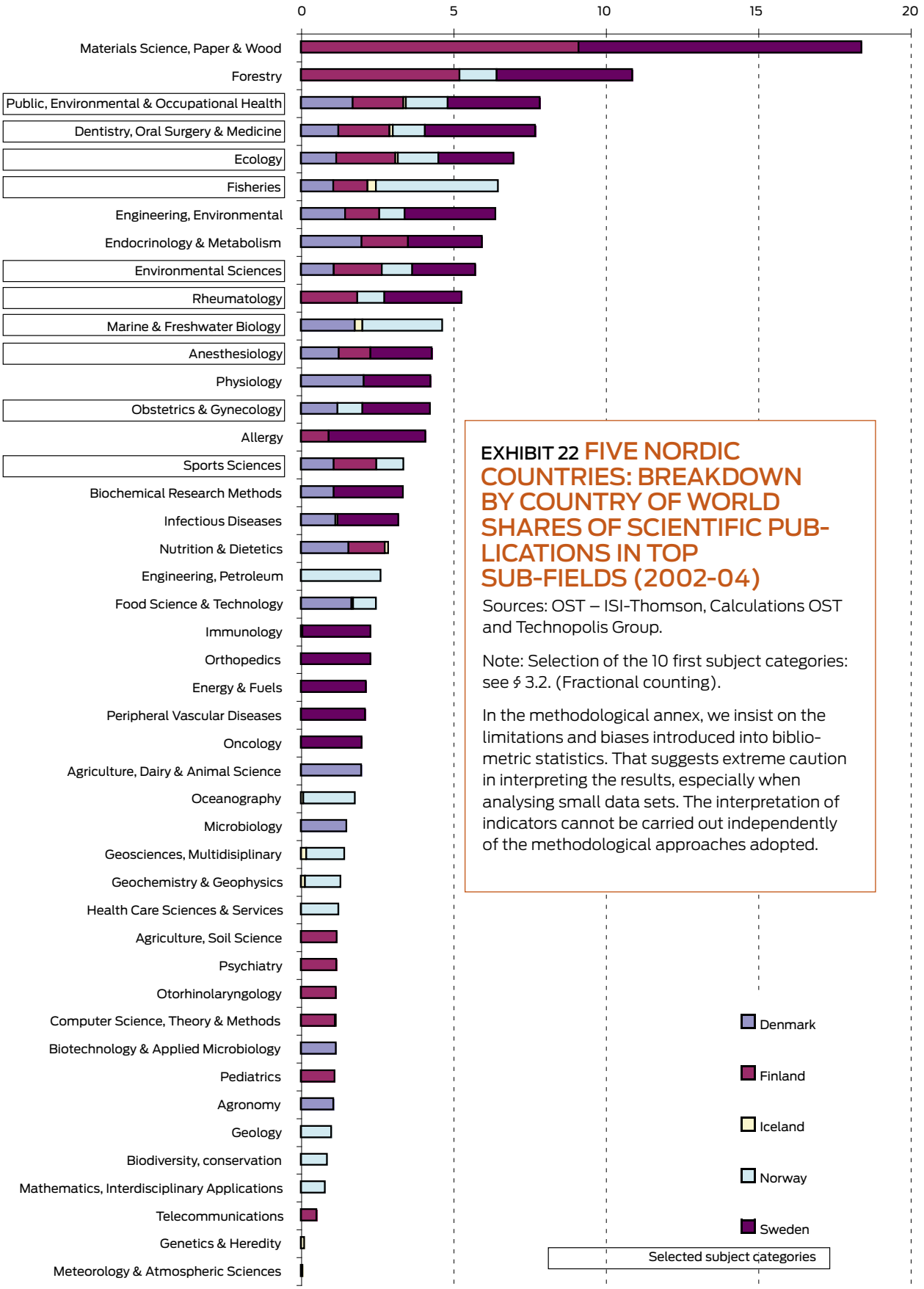


EXHIBIT 22 FIVE NORDIC COUNTRIES: BREAKDOWN BY COUNTRY OF WORLD SHARES OF SCIENTIFIC PUBLICATIONS IN TOP SUB-FIELDS (2002-04)

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

Note: Selection of the 10 first subject categories: see § 3.2. (Fractional counting).

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

EXHIBIT 23
FIVE NORDIC COUNTRIES: WORLD SHARES OF CITATIONS

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

Note: R: Rank, WS: World share of citation. (Fractional counting). Selection of the 10 first subject categories: see ⸗ 3.2.

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

		1999–2001		2002–04		2004/01	
Subject category	Country	WS	R	WS	R	%	R
Fisheries	Denmark	1,89	6	1,04	20	-45%	20
	Finland	1,06	16	1,01	15	-4%	14
	Iceland	0,29	1	0,50	2	70%	9
	Norway	5,36	1	6,34	1	18%	10
	Total	8,61		8,89		3%	
Obstetrics & Gynecology	Denmark	1,75	8	1,68	11	-4%	13
	Norway	1,00	12	0,86	18	-13%	14
	Sweden	2,88	10	2,72	9	-5%	7
	Total	5,63		5,26		-6%	
Anesthesiology	Denmark	1,85	7	2,14	7	16%	8
	Finland	0,96	17	1,32	12	37%	4
	Sweden	2,58	14	2,53	12	-2%	5
	Total	5,39		5,99		11%	
Marine & Freshwater Biology	Denmark	2,73	2	2,46	6	-10%	15
	Iceland	0,17	4	0,33	4	100%	8
	Norway	2,62	3	3,37	3	29%	8
	Total	5,52		6,16		12%	
Ecology	Denmark	1,75	9	1,16	17	-33%	18
	Finland	1,63	10	2,44	3	50%	3
	Iceland	0,02	17	0,11	12	468%	2
	Norway	1,65	6	1,36	7	-17%	17
	Sweden	3,70	7	2,81	7	-24%	16
	Total	8,75		7,88		-10%	
Sports Sciences	Denmark	1,50	16	2,49	5	66%	1
	Finland	1,77	8	2,23	4	26%	5
	Norway	0,63	18	0,82	19	30%	6
	Total	3,90		5,54		42%	
Dentistry, Oral Surgery & Medicine	Denmark	1,58	14	1,57	13	-1%	11
	Finland	2,03	4	2,12	6	5%	11
	Iceland	0,03	16	0,03	18	30%	11
	Norway	1,75	5	1,40	6	-20%	18
	Sweden	5,38	4	3,87	4	-28%	18
	Total	10,77		8,99		-17%	
Rheumatology	Finland	2,41	3	1,80	9	-26%	18
	Norway	1,14	9	0,98	16	-14%	15
	Sweden	2,28	15	3,36	5	47%	1
	Total	5,83		6,13		5%	
Public, Environmental & Occupational Health	Denmark	1,65	13	1,96	8	18%	6
	Finland	1,50	11	1,80	8	20%	7
	Iceland	0,12	6	0,09	13	-21%	15
	Norway	0,89	15	1,08	12	22%	9
	Sweden	2,95	9	2,50	14	-15%	12
	Total	7,11		7,43		5%	
Environmental Sciences	Denmark	1,71	10	1,33	16	-22%	17
	Finland	1,70	9	1,64	11	-4%	13
	Norway	1,13	10	1,21	9	7%	12
	Sweden	2,72	12	2,77	8	2%	3
	Total	7,26		6,95		-4%	

3.2.3 World Shares of Citations

Citation performance is the traditional bibliometric indicator for quality or excellence. Exhibit 23 presents the relevant data for the Top-10 sub-fields. As with the numbers of publications, on this indicator there is some tendency to stagnation in certain (but not all) medical fields, especially Dentistry, and also in Ecology and Environmental Sciences.

Except for two scientific fields (Environmental Sciences and Obstetrics & Gynaecology), the world shares of scientific citations in 2002/04 are inversely related to their change between 1999/2001 and 2002/04, suggesting that we have here a mix of smaller but improving sub-fields and larger ones that are declining – at least on this indicator. Sports Sciences, Marine and Freshwater Biology, Anaesthesiology, Rheumatology, Public Environmental and Occupational Health and Fisheries are all improving in quality and may therefore be especially interesting targets for Nordic funding.

EXHIBIT 24

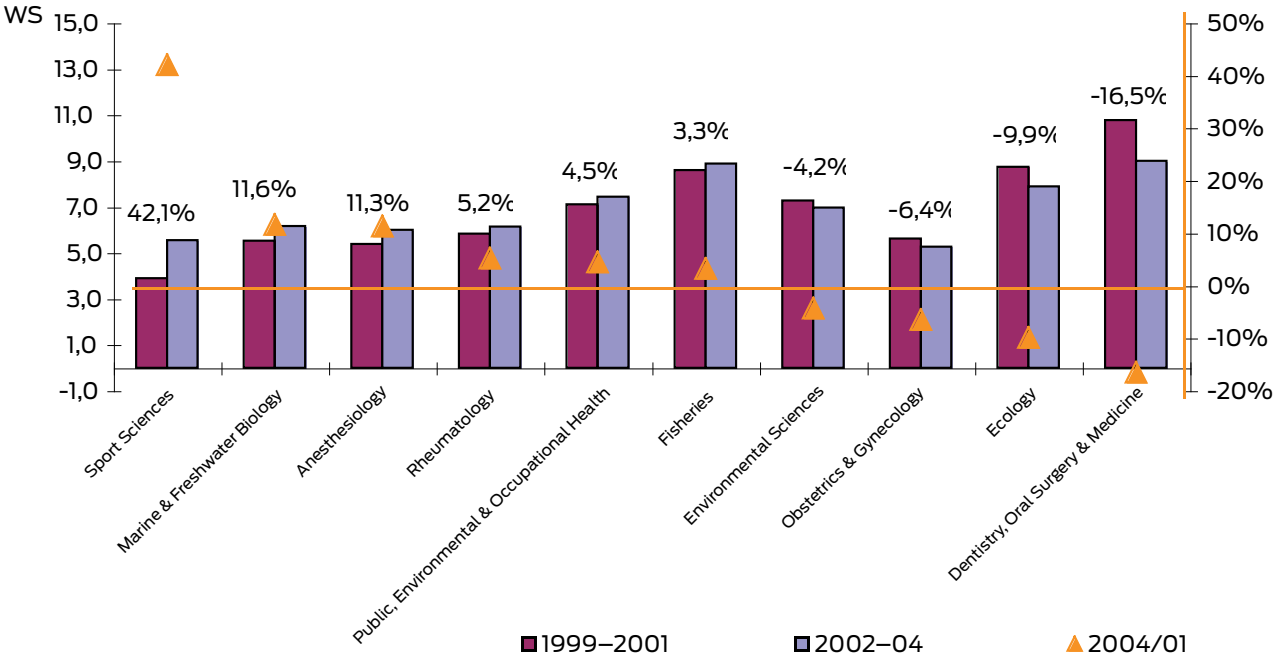
FIVE NORDIC COUNTRIES: WORLD SHARES OF CITATIONS

Presentation based on 2004 ranking	1999–2001		2002–04		2004/01	
Subject category	**WS**	**R**	**WS**	**R**	**%**	**R**
Dentistry, Oral Surgery & Medicine	10,77	3	8,99	3	-17%	37
Fisheries	8,61	5	8,89	4	3%	19
Ecology	8,75	4	7,88	5	-10%	30
Public, Environmental & Occupational Health	7,11	7	7,43	6	5%	17
Environmental Sciences	7,27	6	6,96	7	-4%	25
Marine & Freshwater Biology	5,52	13	6,16	9	12%	13
Rheumatology	5,83	10	6,13	10	5%	16
Anesthesiology	5,39	15	5,99	11	11%	14
Sports Sciences	3,90	20	5,54	13	42%	5
Obstetrics & Gynecology	5,63	12	5,26	14	-6%	28

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. Note: R: Rank, WS: World share of citation. (Fractional counting). Selection of the 10 first subject categories: see § 3.2.

Exhibit 24 presents the citation data in rank order, based on the 2002/04 citations while Exhibit 25 shows these data in graphical terms, ordered by the growth in the share of citations.

EXHIBIT 25 FIVE NORDIC COUNTRIES: WORLD SHARES OF SCIENTIFIC CITATIONS - THE 10 SELECTED SUBJECT CATEGORIES



Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: Selection of the 10 first subject categories: see ∮ 3.2. (Fractional counting).

Exhibit 26 shows, for each sub-field, the breakdown by country of the world shares of Nordic scientific citations, in decreasing order by ranking. As in the absolute volume of publications, the strength of Nordic performance on this quality indicator in Materials Science, Paper and Wood and in Forestry suggest that these could be interesting areas for funding, despite their failure to make our Top-10 list.

3.2.4 Impact factors

Impact factors are the other important bibliometric indicators of quality. This sub-section presents impact factors of the five Nordic countries' scientific publications within the prioritised sub-fields.

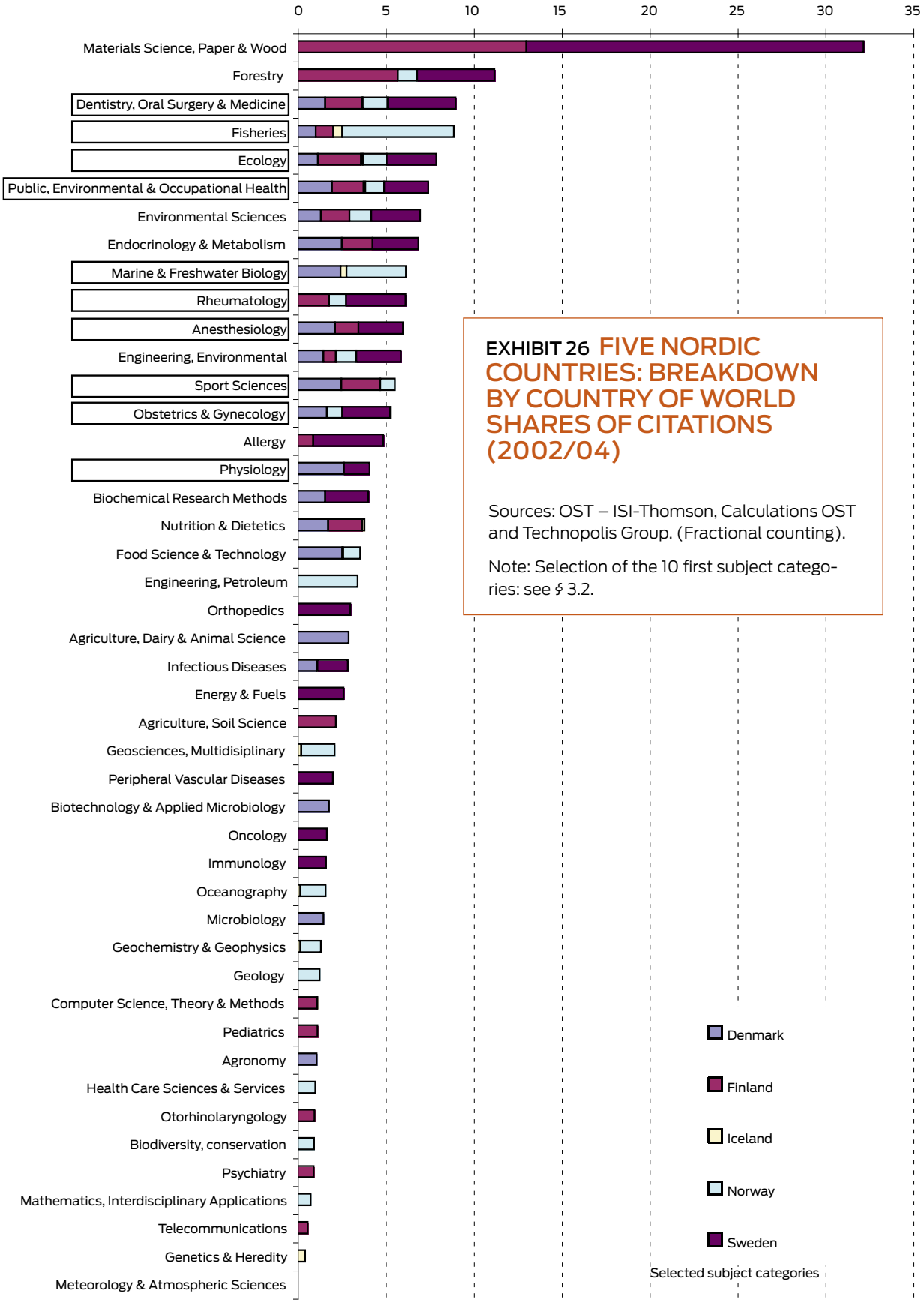


EXHIBIT 26 **FIVE NORDIC COUNTRIES: BREAKDOWN BY COUNTRY OF WORLD SHARES OF CITATIONS (2002/04)**

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Fractional counting).

Note: Selection of the 10 first subject categories: see ∮ 3.2.

EXHIBIT 27 IMPACT FACTOR DEFINITION

(MORE INFORMATION ON IMPACT INDICATORS IS AVAILABLE IN APPENDIX C)

The impact factor at level of journals is a quantitative tool for ranking, evaluating, categorizing, and comparing journals; it is a measure of the frequency with which the "average article" in a journal has been cited in a particular year or period. The impact factor of a journal is calculated by dividing the number of current year citations to the source items published in that journal for example during the previous two years:

- **A** = total cites in 2004
- **B** = 2004 cites to articles published in 2002-2003 (this is a subset of A)
- **C** = number of articles published in 2002-2003
- **D** = B/C = 2004 impact factor

The impact factor is useful in clarifying the significance of absolute (or total) citation frequencies. It eliminates some of the bias of such counts which favour large journals over small ones, or frequently issued journals over less frequently issued ones, and of older journals over newer ones. Particularly in the latter case such journals have a larger citable body of literature than smaller or younger journals. Other things being equal, the larger the number of previously published articles, the more often a journal will be cited.

Sources: adapted from http://scientific.thomson.com/free/essays/journalcitationreports/impactfactor/

On average (all countries together), impact factors of the 10 selected sub-fields vary between 1.01 (Public, Environmental & Occupational Health) and 1.60 (Sports Sciences) in 2002/04. This indicator confirms the sense of stagnation communicated by Nordic citation performance in Obstetrics and Gynaecology and in Dentistry. However, while the falling citation rates suggested problems in Ecology and Environmental Sciences, the impact factors of the journals where Nordic researchers publish in these sub-fields have been rising. So, on one indicator quality has fallen while on the other it has risen – perhaps an important reminder of the need to qualify bibliometrics-based analysis with qualitative understanding.

		1999–2001		2002–04		2004/01	
Subject category	**Country**	**WS**	**R**	**WS**	**R**	**%**	**R**
Fisheries	Denmark	1,49	6	0,98	19	-34%	19
	Finland	0,95	14	0,90	17	-5%	16
	Iceland	1,39	6	1,75	5	26%	7
	Norway	1,30	3	1,58	1	22%	5
	Average	**1,28**		**1,30**		**2%**	
Obstetrics & Gynecology	Denmark	1,43	8	1,40	7	-2%	10
	Norway	1,14	7	1,05	12	-9%	16
	Sweden	1,27	8	1,23	8	-3%	10
	Average	**1,28**		**1,22**		**-4%**	
Anesthesiology	Denmark	1,60	3	1,71	2	7%	6
	Finland	0,87	18	1,28	5	47%	1
	Sweden	1,26	9	1,26	5	0%	9
	Average	**1,24**		**1,42**		**14%**	
Marine & Freshwater Biology	Denmark	1,46	7	1,39	8	-5%	14
	Iceland	1,10	11	1,34	8	22%	9
	Norway	1,27	4	1,28	7	1%	12
	Average	**1,28**		**1,34**		**5%**	
Ecology	Denmark	1,37	9	1,00	17	-27%	18
	Finland	0,96	13	1,26	7	31%	4
	Iceland	0,51	17	1,20	13	137%	4
	Norway	1,13	8	1,03	13	-9%	17
	Sweden	1,30	6	1,14	9	-12%	15
	Average	**1,05**		**1,13**		**7%**	
Sports Sciences	Denmark	1,28	12	2,29	1	78%	1
	Finland	1,20	6	1,61	3	34%	3
	Norway	0,87	13	0,91	16	5%	11
	Average	**1,12**		**1,60**		**43%**	
Dentistry, Oral Surgery & Medicine	Denmark	1,31	11	1,28	10	-3%	11
	Finland	1,27	4	1,26	6	-1%	13
	Iceland	0,85	14	0,31	19	-63%	18
	Norway	1,25	5	1,34	4	7%	10
	Sweden	1,24	10	1,07	11	-13%	16
	Average	**1,18**		**1,05**		**-11%**	
Rheumatology	Finland	0,98	11	0,96	16	-1%	14
	Norway	0,86	15	1,12	10	30%	4
	Sweden	1,03	12	1,32	3	29%	1
	Average	**0,95**		**1,14**		**19%**	
Public, Environmental & Occupational Health	Denmark	1,11	14	1,15	13	4%	7
	Finland	0,87	17	1,08	11	24%	5
	Iceland	2,05	3	1,20	12	-41%	15
	Norway	0,80	17	0,78	20	-2%	14
	Sweden	0,92	16	0,83	18	-10%	14
	Average	**1,15**		**1,01**		**-12%**	
Environmental Sciences	Denmark	1,32	10	1,23	12	-7%	16
	Finland	1,10	8	1,04	12	-5%	15
	Norway	1,06	11	1,22	9	15%	7
	Sweden	1,27	7	1,34	2	5%	4
	Average	**1,19**		**1,21**		**2%**	

EXHIBIT 28
FIVE NORDIC COUNTRIES: IMPACT FACTORS

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

Note: Selection of the 10 first subject categories: see § 3.2.

R: Rank; IF: Impact Factor. (Fractional counting).

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

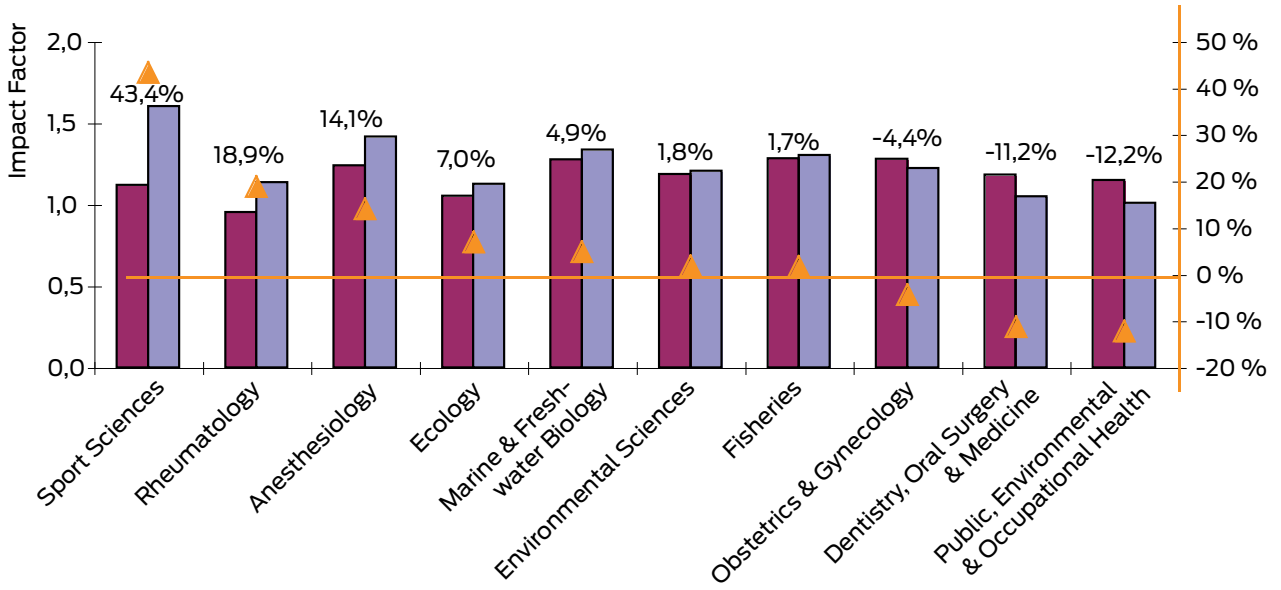
EXHIBIT 29 FIVE NORDIC COUNTRIES: IMPACT FACTORS 2/2

PRESENTATION BASED ON 2004 RANKING	1999–2001		2002–04		2004/01	
Subject category	**IF**	**R**	**IF**	**R**	**%**	**R**
Sports Sciences	1,12	8	1,60	1	43 %	1
Anesthesiology	1,24	4	1,42	2	14 %	3
Marine & Freshwater Biology	1,28	3	1,34	3	5 %	5
Fisheries	1,28	1	1,30	4	2 %	7
Obstetrics & Gynecology	1,28	2	1,22	5	-4 %	8
Environmental Sciences	1,19	5	1,21	6	2 %	6
Rheumatology	0,95	10	1,14	7	19 %	2
Ecology	1,05	9	1,13	8	7 %	4
Dentistry, Oral Surgery & Medicine	1,18	6	1,05	9	-11 %	9
Public, Environmental & Occupational Health	1,15	7	1,01	10	-12 %	10

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: Selection of the 10 first subject categories: see ∮ 3.2.
R: Rank; IF: Impact Factor. (Fractional counting).

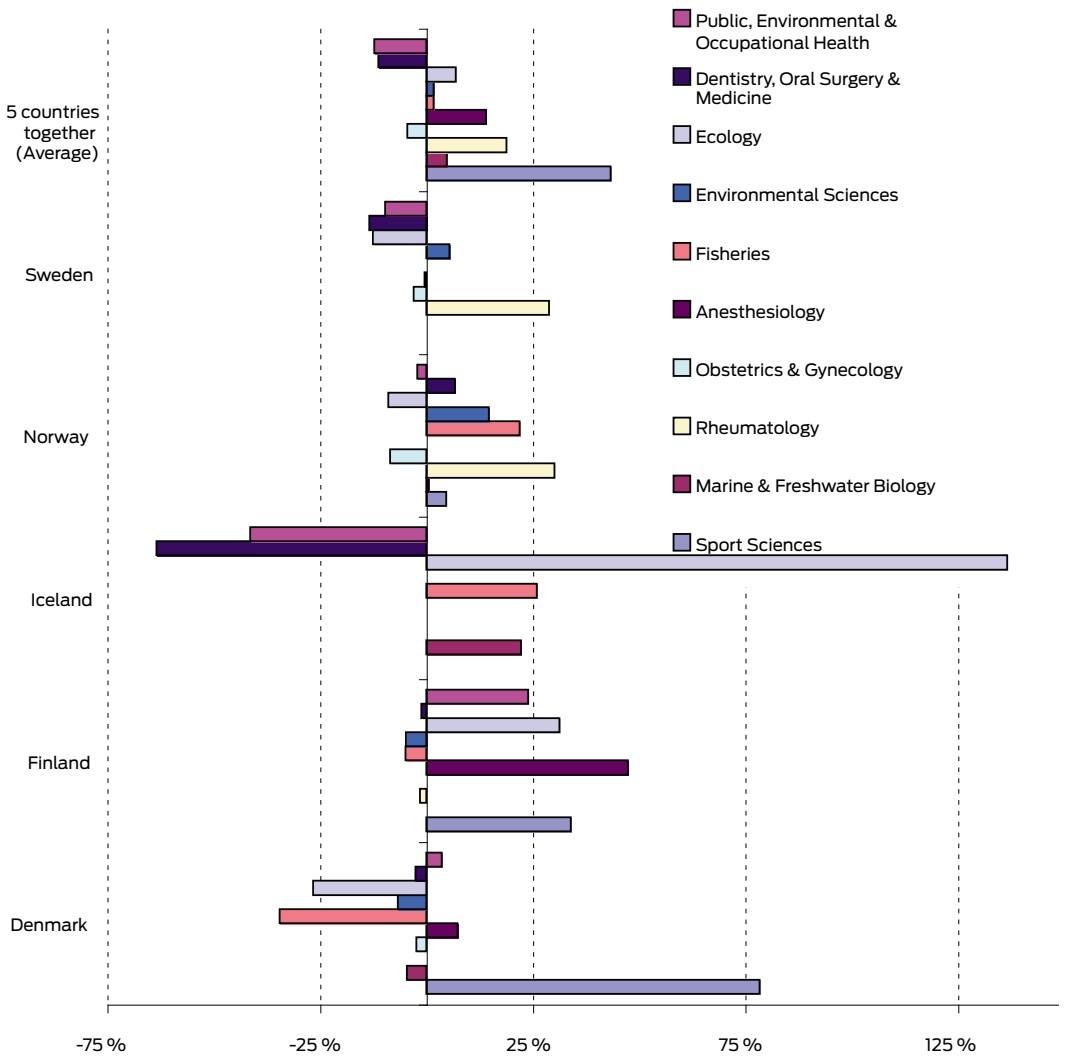
Exhibit 29 presents the impact factors in their rank order in 2004. Exhibit 30 presents these results graphically. Sports Sciences have experienced the strongest improvement in terms of impact factor (+43.4%). Overall, most of the 10 scientific fields had a positive change, so the impact factors suggest a more positive picture than the share of citations. This is likely to be because the citation shares are influenced by the growth in the overall size of the scientific community, while the impact factors provide an indicator of absolute quality.

EXHIBIT 30 FIVE NORDIC COUNTRIES: IMPACT FACTORS



Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: Selection of the 10 first subject categories: see ∮ 3.2. (Fractional counting).

EXHIBIT 31 FIVE NORDIC COUNTRIES: IMPACT FACTORS (PERCENT CHANGE BETWEEN 1999/2001 AND 2002/04)



Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

Note: Selection of the 10 first subject categories: see § 3.2. (Fractional counting).

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

3.2.5 The Investment Perspective

As with the major fields, we have compared the Nordic positions and trends in performance in the 10 sub-fields in order to develop an investment perspective on them. It is important to read this analysis as a comparison of the sub-fields **relative to each other** and to recall that these are the Top-10 Nordic sub-fields according to the selection process we used earlier, so each of them are in important respects strong and there are good arguments for each of them to be funded.

EXHIBIT 32 REASONING TO SUPPORT INVESTMENT PERSPECTIVE, 10 SUB-FIELDS

	Position 2002/04				Trend 1999/2001 - 2002/04				Leverage 2004	
	Total Nordic Publications*	**World Share of Publications**	**Citation shares**	**Impact Factors**	**Total Nordic Publications***	**World Share of Publications**	**Citation Shares**	**Impact factors**	**Citation / Publi-cation Shares**	**World Share per Paper**
Fisheries	292	6.5%	8.9%	1.30	7 %	-4 %	3 %	2 %	1.37	0.022%
Obstetrics & Gynae.	371	4.3%	5.3%	1.22	1 %	3 %	-6 %	-4 %	1.24	0.011%
Anaesthesiology	236	4.3%	6.0%	1.42	-5 %	0 %	11 %	14 %	1.39	0.018%
M&F Biology	431	4.7%	6.2%	1.34	16 %	14 %	12 %	5 %	1.32	0.011%
Ecology	888	7.0%	7.9%	1.13	15 %	-5 %	-10 %	7 %	1.13	0.008%
Sports Science	189	3.4%	5.5%	1.60	15 %	0 %	42 %	43 %	1.64	0.018%
Dentistry	439	7.7%	9.0%	1.05	-2 %	-10 %	-17 %	-11 %	1.17	0.017%
Rheumatology	221	5.3%	6.1%	1.14	6 %	-12 %	5 %	19 %	1.16	0.024%
Public Health	844	7.8%	7.4%	1.01	15 %	3 %	5 %	-12 %	0.95	0.009%
Environmental Sciences	1165	5.7%	7.0%	1.21	15 %	-6 %	-4 %	2 %	1.22	0.005%
Mean	508	5.7%	6.9%	1.24	8 %	-2 %	4 %	7 %	1.26	0.014%
s.d. / 2	169	0.8%	0.7%	0	4 %	4 %	8 %	8 %	0.09	0.003%
Mean +(s.d./2)	676	6.4%	7.6%	1.33	12 %	2 %	12 %	15 %	1.35	0.018%
Mean -(s.d./2)	339	4.9%	6.3%	1.15	4 %	-5 %	-4 %	-2 %	1.17	0.011%
	L/M/H	**L/M/H**	**L/M/H**	**L/M/H**	**Rising or Falling**	**"-" if less than -5%**	**Rising or Falling**	**Rising or Falling**	**L/M/H**	**L/M/H**
Fisheries	L	H	H	M	+	+	+	+	H	H
Obstetrics & Gynae	M	L	L	M	+	+	-	-	M	L
Anaesthesiology	L	L	L	H	-	+	+	+	H	H
M&F Biology	M	L	L	H	+	+	+	+	M	L
Ecology	H	H	H	L	+	+	-	+	L	L
Sports Science	L	L	L	H	+	+	+	+	H	H
Dentistry	M	H	H	L	-	-	-	-	M	M
Rheumatology	L	M	L	L	+	-	+	+	L	H
Public Health	H	H	M	L	+	+	+	-	L	L
Environmental Sciences	H	M	M	M	+	-	-	+	M	L

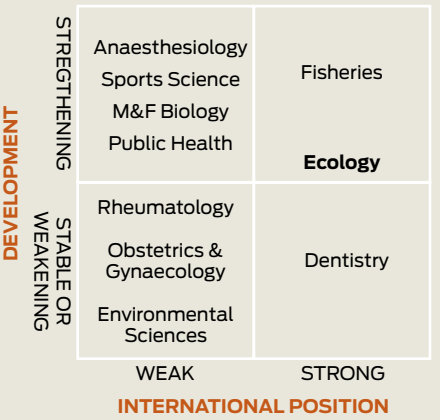
* Full counting

We have considered the 10 sub-fields on two dimensions: current position; and the trend in their development. In Exhibit 32 we show our thinking. (Note that the columns for total publications are for reference only; they are not used.) This necessarily includes some arbitrary judgements and many alternative readings are possible. On the 'position' dimension, we have looked at how far world shares of publications, shares of citations and impact factors deviate from the mean for the 10 sub-fields. Those whose position exceeds the mean by half a standard deviation or more we regards as 'high' and those which fall half a standard deviation or more below the mean we regard as 'low' with the remainder being 'medium'. We regard as strong those sub-fields that have a high share of world publications and either a high share of citations or a high impact factor.

To calibrate the trends in development dimension, we have regarded the share of world publications as positive if the actual growth rate is -5% or above (approximately compensating for the growth in the size of the scientific community). We have then looked at whether citation shares and impact factors are growing or declining. We regard a field as being in the process of strengthening if it has a growth rate of -5% or more **and** either the share of world citations or the impact factor is growing.

As at the field level, we consider 'leverage' in terms of the share of world publications generated by one paper. (An alternative concept of 'leverage', namely the ratio of world citation shares to world publication shares for the Nordic countries, produces pretty much the same result.) Exhibit 33 shows the results of this analysis, using the same positioning matrix as we employed for the large fields of science. Ecology is actually a borderline case between the upper and lower half of the diagram.

EXHIBIT 33 STRATEGIC POSITIONING MATRIX: SUBFIELDS



Note: High leverage fields are italicised

3.3 Scientific Collaboration

Before we finally draw conclusions based on Exhibit 33 and the thinking behind it, we need to consider the shape of the research communities that would benefit from funding. We do this by looking at co-publication, which is the bibliometric indicator for collaboration. This is not a selection criterion in our choice of 10 priority sub-fields. The data in this and the next section are presented as background for NordForsk to consider when setting funding priorities. Exhibit 34 presents the data regarding the structure of co-publications in 2004 for each of the 10 selected sub-fields for the 5 Nordic countries. For each country, and per sub-field, it shows

- The number of publications, including publications with "only one address" vs. co-publications; the number of co-publications is broken down between national and international ones
- The breakdown in percent of the number of 'single' publications ("only one address") and co-publications ("more than one address")

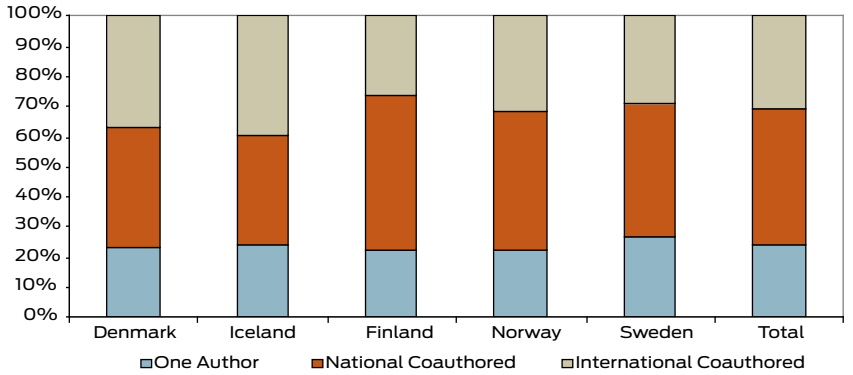
EXHIBIT 34 SCIENTIFIC COLLABORATIONS OF THE FIVE NORDIC COUNTRIES: TYPOLOGY OF PUBLICATIONS (2004)

		Anesthesiology	Dentistry, Oral Surgery & Medicine	Ecology	Environmental Sciences	Fisheries	Public, Envoronmental & Occupational Health	Marine & Freshwater Biology	Obstetrics & Gynecology	Rheumatology	Sport Sciences
DENMARK	Number of publication - full count (2004)										
	Only one adresse	15	15	43	68	17	28	27	20	9	16
	Total co-publications	48	51	101	184	38	166	87	82	41	46
	Total publications	63	66	144	252	55	194	114	102	50	62
	- National co-publications	40	29	40	72	14	101	33	54	30	27
	- Not-National co-publications	8	22	61	112	24	65	54	28	11	19
	Breakdown (%) by category of publication (2004)										
	Only one adresse	23,8%	22,7%	29,9%	27,0%	30,9%	14,4%	23,7%	19,6%	18,0%	25,8%
	Higher than one adresse	76,2%	77,3%	70,1%	73,0%	69,1%	85,6%	76,3%	80,4%	82,0%	74,2%
	Total publications	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
ICELAND	Number of publication - full count (2004)										
	Only one adresse	0	2	9	2	4	2	11	1	1	0
	Total co-publications	1	15	22	5	10	12	21	6	1	6
	Total publications	1	17	31	7	14	14	32	7	2	6
	- National co-publications	.	4	13	2	4	3	15	3	1	1
	- Not-National co-publications		11	9	3	6	9	6	3	0	5
	Breakdown (%) by category of publication (2004)										
	Only one adresse	0,0%	11,8%	29,0%	28,6%	28,6%	14,3%	34,4%	14,3%	50,0%	0,0%
	Higher than one adresse		88,2%	71,0%	71,4%	71,4%	85,7%	65,6%	85,7%	50,0%	100,0%
	Total publications	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
FINLAND	Number of publication - full count (2004)										
	Only one adresse	9	15	69	66	13	31	30	12	4	9
	Total co-publications	47	82	144	203	36	144	51	78	72	59
	Total publications	56	97	213	269	49	175	81	90	76	68
	- National co-publications	40	57	79	128	26	97	27	61	49	47
	- Not-National co-publications	7	25	65	75	10	47	24	17	23	12
	Breakdown (%) by category of publication (2004)										
	Only one adresse	16,1%	15,5%	32,4%	24,5%	26,5%	17,7%	37,0%	13,3%	5,3%	13,2%
	Higher than one adresse	83,9%	84,5%	67,6%	75,5%	73,5%	82,3%	63,0%	86,7%	94,7%	86,8%
	Total publications	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
NORWAY	Number of publication - full count (2004)										
	Only one adresse	3	7	35	45	37	29	63	12	5	25
	Total co-publications	29	46	126	161	126	146	167	67	22	44
	Total publications	32	53	161	206	163	175	230	79	27	69
	- National co-publications	22	21	71	77	91	90	103	44	12	25
	- Not-National co-publications	7	25	55	84	35	56	64	23	10	19
	Breakdown (%) by category of publication (2004)										
	Only one adresse	9,4%	13,2%	21,7%	21,8%	22,7%	16,6%	27,4%	15,2%	18,5%	36,2%
	Higher than one adresse	90,6%	86,8%	78,3%	78,2%	77,3%	83,4%	72,6%	84,8%	81,5%	63,8%
	Total publications	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %
SWEDEN	Number of publication - full count (2004)										
	Only one adresse	23	33	88	149	13	49	46	41	24	24
	Total co-publications	68	143	192	296	14	239	77	144	92	91
	Total publications	91	176	280	445	27	288	123	185	116	115
	- National co-publications	57	100	77	156	8	153	30	104	64	65
	- Not-National co-publications	11	43	115	140	6	86	47	40	28	26
	Breakdown (%) by category of publication (2004)										
	Only one adresse	25,3%	18,8%	31,4%	33,5%	48,1%	17,0%	37,4%	22,2%	20,7%	20,9%
	Higher than one adresse	74,7%	81,3%	68,6%	66,5%	51,9%	83,0%	62,6%	77,8%	79,3%	79,1%
	Total publications	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %	100 %

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Full counting). In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

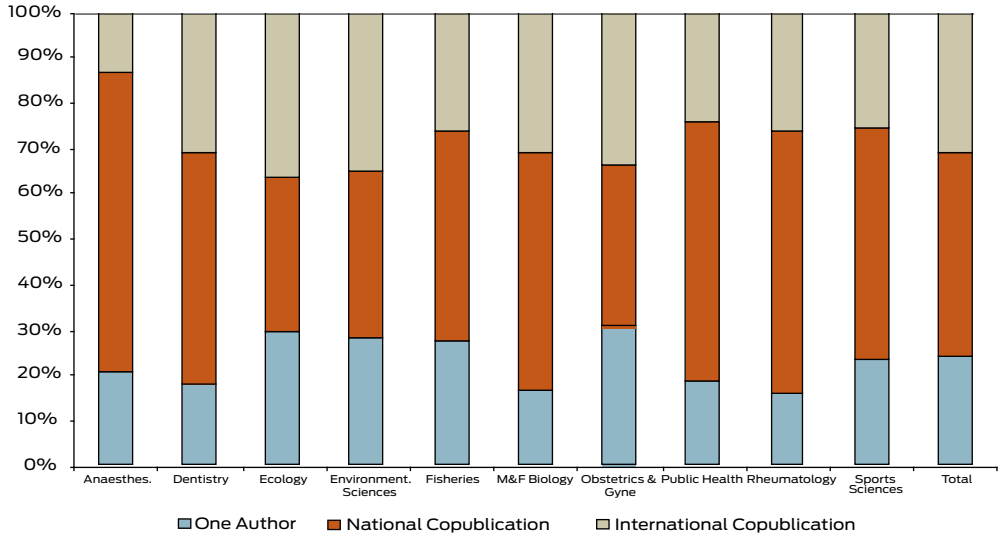
Note: National co-publications: publications with at least two national addresses and one international address. Not-National co-publications: pubications with only one national address and at least one international address.

EXHIBIT 35 CO-PUBLICATION LINKS OF THE NORDIC COUNTRIES, TOTAL OF 10 SUB-FIELDS, 2004



Note: Full counting. One publication can generate more than one link

EXHIBIT 36 NORDIC CO-PUBLICATION LINKS IN 10 SUB-FIELDS, 2004



Note: Full counting. One publication can generate more than one link Exhibit 35 Co-publication Links of the Nordic Countries, Total of 10 Sub-fields, 2004

A detailed, country by country analysis of co-publications across countries is presented for each of the 10 sub-fields in Appendix G. The second part of each table shows, as a benchmark, the total number of co-publications for each of the 10 first countries' partners in 2004. Exhibit 35 and Exhibit 36 summarise these co-publication data.

Exhibit 35 shows that about a quarter of the publications in the 10 sub-fields are written by single authors. The Finns are the most likely (52% of links) to have national co-authors and correspondingly the least likely (26%) to co-author with foreigners. This suggests that the Finnish policy drive to internationalise research may be well founded. Not surprisingly, given the small population, Icelanders are the most likely (40%) to have international links and least likely (36%) to have national links.

Exhibit 36 shows the cooperation pattern for the 10 sub-fields, revealing much less consistent behaviour. International links are as low as 14% in anaesthesia, while the next-lowest field is Public Health at 24%. In most fields about one third of the cooperation links involve international co-publication. Ecology

(37%) and the Environmental Sciences (35%) are the most internationalised sub-fields. The medically orientated sub-fields tend to be in the lower part of the range for international co-publication, with the exception of Obstetrics and Gynaecology, where 34% of the publications are internationally co-authored.

3.4 Data Analyses at National and Institutional Levels

We have prepared an extensive set of tables showing

- Which organisations in each country are the major publishing institutions
- The main organisations per country publishing in each of the Top-10 sub-fields
- The main partner institutions per field for each country

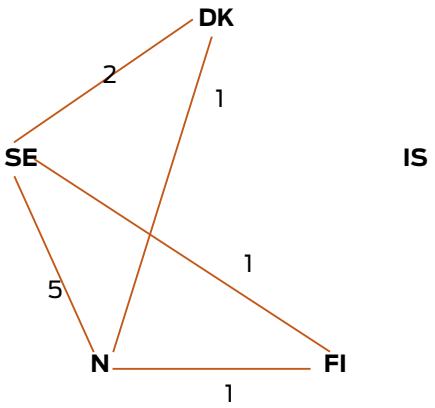
These are shown in Appendix H. Inter alia, they provide a guide to likely beneficiaries of funding per field.

3.4.1 Co-publications at national level

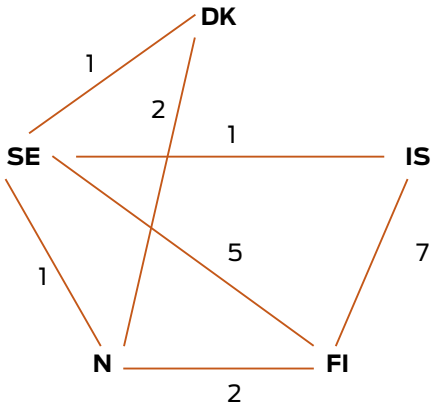
Exhibit 37 shows the co-publication links among the Nordic countries in the Top-10 sub-fields. (The number in brackets in the description of each sub-field is the total number of links for the sub-field. Note that since the basis is full counting, a single co-publication can give rise to several links if there are many authors.) Clearly, there is wide variation among the sub-fields in the amount of existing collaboration, which is especially intense in Environmental Sciences and Public Health. Anaesthesia, Dentistry and Rheumatology all involve little Nordic cooperation, while Obstetrics and Gynaecology again behaves differently from the other medial sub-fields and is rather intensely collaborative within the Nordic region.

EXHIBIT 37 CO-PUBLICATION NETWORKS AMONG NORDIC COUNTRIES, TOP-10 SUB-FIELDS, 2004

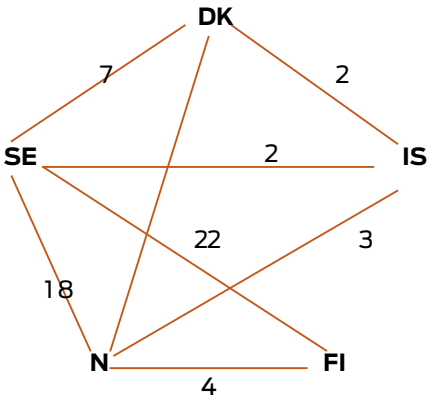
Anaesthesiology (10)



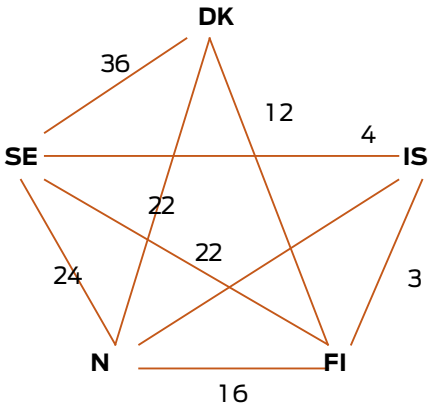
Dentistry (19)



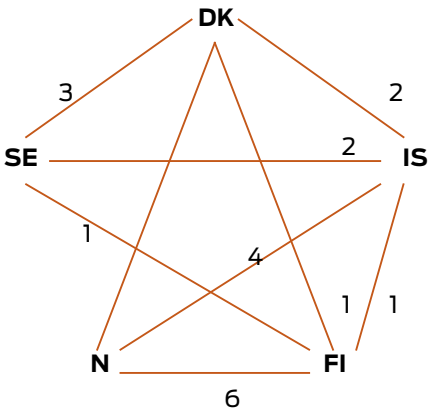
Ecology (58)



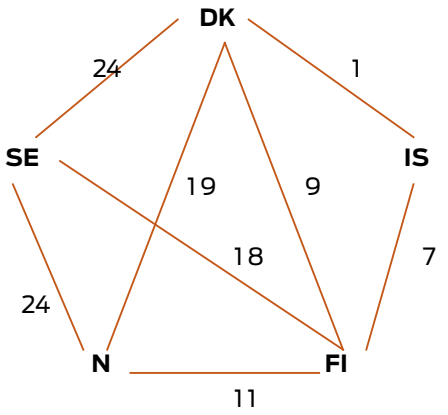
Environmental Sciences (140)



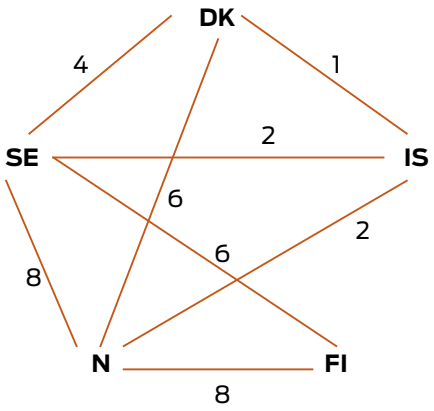
Fisheries (26)



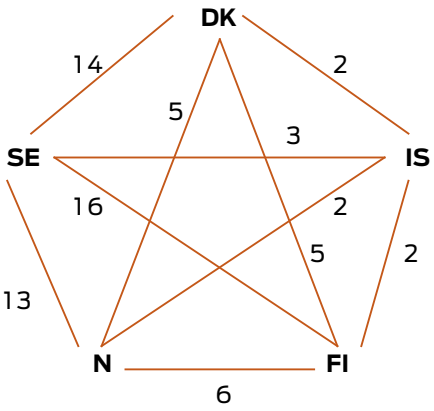
Public Health (111)



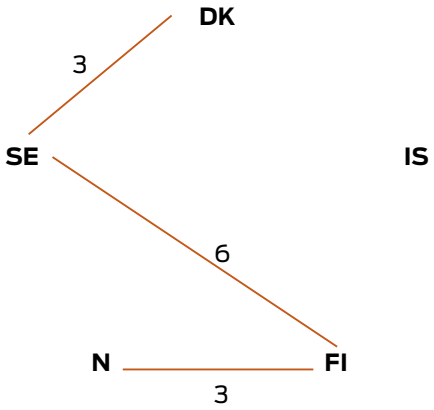
Marine, Freshwater Biology (37)



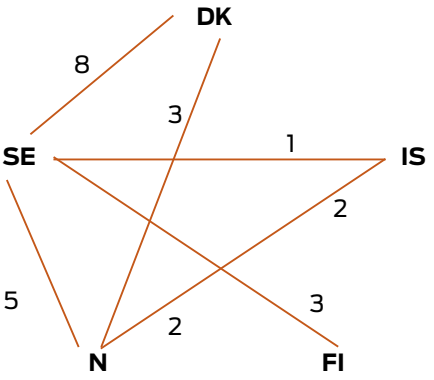
Obstetrics & Gynaecology (68)



Rheumatology (12)

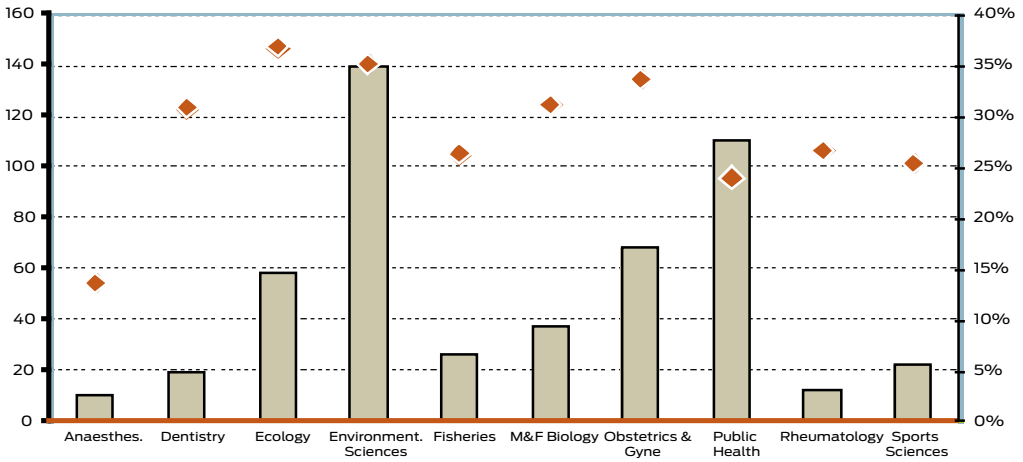


Sports Science (22)



Source: Appendix G. Note that since only the 10 most important partner countries are shown in that Appendix, this Exhibit may tend to under-count co-publication links

EXHIBIT 38 NUMBER OF NORDIC CO-PUBLICATION LINKS AND % OF INTERNATIONAL CO-AUTHORSHIPS, TOP-10 SUB-FIELDS, 2004



Source: Appendix G

Exhibit 38 shows for each sub-field the total number of Nordic co-publication links illustrated in Exhibit 37 and the percentage of international co-authorships in total Nordic publications (Exhibit 36). This confirms the impression of anaesthesiology as a rather national concern (in addition to being a rather small field), while the other medical sub-fields involve much more international co-publication. International co-authorship in Environmental Sciences and Public Health seem likely to be rather more focused on the Nordic area than in other sub-fields, while Obstetrics and Gynaecology occupies an intermediate position.

3.4.2 Co-authorship at the institutional level

Of course it is one thing to know that there are many co-authorship links between Nordic countries in certain sub-fields and another to understand whether these linkages are fragmented or represent more solid alliances among institutions. These are described in detail in Appendix H.3 and we have summarised them sub-field by sub-field in the following Exhibits. Where possible, we have only shown rather strong links: 3 or more co-publications in 2004. However, in about half the fields there are insufficient strong links to show much of a picture, so we have shown all links represented by 2 co-publications or more. The thickness of the links is proportional to the number of papers, with the thinnest link line representing 2 co-publications and the thickest representing 9 co-publications. We represent Nordic institutions by blue (dark) nodes and non-Nordic ones by red (lighter) ones.

EXHIBIT 39 ANAESTHESIOLOGY – 2 OR MORE TIES

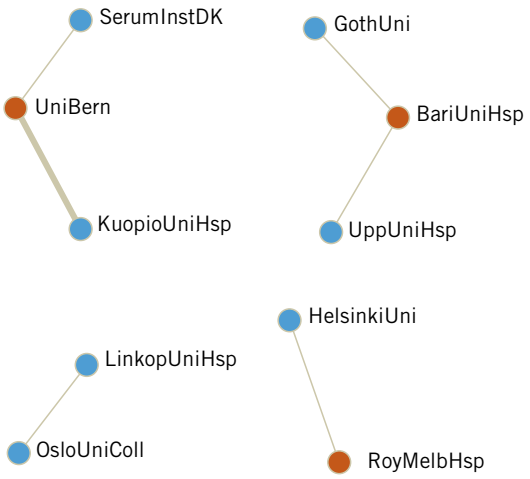


EXHIBIT 40 DENTISTRY – 2 OR MORE TIES

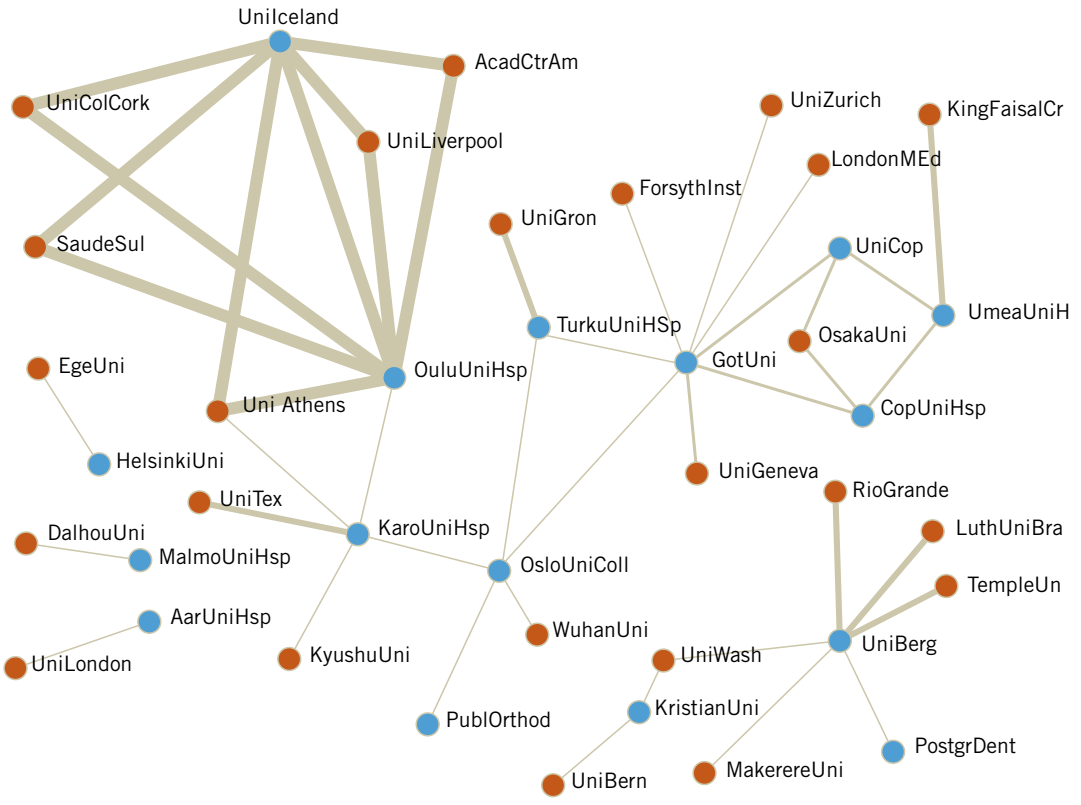


EXHIBIT 41 ECOLOGY – 2 OR MORE TIES

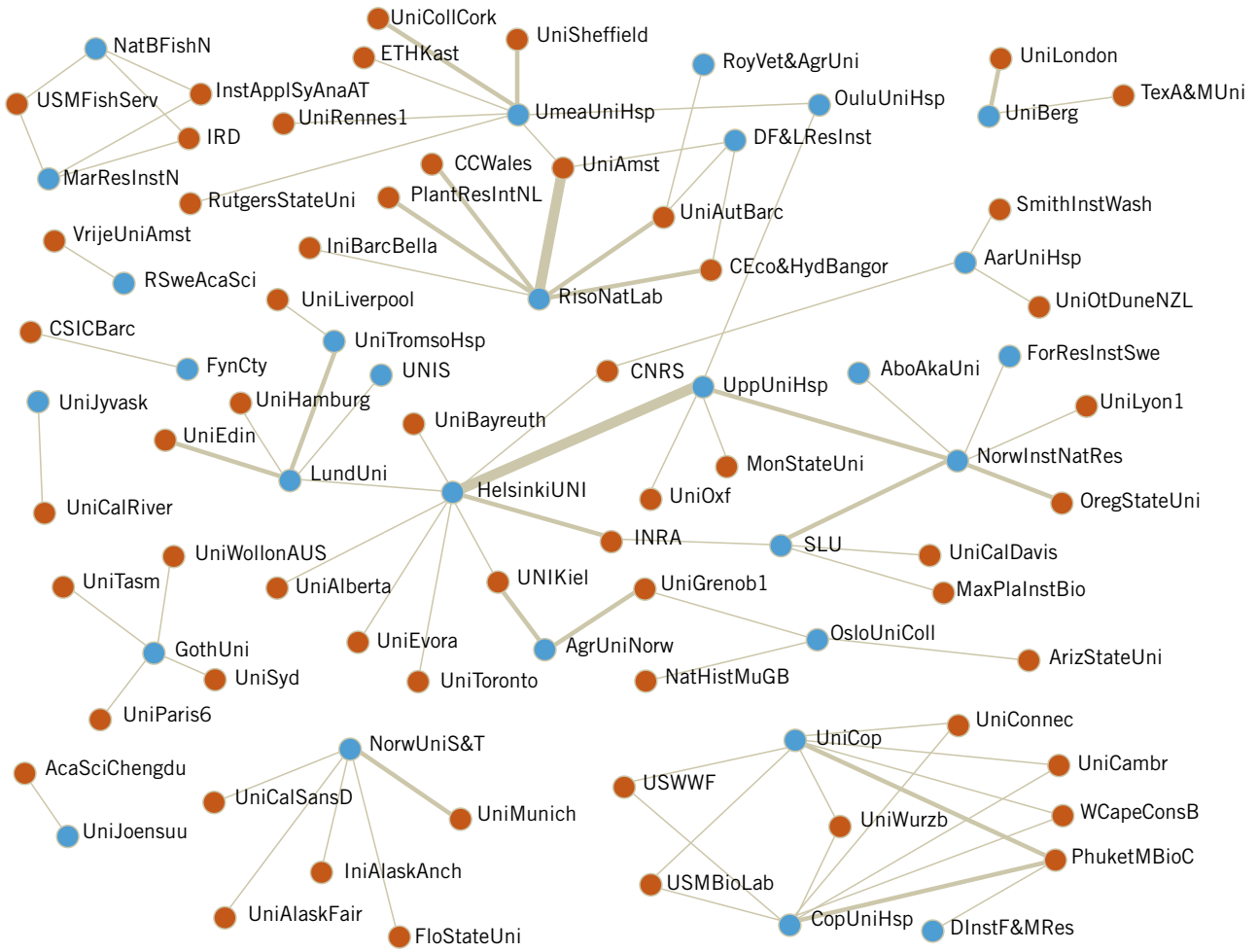


EXHIBIT 42 ENVIRONMENTAL SCIENCES – 2 OR MORE TIES

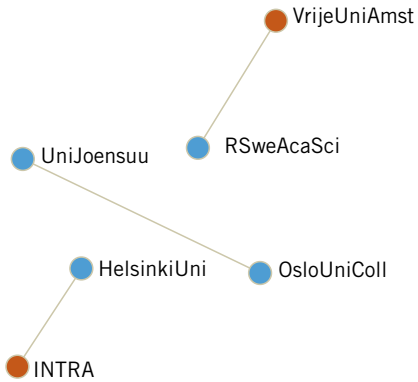


EXHIBIT 43 FISHERIES – 2 OR MORE TIES

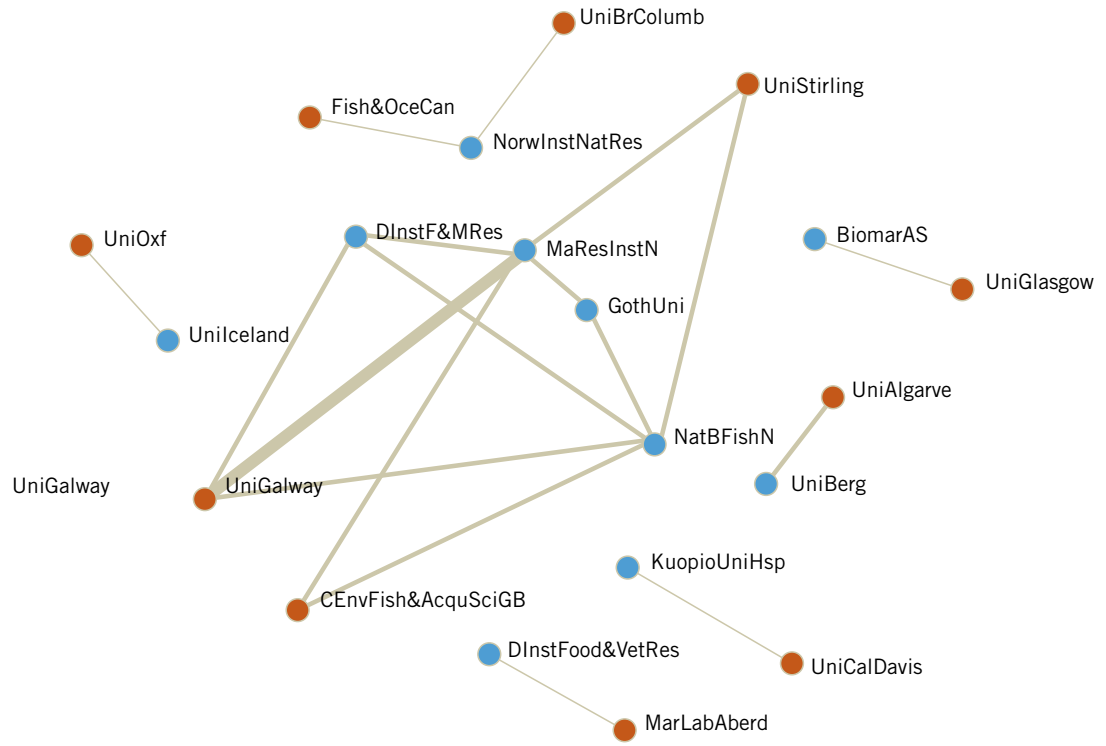


EXHIBIT 44 MARINE AND FRESHWATER BIOLOGY – 2 OR MORE TIES

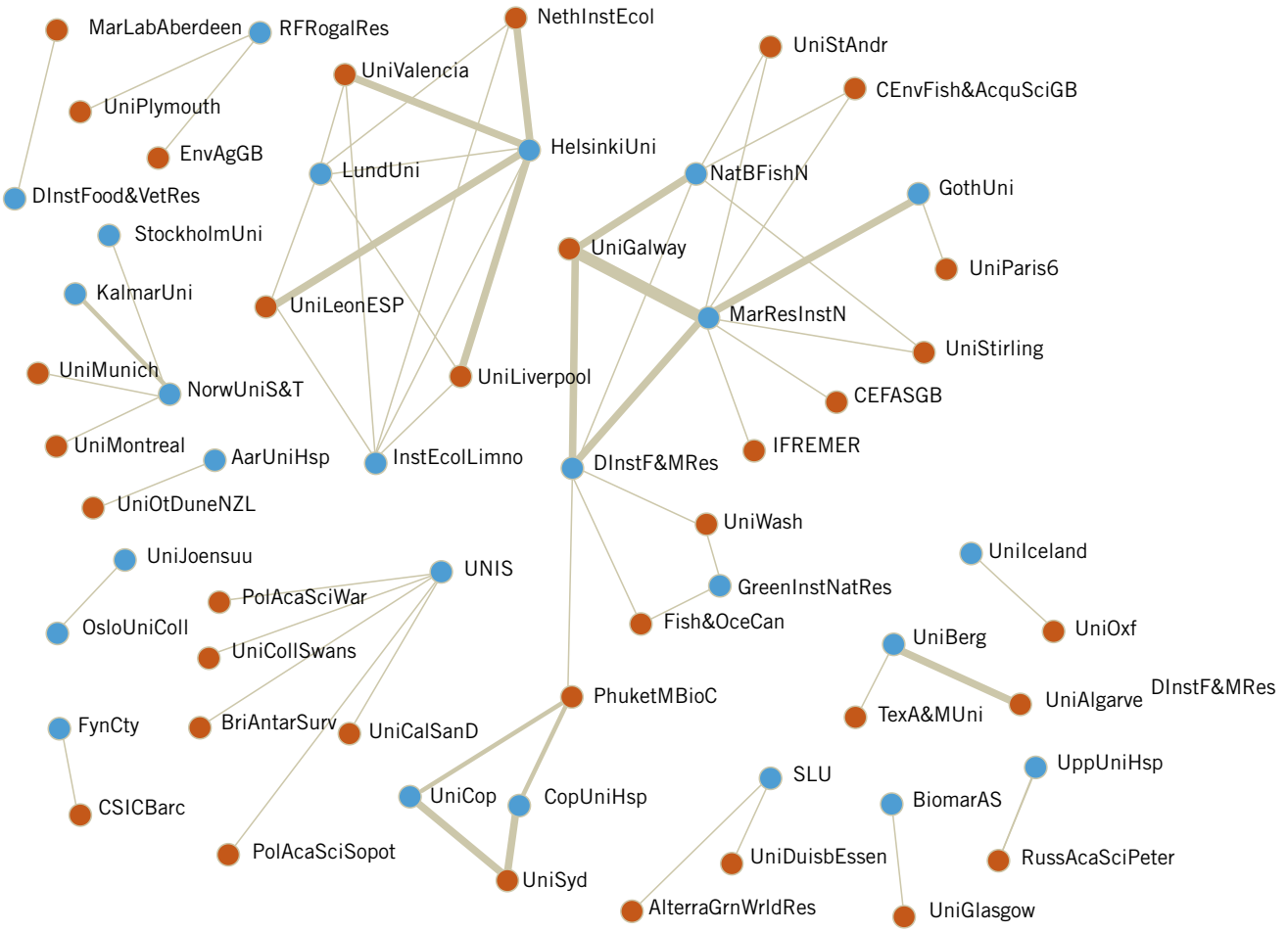


EXHIBIT 45 OBSTETRICS & GYNAECOLOGY – 2 OR MORE TIES

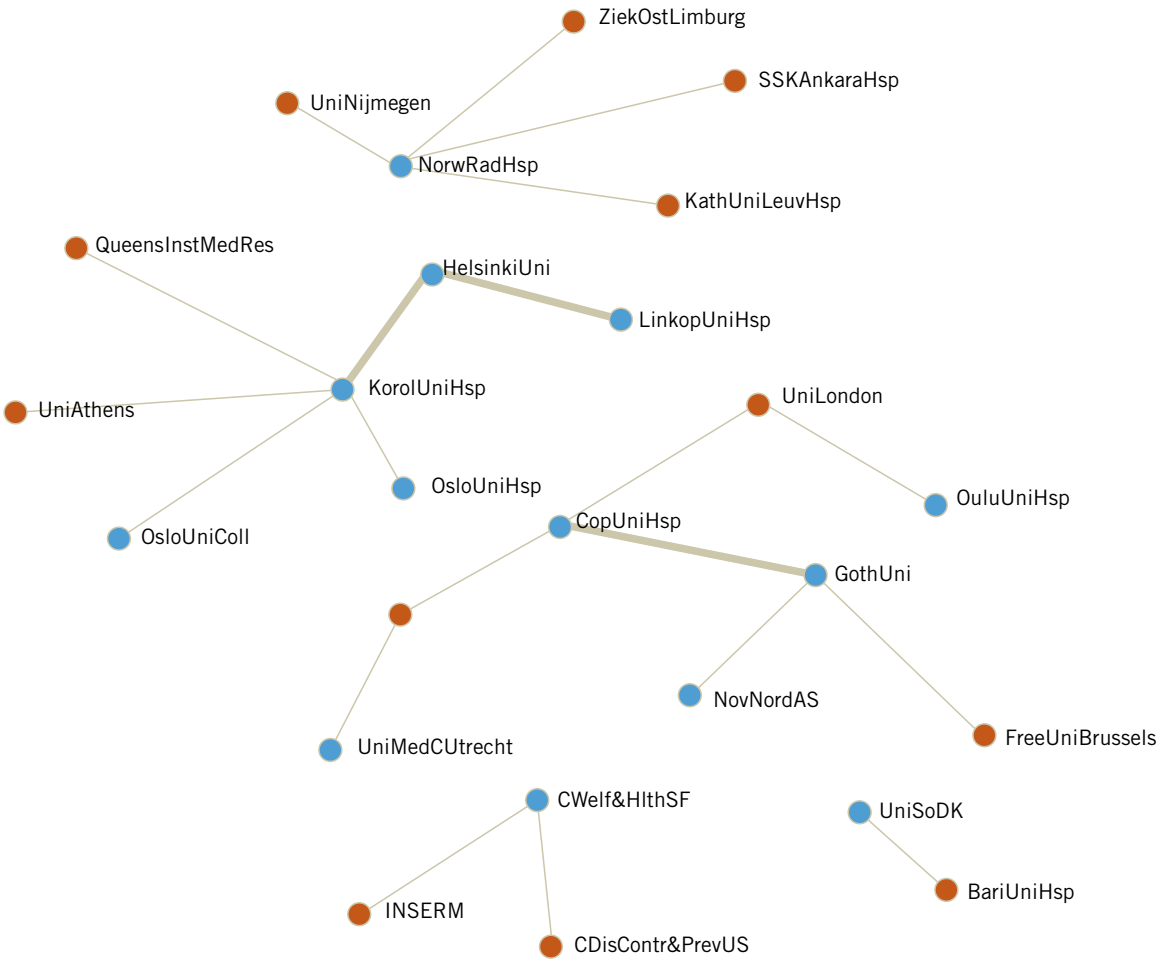


EXHIBIT 46 PUBLIC HEALTH – 2 OR MORE TIES

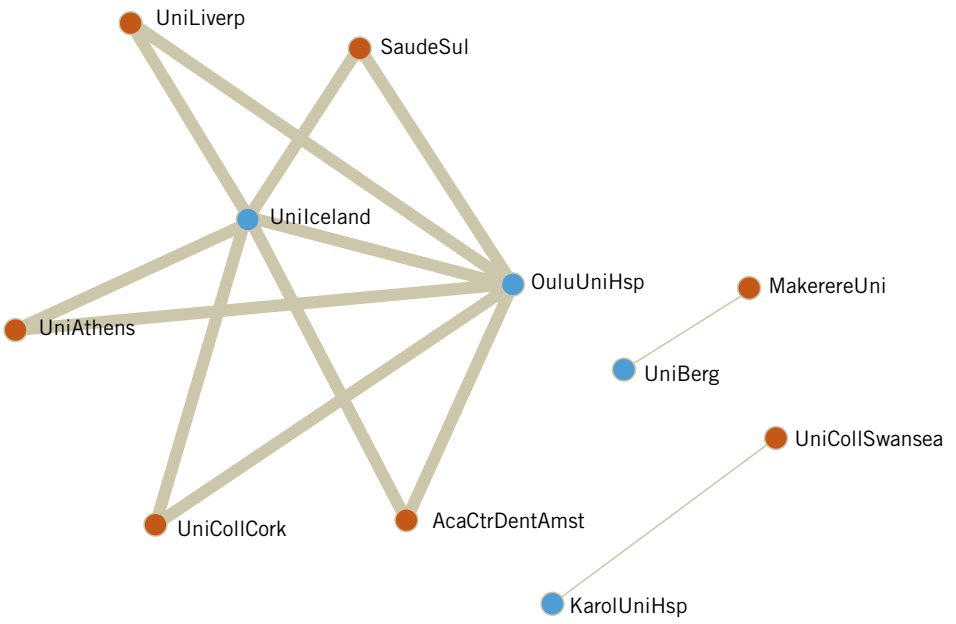


EXHIBIT 47 RHEUMATOLOGY – 2 OR MORE TIES

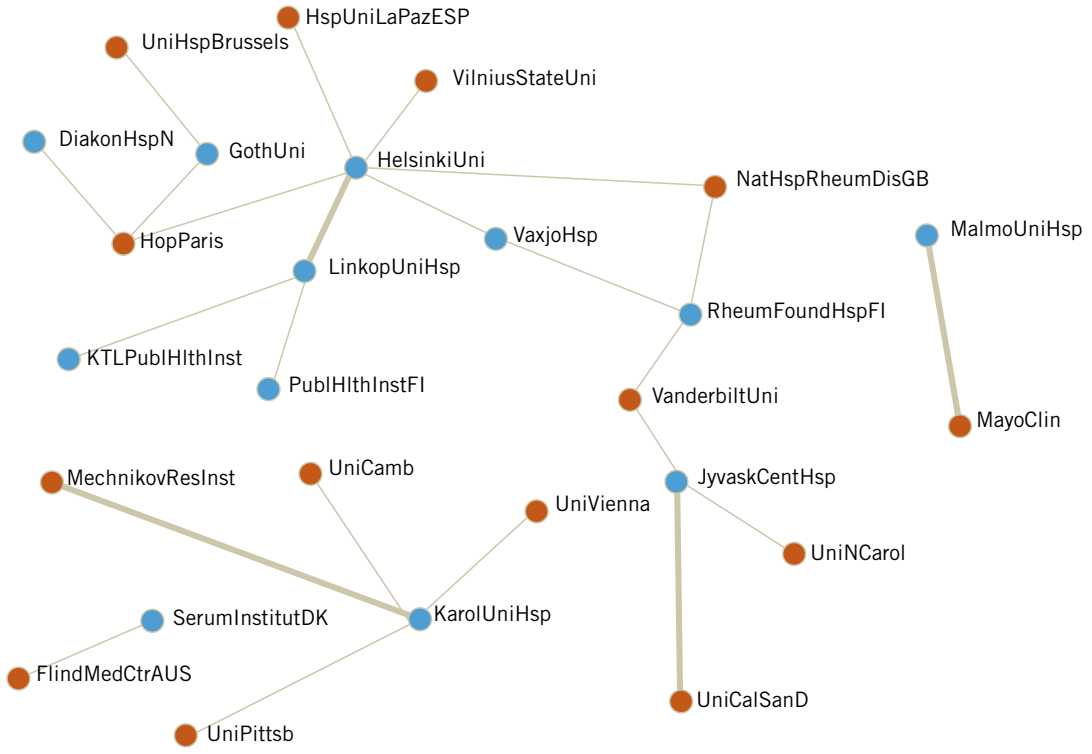
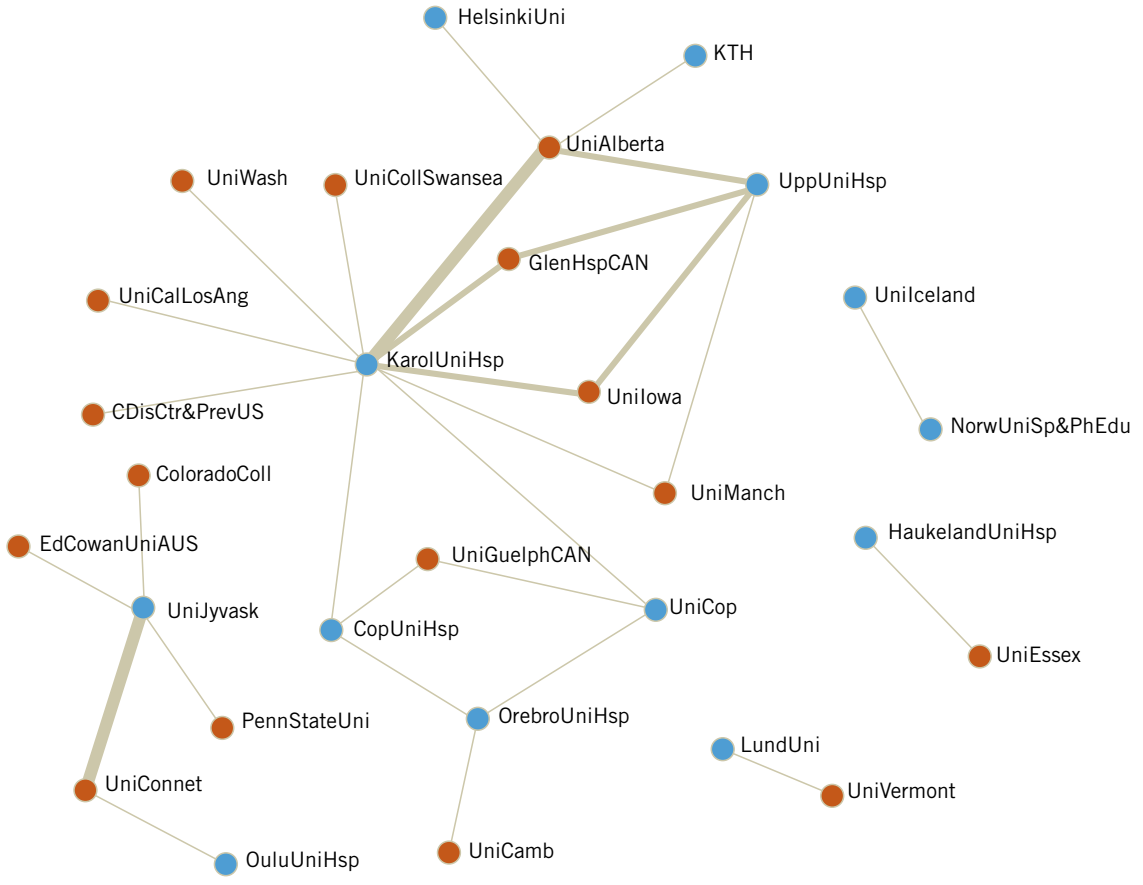
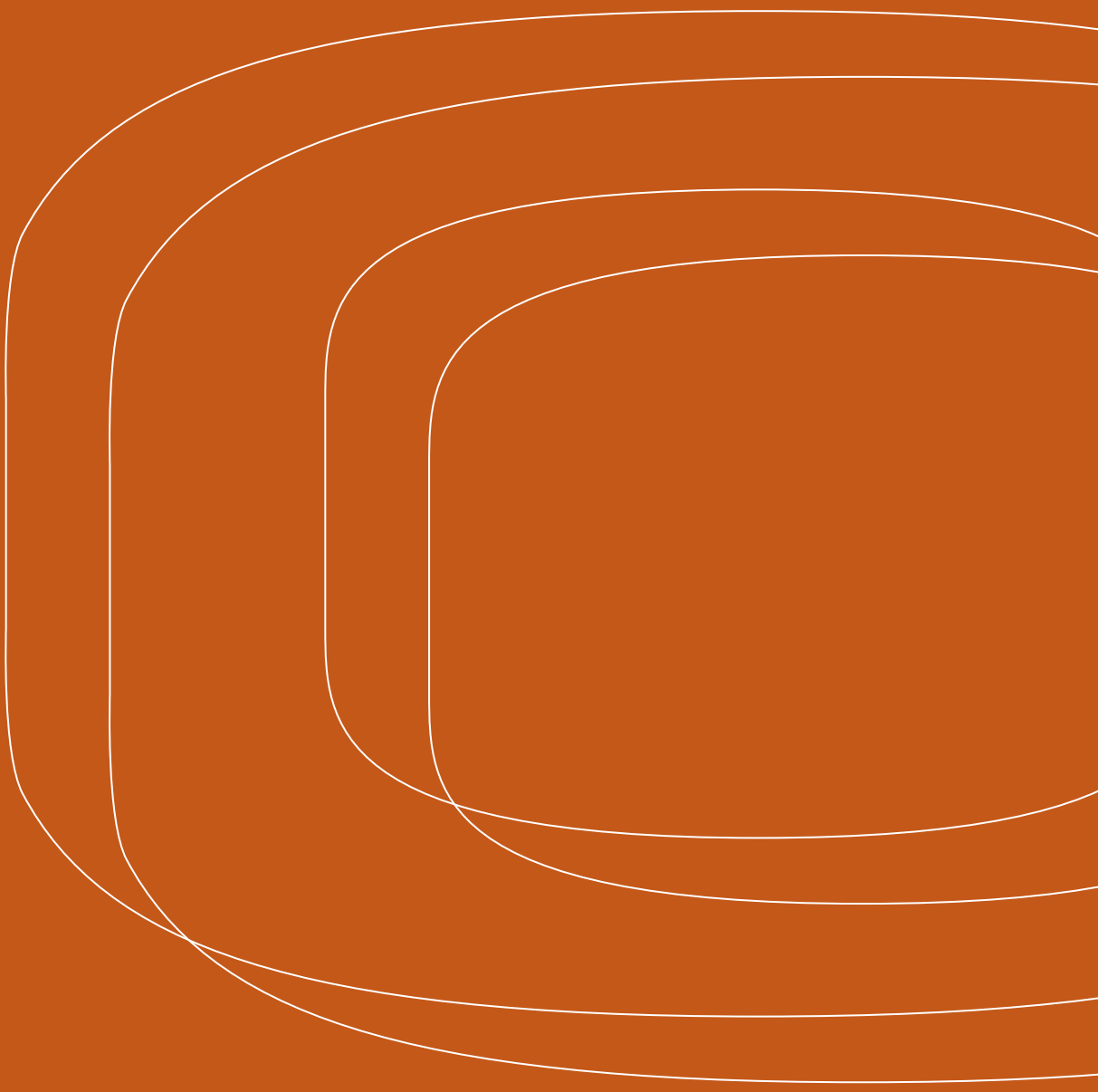


EXHIBIT 48 SPORTS SCIENCE – 2 OR MORE TIES





3.4.3 The investment perspective

It is useful to understand the nature of the cooperation networks in the different sub-fields because these are likely to be activated by additional funding from NordForsk. Thus we can see that in some fields there are well established partnerships that could make use of funding while in others it would probably be more necessary to build new relationships.

Exhibit 49 provides summary data about the networks of co-authorship relationships in the Top-10 sub-fields. The institutional level indicators are based on the analysis in Exhibit 39 to Exhibit 48 while the national level indicators relate to the national-level networks in Exhibit 37.

The institutional level networks visible in this study are networks in which Nordic authors are involved. Obviously, they do not tell us about the wider international networks of which they form sub-sets. The proportion of Nordic nodes among all the institutions (column B) is in several fields high, suggesting that the size of the Nordic researchers' active international partnership networks is limited and the complexity of the networks is low. The proportion of international relationships between Nordic actors in total institutional relationships (column D) is generally modest, so the majority of the Nordic institutions' relationships are outward facing.

The national level links described in column E have a quite different basis – a fact that must be remembered when interpreting Exhibit 49. These are numbers of links among individual authors. Papers with multiple authors generate multiple links. Every co-authored paper in 2004 contributes to this indicator, while inter-institutional links are counted in column C only if there are two or more co-publications in that year. Two oddities are evident, nonetheless, in comparing columns C and E. In both Environmental Sciences and Ecology, the large numbers of international links are not reflected at the institutional level, suggesting that there are particularly many papers in these categories that have multiple authors or that there are many one-paper collaborations during the course of a year – or perhaps both. On either interpretation, there would appear to be many nascent relationships in these sub-fields that could be strengthened through cross-border funding.

EXHIBIT 49 SOME NETWORK INDICATORS, TOP-10 SUB-FIELDS, 2004

Sub-field	Institutional Level				National Level
	A	B	C	D	E
	Total No. of nodes	Of which Nordic nodes (% of total)	Total number of relationships	Number of relationships between Nordic nodes	Number of intra-Nordic national links (Exhibit 37)
Anaesthesiology	10	7 (70%)	6	1 (17%)	10
Dentistry	40	16 (40%)	44	11 (25%)	19
Ecology	86	29 (34%)	88	11 (13%)	58
Environmental Sciences	6	4 (75%)	3	1 (33%)	140
Fisheries	20	10 (50%)	18	4 (22%)	26
Marine & Freshwater Biology	59	25 (42%)	50	9 (18%)	37
Obstetrics & Gynaecology	20	13 (65%)	20	4 (20%)	68
Public Health	11	4 (36%)	13	1 (8%)	111
Rheumatology	26	12 (46%)	21	5 (24%)	12
Sports Sciences	29	13 (45%)	27	5 (19%)	22

Note: Institutional relationships based on 2 or more co-publications. National level is based on single co-publication links, where multiple counting is possible

In Exhibit 50 we summarise characteristics of the sub-field networks relevant to funding. Dentistry, Ecology and Marine and Freshwater Biology are clearly attractive areas for funding, with comparatively strong existing networks.

Environmental Sciences and Public Health appear to involve big but fragmented networks, not visible at the institutional level but potentially interesting as bases that could be strengthened through Nordic collaboration, for example in centres of excellence. The other sub-fields all seem to have a basis in small, connected Nordic networks on which additional funding could build.

EXHIBIT 50 NETWORK CHARACTERISTICS, TOP-10 SUB-FIELDS, 2004

Sub-field	Strategic Position	Focus	Nordic Network Size	Conn-ected	Fringe	Nodes	Key nodes	No of key nodes
Anaesthesiology	?	Nordic	Small	Y	N	DFNS	-	-
Dentistry	cow	Int'l	Big	Y	N	DFINS	IFSN	9
Ecology	star/cow	Int'l	Big	Y	N	DFINS	DNS	15
Environmental Sciences	dog	Nordic	Small	N	Y	NFS	-	-
Fisheries	star	Mixed	Small	Y	N	DFINS	DN	3
Marine & Freshwater Biology	?	Int'l	Big	Y	N	DFINS	FINS	6
Obstetrics & Gynaecology	dog	Nordic	Small	Y	N	DNFS	DSN	4
Public Health	?	Int'l	Small	N	Y	FINS	IF	2
Rheumatology	dog	Mixed	Small	Y	N	DFNS	FS	5
Sports Sciences	?	Mixed	Small	Y	N	DFINS	DFS	5

Note: Strategic positions are taken from Exhibit 33; sub-fields with high leverage are italicised.
The focus of the Nordic networks is Nordic if Nordic nodes account for 55% or more of the total nodes shown in the sub-field network diagrams above; International if Nordic nodes are 45% or less; others are described as Mixed.
Networks are Big if they have 9-11 Nordic members; otherwise they are Small
Networks are Connected if there is at least one sub-network visible in the network diagrams that has multiple Nordic members.
There is a Fringe where there are many national co-publications that are clearly not accounted for by the networks drawn at the institutional level.
The Nodes column indicates which Nordic countries have at least one node present in the relevant network diagram
Key nodes are Nordic nodes that are members of sub-networks of at least three members. Their nationality and number are shown in the last two columns.

4. Comparison with Other Sources

This chapter presents a review of the existing bibliometric literature as well as non-bibliometric studies with focus on research excellence in the Nordic countries. The aim is to compare the conclusions reached in our bibliometric work with those derived at in other studies. This comparison will contribute to the interpretation of our results. The results from this part of the study shows that the results derived in our bibliometric work are by and large verified in other studies.

4.1 Description of the Literature Review Method

The literature reviewed has partly been provided by the research councils in the Nordic countries (several of the bibliometric studies have been conducted by or on commission from the research councils). In addition, we have searched for relevant literature on the internet (http://www.google.se and http://scholar.google.se).

The literature review highlighted a number of difficulties related to the comparison. To begin with, it should be noted that no bibliometric studies on Iceland have been found in the review process. The literature focusing on Social Science and Humanities is very limited.

Secondly, the review showed that there are few bibliometric studies that present data on such a disaggregated level as our study when it comes to divisions into sub-fields, and none of these provide data across the `Nordic region as a whole. What is included in the larger fields, i.e. on a more aggregated level, may also differ slightly between the studies.

Thirdly, the various studies also differ in terms of focus, ie whether they focus on publications and citations in relation to the total number of the recorded publications in the country or as part of the world share, or whether they uses impact factor indicators.

Together these differences contribute to the difficulty of making reliable comparisons and in order to overcome them we have been obliged to pursue the comparison on more aggregated levels rather than on the level of sub-fields.

4.2 Main Results from the Literature Review

Our bibliometric study showed that the Nordic countries are especially strong in Medical research, Applied Biology – Ecology, and Earth, Space and Sciences and within these aggregated categories the following ten sub-fields: Anaesthesiology, Dentistry, Oral surgery & Medicine, Ecology, Environmental & Occupational Health, Rheumatology, and Sports Sciences. The results from the literature review will be discussed in relation to the three main scientific fields, since few of the studies found in the review has focused on the development of publications and citations shares at the level of the sub-fields.

4.2.1 Medicine

The conclusion reached in our bibliometric study that medicine research is the dominating scientific field in terms of publications and citations is confirmed by comparisons with other bibliometric studies of the Nordic countries (cf. Karlsson & Wadskog, 2006; Hinze, 2001, Aksnes, 2005, Lehvo & Nuutinen, 2006). In a comparison of relative citation impacts for OECD countries all five Nordic countries are listed above one (Lehvo & Nuutinen, 2005:36). Karlsson & Wadskog show that medicine accounts for approximately 50 % of the publication volume in Sweden, Denmark and Finland. In Norway, Medicine only accounts for 43 % of all the publication, but is still the largest scientific field (compared with natural science, agronomy, engineering, humanities, and social science). The dominance of especially Clinical Medicine (32.8 %) in Norway is supported in Aksnes' study, which focuses on which sub-fields Norwegian researchers mainly publish in (Aksnes, 2005). Similar results were derived in Hinze's study of the Nordic countries' specialisation profiles, which show that medical research and Biotechnology are emphasised in Sweden, Denmark and Finland, but, less so in Norway.[5]

It is only the Finnish study (Lehvo & Nuutinen, 2006) that reports at the level of subfields. According to this study, the relative citation impacts for Finnish disciplines/subfields in 2001–2005 are consistent with the results of our study. Thus, apart from Anaesthesiology, all the other sub-fields we identify (Dentistry, Oral surgery & Medicine, Ecology, Environmental & Occupational Health, Rheumatology, and Sports Sciences) show a relative citation impact above one in comparison with the relative citation impact for OECD (Lehvo & Nuutinen, 2006:38).

The comparator studies confirm the strong but declining importance of medicine in the Nordic area. The relative shares of medicine publications have decreased between 1982/84 to 2000/02 in the Nordic countries. Thus, Karlsson & Wadskog (2006) show that the relative shares of publications in Medicine have decreased in Denmark (from 63.1 to 49 %), Finland (from 59.8 to 48.4 %) and Norway (from 53.6 to 42.7 %).[6] In the Swedish Research Council's strategy document for 2005–08, a similar pattern is shown for Sweden with a decrease in both publication and citation shares in the 1980s and 1990s compared with the Western European average (Vetenskapsrådet, 2004).

4.2.2 Biology (Applied biology – Ecology)

According to the results of our bibliometric study Biology and especially the sub-fields of Applied Biology and Ecology appear to be strong scientific fields in the Nordic countries. These findings are supported in Aksnes' study, which shows that Biology constitutes the second most important sub-field in terms of number of publications by Norwegian researchers (Aksnes 2005:17). In Aksnes' study, Biology includes both the sub-fields belonging to Applied Biology & Ecology and Earth, Space and Science, i.e. Ecology, Fisheries, Marine & Freshwater Biology and Environmental Sciences.[7] According to Hinze's findings (2001), it is not only Norway which shows distinct research activities in Ecology but also Denmark, Finland, and Sweden. This increase is also supported in Lehvo's and Nuutinen's report from Finland (2006). According to their study, the number of publications in the natural science increased by 80 % from 1991–95 to 2001–05 in Finland. A closer look at the specific sub-fields of natural sciences show that the number of publications in Ecology, Plant & Animal Sciences, Experimental Biology (all part of the major field of Biology) has increased by 96 % from 1991–95 to 2001–05 in Finland. All these sub-fields also indicate a relative citation impact above that of OECD (Lehvo & Nuutinen, 2006:38). Thus, the relative citation impacts are Ecology 1.26, Animal Sciences 1.30 (however, lower for Plant Sciences 0.86) and Experimental Biology 1.17.[8]

4.2.3 Earth, Space and Sciences

Looking at the broad fields of Earth, Space and Sciences, Hinze's study of the Nordic countries' specialisation profiles indicated that Norway differed from the Denmark, Sweden and Finland in the sense that the country showed a more pronounced orientation to Marine Sci-

ence (which was also verified by Aksnes, see above) and Geosciences. In terms of number of publications in the sub-field of Earth Science, Finland shows a strong positively development with a change of 193 % from 1991–95 to 2001–05 and a relative citation impact in 2001–05 of 1.25.[9]

4.2.4 Social Science and Humanities

The literature is largely silent on this subject. According to Lehvo & Nuutinen, all five Nordic countries rate a lower relative citation impact than one in a comparison among the OECD countries. However, the similar comparison in relation to Humanities indicates an opposite position with all countries showing a higher relative citation impact (Lehvo & Nuutinen, 2006:37). According to the relative citation impact measurement, it is library & Information Science and Education that are Finland's strongest fields. According to Hinze, Economics & Management is the only area in Social Science in which Norway shows activities above average relative to its other publication activities (Hinze 2001). No bibliometric studies have been found on Sweden, Denmark or Iceland presenting data at the level of subfields.

4.3 Conclusions

Differences in measures and entities in the studied literature have made it difficult to make precise comparisons. Nevertheless, this comparison indicates that the conclusions reached in our bibliometric study do largely correspond to those reached in other studies. The main conclusions from the comparison are

- Medical research is the dominant scientific field in terms of publications and citations. However, the relative shares of medicine publications have decreased from 1982/84 to 2000/02 in the Nordic countries
- Data for Finland on relative citation impact compared with OECD indicate that the subfields identified in our study largely correspond with those disciplines which show a relative citation impact above one in comparison with the relative citation impact for OECD
- The other studies also indicate that research activities in Ecology are important in the Nordic countries. The number of publications have increased in for example Finland by 96 % between 1991–95 to 2001–05
- In the absence of any evident contradictions between the findings in the relevant literature and our own work in this study, we see no reason to doubt our own results.

Literature references may be found in Appendix J.

5. Conclusions and Policy Implications

This Chapter draws together findings form the report and sets out some policy implications. It is important to recall that bibliometric indicators are backward-looking and that they only give a partial view of performance. While we believe our policy suggestions are internally consistent, they therefore need to be combined with other forms of strategic intelligence before being implemented.

5.1 Findings

In this report we have worked both at the level of 8 large fields of science and at the sub-field level, where we have selected and focused on 10 subfields in which the Nordic countries collectively do well, based on bibliometric indicators.

There are modest variations among the balance of effort devoted to different fields by the Nordic countries, but overall the pattern differs by only a few percentage points among the countries so in many respects we can see them as homogenous – at least at the level of major fields of science. The Nordic countries' overall share of world scientific output has been gently declining, as has been the case for most other established members of the scientific community, because that community has itself been growing. Together, the Nordic countries produce about three and a half percent of the world's scientific output – a very impressive performance, given their small size. Their greatest volume of output is in medicine, followed by fundamental biology. They are most specialised in: Fundamental Biology; Applied Biology-ecology; Earth and Space Science; and Medicine. Specialisation is growing in the first three fields but declining in medicine. In fact, the Nordic countries are losing share of world publications fastest in medicine and in chemistry. Publication data cannot tell us whether there are individual Nordic acts of brilliance in these fields, but overall they appear rather mature and Nordic performance is stagnating.

At the level of sub-fields, we identified the following as the ten most attractive

- Fisheries
- Obstetrics and Gynaecology
- Anaesthesiology
- Marine and Freshwater Biology
- Ecology
- Sports Sciences
- Dentistry, Oral Surgery and Medicine
- Rheumatology
- Public, Environmental and Occupational Health
- Environmental Sciences

5.2 Policy Implications

Most good designs are generated through a mixture of top-down and bottom-up approaches. Working top-down creates order. Working bottom up makes sure the order is connected to reality. Ideally, therefore, we would like to see Nordforsk working with a

combination of completely open instruments that capture bottom-up opportunities and top-down instruments that focus on fields where current or future Nordic Strength is visible. This report, obviously, addresses the second type of instrument but not the first.

NordForsk's mission is not to maintain the overall health of Nordic science but to invest in Nordic Strength. We have therefore taken something of an investor's perspective in this study, aiming to focus resources on selected areas of established or likely strength. NordForsk could choose among three alternative top-down strategies, in pursuit of its mission.

1. Only fund the best, focusing on areas of established strength ('stars' in our strategic terminology)
2. Build on promising beginnings, looking for positions where the Nordic countries may not be the strongest but where the signals are that there is improvement and therefore that there are opportunities for NordForsk to accelerate that improvement. These would tend to be 'question marks' (?s) in our strategic terminology
3. Reinvigorate established but stagnating areas, which tend to be in the 'cow' category in our strategic terminology

Option 1 is clearly in line with NordForsk's mission. Option 3 is less clearly so. Given that 'cow' fields tend to be large and established, it would take a lot of effort to revive them, while NordForsk has rather limited means, and there are likely to be strong internal reasons for the stagnation in these fields, so this appears to be an unattractive option for NordForsk. Option 2 is more consistent with the mission, but also involves placing less certain investment bets than Option 1. We suggest that a viable strategy is to combine Option 1 with making selected investments under Option 2 that appear likely to have high returns. In our analysis, these are fields with high 'leverage'.

EXHIBIT 51 STRATEGIC OPTIONS AND SUGGESTED FUNDING PRIORITIES

Strategic Options	Field Level	Sub-Field Level	Network Characteristics of Sub-fields
Option 1	Applied Biology-ecology	Fisheries	Small, connected
	Earth and Space Sciences	(Ecology)	Large, connected
	Fundamental Biology		
Option 2	Mathematics	Anaesthesiology	Little Nordic networking
	Engineering and technology	Sports Science	Small, connected
	Physics	Marine and Freshwater Biology	Large, connected
		Public Health	Fragmented
Option 3	Medicine	Dentistry	Large, connected

Note: Shaded cells represent suggested funding priorities

At the level of large fields, our analysis suggests that the major Nordic opportunities are in

- **Applied Biology**, where the region has a strong position that is increasing in strength, and where a marginal increase in output is likely to lead to a comparatively large increase in share of world publications (funding has high 'leverage) (Option 1)
- **Earth and Space Sciences**, where the region similarly has a strong position that is increasing in strength, and where a funding also has high leverage (Option 1)
- **Fundamental Biology**, where the region's position is strong and strengthening, although funding leverage is not so high (Option 1)
- **Mathematics**, where the region's position is modest but strengthening and which offers high leverage (a high-leverage opportunity within Option 2)

At the level of sub-fields, the logic is a little more complex. The first consideration is that **all** the ten sub-fields are interesting potential investments, in so far as they have passed a rather rigorous selection process and appear to be the best out of more than 170 scientific fields. We have, however, also looked in more detail at performance and network characteristics of these 10 sub-fields, comparing them with each other rather than with the 170+ sub-fields. On this basis, we can make some suggestions for where and why NordForsk could prioritise among the Top-10 sub-fields if it so chooses.

- **Fisheries**, which has a strong and strengthening position and core network of interconnected Nordic institutions on which to build (Option 1)
- **Ecology** is less of a clear-cut case, lying close to or on the border between the 'star' and the 'cow' categories owing to the fact that the strong existing Nordic position is not clearly strengthening. It does, however, have strong networks that offer a good basis for further collaboration (Option 1/3)
- **Sports Science** is a rather young sub-field, where the Nordic area is building strength and has already established small but connected networks. It offers high leverage and makes an attractive investment (Option 2)
- While **Marine and Freshwater Biology** does not offer high leverage, it is a strengthening field with good established Nordic networks that could also be an attractive investment (Option 2)

On the face of it, **Anaesthesiology** could be funded under Option 2, especially as it has high leverage, but the performance indicators on excellence are mixed and there seem to be no clear-cut intra-Nordic Nordic networks in this sub-field. **Public Health** is a typically Nordic area of concern where the Nordic region's international position is not among the strongest in the sub-fields and networks are difficult to identify, apparently owing to fragmentation. This sub-field may deserve further inspection.

At the sub-field level, we observed earlier that Materials Science, Paper and Wood as well as Forestry are sub-fields that are strong at the Nordic level but do not for various reasons make it into the Top-10 sub-fields. NordForsk may wish separately to consider the desirability of funding these.

Given the current state of the art in bibliometrics, it is not possible to say anything meaningful about funding priorities in the humanities and social sciences in this study. Neither were the national research councils able to help us with any systematic information about these fields. For the time being, at least, this means that our policy recommendation is to fund these through NordForsk's bottom-up instruments.

The objective of this study was to provide a basis for a Nordic discussion about priorities for cooperation in researcher-driven research via NordForsk and the Nordic research councils. As we indicate, a bibliometric study is, on its own, no basis for setting such policy priorities. However we suggest that it is very useful as a way to inform a discussion of common priorities among Nordic funders, providing a set of hypotheses about potentially attractive areas for funding. Nordforsk should now

- Launch an open discussion about the opportunities to direct calls for joint Nordic research activities at least in the sub-areas (and possibly also in the larger fields) identifies in this report
- Include in that discussion (a) the views of member research councils and other stakeholders on areas of opportunity excluded from this report because inadequate bibliometric indicators are available and (b) counter-proposals for the 'hard' science – but require that such proposals and counter-proposals be supported with evidence
- Invite suggestions for alternative instruments to the NoCE model, which otherwise will be the natural way to implement Nordic research collaborations in the sub-fields identified
- Identify, in discussion with member councils, means to ensure that directed calls will be co-funded (if necessary) at the national level, given the rules under which the national councils operate

APPENDICES

APPENDIX A

SCIENTOMETRIC APPROACHES: AN INTRODUCTION

The characterization of academic outcome resulting from research activities is considered a main element in assessment of the scientific country performance. But academic outcome is manifold. It covers: the production of codified knowledge (articles in refereed reviews...), the production of embodied knowledge (PhD...), and other types of academic production (conferences, books, CDs, temporary or permanent exhibitions...) as well as Internet visibility (electronic working papers...).

Scientometrics, based on the enumeration and statistical analysis of scientific output in the form of articles, publications, citations, and other, more complex indicators, is an important tool in evaluating research activities, laboratories, research institutions as well as scientists, or scientific specialisations and performance of countries.

Existing literature in scientometrics and indicators provides a considerable foundation of expertise. Bibliometric indicators are to be calculated on the basis of different types of documents (called "articles") that have been published in scientific journals by research laboratories. The principal database available for these calculations is the Science Citation Index (SCI), the standard tool in bibliometrics for the exact sciences.

The limitations of scientometrics are also well known. It is important to keep in mind the difficulty that evaluation of published research faces in social sciences.

The general limitations and biases of ISI-based bibliometrics apply. Caution is recommended in interpreting the results, especially when, analysing small statistical units, for example from small countries, or obtained by cross-tabulations (discipline-country) or square linkages (co-publications). Such figures are also expected to be strongly fluctuating in time series. Moreover, asymmetrical statistical distributions, common in bibliometrics make some figures extremely sensitive to the values generated by highly productive individuals. This general rule applies to many of the countries studied in this report, which are of small scientific size.

The use of data about scientific publications for the analysis of the national academic production is a tool commonly used by institutions, policy-makers, stakeholders. Bibliometric data are, for instance, frequently used to construct rankings and changes or to compare countries by fields, sub-fields... (as well as institutions, research entities or individuals):

- Positioning countries' scientific production and specialisation (strong/weakness approaches...);
- Characterising publication strategies (one author, numerous authors, international co-publications...);
- Identifying main scientific partners and positioning each country in the international co-publications of the countries (networks analysis...);
- Analysing scientific visibility (citations analyses, impact indicators...).

APPENDIX B

BIBLIOMETRIC TOOLS

B1. THOMSON SCIENTIFIC DATABASE IS THE STANDARD TOOL IN BIBLIOMETRICS FOR THE EXACT SCIENCES

Bibliometrics studies are bound to the *de facto* monopoly established by Thomson Scientific - formerly known as the Institute for Scientific Information. This private company provides access to an information system which consists of five databases[10] that contain current and retrospective multidisciplinary information from approximately 8,700 of the most prestigious, high impact research journals in the world.

Thomson Scientific database is therefore the standard tool in bibliometrics for the exact sciences. It is a very selective database, fairly oriented toward good quality academic scientific activity for well-internationalised fundamental disciplines. Its representativeness is less good in applied fields, or field research, or fields where research has a national tradition, and also in disciplines where information passes by other channels, most notably computer science.

This unique source tells only part of the story of academic production, due to delineation considerations, balance among disciplines, 'biases' of coverage including a strong positive bias for english-speaking researchers ... Studies have shown that corrections of coverage may change significantly performance indicators, sometimes in a spectacular way. The adjustment of perimeter of journal inclusion within databases will determine variations in the classic bibliometric indicators used for comparison, such as world shares of publications or relative impacts. For instance, considering the case of the whole Russia as one scientific actor, an adjustment in the perimeter of journal inclusion have modified the performance indicators by a factor 2[11].

It is also important to keep in mind the well-known difficulty that evaluation of published research faces in social sciences. The documentary databases established under the Thomson Scientific are generally considered to be inappropriate for characterising the production of non-Anglophone researchers, in the sense that a number of the journals which are considered important scientific references by non-Anglophones are not included in these databases. The bibliometric evaluation of work published in these disciplines necessitates the construction of a list of journals considered as scientific by the community of researchers concerned, a list from which, then, can be calculated conventional bibliometric indicators.

B.2 REFERENCE TABLES

The research activities can be classified according to various levels of desegregation (OST – French Observatory of Sciences and Techniques). OST has developed an aggregated level which encompasses 9 disciplines:

- applied biology - ecology
- fundamental biology
- chemistry
- multidisciplinary journals (not presented in this study)
- mathematics
- physics
- medical research
- earth and space sciences
- engineering

All subject categories are described in Appendix D.

THREE MAIN PRINCIPLES

The scope of scientometrics information can be easily described with three principles:

- **Firstly, scientometrics information is available at three levels of scientific specialisation, which are from the finest grained to the most aggregated levels:**
  - Scientific specialties level - from the Thomson Scientific Database – which encompasses 171 categories;
  - Sub-disciplines level, which encompasses 32 sub disciplines;
  - Disciplines level which encompasses 9 categories.
- **Secondly, scientometrics information can be available at different levels of geo-localisation:**
  - regions (defined as NUTS 3) : +/- 200 regions (EU25)
  - countries : 25
  - EU 25
  - Europe (EU25+ Commonwealth of Independent States / CIS + European Free Trade Association / EFTA...)
  - world
- **Finally, scientometrics information available should relate to three aspects of scientific outcome:**
  - Production (number and "market share" of articles, specialisation of production)
  - Collaboration (profile of authorship – single author and various geographical patterns of co-authoring – and specialisation of collaboration)
  - Visibility (number and "market share" of citations, direct impact and relative impact normalised as ratio of relative citation, profile of activities by class of visibility)

The table below identifies the type of information which should compose a complete set of reference tables.

EXHIBIT 52 TYPE OF INFORMATION THAT SHOULD COMPOSE A COMPLETE SET OF REFERENCE TABLES

	Country	EU25 / EUROPE	World
Production	· Number of Country's publications (full counting)	· Number of EU25's publications (full counting)	· Number of World's publications (full counting)
	· Country's world market share of publication	· EU25's worldmarket share of publication	· World's specialisation profile of production (% by disciplines...)
	· Country's specialisation profile of production (% by disciplines...)	· EU25's specialisation profile of production (% by disciplines)...	
Collaboration	· Country's number of publications with single author	· EU25's number of publications with single author	· World's number of publications with single author
	· Country's number of co-publications with a co-author in the same Country	· EU25's number of co-publications with a co-author from within EU25	
	· Country's number of co-publications with a co-author from another country within the EU 25 or Europe	· EU25's number of co-publications with a co-author from outside the EU25	
	· Country's first 10 co-authoring Countries- with a co-author from another country inside the EU25or Europe	· EU25's first 10co-authoring Countries- with a co-author from outside the EU25	
	· Country's number of co-publications with a co-author from another country outside the EU 25 or Europe	· EU25's specialisation profile of collaboration (% by co-authoring territorial entities)	
	· Country's first 10 co-authoring Countries- witha co-author from outside the EU25 or Europe		
	· Country's specialisation profile of collaboration (% by co-authoring territorial entities)		
Visibility	· Number of Country's Citations (counting)	· Number of EU25's Citations (counting)	· Number of World's Citations (counting)
	· Country's world market share of citations	· EU25's worldmarket share of citations	
	· Country's specialisation profile of citations (% by disciplines)	· EU25's specialisation profile of citations(% by disciplines)	
	· Country's Direct impact	· EU25's Directimpact	
	· Country's Relative impact	· EU25's Relative impact	
	· Country's Profile of activity by class of visibility (% of papers by classes of citations)	· EU25's Profile of activity by class of visibility (% of papers by classes of citations)	

APPENDIX C

TYPES OF BIBLIOMETRIC INDEXES / VOCABULARY

C.1 PRODUCTION AND PRODUCTIVITY INDEXES

The production of scientific articles can be measured in absolute terms (in number of publications) and in shares (of publications, of citations, etc.), the latter being calculated at various scales (e.g. geographic scale such as national share, area, continental, or world).

Production can be cut up according to "disciplinary field" at the various levels of desegregation which have been presented above.

Options of counting process

The scientific articles often being co-signed by many authors and many institutions, several options of counting process can be chosen, in particular the fractional count and the integer count.

- In a logical process of contribution to world science, the authors' contributions to each article are fractioned in order to get a total of 100% on the whole group of authors. This principle is also applied to the possible repartition of a scientific journal in several specialities. This type of count, called "fractional", where each article has a unitary weight, is additional in every scale and well adapted to macro-analysis. Extended to the impacts, this type of count is preferable for international visibility comparison (see below).
- The other logical process to consider the "participation" in world science relies on count of "distinct integer": each actor is credited with a participatory unit as long as he is present in a publication, and this logical process is extended to disciplinary affiliations of the journals. The number of participations is superior to the contribution.

For example, France can be present in 8% of the world publications but contributes to 5% when the fractional count is applied. Because of multiple counts, this kind of count produces sums of actors' participations that are superior to 100% and the data vary with the scale changes. Despite this inconvenient, the "Full counting" are well adapted to micro-analysis (for instance at a university level) and is easier to comment for co-publications.

What means a count of articles if it is not related to the total number of publications in this scientific field? This information is required to calculate "market shares" (calculated at the world or the EU level) which could be presented in appropriate tables.

Taking into account the size factor

The scientific production of a country is obviously linked to its size. Various methods have been tested for taking into account the size factor. One approach is simply consisting in making a ratio between the output produced

(e.g. articles published) and the total inputs marshalled for this production. Work by economists illustrates the variety of productivity ratios which can be envisioned depending on whether the denominator concerns staff size, budget, population, and so forth.

Activity index

The sectorial specialisation index (the "activity index" for bibliometricians) relates the weight of a given country in a specific discipline to the country's weight in all disciplines combined, or the weight of a given discipline within the country to the discipline's weight world-wide. This probabilistic index is one that enables establishing and comparing the discipline-by-discipline profile of various countries. The dispersion observed in these index values for a given country provides a perception of the overall level of specialisation in the country's research strategy. When the specialisation index is higher than 1, then the considered country/zone is more specialised in the considered discipline than the average of the other countries/zones.

C.2 Collaboration indexes

The analysis of co-publications can be carried out for different sorts of measurements: absolute flows, normalised flows, mutual affinities, etc.

Scientific activity is by nature cooperative whether that being within a group or among groups. Bibliometric analyses are concerned mainly with institutional collaborations (related to the address data for the author) and very little concerned with collaboration among individuals.

The term "co-publication"

The term "co-publication" is used for publications arising from collaboration among different laboratories that results in an article published with several signatures.

As an example, the co-presence of two or more universities on the same article but that are giving different addresses identifies a "co-publication", whereas the co-presence of universities on the same article giving the same address can be thought of as collaboration by institutional arrangement (i.e. structural or affiliated co-presence).

Indexes of collaborations

Various indexes of collaborations can be calculated: for instance, the percentage of co-authored papers, the percentage of internationally co-authored papers, co-authored papers written with researchers from a given country or from a given institution.

C.3 Visibility Indexes

Scientific articles include a bibliography, the "cited articles". The number of references made to an article ("citations received" by this article) is thus a measure of its visibility – or, as often said, its "impact".

Citation analysis

Citation analysis, which has been studied in a vast literature, measures the scientific utility, visibility, and international influence of a publication. It depends nevertheless on a number of factors such as the journal and the language of publication, the habits of citation in a certain discipline, the focus of the article (fundamental, applied, methodological, or other).

The interpretation of citation data as a direct measure of quality is therefore incorrect (for example an article in English has at least five times more chance of being cited that the same article published in French).

The social character of the citation reflects also cautions against simplistic interpretation (accommodating citations, etc.); citation effects are amplified, for example, in the case of the most visible articles.

An important parameter is the variety of citation behaviour from discipline to discipline, resulting in the average number of citations per article varying widely between, for example, fundamental biology and mathematics[12]. Measurement is therefore sensitive to the chosen categories.

It is important to use indicators susceptible to allow a comparison from one field to another, like relative impact. Nonetheless, a defined field at a given level (say, by discipline) incorporates a heterogeneous situation at lower levels (by specialty, or by journal, for example). Different levels chosen for analysis (normalisation by journal, speciality, academic discipline) lead to differing evaluations.

Relevant indicators may provide information about the overall visibility of a university and relative impact by discipline.

Impact indicators

In bibliometrics, "impact" describes the number of citations per article. Direct impact is the average number of citations per article for a given actor (e.g. a university), according to a certain counting method and across a defined period of time. Relative impact is a ratio of the absolute impact of the actor for a given field to an average reference impact for that field (for example the average impact for a country, for the world)[13].

A relative impact above 1 indicates a greater visibility than the reference. This measurement is characteristic of a given level of observation and allows the comparison of one field with another at this level, for example among disciplines, without translating the heterogeneity of characteristics within the discipline.

In order to take account of the heterogeneity of citation behaviour, it is necessary to turn to normalised indicators for scientific fields, for example by discipline or by journal. One well-known form of normalised indicator is the ratio of relative citation (RRC), which effects a normalisation at the level of the journal. In this approach, relative impact is considered as resulting from combining the hoped-for relative impact with the ratio of relative citation (RRC). The RRC translates a normalisation by scientific journal, which is assimilated to a particular specialty with its own bibliometric characteristics.

From this viewpoint, citations received by an author for an article are considered as resulting from two components:

- on the one hand the expected level of citation (the average impact for articles in a given journal)[14];
- and on the other hand the ratio between the citations actually received and the number expected.

In this way it is possible to characterise the RRC for each actor (institution, country...), which is by construction the ratio of real impact to expected impact. The RRC therefore shows for each actor the over- or under-visibility of this actor considering the journals in which it publishes.

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APPENDIX D

DESCRIPTION OF THE "SUBJECT CATEGORIES"

Se descriptions of the Top-10 sub-fields below. A complete catalogue of subject category descriptions is available at: : http://scientific.thomson.com/mjl/scope/scope_sci.html#AA

CATEGORY NAME:
ANESTHESIOLOGY
CATEGORY DESCRIPTION:
Anesthesiology covers resources that focus on the administration of anesthetics, the treatment of pain, and the use of life support systems. This category also includes specific resources on cardiovascular anesthesia, pediatric anesthesia, and neurosurgical anesthesia.

CATEGORY NAME:
DENTISTRY, ORAL SURGERY & MEDICINE
CATEGORY DESCRIPTION:
Dentistry, Oral Surgery & Medicine covers resources on the anatomy, physiology, biochemistry, and pathology of the teeth and oral cavity. This category includes specific resources on periodontal disease, dental implants, oral and maxillofacial surgery, oral pathology, and oral surgery. Coverage also includes resources on community dentistry, public health dentistry, and pediatric dentistry.

CATEGORY NAME:
ECOLOGY
CATEGORY DESCRIPTION:
Ecology covers resources concerning many areas relating to the study of the interrelationship of organisms and their environments, including ecological economics, ecological engineering, ecotoxicology, ecological modeling, changeary ecology, biogeography, chemical ecology, marine ecology, wildlife research, microbial ecology, molecular ecology, and population ecology. This category also includes general ecology resources and ones devoted to particular ecological systems.

CATEGORY NAME:
ENVIRONMENTAL SCIENCES
CATEGORY DESCRIPTION:
Environmental Sciences covers resources concerning many aspects of the study of the environment, among them environmental contamination and toxicology, environmental health, environmental monitoring, environmental geology, and environmental management. This category also includes soil science and conservation, water resources research and engineering and climate change.

CATEGORY NAME:
FISHERIES
CATEGORY DESCRIPTION:
Fisheries covers resources concerning numerous aspects of fisheries science, technology and industry, including fish pathology, fish physiology and biochemistry, fish diseases and aquaculture.

CATEGORY NAME:
GEOCHEMISTRY & GEOPHYSICS
CATEGORY DESCRIPTION:
Resources in this category may focus on either Geochemistry or Geophysics or both. Geochemistry covers resources that deal with the chemical composition and chemical changes in the Earth or other planets or asteroids. Topics include research on related chemical and geological properties of substances, applied geochemistry, organic geochemistry, and biogeochemistry. Geophysics covers resources on the application of the methods and techniques of physics to the study of the structure of the Earth and the processes affecting it. Topics addressed include seismology, tectonics, tectonophysics, geomagnetism, radioactivity, and rock mechanics.

CATEGORY NAME:
OBSTETRICS & GYNECOLOGY
CATEGORY DESCRIPTION:
Obstetrics & Gynecology covers resources on the medical fields concerned with female reproductive function and reproductive organs. Obstetrics covers resources on pregnancy, fetal health, labor, and puerperium. Gynecology covers resources on the health and diseases of female sex organs and their impact on women's overall health. This category also includes resources on fertility, infertility, and contraception.

CATEGORY NAME:
PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH
CATEGORY DESCRIPTION:
Public, Environmental & Occupational Health covers resources dealing with epidemiology, hygiene, and health; parasitic diseases and parasitology; tropical medicine; industrial medicine; occupational medicine; infection control; and preventive medicine. Also included are resources on environmental health; cancer causes and control; aviation, aerosol, and wilderness medicine.

CATEGORY NAME:
RHEUMATOLOGY
CATEGORY DESCRIPTION:
Rheumatology covers resources on clinical, therapeutic, and laboratory research about arthritis and rheumatism, the chronic degenerative autoimmune inflammatory diseases that primarily affect joints and connective tissue.

CATEGORY NAME:
SPORT SCIENCES
CATEGORY DESCRIPTION:
Sport Sciences covers resources on the applied physiology of human performance, physical conditioning for sports participation, optimal nutrition for sports performance, and the prevention and treatment of sports-related injuries and diseases. This category also includes resources on sport psychology and sociology.

APPENDIX E

SOCIAL SCIENCES AND ARTS & HUMANITIES CITATION INDEXES

The Arts & Humanities Citation Index® (A&HCI ®) and Arts & Humanities Search® provide access to current and retrospective bibliographic information and cited references found in nearly 1,130 of the world's leading arts & humanities journals. They also cover individually selected, relevant items from approximately 7,000 of the world's leading science and social sciences journals[15].

Social Sciences Citation Index® The Social Sciences Citation Index® (SSCI®)[16] and Social SciSearch® provide access to current and retrospective bibliographic information, author abstracts, and cited references found in over 1,700 of the world's leading scholarly social sciences journals covering more than 50 disciplines. They also cover individually selected, relevant items from approximately 3,300 of the world's leading science and technology journals.

Social Sciences journals undergo the same thorough evaluation as Natural Science journals. Publishing standards, editorial content, international diversity, and citation data are all considered. Standard citation metrics are employed while keeping in mind that, in general, Impact Factors and overall citation rates in the Social Sciences are lower than those in the Natural Sciences. In both these fields citation activity tends to follow a linear pattern of rise, peak, and decline.

Publishing standards, including timeliness, are also important in the evaluation of Arts and Humanities journals. Citations in the Arts and Humanities, however, do not necessarily follow this same predictable pattern as citations to Social Sciences and Natural Sciences articles. Citations to an article on the 19th Century Romantic novel, for example, may accrue slowly at first, and then slacken, fluctuating over time in cycles consistent with scholars' varying interest in the topic. In addition, Arts and Humanities journal articles reference non-journal sources heavily (e.g., books, musical compositions, works of art and literature). Consequently, citation data, while sometimes useful, are frequently much less so in journal evaluations in the Arts and Humanities.

Arts & Humanities journals are selected[17] by the primary editor with the support of the subject experts from the ISI Arts & Humanities indexing staff. The goal is the collection of superb Arts and Humanities content that reflects the complex nature of cultural phenomena across a broad range of fields.

EXHIBIT 53 MULTIDISCIPLINARY SCOPE

SCIENCE CITATION INDEX EXPANDED	SOCIAL SCIENCES CITATION INDEX	ARTS & HUMANITIES CITATION INDEX
Agriculture & Food Technology	Anthropology	Archaeology
Astronomy	Archaeology	Architecture
Behavioral Sciences	Area Studies	Art
Biochemistry	Business & Finance	Asian Studies
Biology	Communication	Classics
Biomedical Sciences	Criminology & Penology	Dance
Chemistry	Demography	Film
Computer Sciences	Economics	Folklore
Electronics	Education	History
Engineering	Environmental Studies	Humanities
Environmental Sciences	Ergonomics	Language
Genetics	Ethnic Studies	Linguistics
Geosciences	Family Studies	Literary Reviews
Instrumentation	Geography	Literature
Materials Science	Geriatrics	Music
Mathematics	Health & Rehabilitation	Philosophy
Medicine	Industrial & Labor Relations	Poetry
Microbiology	Information & Library Science	Religion
Nuclear Science	International Relations	Television & Radio
Pharmacology	Law	Theater
Physics	Linguistics	
Psychiatry & Psychology	Management Science	
Statistics & Probability	Nursing	
Technology & Applied Science	Operations Research	
Veterinary Medicine	Planning & Development	
Zoology	Political Science	
	Psychiatry	
	Psychology	
	Public Administration	
	Sociology	
	Urban Studies	
	Women's Studies	

Source : http://scientific.thomson.com/media/sczip/wos_workbook_7_8.zip

APPENDIX F

'MAIN TABLES' – 20 SUB-FIELDS PER COUNTRY

EXHIBIT 54 MAIN TABLES FOR DENMARK

Number of publications	1999-01		2002-04		Trend	
	N	R	N	R	%	R
Engineering, Environmental	66	17	92	15	39,9%	1
Nutrition & Dietetics	82	14	108	12	31,8%	2
Biotechnology & Applied Microbiology	154	7	198	4	28,8%	3
Public, Environmental & Occupational Health	154	6	191	6	23,5%	4
Agriculture, Dairy & Animal Science	84	13	100	14	19,0%	5
Environmental Sciences	213	3	249	3	17,1%	6
Food Science & Technology	151	8	177	7	17,0%	7
Infectious Diseases	109	10	122	10	11,9%	8
Anesthesiology	65	18	71	18	9,3%	9
Biochemical Research Methods	107	12	116	11	8,4%	10
Ecology	148	9	160	9	8,1%	11
Microbiology	275	2	293	1	6,4%	12
Dentistry, Oral Surgery & Medicine	70	16	74	16	6,2%	13
Physiology	196	4	198	4	1,0%	14
Sports Sciences	63	19	63	19	0,5%	15
Endocrinology & Metabolism	289	1	290	2	0,2%	16
Marine & Freshwater Biology	164	5	162	8	-1,2%	17
Obstetrics & Gynecology	107	11	106	13	-1,2%	18
Agronomy	75	15	72	17	-4,0%	19
Fisheries	62	20	52	20	-15,6%	20

World shares (%) of publications	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Agriculture, Dairy & Animal Science	1,61	5	1,98	3	23,1%	1
Engineering, Environmental	1,21	13	1,46	9	20,1%	2
Biotechnology & Applied Microbiology	0,98	20	1,14	14	16,9%	3
Nutrition & Dietetics	1,34	8	1,56	7	16,7%	4
Public, Environmental & Occupational Health	1,49	7	1,70	5	14,3%	5
Infectious Diseases	1,01	18	1,14	15	12,5%	6
Anesthesiology	1,16	16	1,25	10	8,1%	7
Agronomy	1,00	19	1,07	19	7,1%	8
Physiology	1,97	2	2,07	1	5,1%	9
Dentistry, Oral Surgery & Medicine	1,21	14	1,23	11	1,4%	10
Food Science & Technology	1,63	4	1,66	6	1,3%	11
Obstetrics & Gynecology	1,22	12	1,20	12	-1,7%	12
Microbiology	1,53	6	1,50	8	-2,2%	13
Endocrinology & Metabolism	2,06	1	2,00	2	-3,3%	14
Marine & Freshwater Biology	1,88	3	1,77	4	-5,9%	15
Biochemical Research Methods	1,15	17	1,08	18	-5,9%	16
Sports Sciences	1,17	15	1,09	16	-6,9%	17
Ecology	1,28	10	1,16	13	-9,2%	18
Fisheries	1,27	11	1,06	20	-16,4%	19
Environmental Sciences	1,30	9	1,08	17	-16,7%	20

Specialisation index	1999-01		2002-04		Trend	
	SI	R	SI	R	%	R
Agriculture, Dairy & Animal Science	2,19	5	2,81	3	28,4%	1
Engineering, Environmental	1,65	13	2,06	9	25,3%	2
Biotechnology & Applied Microbiology	1,33	20	1,62	14	22,0%	3
Nutrition & Dietetics	1,82	8	2,22	7	21,8%	4
Public, Environmental & Occupational Health	2,02	7	2,41	5	19,3%	5
Infectious Diseases	1,37	18	1,61	15	17,4%	6
Anesthesiology	1,57	16	1,77	10	12,8%	7
Agronomy	1,35	19	1,51	19	11,8%	8
Physiology	2,67	2	2,93	1	9,7%	9
Dentistry, Oral Surgery & Medicine	1,64	14	1,74	11	5,8%	10
Food Science & Technology	2,22	4	2,35	6	5,7%	11
Obstetrics & Gynecology	1,66	12	1,70	12	2,6%	12
Microbiology	2,08	6	2,12	8	2,1%	13
Endocrinology & Metabolism	2,80	1	2,83	2	1,0%	14
Marine & Freshwater Biology	2,55	3	2,50	4	-1,8%	15
Biochemical Research Methods	1,56	17	1,53	18	-1,8%	16
Sports Sciences	1,58	15	1,54	16	-2,8%	17
Ecology	1,74	10	1,65	13	-5,3%	18
Fisheries	1,72	11	1,50	20	-12,8%	19
Environmental Sciences	1,77	9	1,54	17	-13,1%	20

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.

Note: selection of the 20 first subject categories: decreasing order of World share and N > 50.

N: Number of publications (Full counting)
WS: World share (Fractional counting)
R: Rank
%: Trend between 1999–01 and 2002–04

World shares (%) of citations (2 years)	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Sports Sciences	1,50	16	2,49	5	66,1%	1
Biotechnology & Applied Microbiology	1,18	19	1,79	9	51,6%	2
Physiology	2,12	5	2,64	2	24,6%	3
Infectious Diseases	0,89	20	1,08	19	21,7%	4
Nutrition & Dietetics	1,47	17	1,74	10	18,7%	5
Public, Environmental & Occupational Health	1,65	13	1,96	8	18,4%	6
Agriculture, Dairy & Animal Science	2,46	3	2,91	1	18,1%	7
Anesthesiology	1,85	7	2,14	7	16,1%	8
Endocrinology & Metabolism	2,18	4	2,51	4	15,0%	9
Engineering, Environmental	1,32	18	1,49	14	12,1%	10
Dentistry, Oral Surgery & Medicine	1,58	14	1,57	13	-1,1%	11
Microbiology	1,53	15	1,49	15	-2,7%	12
Obstetrics & Gynecology	1,75	8	1,68	11	-4,0%	13
Biochemical Research Methods	1,71	11	1,57	12	-8,4%	14
Marine & Freshwater Biology	2,73	2	2,46	6	-10,1%	15
Food Science & Technology	3,05	1	2,55	3	-16,4%	16
Environmental Sciences	1,71	10	1,33	16	-22,2%	17
Ecology	1,75	9	1,16	17	-33,4%	18
Agronomy	1,70	12	1,09	18	-35,8%	19
Fisheries	1,89	6	1,04	20	-45,2%	20

Impact factors	1999-01		2002-04		Trend	
	IF	R	IF	R	%	R
Sports Sciences	1,28	12	2,29	1	78,4%	1
Biotechnology & Applied Microbiology	1,21	13	1,57	3	29,6%	2
Endocrinology & Metabolism	1,06	18	1,26	11	18,9%	3
Physiology	1,08	17	1,28	9	18,6%	4
Infectious Diseases	0,88	20	0,95	20	8,2%	5
Anesthesiology	1,60	3	1,71	2	7,4%	6
Public, Environmental & Occupational Health	1,11	14	1,15	13	3,6%	7
Nutrition & Dietetics	1,10	15	1,11	14	1,7%	8
Microbiology	1,00	19	0,99	18	-0,5%	9
Obstetrics & Gynecology	1,43	8	1,40	7	-2,4%	10
Dentistry, Oral Surgery & Medicine	1,31	11	1,28	10	-2,5%	11
Biochemical Research Methods	1,50	5	1,46	6	-2,7%	12
Agriculture, Dairy & Animal Science	1,53	4	1,47	5	-4,1%	13
Marine & Freshwater Biology	1,46	7	1,39	8	-4,5%	14
Engineering, Environmental	1,09	16	1,02	16	-6,6%	15
Environmental Sciences	1,32	10	1,23	12	-6,6%	16
Food Science & Technology	1,87	1	1,54	4	-17,5%	17
Ecology	1,37	9	1,00	17	-26,6%	18
Fisheries	1,49	6	0,98	19	-34,4%	19
Agronomy	1,71	2	1,02	15	-40,0%	20

EXHIBIT 55 MAIN TABLES FOR FINLAND

Number of publications	1999-01		2002-04		Trend	
	N	R	N	R	%	R
Computer Science, Theory & Methods	84	9	165	5	97,6%	1
Ecology	156	4	224	2	44,1%	2
Agriculture, Soil Science	26	20	33	20	26,9%	3
Telecommunications	45	18	54	16	18,4%	4
Nutrition & Dietetics	72	13	84	11	17,2%	5
Dentistry, Oral Surgery & Medicine	81	11	94	9	16,9%	6
Forestry	113	6	132	6	16,9%	7
Environmental Sciences	244	1	280	1	14,8%	8
Fisheries	38	19	43	18	13,0%	9
Psychiatry	107	7	114	8	6,9%	10
Sports Sciences	69	15	73	13	6,3%	11
Engineering, Environmental	60	17	62	14	3,9%	12
Public, Environmental & Occupational Health	166	3	171	4	2,6%	13
Endocrinology & Metabolism	212	2	214	3	0,9%	14
Materials Science, Paper & Wood	92	8	93	10	0,4%	15
Rheumatology	81	10	77	12	-5,3%	16
Pediatrics	134	5	126	7	-6,0%	17
Anesthesiology	72	12	55	15	-23,6%	18
Otorhinolaryngology	71	14	46	17	-35,4%	19
Allergy	62	16	39	19	-38,0%	20

World shares (%) of publications	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Agriculture, Soil Science	0,79	19	1,17	11	47,5%	1
Materials Science, Paper & Wood	7,80	1	9,11	1	16,8%	2
Computer Science, Theory & Methods	0,96	17	1,12	15	16,6%	3
Ecology	1,70	6	1,94	3	13,9%	4
Telecommunications	0,48	20	0,51	20	7,1%	5
Nutrition & Dietetics	1,11	14	1,19	10	6,9%	6
Dentistry, Oral Surgery & Medicine	1,59	8	1,69	5	6,0%	7
Environmental Sciences	1,55	9	1,57	7	1,0%	8
Fisheries	1,11	15	1,12	16	0,6%	9
Psychiatry	1,16	13	1,16	12	0,3%	10
Allergy	0,92	18	0,91	19	-1,1%	11
Public, Environmental & Occupational Health	1,73	5	1,67	6	-3,5%	12
Endocrinology & Metabolism	1,60	7	1,52	8	-5,1%	13
Forestry	5,49	2	5,20	2	-5,2%	14
Sports Sciences	1,47	10	1,39	9	-6,0%	15
Anesthesiology	1,11	16	1,04	18	-6,8%	16
Pediatrics	1,20	12	1,11	17	-7,1%	17
Engineering, Environmental	1,25	11	1,12	14	-10,4%	18
Rheumatology	2,46	3	1,86	4	-24,4%	19
Otorhinolaryngology	1,79	4	1,15	13	-35,3%	20

Specialisation index	1999-01		2002-04		Trend	
	SI	R	SI	R	%	R
Agriculture, Soil Science	1,07	19	1,64	11	53,3%	1
Materials Science, Paper & Wood	10,50	1	12,75	1	21,4%	2
Computer Science, Theory & Methods	1,29	17	1,57	15	21,1%	3
Ecology	2,30	6	2,72	3	18,3%	4
Telecommunications	0,65	20	0,72	20	11,3%	5
Nutrition & Dietetics	1,50	14	1,67	10	11,1%	6
Dentistry, Oral Surgery & Medicine	2,14	8	2,36	5	10,2%	7
Environmental Sciences	2,09	9	2,20	7	5,0%	8
Fisheries	1,50	15	1,57	16	4,6%	9
Psychiatry	1,56	13	1,62	12	4,2%	10
Allergy	1,24	18	1,27	19	2,7%	11
Public, Environmental & Occupational Health	2,33	5	2,34	6	0,3%	12
Endocrinology & Metabolism	2,15	7	2,12	8	-1,4%	13
Forestry	7,39	2	7,28	2	-1,5%	14
Sports Sciences	1,99	10	1,94	9	-2,3%	15
Anesthesiology	1,50	16	1,45	18	-3,2%	16
Pediatrics	1,61	12	1,56	17	-3,5%	17
Engineering, Environmental	1,69	11	1,57	14	-6,9%	18
Rheumatology	3,32	3	2,61	4	-21,5%	19
Otorhinolaryngology	2,41	4	1,62	13	-32,8%	20

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.

Note: selection of the 20 first subject categories: decreasing order of World share and N > 50.

N: Number of publications (Full counting)
WS: World share (Fractional counting)
R: Rank
%: Trend between 1999-2001 and 2002–04

World shares (%) of citations (2 years)	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Agriculture, Soil Science	1,33	13	2,18	5	63,6%	1
Materials Science, Paper & Wood	8,18	1	13,01	1	59,1%	2
Ecology	1,63	10	2,44	3	49,5%	3
Anesthesiology	0,96	17	1,32	12	37,4%	4
Sports Sciences	1,77	8	2,23	4	25,9%	5
Telecommunications	0,47	20	0,57	20	22,3%	6
Public, Environmental & Occupational Health	1,50	11	1,80	8	19,7%	7
Forestry	5,00	2	5,72	2	14,3%	8
Allergy	0,80	19	0,90	18	12,8%	9
Nutrition & Dietetics	1,81	6	1,94	7	7,4%	10
Dentistry, Oral Surgery & Medicine	2,03	4	2,12	6	4,8%	11
Endocrinology & Metabolism	1,80	7	1,77	10	-1,9%	12
Environmental Sciences	1,70	9	1,64	11	-3,8%	13
Fisheries	1,06	16	1,01	15	-4,2%	14
Computer Science, Theory & Methods	1,19	15	1,11	14	-6,5%	15
Engineering, Environmental	0,90	18	0,71	19	-21,6%	16
Psychiatry	1,23	14	0,91	17	-25,5%	17
Rheumatology	2,41	3	1,80	9	-25,5%	18
Otorhinolaryngology	1,33	12	0,96	16	-27,5%	19
Pediatrics	1,94	5	1,13	13	-41,6%	20

Impact factors	1999-01		2002-04		Trend	
	IF	R	IF	R	%	R
Anesthesiology	0,87	18	1,28	5	47,4%	1
Materials Science, Paper & Wood	1,05	10	1,43	4	36,1%	2
Sports Sciences	1,20	6	1,61	3	34,0%	3
Ecology	0,96	13	1,26	7	31,3%	4
Public, Environmental & Occupational Health	0,87	17	1,08	11	24,0%	5
Forestry	0,91	15	1,10	10	20,6%	6
Telecommunications	0,98	12	1,11	9	14,2%	7
Allergy	0,87	16	0,99	15	14,1%	8
Otorhinolaryngology	0,75	19	0,83	18	12,1%	9
Agriculture, Soil Science	1,68	1	1,86	1	10,9%	10
Endocrinology & Metabolism	1,13	7	1,17	8	3,4%	11
Nutrition & Dietetics	1,62	3	1,63	2	0,4%	12
Dentistry, Oral Surgery & Medicine	1,27	4	1,26	6	-1,1%	13
Rheumatology	0,98	11	0,96	16	-1,5%	14
Environmental Sciences	1,10	8	1,04	12	-4,8%	15
Fisheries	0,95	14	0,90	17	-4,8%	16
Engineering, Environmental	0,72	20	0,63	20	-12,5%	17
Computer Science, Theory & Methods	1,24	5	0,99	14	-19,8%	18
Psychiatry	1,06	9	0,79	19	-25,7%	19
Pediatrics	1,62	2	1,02	13	-37,1%	20

EXHIBIT 56 MAIN TABLES FOR ICELAND

Number of publications	1999-01		2002-04		Trend	
	N	R	N	R	%	R
Dentistry, Oral Surgery & Medicine	2	18	9	11	420,0%	1
Rehabilitation	1	19	3	20	400,0%	2
Nutrition & Dietetics	2	16	7	15	200,0%	3
Ecology	6	10	16	6	147,4%	4
Dermatology & Venereal Diseases	2	16	5	18	128,6%	5
Public, Environmental & Occupational Health	5	13	11	8	100,0%	6
Computer Science, Theory & Methods	4	14	7	14	100,0%	7
Marine & Freshwater Biology	16	3	27	2	70,2%	8
Obstetrics & Gynecology	4	14	6	17	54,5%	9
Geosciences, Multidisiplinary	21	1	32	1	48,4%	10
Geochemistry & Geophysics	15	4	20	3	34,1%	11
Fisheries	12	5	16	5	33,3%	12
Infectious Diseases	6	11	8	12	33,3%	12
Food Science & Technology	6	11	8	13	27,8%	14
Meteorology & Atmospheric Sciences	7	9	9	10	22,7%	15
Immunology	12	5	14	7	19,4%	16
Oceanography	9	7	11	8	18,5%	17
Genetics & Heredity	18	2	17	4	-5,6%	18
Rheumatology	9	8	4	19	-50,0%	19
Limnology	0	20	7	16		NA

World shares (%) of publications	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Rehabilitation	0,01	19	0,17	5	1127,4%	1
Dermatology & Venereal Diseases	0,02	18	0,07	14	287,9%	2
Dentistry, Oral Surgery & Medicine	0,03	16	0,11	8	254,2%	3
Nutrition & Dietetics	0,04	13	0,11	7	205,6%	4
Ecology	0,04	14	0,09	11	140,0%	5
Marine & Freshwater Biology	0,15	3	0,25	3	63,5%	6
Meteorology & Atmospheric Sciences	0,04	15	0,06	18	56,7%	7
Genetics & Heredity	0,07	7	0,11	9	43,5%	8
Immunology	0,04	11	0,06	17	42,9%	9
Geosciences, Multidisiplinary	0,13	5	0,18	4	39,9%	10
Fisheries	0,21	1	0,28	2	35,2%	11
Public, Environmental & Occupational Health	0,06	8	0,08	13	34,5%	12
Infectious Diseases	0,05	9	0,07	15	34,3%	13
Obstetrics & Gynecology	0,04	12	0,05	19	29,5%	14
Food Science & Technology	0,05	10	0,06	16	26,9%	15
Computer Science, Theory & Methods	0,03	17	0,03	20	21,8%	16
Geochemistry & Geophysics	0,13	4	0,15	6	11,5%	17
Oceanography	0,09	6	0,08	12	-11,4%	18
Rheumatology	0,20	2	0,10	10	-50,9%	19
Limnology	0,00	20	0,41	1		NA

Specialisation index	1999-01		2002-04		Trend	
	SI	R	SI	R	%	R
Rehabilitation	0,63	19	6,40	5	922,4%	1
Dermatology & Venereal Diseases	0,84	18	2,72	14	223,1%	2
Dentistry, Oral Surgery & Medicine	1,34	16	3,96	8	195,0%	3
Nutrition & Dietetics	1,66	13	4,23	7	154,5%	4
Ecology	1,63	14	3,25	11	99,9%	5
Marine & Freshwater Biology	6,75	3	9,20	3	36,2%	6
Meteorology & Atmospheric Sciences	1,61	15	2,10	18	30,5%	7
Genetics & Heredity	3,30	7	3,94	9	19,6%	8
Immunology	1,88	11	2,24	17	19,0%	9
Geosciences, Multidisiplinary	5,62	5	6,55	4	16,5%	10
Fisheries	9,29	1	10,46	2	12,6%	11
Public, Environmental & Occupational Health	2,57	8	2,88	13	12,0%	12
Infectious Diseases	2,34	9	2,61	15	11,9%	13
Obstetrics & Gynecology	1,77	12	1,91	19	7,9%	14
Food Science & Technology	2,23	10	2,36	16	5,7%	15
Computer Science, Theory & Methods	1,11	17	1,12	20	1,4%	16
Geochemistry & Geophysics	5,76	4	5,34	6	-7,1%	17
Oceanography	4,11	6	3,04	12	-26,2%	18
Rheumatology	8,77	2	3,58	10	-59,1%	19
Limnology	0,00	20	14,93	1		NA

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.

Note: selection of the 20 first subject categories: decreasing order of World share.

N: Number of publications (Full counting)
WS: World share (Fractional counting)
R: Rank
%: Trend between 1999–2001 and 2002–04

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

World shares (%) of citations (2 years)	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Dermatology & Venereal Diseases	0,03	15	0,22	5	704,7%	1
Ecology	0,02	17	0,11	12	467,9%	2
Genetics & Heredity	0,09	7	0,45	3	375,0%	3
Computer Science, Theory & Methods	0,01	19	0,04	16	329,8%	4
Rehabilitation	0,03	13	0,13	10	300,5%	5
Nutrition & Dietetics	0,03	14	0,12	11	294,7%	6
Oceanography	0,07	10	0,17	8	154,2%	7
Marine & Freshwater Biology	0,17	4	0,33	4	100,0%	8
Fisheries	0,29	1	0,50	2	70,4%	9
Geosciences, Multidisiplinary	0,15	5	0,21	6	40,7%	10
Dentistry, Oral Surgery & Medicine	0,03	16	0,03	18	29,6%	11
Immunology	0,02	18	0,02	20	11,5%	12
Geochemistry & Geophysics	0,18	3	0,18	7	-3,3%	13
Obstetrics & Gynecology	0,08	8	0,08	14	-5,3%	14
Public, Environmental & Occupational Health	0,12	6	0,09	13	-21,1%	15
Food Science & Technology	0,05	11	0,03	17	-24,5%	16
Meteorology & Atmospheric Sciences	0,04	12	0,03	19	-26,8%	17
Infectious Diseases	0,07	9	0,05	15	-27,6%	18
Rheumatology	0,23	2	0,14	9	-39,6%	19
Limnology	0,00	20	1,02	1		NA

Impact factors	1999-01		2002-04		Trend	
	IF	R	IF	R	%	R
Computer Science, Theory & Methods	0,35	19	1,24	9	253,0%	1
Genetics & Heredity	1,27	8	4,20	1	230,9%	2
Oceanography	0,70	16	2,01	4	186,7%	3
Ecology	0,51	17	1,20	13	136,6%	4
Dermatology & Venereal Diseases	1,42	4	2,95	2	107,4%	5
Nutrition & Dietetics	0,82	15	1,06	14	29,2%	6
Fisheries	1,39	6	1,75	5	26,0%	7
Rheumatology	1,17	10	1,44	7	23,1%	8
Marine & Freshwater Biology	1,10	11	1,34	8	22,3%	9
Geosciences, Multidisiplinary	1,19	9	1,20	11	0,6%	10
Geochemistry & Geophysics	1,42	5	1,23	10	-13,2%	11
Immunology	0,36	18	0,28	20	-22,0%	12
Obstetrics & Gynecology	2,11	2	1,54	6	-26,9%	13
Food Science & Technology	0,91	13	0,54	17	-40,5%	14
Public, Environmental & Occupational Health	2,05	3	1,20	12	-41,3%	15
Infectious Diseases	1,33	7	0,72	16	-46,1%	16
Meteorology & Atmospheric Sciences	1,02	12	0,48	18	-53,3%	17
Dentistry, Oral Surgery & Medicine	0,85	14	0,31	19	-63,4%	18
Rehabilitation	2,34	1	0,76	15	-67,4%	19
Limnology	0,00	20	2,52	3		NA

EXHIBIT 57 MAIN TABLES FOR NORWAY

Number of publications	1999-01		2002-04		Trend	
	N	R	N	R	%	R
Sports Sciences	33	16	53	13	58,0%	1
Public, Environmental & Occupational Health	107	8	155	6	45,0%	2
Health Care Sciences & Services	36	15	52	15	43,5%	3
Marine & Freshwater Biology	191	2	242	1	26,3%	4
Food Science & Technology	67	12	84	10	25,5%	5
Engineering, Environmental	43	13	53	13	22,5%	6
Oceanography	106	9	125	7	17,6%	7
Fisheries	160	5	181	4	13,1%	8
Agronomy	25	19	28	18	12,0%	9
Environmental Sciences	191	3	206	3	8,2%	10
Geochemistry & Geophysics	113	7	120	8	6,8%	11
Obstetrics & Gynecology	69	11	71	11	3,4%	12
Ecology	168	4	171	5	2,2%	13
Acoustics	23	20	23	19	1,4%	14
Geosciences, Multidisiplinary	227	1	226	2	-0,4%	15
Dentistry, Oral Surgery & Medicine	76	10	67	12	-11,8%	16
Geology	33	17	29	17	-13,1%	17
Chemistry, Physical	130	6	111	9	-14,8%	18
Agriculture, Soil Science	27	18	22	20	-17,3%	19
Engineering, Petroleum	42	14	33	16	-22,8%	20

World shares (%) of publications	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Health Care Sciences & Services	0,92	15	1,24	8	34,2%	1
Oceanography	1,27	10	1,70	4	34,0%	2
Marine & Freshwater Biology	2,06	3	2,63	2	27,9%	3
Public, Environmental & Occupational Health	1,11	11	1,38	5	24,6%	4
Sports Sciences	0,72	18	0,90	14	24,5%	5
Agronomy	1,00	14	1,22	9	22,9%	6
Acoustics	0,64	19	0,78	19	22,0%	7
Food Science & Technology	0,62	20	0,75	20	20,3%	8
Geochemistry & Geophysics	1,03	13	1,16	10	12,6%	9
Engineering, Environmental	0,78	17	0,83	18	6,4%	10
Fisheries	4,13	1	4,01	1	-3,1%	11
Engineering, Petroleum	2,75	2	2,62	3	-4,8%	12
Obstetrics & Gynecology	0,87	16	0,83	17	-5,3%	13
Geosciences, Multidisiplinary	1,33	7	1,25	7	-6,0%	14
Environmental Sciences	1,07	12	1,00	12	-6,3%	15
Ecology	1,46	5	1,32	6	-9,3%	16
Geology	1,32	9	0,99	13	-24,9%	17
Dentistry, Oral Surgery & Medicine	1,40	6	1,05	11	-25,3%	18
Chemistry, Physical	1,32	8	0,88	15	-33,9%	19
Agriculture, Soil Science	1,52	4	1	16	-43,6%	20

Specialisation index	1999-01		2002-04		Trend	
	SI	R	SI	R	%	R
Health Care Sciences & Services	1,99	15	2,81	8	41,4%	1
Oceanography	2,73	10	3,86	4	41,1%	2
Marine & Freshwater Biology	4,44	3	5,98	2	34,7%	3
Public, Environmental & Occupational Health	2,39	11	3,13	5	31,3%	4
Sports Sciences	1,56	18	2,04	14	31,1%	5
Agronomy	2,15	14	2,78	9	29,5%	6
Acoustics	1,38	19	1,78	19	28,5%	7
Food Science & Technology	1,34	20	1,70	20	26,7%	8
Geochemistry & Geophysics	2,22	13	2,63	10	18,6%	9
Engineering, Environmental	1,67	17	1,88	18	12,1%	10
Fisheries	8,92	1	9,10	1	2,1%	11
Engineering, Petroleum	5,94	2	5,96	3	0,3%	12
Obstetrics & Gynecology	1,88	16	1,88	17	-0,3%	13
Geosciences, Multidisiplinary	2,86	7	2,83	7	-1,0%	14
Environmental Sciences	2,30	12	2,27	12	-1,3%	15
Ecology	3,15	5	3,01	6	-4,5%	16
Geology	2,85	9	2,26	13	-20,9%	17
Dentistry, Oral Surgery & Medicine	3,02	6	2,38	11	-21,3%	18
Chemistry, Physical	2,86	8	1,99	15	-30,4%	19
Agriculture, Soil Science	3,29	4	1,95	16	-40,6%	20

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.

Note: selection of the 20 first subject categories: decreasing order of World share and N > 50.

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

World shares (%) of citations (2 years)	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Acoustics	0,25	20	0,76	20	201,9%	1
Engineering, Environmental	0,46	19	1,15	11	148,4%	2
Agronomy	0,79	17	1,07	13	35,4%	3
Oceanography	1,08	11	1,43	5	31,8%	4
Geochemistry & Geophysics	0,88	16	1,16	10	30,8%	5
Sports Sciences	0,63	18	0,82	19	30,3%	6
Geosciences, Multidisiplinary	1,48	8	1,91	4	28,6%	7
Marine & Freshwater Biology	2,62	3	3,37	3	28,6%	8
Public, Environmental & Occupational Health	0,89	15	1,08	12	22,0%	9
Fisheries	5,36	1	6,34	1	18,2%	10
Health Care Sciences & Services	0,92	14	1,03	14	11,1%	11
Environmental Sciences	1,13	10	1,21	9	7,5%	12
Food Science & Technology	0,97	13	0,98	15	1,6%	13
Obstetrics & Gynecology	1,00	12	0,86	18	-13,4%	14
Chemistry, Physical	1,14	9	0,98	16	-14,0%	15
Geology	1,49	7	1,25	8	-15,7%	16
Ecology	1,65	6	1,36	7	-17,4%	17
Dentistry, Oral Surgery & Medicine	1,75	5	1,40	6	-20,2%	18
Engineering, Petroleum	4,53	2	3,43	2	-24,4%	19
Agriculture, Soil Science	1,81	4	0,95	17	-47,5%	20

Impact factors	1999-01		2002-04		Trend	
	IF	R	IF	R	%	R
Acoustics	0,39	20	0,97	15	147,5%	1
Engineering, Environmental	0,60	19	1,39	3	133,4%	2
Geosciences, Multidisiplinary	1,12	10	1,53	2	36,9%	3
Chemistry, Physical	0,86	15	1,12	10	30,2%	4
Fisheries	1,30	3	1,58	1	22,0%	5
Geochemistry & Geophysics	0,86	14	1,00	14	16,2%	6
Environmental Sciences	1,06	11	1,22	9	14,7%	7
Geology	1,13	9	1,26	8	12,2%	8
Agronomy	0,80	18	0,88	17	10,2%	9
Dentistry, Oral Surgery & Medicine	1,25	5	1,34	4	6,7%	10
Sports Sciences	0,87	13	0,91	16	4,7%	11
Marine & Freshwater Biology	1,27	4	1,28	7	0,5%	12
Oceanography	0,86	16	0,84	18	-1,6%	13
Public, Environmental & Occupational Health	0,80	17	0,78	20	-2,1%	14
Agriculture, Soil Science	1,19	6	1,11	11	-6,9%	15
Obstetrics & Gynecology	1,14	7	1,05	12	-8,5%	16
Ecology	1,13	8	1,03	13	-8,9%	17
Food Science & Technology	1,56	2	1,32	5	-15,5%	18
Health Care Sciences & Services	1,00	12	0,83	19	-17,2%	19
Engineering, Petroleum	1,65	1	1,31	6	-20,6%	20

EXHIBIT 58 MAIN TABLES FOR SWEDEN

Number of publications	1999-01		2002-04		Trend	
	N	R	N	R	%	R
Engineering, Environmental	117	15	161	13	36,9%	1
Energy & Fuels	91	19	121	16	33,1%	2
Rheumatology	82	20	106	18	29,7%	3
Environmental Sciences	364	4	430	3	18,2%	4
Biochemical Research Methods	219	9	243	7	10,8%	5
Ecology	294	6	317	5	7,7%	6
Oncology	521	2	550	1	5,6%	7
Public, Environmental & Occupational Health	300	5	316	6	5,1%	8
Obstetrics & Gynecology	193	12	194	11	0,7%	9
Endocrinology & Metabolism	384	3	382	4	-0,7%	10
Anesthesiology	111	16	110	17	-0,9%	11
Infectious Diseases	198	11	194	11	-1,9%	12
Peripheral Vascular Diseases	229	8	220	8	-4,2%	13
Materials Science, Paper & Wood	106	18	98	19	-7,5%	14
Dentistry, Oral Surgery & Medicine	217	10	195	10	-10,3%	15
Physiology	237	7	211	9	-10,8%	16
Forestry	143	14	126	15	-11,9%	17
Immunology	585	1	506	2	-13,4%	18
Allergy	107	17	91	20	-15,5%	19
Orthopedics	171	13	131	14	-23,2%	20

World shares (%) of publications	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Energy & Fuels	1,71	20	2,13	15	24,7%	1
Rheumatology	2,22	15	2,53	7	14,2%	2
Materials Science, Paper & Wood	8,22	1	9,27	1	12,8%	3
Engineering, Environmental	2,74	8	2,99	6	8,8%	4
Anesthesiology	2,04	19	2,01	18	-1,6%	5
Obstetrics & Gynecology	2,28	14	2,22	13	-2,6%	6
Environmental Sciences	2,14	18	2,07	17	-3,3%	7
Public, Environmental & Occupational Health	3,21	6	3,01	5	-6,2%	8
Biochemical Research Methods	2,45	12	2,27	11	-7,3%	9
Peripheral Vascular Diseases	2,31	13	2,11	16	-8,7%	10
Endocrinology & Metabolism	2,66	9	2,43	9	-8,7%	11
Oncology	2,20	17	1,99	20	-9,5%	12
Infectious Diseases	2,20	16	1,99	19	-9,5%	13
Physiology	2,46	11	2,19	14	-10,7%	14
Allergy	3,59	4	3,17	4	-11,7%	15
Immunology	2,54	10	2,23	12	-12,3%	16
Ecology	2,84	7	2,47	8	-13,3%	17
Dentistry, Oral Surgery & Medicine	4,35	3	3,61	3	-17,0%	18
Forestry	6,06	2	4,45	2	-26,5%	19
Orthopedics	3,40	5	2,28	10	-32,9%	20

Specialisation index	1999-01		2002-04		Trend	
	SI	R	SI	R	%	R
Energy & Fuels	1,15	20	1,54	15	34,6%	1
Rheumatology	1,49	15	1,84	7	23,2%	2
Materials Science, Paper & Wood	5,52	1	6,72	1	21,6%	3
Engineering, Environmental	1,84	8	2,16	6	17,3%	4
Anesthesiology	1,37	19	1,46	18	6,2%	5
Obstetrics & Gynecology	1,53	14	1,61	13	5,1%	6
Environmental Sciences	1,44	18	1,50	17	4,3%	7
Public, Environmental & Occupational Health	2,15	6	2,18	5	1,2%	8
Biochemical Research Methods	1,64	12	1,64	11	0,0%	9
Peripheral Vascular Diseases	1,55	13	1,52	16	-1,5%	10
Endocrinology & Metabolism	1,79	9	1,76	9	-1,5%	11
Oncology	1,48	17	1,44	20	-2,3%	12
Infectious Diseases	1,48	16	1,44	19	-2,4%	13
Physiology	1,65	11	1,59	14	-3,7%	14
Allergy	2,41	4	2,30	4	-4,8%	15
Immunology	1,71	10	1,61	12	-5,4%	16
Ecology	1,91	7	1,79	8	-6,4%	17
Dentistry, Oral Surgery & Medicine	2,92	3	2,62	3	-10,4%	18
Forestry	4,07	2	3,23	2	-20,8%	19
Orthopedics	2,28	5	1,65	10	-27,7%	20

Sources: OST – ISI-Thomson, Calculations OST & Technopolis Group.

Note: selection of the 20 first subject categories: decreasing order of World share and N > 50.

In the methodological annex, we insist on the limitations and biases introduced into bibliometric statistics. That suggests extreme caution in interpreting the results, especially when analysing small data sets. The interpretation of indicators cannot be carried out independently of the methodological approaches adopted.

World shares (%) of citations (2 years)	1999-01		2002-04		Trend	
	WS	R	WS	R	%	R
Rheumatology	2,28	15	3,36	5	47,2%	1
Materials Science, Paper & Wood	16,45	1	19,19	1	16,7%	2
Environmental Sciences	2,72	12	2,77	8	1,9%	3
Endocrinology & Metabolism	2,62	13	2,58	11	-1,4%	4
Anesthesiology	2,58	14	2,53	12	-1,9%	5
Immunology	1,69	20	1,60	19	-5,5%	6
Obstetrics & Gynecology	2,88	10	2,72	9	-5,5%	7
Peripheral Vascular Diseases	2,15	16	2,02	16	-6,0%	8
Infectious Diseases	1,86	19	1,72	17	-7,4%	9
Biochemical Research Methods	2,78	11	2,46	15	-11,5%	10
Energy & Fuels	3,08	8	2,62	10	-15,0%	11
Public, Environmental & Occupational Health	2,95	9	2,50	14	-15,2%	12
Allergy	4,69	5	3,96	3	-15,4%	13
Oncology	1,98	17	1,67	18	-15,6%	14
Forestry	5,70	3	4,39	2	-23,0%	15
Ecology	3,70	7	2,81	7	-24,1%	16
Physiology	1,96	18	1,46	20	-25,5%	17
Dentistry, Oral Surgery & Medicine	5,38	4	3,87	4	-28,1%	18
Engineering, Environmental	3,82	6	2,52	13	-33,9%	19
Orthopedics	5,70	2	3,02	6	-47,1%	20

Impact factors	1999-01		2002-04		Trend	
	IF	R	IF	R	%	R
Rheumatology	1,03	12	1,32	3	28,9%	1
Endocrinology & Metabolism	0,99	13	1,06	12	8,0%	2
Immunology	0,67	20	0,72	19	7,7%	3
Environmental Sciences	1,27	7	1,34	2	5,4%	4
Forestry	0,94	14	0,99	13	4,9%	5
Materials Science, Paper & Wood	2,00	1	2,07	1	3,4%	6
Peripheral Vascular Diseases	0,93	15	0,96	14	2,9%	7
Infectious Diseases	0,85	18	0,87	15	2,3%	8
Anesthesiology	1,26	9	1,26	5	-0,4%	9
Obstetrics & Gynecology	1,27	8	1,23	8	-3,0%	10
Allergy	1,30	5	1,25	6	-4,2%	11
Biochemical Research Methods	1,14	11	1,08	10	-4,5%	12
Oncology	0,90	17	0,84	17	-6,8%	13
Public, Environmental & Occupational Health	0,92	16	0,83	18	-9,6%	14
Ecology	1,30	6	1,14	9	-12,5%	15
Dentistry, Oral Surgery & Medicine	1,24	10	1,07	11	-13,4%	16
Physiology	0,80	19	0,67	20	-16,5%	17
Orthopedics	1,68	3	1,32	4	-21,2%	18
Energy & Fuels	1,80	2	1,23	7	-31,8%	19
Engineering, Environmental	1,39	4	0,84	16	-39,2%	20

APPENDIX G

COUNTRY-LEVEL COLLABORATION PATTERNS

EXHIBIT 59 SCIENTIFIC COLLABORATIONS OF DENMARK (2004)

DNK Rank	Anesthesiology		Dentistry, Oral Surgery & Medicine		Ecology		Environmental Sciences		Fisheries		Public, Environmental & Occupational Health		Marine & Freshwater Biology		Obstetrics & Gynecology		Rheumatology		Sports Sciences	
The ten first countries partners (2004)																				
1	Germany	3	Sweden	11	United-Kingdom	19	United-Kingdom	36	United-Kingdom	7	United-Kingdom	33	Germany	12	Sweden	14	Belgium	5	Sweden	8
2	Belgium	2	Japan	5	United-States	18	Sweden	36	Canada	6	Germany	25	United-Kingdom	12	United-Kingdom	7	France	3	United-Kingdom	7
3	Switzerland	2	United-States	5	The Netherlands	16	United-States	36	Germany	6	Sweden	24	United-States	11	Italy	7	United-Kingdom	3	United-States	6
4	New Zealand	2	United-Kingdom	4	Spain	14	Germany	31	Norway	6	United-States	23	Australia	7	United-States	7	Italy	3	Norway	3
5	Sweden	2	The Netherlands	4	Germany	8	Norway	22	United-States	6	The Netherlands	22	Canada	7	Germany	5	The Netherlands	3	Canada	2
6	United-States	2	Germany	3	France	7	Canada	17	Ireland	4	Norway	19	Spain	7	Finland	5	Sweden	3	Japan	2
7	Austria	1	Brasil	2	Sweden	7	Russia	17	Sweden	3	France	18	France	6	Norway	5	United-States	3	Australia	1
8	Canada	1	Switzerland	2	Canada	4	Switzerland	17	Iceland	2	Spain	13	Norway	6	Brasil	2	Australia	2	Brasil	1
9	Spain	1	Ireland	2	Thailand	4	The Netherlands	17	Italy	2	Switzerland	9	The Netherlands	5	France	2	Canada	2	China	1
10	France	1	Italy	2	South Africa	4	Italy	15	Australia	1	Finland	9	Ireland	4	Iceland	2	Germany	2	Estonia	1
Total number of co-publications for each of the 10 first countries partners (2004)																				
1	Germany	303	Sweden	143	United-Kingdom	707	United-Kingdom	795	United-Kingdom	142	United-Kingdom	775	Germany	259	Sweden	144	Belgium	55	Sweden	91
2	Belgium	55	Japan	383	United-States	2280	Sweden	296	Canada	187	Germany	275	United-Kingdom	393	United-Kingdom	450	France	169	United-Kingdom	293
3	Switzerland	99	United-States	764	The Netherlands	212	United-States	3236	Germany	48	Sweden	239	United-States	998	Italy	280	United-Kingdom	312	United-States	1473
4	New Zealand	19	United-Kingdom	349	Spain	253	Germany	643	Norway	126	United-States	3133	Australia	275	United-States	1365	Italy	142	Norway	44
5	Sweden	68	The Netherlands	109	Germany	360	Norway	161	United-States	543	The Netherlands	309	Canada	317	Germany	259	The Netherlands	181	Canada	281
6	United-States	635	Germany	209	France	414	Canada	719	Ireland	10	Norway	146	Spain	217	Finland	78	Sweden	92	Japan	169
7	Austria	64	Brasil	245	Sweden	192	Russia	114	Sweden	14	France	291	France	291	Norway	67	United-States	588	Australia	218
8	Canada	139	Switzerland	78	Canada	388	Switzerland	216	Iceland	10	Spain	161	Norway	167	Brasil	63	Australia	63	Brasil	18
9	Spain	25	Ireland	26	Thailand	17	The Netherlands	300	Italy	48	Switzerland	164	The Netherlands	109	France	206	Canada	125	China	36
10	France	158	Italy	135	South Africa	106	Italy	448	Australia	147	Finland	144	Ireland	41	Iceland	6	Germany	240	Estonia	4

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Full counting).

EXHIBIT 60 SCIENTIFIC COLLABORATIONS OF ICELAND (2004)

ISL Rank	Anesthesiology	Dentistry, Oral Surgery & Medicine	Ecology	Environmental Sciences	Fisheries	Public, Environmental & Occupational Health	Marine & Freshwater Biology	Obstetrics & Gynecology	Rheumatology	Sports Sciences
The ten first countries partners (2004)										
1	United-States 1	United-Kingdom 8	United-Kingdom 4	Sweden 4	Norway 4	United-Kingdom 8	United-Kingdom 4	Sweden 3	Canada 1	Norway 2
2	. .	Ireland 8	Norway 3	Finland 3	United-Kingdom 3	Ireland 8	Norway 2	Denmark 2	. .	Austria 1
3	. .	Finland 7	Denmark 2	Germany 2	Denmark 2	Finland 7	Sweden 2	Finland 2	. .	Sweden 1
4	. .	The Netherlands 7	Finland 2	Denmark 2	Sweden 2	The Netherlands 7	United-States 2	Norway 2	. .	USA 1
5	. .	Portugal 7	Sweden 2	Norway 2	United-States 2	Portugal 7	Canada 1	The Netherlands 1	. .	. .
6	. .	Greece 6	Belgium 1	Canada 1	Canada 1	Greece 6	Germany 1	. .	. .	. .
7	. .	Denmark 1	Canada 1	Russia 1	Germany 1	Denmark 1	Denmark 1	. .	. .	. .
8	. .	Sweden 1	Germany 1	Italy 1	Finland 1	New Zealand 1	Japan 1	. .	. .	. .
9	. .	United-States 1	Japan 1	Poland 1	Poland 1	. .	Poland 1	. .	. .	. .
10	. .	. .	United-States 1	United-States 1	. .	. .	. .	. .	. .	. .
Total number of co-publications for each of the 10 first countries partners (2004)										
1	United-States 635	United-Kingdom 349	United-Kingdom 707	Sweden 296	Norway 126	United-Kingdom 775	United-Kingdom 393	Sweden 144	Canada 125	Norway 44
2	. .	Ireland 26	Norway 126	Finland 203	United-Kingdom 142	Ireland 32	Norway 167	Denmark 82	. .	Austria 21
3	. .	Finland 82	Denmark 101	Germany 643	Denmark 38	Finland 144	Sweden 77	Finland 78	. .	Sweden 91
4	. .	The Netherlands 109	Finland 144	Denmark 184	Sweden 14	The Netherlands 309	United-States 998	Norway 67	. .	USA 1473
5	. .	Portugal 7	Sweden 192	Norway 161	United-States 543	Portugal 20	Canada 317	The Netherlands 223	. .	. .
6	. .	Greece 62	Belgium 100	Canada 719	Canada 187	Greece 48	Germany 259	. .	. .	. .
7	. .	Denmark 51	Canada 388	Russia 114	Germany 48	Denmark 166	Denmark 87	. .	. .	. .
8	. .	Sweden 143	Germany 360	Italy 448	Finland 36	New Zealand 43	Japan 261	. .	. .	. .
9	. .	United-States 764	Japan 215	Poland 171	Poland 12	. .	Poland 38	. .	. .	. .
10	. .	. .	United-States 2280	United-States 3236	. .	. .	. .	. .	. .	. .

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Full counting).

EXHIBIT 61 SCIENTIFIC COLLABORATIONS OF FINLAND (2004)

FIN Rank	Anesthesiology		Dentistry, Oral Surgery & Medicine		Ecology		Environmental Sciences		Fisheries		Public, Environmental & Occupational Health		Marine & Freshwater Biology		Obstetrics & Gynecology		Rheumatology		Sports Sciences	
The ten first countries partners (2004)																				
1	Switzerland	3	The Netherlands	14	United-States	27	United-States	32	Norway	6	United-Kingdom	29	Norway	8	Sweden	16	United-States	24	United-States	12
2	United-States	3	United-Kingdom	11	Sweden	22	Sweden	22	United-States	2	United-States	28	Sweden	6	United-Kingdom	10	United-Kingdom	7	France	5
3	Australia	2	Ireland	8	United-Kingdom	16	Germany	21	Belgium	1	The Netherlands	21	Germany	5	United-States	7	Sweden	6	Canada	4
4	Belgium	1	Greece	7	Germany	10	United-Kingdom	20	Canada	1	Germany	19	The Netherlands	5	Norway	6	Italy	5	Australia	3
5	France	1	Iceland	7	France	8	Norway	16	Russia	1	Sweden	18	Spain	4	Denmark	5	France	4	Germany	3
6	United-Kingdom	1	Portugal	7	Canada	7	Italy	15	Switzerland	1	France	11	United-Kingdom	4	Germany	4	The Netherlands	4	Sweden	3
7	Italy	1	United-States	6	The Netherlands	5	Denmark	12	Germany	1	Norway	11	France	2	Belgium	3	Belgium	3	Spain	2
8	The Netherlands	1	Canada	5	Norway	4	Russia	11	Denmark	1	Canada	9	United-States	2	France	3	Switzerland	3	Italy	2
9	Norway	1	Sweden	5	Estonia	3	France	10	Estonia	1	Denmark	9	Belgium	1	The Netherlands	3	Germany	3	Bulgaria	1
10	Sweden	1	Turkey	3	Portugal	3	Belgium	9	France	1	Greece	9	Canada	1	Estonia	2	Spain	3	Russia	1
Total number of co-publications for each of the 10 first countries partners (2004)																				
1	Switzerland	99	The Netherlands	109	United-States	2280	United-States	3236	Norway	126	United-Kingdom	775	Norway	167	Sweden	144	United-States	588	United-States	1473
2	United-States	635	United-Kingdom	349	Sweden	192	Sweden	296	United-States	543	United-States	3133	Sweden	77	United-Kingdom	450	United-Kingdom	312	France	172
3	Australia	100	Ireland	26	United-Kingdom	707	Germany	643	Belgium	30	The Netherlands	309	Germany	259	United-States	1365	Sweden	92	Canada	281
4	Belgium	55	Greece	62	Germany	360	United-Kingdom	795	Canada	187	Germany	275	The Netherlands	109	Norway	67	Italy	142	Australia	218
5	France	158	Iceland	15	France	414	Norway	161	Russia	10	Sweden	239	Spain	217	Denmark	82	France	169	Germany	159
6	United-Kingdom	218	Portugal	7	Canada	388	Italy	448	Switzerland	5	France	291	United-Kingdom	393	Germany	259	The Netherlands	181	Sweden	91
7	Italy	63	United-States	764	The Netherlands	212	Denmark	184	Germany	48	Norway	146	France	291	Belgium	106	Belgium	55	Spain	24
8	The Netherlands	64	Canada	82	Norway	126	Russia	114	Denmark	38	Canada	362	United-States	998	France	206	Switzerland	69	Italy	77
9	Norway	29	Sweden	143	Estonia	13	France	481	Estonia	3	Denmark	166	Belgium	96	The Netherlands	223	Germany	240	Bulgaria	1
10	Sweden	68	Turkey	146	Portugal	58	Belgium	189	France	120	Greece	48	Canada	317	Estonia	2	Spain	91	Russia	8

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Full counting).

EXHIBIT 62 SCIENTIFIC COLLABORATIONS OF NORWAY (2004)

NOR Rank	Anesthesiology		Dentistry, Oral Surgery & Medicine		Ecology		Environmental Sciences		Fisheries		Public, Environmental & Occupational Health		Marine & Freshwater Biology		Obstetrics & Gynecology		Rheumatology		Sports Sciences	
The ten first countries partners (2004)																				
1	Sweden	5	Sweden	13	United-Kingdom	22	United-Kingdom	44	United-Kingdom	15	United-States	26	United-Kingdom	32	Sweden	13	The Netherlands	5	United-Kingdom	5
2	Germany	2	United-States	11	United-States	20	United-States	31	United-States	14	Sweden	24	United-States	18	United-Kingdom	8	United-Kingdom	4	Sweden	5
3	United-Kingdom	2	Brasil	4	Sweden	18	Sweden	29	Canada	6	Denmark	19	Germany	12	Finland	6	Switzerland	3	United-States	4
4	Denmark	1	United-Kingdom	4	France	12	Germany	22	Denmark	6	France	16	Finland	8	Belgium	5	Germany	3	Germany	3
5	Egypte	1	Japan	3	Germany	10	Denmark	22	Finland	6	United-Kingdom	16	Sweden	8	Denmark	5	Finland	3	Denmark	3
6	Finland	1	China	2	Canada	4	Russia	18	Ireland	5	The Netherlands	16	Canada	7	The Netherlands	4	France	3	France	2
7	United-States	1	Denmark	2	Finland	4	Finland	16	Iceland	4	Germany	13	Denmark	6	United-States	4	United-States	3	Iceland	2
8	.	.	Finland	2	The Netherlands	4	Canada	15	Portugal	4	Finland	11	France	6	Germany	3	Australia	2	The Netherlands	2
9	.	.	Ouganda	2	Austria	3	The Netherlands	14	Spain	3	Spain	8	Ireland	6	Canada	2	Spain	2	Belgium	1
10	.	.	Austria	1	Iceland	3	France	12	France	3	Italy	7	Poland	5	Switzerland	2	Italy	2	Estonia	1
Total number of co-publications for each of the 10 first countries partners (2004)																				
1	Sweden	68	Sweden	143	United-Kingdom	707	United-Kingdom	795	United-Kingdom	142	United-States	3133	United-Kingdom	393	Sweden	144	The Netherlands	181	United-Kingdom	293
2	Germany	303	United-States	764	United-States	2280	United-States	3236	United-States	543	Sweden	239	United-States	998	United-Kingdom	450	United-Kingdom	312	Sweden	91
3	United-Kingdom	218	Brasil	245	Sweden	192	Sweden	296	Canada	187	Denmark	166	Germany	259	Finland	78	Switzerland	69	United-States	1473
4	Denmark	48	United-Kingdom	349	France	414	Germany	643	Denmark	38	France	291	Finland	51	Belgium	106	Germany	240	Germany	159
5	Egypte	3	Japan	383	Germany	360	Denmark	184	Finland	36	United-Kingdom	775	Sweden	77	Denmark	82	Finland	72	Denmark	46
6	Finland	47	China	78	Canada	388	Russia	114	Ireland	10	The Netherlands	309	Canada	317	The Netherlands	223	France	169	France	172
7	United-States	635	Denmark	51	Finland	144	Finland	203	Iceland	10	Germany	275	Denmark	87	United-States	1365	United-States	588	Iceland	6
8	.	.	Finland	82	The Netherlands	212	Canada	719	Portugal	39	Finland	144	France	291	Germany	259	Australia	63	The Netherlands	112
9	.	.	Ouganda	3	Austria	55	The Netherlands	300	Spain	87	Spain	161	Ireland	41	Canada	171	Spain	91	Belgium	54
10	.	.	Austria	31	Iceland	22	France	481	France	120	Italy	218	Poland	38	Switzerland	55	Italy	142	Estonia	4

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Full counting).

EXHIBIT 63 SCIENTIFIC COLLABORATIONS OF SWEDEN (2004)

SWE Rank	Anesthesiology		Dentistry, Oral Surgery & Medicine		Ecology		Environmental Sciences		Fisheries		Public, Environmental & Occupational Health		Marine & Freshwater Biology		Obstetrics & Gynecology		Rheumatology		Sports Sciences	
The ten first countries partners (2004)																				
1	Norway	5	United-States	21	United-Kingdom	32	United-States	51	Canada	3	United-States	38	United-Kingdom	13	Finland	16	United-States	17	United-States	21
2	Italy	3	Norway	13	United-States	28	United-Kingdom	42	Denmark	3	United-Kingdom	27	Germany	10	Denmark	14	United-Kingdom	16	United-Kingdom	11
3	Liban	3	Denmark	11	Finland	22	Germany	40	Norway	3	Germany	24	The Netherlands	8	United-States	14	Germany	8	Canada	10
4	United-States	3	Switzerland	10	Germany	18	Denmark	36	United-Kingdom	2	Denmark	24	Norway	8	Norway	13	France	7	Denmark	8
5	Canada	2	Japan	8	Norway	18	Norway	29	Iceland	2	Norway	24	Finland	6	United-Kingdom	9	Finland	6	Australia	5
6	Germany	2	United-Kingdom	7	France	15	Finland	22	United-States	2	France	21	United-States	6	Italy	7	The Netherlands	6	Norway	5
7	Denmark	2	Finland	5	The Netherlands	13	The Netherlands	22	Switzerland	1	Finland	18	Denmark	4	Germany	6	Austria	4	Finland	3
8	Spain	1	The Netherlands	5	Canada	12	Canada	19	Chile	1	Italy	14	Spain	4	The Netherlands	6	Canada	4	France	3
9	Estonia	1	Greece	4	Spain	8	Italy	18	Germany	1	The Netherlands	13	France	4	Belgium	4	Russia	4	Germany	2
10	Finland	1	Saudi Arabia	4	Switzerland	7	Switzerland	17	Finland	1	Spain	10	Australia	2	Australia	3	Belgium	3	Brasil	1
Total number of co-publications for each of the 10 first countries partners (2004)																				
1	Norway	29	United-States	764	United-Kingdom	707	United-States	3236	Canada	187	United-States	3133	United-Kingdom	393	Finland	78	United-States	588	United-States	1473
2	Italy	63	Norway	46	United-States	2280	United-Kingdom	795	Denmark	38	United-Kingdom	775	Germany	259	Denmark	82	United-Kingdom	312	United-Kingdom	293
3	Liban	6	Denmark	51	Finland	144	Germany	643	Norway	126	Germany	275	The Netherlands	109	United-States	1365	Germany	240	Canada	281
4	United-States	635	Switzerland	78	Germany	360	Denmark	184	United-Kingdom	142	Denmark	166	Norway	167	Norway	67	France	169	Denmark	46
5	Canada	139	Japan	383	Norway	126	Norway	161	Iceland	10	Norway	146	Finland	51	United-Kingdom	450	Finland	72	Australia	218
6	Germany	303	United-Kingdom	349	France	414	Finland	203	United-States	543	France	291	United-States	998	Italy	280	The Netherlands	181	Norway	44
7	Denmark	48	Finland	82	The Netherlands	212	The Netherlands	300	Switzerland	5	Finland	144	Denmark	87	Germany	259	Austria	45	Finland	59
8	Spain	25	The Netherlands	109	Canada	388	Canada	719	Chile	36	Italy	218	Spain	217	The Netherlands	223	Canada	125	France	172
9	Estonia	1	Greece	62	Spain	253	Italy	448	Germany	48	The Netherlands	309	France	291	Belgium	106	Russia	6	Germany	159
10	Finland	47	Saudi Arabia	13	Switzerland	111	Switzerland	216	Finland	36	Spain	161	Australia	275	Australia	148	Belgium	55	Brasil	18

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group. (Full counting).

APPENDIX H

IDENTIFICATION OF PUBLISHING RESEARCH LABS AND CO-PUBLICATION PARTNERS FOR DATA ANALYSES AT INSTITUTIONAL LEVEL

The analysis here concentrates on the identification of the publishing institutions in each of the five Nordic countries and for the 10 selected scientific fields (address and number of participations in scientific publications), and highlights the main scientific institutions in each country by subject category.

H.1 Main Scientific Institutions

The identification of the 'main scientific institutions' is based on a cleaning process of nearly 5,000 scientific publication's address labs.

For each of these 10 selected subject categories, and per country, the following tables provide at institutional level: production information (number of publications in the sub-field and share of publication in the sub-field) and identification information.

In red are indicated the number of participations in (co-)publications over 50, and in blue the number of participations in (co-) publications under 10.

As an example, the Copenhagen University Hospital performs best in Public, Environmental & Occupational Health with 101 participations in scientific publications in 2004. Most of the participations of the Copenhagen University Hospital, all fields together, issue from Copenhagen (386 participations in scientific publications).

EXHIBIT 64 EXAMPLE OF RESULT OF THE CLEANING PROCESS

Country Denmark	Name of the Institution (Result of the cleaning process)	Original names of the institution
	Aalborg Univ Hosp	Aalborg Cty Hosp Aalborg Hosp Aalborg Univ Hosp Aarhus & Aalborg Univ Hosp ...
	Copenhagen City Heart Study	City Copenhagen & Fredericksberg Copenhagen City Heart Study Copenhagen Cty Cty Frederiksborg ...
	...	...

EXHIBIT 65 DENMARK: INSTITUTION AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY 10 SELECTED SCIENTIFIC FIELD (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Anesthegiology	Dentistry, Oral Surgery & Medicine	Public, Environmental & Occupational Health	Obstetrics & Gynecology	Rheumatology	Sports Sciences	Ecology	Fisheries	Environmental sciences	Marine & Freshwater Biology
Copenhagen Univ Hosp	31	58	101	72	32	40	45	5	43	42
Univ Copenhagen	12	48	75	40	18	35	44	5	42	42
Aarhus Univ Hosp	31	52	83	23	18	9	39	6	29	20
Natl Environm Res Inst			1				37	1	59	32
Univ So Denmark	1	1	26	32	1	11	9	2	9	15
Tech Univ Denmark		1	5			1	2	1	67	2
Danish Inst Fisheries & Marine Res							11	28	3	28
Statens Serum Inst	14	2	14	1	7	9			14	1
Natl Inst Occupat Hlth			36			14			10	
Royal Vet & Agr Univ		1	9	1			16	7	17	5

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 66 DENMARK: LIST OF INSTITUTION AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY CITY (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Copenhagen	Aarhus	Roskilde	Odense	Lyngby	Frederiksberg	Charlottenlund	Aalborg	Hvidovre	Silkeborg	Helsingor	Hillerod	Ronde	Glostrup	Herlev	Horsholm	Risskov
Copenhagen Univ Hosp	386			1		4	1		16		22	12		7	11		
Univ Copenhagen	292			1		4	1		13		22	12		3	5		
Aarhus Univ Hosp		291						3									14
Natl Environm Res Inst	2		71							32		1	22				
Univ So Denmark				94													
Tech Univ Denmark					76												
Danish Inst Fisheries & Marine Res					1	8	43			15							
Statens Serum Inst	25							36									
Natl Inst Occupat Hlth	60																
Royal Vet & Agr Univ	7					44										2	

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 67 SWEDEN: INSTITUTION AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY 10 SELECTED SCIENTIFIC FIELD (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Anesthegiology	Dentistry, Oral Surgery & Medicine	Public, Environmental & Occupational Health	Obstetrics & Gynecology	Rheumatology	Sports Sciences	Ecology	Fisheries	Environmental sciences	Marine & Freshwater Biology
Karolinska Univ Hosp & Inst	40	64	221	115	88	75	1		10	
Gothenburg Univ	12	122	45	37	28	20	39	4	53	35
Lund Univ	10	3	44	39	33	12	65	3	91	18
Uppsala Univ Hosp	21	11	25	24	18	18	72	7	33	31
Umea Univ Hosp	4	47	50	22	4	17	46	1	36	7
Swedish Univ Agr Sci SLU			3		1		89	7	90	15
Stockholm Univ		1	12			4	24	10	67	26
Univ Hosp	22	6	44	22	4	6			10	
Malmo Univ Hosp	4	63	12	13	15	2			3	2
Linkoping Univ Hosp	15	3	25	15	20	10	4		15	

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 68 SWEDEN: LIST OF INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY CITY (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Stockholm	Gothenburg	Lund	Uppsala	Umea	Linkoping	Malmo	Orebro	Huddinge	Kalmar	Norrkoping	Fiskebackskil	Molndal	Stromstad	Gavle	Helsingborg	Solna	Alnarp	Kristianstad	Riddarhyttan
Karolinska Univ Hosp & Inst	537			1		1			68								3			
Gothenburg Univ		363										15	3	14						
Lund Univ*			264				52									2				
Uppsala Univ Hosp	2			245											1					
Umea Univ Hosp					230															
Swedish Univ Agr Sci SLU				123	56													13	1	9
Stockholm Univ	139								1											
Univ Hosp (not complete adr)			32	8	6	32	8	28												
Malmo Univ Hosp*							114													
Linkoping Univ Hosp						105					1									

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: Malmo univ hosp is a part of Lund univ hosp.

EXHIBIT 69 NORWAY: INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY 10 SELECTED SCIENTIFIC FIELD (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Anesthegiology	Dentistry, Oral Surgery & Medicine	Ecology	Environmental sciences	Fisheries	Public, Environmental & Occupational Health	Marine & Freshwater Biology	Obstetrics & Gynecology	Rheumatology	Sports Sciences
Univ Bergen	4	67	36	23	38	63	57	17	3	10
Oslo Univ Coll	15	48	45	33	18	69	30	27	4	12
Marine Res Inst			24	6	85		87			
Natl Board Fisheries			21	5	66		65			
Norwegian Univ Sci & Technol	5		34	28	6	21	20	15		11
Univ Tromso Hosp			22	21	19	22	20	12	5	
Natl Vet Inst				16	31	8	31			
Agr Univ Norway			32	42	3	4	4			
Norwegian Inst Nat Res			35	6	12		23			
Norwegian Coll Vet Med			6	17	15	14	16			

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 70 NORWAY: LIST OF INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY CITY (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Oslo	Bergen	Trondheim	Tromso	As	Storebo	His	Matredal
Univ Bergen		318						
Oslo Univ Coll	295				1			
Marine Res Inst		138		10		27	14	11
Natl Board Fisheries		104		6		25	11	9
Norwegian Univ Sci & Technol	1		139					
Univ Tromso Hosp				120				
Natl Vet Inst	72	14						
Agr Univ Norway					80			
Norwegian Inst Nat Res	19		39	12				
Norwegian Coll Vet Med	60			6				

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 71 FINLAND: INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY 10 SELECTED SCIENTIFIC FIELD (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Anesthegiology	Dentistry, Oral Surgery & Medicine	Ecology	Environmental sciences	Fisheries	Public, Environmental & Occupational Health	Marine & Freshwater Biology	Obstetrics & Gynecology	Rheumatology	Sports Sciences
Helsinki Univ Hosp	43	107	104	118	10	92	35	89	67	23
Turku Univ Hosp	25	73	57	21	2	16	9	28	14	13
Natl Publ Hlth Inst	4	12	2	49	2	135		15	25	6
Kuopio Univ Hosp	15	14	2	58	5	53	3	24	10	28
Oulu Univ Hosp	13	38	33	21		29	4	47	7	12
Tampere Univ Hosp	13	15		24		15		33	37	25
Univ Jyvaskyla		5	49	24	11	8	9	1	3	46
KTL Natl Publ Hlth Inst	2	6	1	30	1	76		8	13	3
Natl Inst Publ Hlth	2	6	1	26	1	70		9	14	3
Inari Fisheries Res & Aquaculture			15	12	27		27			

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 72 FINLAND: LIST OF INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY CITY (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Helsinki	Kuopio	Turku	Oulu	Jyvaskyla	Tampere	Joensuu	Espoo	Vantaa	Heinola	Rovaniemi	Lahti	Suonenjoki
Helsinki Univ Hosp	618	2	1	1		4		19	10			11	
Turku Univ Hosp			257										
Natl Publ Hlth Inst	146	96	4	4									
Kuopio Univ Hosp		212											
Oulu Univ Hosp				200									
Tampere Univ Hosp	1			1		158							
Univ Jyvaskyla	1				155								
KTL Natl Publ Hlth Inst	77	59	2	2									
Natl Inst Publ Hlth	77	51	2	2									
Inari Fisheries Res & Aquaculture	34		2	5			3						

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 73 ICELAND: LIST OF INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY 10 SELECTED SCIENTIFIC FIELD (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Anesthegiology	Dentistry, Oral Surgery & Medicine	Public, Environmental & Occupational Health	Obstetrics & Gynecology	Rheumatology	Sports Sciences	Ecology	Fisheries	Environmental sciences	Marine & Freshwater Biology
Univ Iceland	1	24	15	3		5	22	7	6	29
Marine Res Inst							2	6	1	8
Landspitalinn Univ Hosp	1	1	3	5	4					
Myvatn Res Stn							11			11

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

EXHIBIT 74 ICELAND: LIST OF INSTITUTIONS AND NUMBER OF DISTINCT ADDRESSES OF RESEARCH LABS – BY CITY (YEAR 2004)

Organisation with at least 10 scientific publications (Participation counting)	Reykjavik	Myvatn
Univ Iceland	112	
Marine Res Inst	17	
Landspitalinn Univ Hosp	14	
Myvatn Res Stn		22

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.

H.2 Main Scientific Institutions by Subject Category

The following tables present the main scientific institutions for each of the 10 selected scientific fields, and the related number of publication (full counting).

As an example, in the field of Anesthegiology, in 2004, in Denmark, the Copenhagen University Hospital and the Aarhus University Hospital issued 18 publications each and therefore hold the first position.

EXHIBIT 75 MAIN SCIENTIFIC INSTITUTIONS: ANAESTHESIOLOGY (YEAR 2004)

	Anesthegiology	
	DNK	N
1	Copenhagen Univ Hosp	18
2	Aarhus Univ Hosp	18
3	Univ Copenhagen	10
4	Statens Serum Inst	10
5	Odense Univ Hosp	5
6	HS Hvidovre Univ Hosp	4
7	Glostrup Univ Hosp	4
8	Rigshosp Univ Hosp	3
9	Herlev Univ Hosp	3
10	Gentofte Univ Hosp	3

	Anesthegiology	
	FIN	N
1	Helsinki Univ / Helsinki Univ Hosp	32
2	Turku Univ Hosp	9
3	Tampere Univ Hosp	9
4	Rheumatism Fdn Hosp	3
5	Oulu Univ Hosp	7
6	Natl Publ Hlth Inst	2
7	Kuopio Univ Hosp	13
8	KTL Natl Publ Hlth Inst	2
9	Jyvaskyla Cent Hosp	2
10	-	

	Anesthegiology	
	ISL	N
1	Landspitalinn Univ Hosp	1
2	-	
3	-	
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

	Anesthegiology	
	NOR	N
1	Oslo Univ Coll	9
2	Haukeland Univ Hosp	5
3	Rikshosp Univ Hosp	4
4	Norwegian Univ Sci & Technol	4
5	Univ Hosp N Norway	3
6	Univ Hosp	3
7	Helsinki Univ Hosp	3
8	Univ Bergen	3
9	Natl Inst Occupat Hlth	3
10	Univ Trondheim Hosp	2

	Anesthegiology	
	SWE	N
1	Karolinska Univ Hosp & Inst	30
2	Uppsala Univ Hosp	16
3	Linkoping Univ Hosp	11
4	Univ Hosp N Norway	9
5	Univ Hosp	9
6	Helsinki Univ Hosp	9
7	Gothenburg Univ	8
8	Orebro Univ Hosp	7
9	Lund Univ	6
10	Univ Lund Hosp	5

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 76 MAIN SCIENTIFIC INSTITUTIONS: DENTISTRY, ORAL SURGERY & MEDICINE (YEAR 2004)

	Dentistry, Oral Surgery & Medicine	
	DNK	N
1	Copenhagen Univ Hosp	31
2	Aarhus Univ Hosp	29
3	Univ Copenhagen	27
4	Rigshosp Univ Hosp	3
5	Publ Dent Hlth Serv	3
6	Univ Hosp N Norway	2
7	Univ Hosp	2
8	Statens Serum Inst	2
9	Helsinki Univ Hosp	2
10	Aalborg Univ Hosp	2

	Dentistry, Oral Surgery & Medicine	
	FIN	N
1	Helsinki Univ / Helsinki Univ Hosp	36
2	Turku Univ Hosp	34
3	Oulu Univ Hosp	26
4	Tampere Univ Hosp	8
5	Kuopio Univ Hosp	4
6	Natl Publ Hlth Inst	3
7	Vaasa Cent Hosp	3
8	Natl Res & Dev Ctr Welfare & Hlth	3
9	Finnish Broadcasting Co	3
10	Ctr Hlth & Social Serv	2

	Dentistry, Oral Surgery & Medicine	
	ISL	N
1	Univ Iceland	16
2	Univ Akureyri	1
3	Reykjavik Hlth Ctr	1
4	Landspitalinn Univ Hosp	1
5	Icelandic Inst Dent Res	1
6	Iceland Heart Assoc	1
7	-	
8	-	
9	-	
10	-	

	Dentistry, Oral Surgery & Medicine	
	SWE	N
1	Gothenburg Univ	68
2	Karolinska Univ Hosp & Inst	36
3	Malmo Univ Hosp	31
4	Umea Univ Hosp	28
5	Publ Dent Hlth Serv	9
6	Inst Postgrad Dent Educ	7
7	Eastman Dent Inst	7
8	Uppsala Univ Hosp	6
9	Swedish Council Technol Assessment I	5
10	Huddinge Univ Hosp	5

	Dentistry, Oral Surgery & Medicine	
	NOR	N
1	Univ Bergen	23
2	Oslo Univ Coll	21
3	Scandinavian Inst Dent Mat	7
4	UNIFOB	2
5	Resource Ctr Oral Hlth Rare Med Con	1
6	Norwegian Radium Hosp Hlth Trust	1
7	Norwegian Inst Public Hlth	1
8	Norwegian Inst Alcohol & Drug Res	1
9	Natl Inst Occupat Hlth	1
10		

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 77 MAIN SCIENTIFIC INSTITUTIONS: ECOLOGY (YEAR 2004)

	Ecology DNK	N
1	Copenhagen Univ Hosp	42
2	Univ Copenhagen	41
3	Aarhus Univ Hosp	35
4	Natl Environm Res Inst	32
5	Riso Natl Lab	12
6	Royal Vet & Agr Univ	11
7	Danish Inst Fisheries & Marine Res	11
8	Univ So Denmark	4
9	Fyn Cty Nat Management & Water Env	4
10	Danish Res Inst Agr Sci	4
	Other	

	Ecology FIN	N
1	Helsinki Univ / Helsinki Univ Hosp	84
2	Turku Univ Hosp	46
3	Univ Jyvaskyla	40
4	Oulu Univ Hosp	26
5	Univ Joensuu	18
6	Finnish Forest Res Inst	18
7	Inari Fisheries Res & Aquaculture	11
8	Finnish Environm Inst	8
9	Abo Akad Univ	4
10	Univ Lapland	3

	Ecology ISL	N
1	Univ Iceland	19
2	Myvatn Res Stn	10
3	Marine Res Inst	2
4	Inst Freshwater Fisheries	2
5	Holar Agr Coll	2
6	Vegagerdin	1
7	Vatnaskil Consulting Engineers	1
8	Univ Akureyri	1
9	Soil Conservat Serv Iceland	1
10	Prokaria Ltd	1

	Ecology SWE	N
1	Swedish Univ Agr Sci SLU	69
2	Uppsala Univ Hosp	64
3	Lund Univ	62
4	Umea Univ Hosp	39
5	Gothenburg Univ	31
6	Stockholm Univ	22
7	Kalmar Univ	8
8	Mid Sweden Univ	6
9	Swedish Museum Nat Hist	5
10	Natl Board Fisheries	5

	Ecology NOR	N
1	Oslo Univ Coll	38
2	Norwegian Inst Nat Res	29
3	Univ Bergen	27
4	Norwegian Univ Sci & Technol	25
5	Agr Univ Norway	21
6	Univ Tromso Hosp	19
7	Marine Res Inst	16
8	Natl Board Fisheries	15
9	UNIS	12
10	Norwegian Inst Water Res	5

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 78 MAIN SCIENTIFIC INSTITUTIONS: ENVIRONMENTAL SCIENCES (YEAR 2004)

	Environmental sciences	
	DNK	N
1	Natl Environm Res Inst	8
2	Univ Copenhagen	7
3	Copenhagen Univ Hosp	7
4	Aarhus Univ Hosp	6
5	Roskilde Univ Hosp	2
6	Riso Natl Lab	2
7	Zool Museum	1
8	Univ So Denmark	1
9	Tech Univ Denmark	1
10	Royal Vet & Agr Univ	1

	Environmental sciences	
	FIN	N
1	Helsinki Univ / Helsinki Univ Hosp	12
2	Finnish Forest Res Inst	8
3	Univ Joensuu	7
4	Turku Univ Hosp	3
5	Finnish Environm Inst	2
6	Univ Jyvaskyla	1
7	Oulu Univ Hosp	1
8	MTT Agrifood Res Finland	1
9	Kuopio Univ Hosp	1
10	Inari Fisheries Res & Aquaculture	1

	Environmental sciences	
	ISL	N
1	Univ Iceland	1
2	Sandgeroi Marine Ctr	1
3	Iceland Forest Res Bugardur	1
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

	Environmental sciences	
	NOR	N
1	Agr Univ Norway	7
2	Oslo Univ Coll	5
3	Akvamiljo AS	3
4	Univ Bergen	2
5	RF Rogaland Res	2
6	Norwegian Univ Sci & Technol	2
7	Norwegian Inst Nat Res	2
8	UNIS	1
9	STATOIL	1
10	Sogn & Fjordane Univ Coll	1

	Environmental sciences	
	SWE	N
1	Swedish Univ Agr Sci SLU	23
2	Lund Univ	11
3	Uppsala Univ Hosp	7
4	Gothenburg Univ	7
5	Stockholm Univ	4
6	Umea Univ Hosp	3
7	Orebro Univ Hosp	3
8	Mid Sweden Univ	3
9	Royal Swedish Acad Sci	2
10	Chalmers Univ Technol	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 79 MAIN SCIENTIFIC INSTITUTIONS: FISHERIES (YEAR 2004)

	Fisheries DNK	N
1	Danish Inst Fisheries & Marine Res	27
2	Royal Vet & Agr Univ	6
3	Univ Copenhagen	5
4	Copenhagen Univ Hosp	5
5	Aarhus Univ Hosp	5
6	Danish Inst Food & Vet Res	4
7	Biomar AS	2
8	Univ So Denmark	1
9	Tech Univ Denmark	1
10	Natl Environm Res Inst	1
	Other	

	Fisheries FIN	N
1	Inari Fisheries Res & Aquaculture	23
2	Univ Jyvaskyla	10
3	Helsinki Univ / Helsinki Univ Hosp	9
4	Finnish Game & Fisheries Res Inst	7
5	Kuopio Univ Hosp	4
6	Laukaa Fisheries Res & Aquaculture	3
7	Finnish Environm Inst	3
8	Turku Univ Hosp	2
9	Oulu Game & Fisheries Res	2
10	Finnish Inst Marine Res	2

	Fisheries ISL	N
1	Univ Iceland	6
2	Marine Res Inst	5
3	Univ Hosp N Norway	1
4	Univ Hosp	1
5	Linuhonnun Ltd	1
6	Inst Freshwater Fisheries	1
7	Helsinki Univ Hosp	1
8	Fiskeldi Eyjafjardar HF	1
9	Cent Bank Iceland	1
10	Blood Bank	1

	Fisheries SWE	N
1	Stockholm Univ	8
2	Natl Board Fisheries	6
3	Swedish Univ Agr Sci SLU	5
4	Uppsala Univ Hosp	3
5	Lund Univ	3
6	Gothenburg Univ	3
7	Marine Res Inst	2
8	Umea Univ Hosp	1
9	Royal Swedish Acad Sci	1
10	Kirstineberg Marine Res Stn	1

	Fisheries NOR	N
1	Marine Res Inst	64
2	Natl Board Fisheries	47
3	Univ Bergen	30
4	Natl Inst Nutr & Seafood Res	20
5	Univ Tromso Hosp	15
6	Oslo Univ Coll	15
7	Norwegian Inst Fisheries & Aquacultur	15
8	Norwegian Inst Nat Res	11
9	Norwegian Coll Vet Med	9
10	Natl Vet Inst	9

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 80 MAIN SCIENTIFIC INSTITUTIONS: MARINE & WATER BIOLOGY (YEAR 2004)

Marine & Freshwater Biology

	DNK	N
1	Univ Copenhagen	31
2	Copenhagen Univ Hosp	31
3	Danish Inst Fisheries & Marine Res	25
4	Natl Environm Res Inst	24
5	Aarhus Univ Hosp	16
6	Univ So Denmark	8
7	Roskilde Univ Hosp	7
8	Fyn Cty Nat Management & Water Env	5
9	Royal Vet & Agr Univ	4
10	Danish Inst Food & Vet Res	4
	Other	

Marine & Freshwater Biology

	FIN	N
1	Helsinki Univ Hosp	28
2	Inari Fisheries Res & Aquaculture	19
3	Abo Akad Univ	12
4	Turku Univ Hosp	8
5	Univ Jyvaskyla	7
6	Finnish Game & Fisheries Res Inst	6
7	Finnish Environm Inst	6
8	Finnish Inst Marine Res	5
9	Oulu Univ Hosp	4
10	Univ Joensuu	3

Marine & Freshwater Biology

	ISL	N
1	Univ Iceland	21
2	Myvatn Res Stn	10
3	Marine Res Inst	4
4	Inst Freshwater Fisheries	2
5	Vegagerdin	1
6	Vatnaskil Consulting Engineers	1
7	Univ Hosp N Norway	1
8	Univ Hosp	1
9	Univ Akureyri	1
10	Sandgeroi Marine Ctr	1

Marine & Freshwater Biology

	SWE	N
1	Stockholm Univ	26
2	Gothenburg Univ	26
3	Uppsala Univ Hosp	23
4	Lund Univ	16
5	Swedish Univ Agr Sci SLU	13
6	Kalmar Univ	8
7	Univ Stockholm	7
8	Umea Univ Hosp	6
9	Natl Board Fisheries	5
10	Swedish Museum Nat Hist	3

Marine & Freshwater Biology

	NOR	N
1	Marine Res Inst	68
2	Natl Board Fisheries	49
3	Univ Bergen	45
4	Oslo Univ Coll	27
5	Univ Tromso Hosp	18
6	Norwegian Univ Sci & Technol	16
7	Norwegian Inst Nat Res	16
8	Norwegian Inst Fisheries & Aquacultur	13
9	Norwegian Coll Vet Med	11
10	Natl Inst Nutr & Seafood Res	11

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 81 MAIN SCIENTIFIC INSTITUTIONS: OBSTETRICS & GYNECOLOGY (YEAR 2004)

	Obstetrics & Gynecology	
	DNK	N
1	Copenhagen Univ Hosp	41
2	Univ Copenhagen	24
3	Univ So Denmark	16
4	Aarhus Univ Hosp	12
5	Odense Univ Hosp	9
6	Rigshosp Univ Hosp	8
7	HS Hvidovre Univ Hosp	7
8	Aalborg Univ Hosp	5
9	Novo Nordisk AS	4
10	Hillerod Hosp	4
	Other	

	Obstetrics & Gynecology	
	FIN	N
1	Helsinki Univ / Helsinki Univ Hosp	46
2	Tampere Univ Hosp	18
3	Oulu Univ Hosp	16
4	Turku Univ Hosp	11
5	Kuopio Univ Hosp	8
6	Univ Hosp N Norway	5
7	Univ Hosp	5
8	Family Federat Finland	4
9	Natl Publ Hlth Inst	3
10	Natl Inst Publ Hlth	3

	Obstetrics & Gynecology	
	ISL	N
1	Univ Iceland	2
2	Landspitalinn Univ Hosp	4
3	DeCode Genet	1
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

	Obstetrics & Gynecology	
	SWE	N
1	Karolinska Univ Hosp & Inst	61
2	Gothenburg Univ	25
3	Lund Univ	21
4	Univ Lund Hosp	18
5	Uppsala Univ Hosp	15
6	Umea Univ Hosp	14
7	Linkoping Univ Hosp	12
8	Orebro Univ Hosp	11
9	Malmo Univ Hosp	10
10	Huddinge Univ Hosp	10

	Obstetrics & Gynecology	
	NOR	N
1	Oslo Univ Coll	20
2	Univ Bergen	11
3	Norwegian Univ Sci & Technol	11
4	Univ Trondheim Hosp	7
5	Univ Tromso Hosp	7
6	Norwegian Radium Hosp Hlth Trust	7
7	Haukeland Univ Hosp	7
8	Norwegian Inst Public Hlth	4
9	Univ Hosp N Norway	3
10	Univ Hosp	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 82 MAIN SCIENTIFIC INSTITUTIONS: PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH (YEAR 2004)

Public, Environmental & Occupational Health

	DNK	N
1	Univ So Denmark	2
2	Univ Copenhagen	2
3	Copenhagen Univ Hosp	2
4	Odense Univ Hosp	1
5	Natl Publ Hlth Inst	1
6	Natl Inst Publ Hlth	1
7	KTL Natl Publ Hlth Inst	1
8	Frederiksberg Univ Hosp	1
9	Copenhagen Gerontol Oral Hlth Res Ctr	1
10	-	

Public, Environmental & Occupational Health

	FIN	N
1	Oulu Univ Hosp	9
2	Helsinki Univ / Helsinki Univ Hosp	2
3	Univ Jyvaskyla	1
4	Natl Res & Dev Ctr Welfare & Hlth	1
5	Finnish Inst Occupat Hlth	1
6	Finnish Broadcasting Co	1
7	Ctr Hlth & Social Serv	1
8	Cent Hosp Jyvaskyla	1
9	-	0
10	-	0

Public, Environmental & Occupational Health

	ISL	N
1	Univ Iceland	8
2	-	
3	-	
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

Public, Environmental & Occupational Health

	ISL	N
1	Univ Iceland	8
2	-	
3	-	
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

Public, Environmental & Occupational Health

	SWE	N
1	Karolinska Univ Hosp & Inst	3
2	Lund Univ	2
3	Umea Univ Hosp	1
4	Swedish Armed Forces	1
5	Orebro Univ Hosp	1
6	Gothenburg Univ	1
7	Dept Rheumatol	1
8	Danderyds Univ Hosp	1
9	-	
10	-	

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 83 MAIN SCIENTIFIC INSTITUTIONS: RHEUMATOLOGY (YEAR 2004)

	Rheumatology	
	DNK	N
1	Copenhagen Univ Hosp	14
2	Aarhus Univ Hosp	12
3	Univ Copenhagen	7
4	Frederiksberg Univ Hosp	6
5	Statens Serum Inst	5
6	Nord Biosci Diagnost AS	5
7	Odense Univ Hosp	4
8	HS Hvidovre Univ Hosp	4
9	Ctr Clin & Basic Res AS	4
10	Rigshosp Univ Hosp	3
	Other	

	Rheumatology	
	FIN	N
1	Helsinki Univ / Helsinki Univ Hosp	31
2	Jyvaskyla Cent Hosp	21
3	Rheumatism Fdn Hosp	16
4	Tampere Univ Hosp	15
5	Natl Publ Hlth Inst	9
6	Turku Univ Hosp	7
7	Kuopio Univ Hosp	6
8	Oulu Univ Hosp	5
9	Cent Hosp Jyvaskyla	4
10	Seinajoki Cent Hosp	3

	Rheumatology	
	ISL	N
1	Landspitalinn Univ Hosp	2
2	-	
3	-	
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

	Rheumatology	
	SWE	N
1	Karolinska Univ Hosp & Inst	41
2	Univ Lund Hosp	21
3	Gothenburg Univ	20
4	Lund Univ	18
5	Linkoping Univ Hosp	12
6	Uppsala Univ Hosp	9
7	Malmo Univ Hosp	8
8	Huddinge Univ Hosp	5
9	Univ Umea Hosp	4
10	Umea Univ Hosp	4

	Rheumatology	
	NOR	N
1	Diakonhjemmet Hosp	8
2	Oslo Univ Coll	4
3	Univ Tromso Hosp	3
4	Cent Hosp Rogaland	3
5	Univ Trondheim Hosp	2
6	Natl Univ Hosp	2
7	Martina Hansens Hosp	2
8	Clin Osteoporosis	2
9	Childrens Hosp	2
10	Akershus Univ Hosp	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

EXHIBIT 84 MAIN SCIENTIFIC INSTITUTIONS: SPORTS SCIENCES (YEAR 2004)

Sports Sciences

	DNK	N
1	Copenhagen Univ Hosp	29
2	Univ Copenhagen	26
3	Statens Serum Inst	7
4	Natl Inst Occupat Hlth	7
5	Univ So Denmark	6
6	Rigshosp Univ Hosp	6
7	Aarhus Univ Hosp	6
8	Bispebjerg Univ Hosp	5
9	Odense Univ Hosp	3
10	Frederiksberg Univ Hosp	3
	Other	

Sports Sciences

	FIN	N
1	Univ Jyvaskyla	25
2	Helsinki Univ / Helsinki Univ Hosp	16
3	Kuopio Univ Hosp	11
4	Tampere Univ Hosp	10
5	UKK Inst Hlth Promot Res	8
6	Turku Univ Hosp	7
7	Oulu Univ Hosp	7
8	KTL Natl Publ Hlth Inst	5
9	Rheumatism Fdn Hosp	3
10	Oulu Reg Inst Occupat Hlth	2

Sports Sciences

	ISL	N
1	Univ Iceland	5
2	-	
3	-	
4	-	
5	-	
6	-	
7	-	
8	-	
9	-	
10	-	

Sports Sciences

	SWE	N
1	Karolinska Univ Hosp & Inst	44
2	Uppsala Univ Hosp	16
3	Umea Univ Hosp	12
4	Univ Lund Hosp	10
5	Linkoping Univ Hosp	10
6	Gothenburg Univ	10
7	Lund Univ	9
8	Huddinge Univ Hosp	5
9	Univ Coll Phys Educ & Sports	4
10	Stockholm Univ	4

Sports Sciences

	NOR	N
1	Norwegian Univ Sport & Phys Educ	21
2	Oslo Univ Coll	10
3	Norwegian Univ Sci & Technol	9
4	Univ Bergen	8
5	Haukeland Univ Hosp	3
6	Akershus Univ Hosp	3
7	Agder Univ Coll	3
8	St Olavs Univ Hosp	2
9	Norwegian Armed Forces Med Serv &	2
10	Martina Hansens Hosp	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting).

H.3 Main scientific partners by subject category for each of the five Nordic countries

The analysis here concentrates on the identification of the publishing institutions in each of the partner countries of the five Nordic countries, and for the 10 selected scientific fields (number of scientific publications and addresses).

The following tables present the main institutions in the partners countries, for each of institutions within the five Nordic countries (Number of publication higher than 2), and for each of the 10 selected scientific fields.

The identification of these 'main scientific institutions' is based on a cleaning process of nearly 2,500 scientific publication's address labs.

EXHIBIT 85 MAIN PARTNER INSTITUTIONS: THE CASE OF DENMARK (YEAR 2004)

Subject category	Country 2	INSTITUTION - Country 2	INSTITUTION - Country 1	N
Anesthegiology	CHE	Univ Bern	Statens Serum Inst	2
Dentistry, Oral Surgery & Medicine	SWE	Gothenburg Univ	Copenhagen Univ Hosp	3
			Univ Copenhagen	2
		Umea Univ Hosp	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
	GBR	Univ London	Aarhus Univ Hosp	2
	JPN	Osaka Univ	Copenhagen Univ Hosp	3
			Univ Copenhagen	3
Ecology	DEU	Univ Wurzburg	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
	ESP	CSIC Barcelona	Fyn Cty Nat Management & Water Environm Div	2
		Univ Autonoma Barcelona	Danish Forest & Landscape Res Inst	2
			Riso Natl Lab	5
			Royal Vet & Agr Univ	2
		Univ Autonoma Barcelona Bellaterra	Riso Natl Lab	2
	FRA	CNRS	Aarhus Univ Hosp	2
	GBR	Countryside Council Wales	Riso Natl Lab	3
		Ctr Ecol & Hydrol Bangor	Danish Forest & Landscape Res Inst	2
			Riso Natl Lab	3
				4
		Univ Cambridge	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
	NLD	Plant Res Int	Riso Natl Lab	3
		Univ Amsterdam	Danish Forest & Landscape Res Inst	3
			Riso Natl Lab	7
	NZL	Univ Otago Dunedin	Aarhus Univ Hosp	2
	THA	Phuket Marine Biol Ctr	Copenhagen Univ Hosp	3
			Danish Inst Fisheries & Marine Res	2
			Natl Environm Res Inst	
			Univ Copenhagen	3
	USA	Marine Biol Lab	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
		Smithsonian Inst Washington	Aarhus Univ Hosp	2
		Univ Connecticut	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
		World Wildlife Fund	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
	ZAF	Western Cape Nat Conservat Board	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
Fisheries	GBR	FRS Marine Lab Aberdeen	Danish Inst Food & Vet Res	2
		Univ Glasgow	Biomar AS	2
	IRL	Natl Univ Ireland Galway	Danish Inst Fisheries & Marine Res	4
	NOR	Marine Res Inst	Danish Inst Fisheries & Marine Res	4
		Natl Board Fisheries	Danish Inst Fisheries & Marine Res	2
Marine & Freshwater Biology	AUS	Univ Sydney	Copenhagen Univ Hosp	5
			Univ Copenhagen	5
	CAN	Fisheries & Oceans Canada	Danish Inst Fisheries & Marine Res	2
			Greenland Inst Nat Resources	2
	ESP	CSIC Barcelona	Fyn Cty Nat Management & Water Environm Div	2
	GBR	FRS Marine Lab Aberdeen	Danish Inst Food & Vet Res	2
		Univ Glasgow	Biomar AS	2
	IRL	Natl Univ Ireland Galway	Danish Inst Fisheries & Marine Res	4
	NOR	Marine Res Inst	Danish Inst Fisheries & Marine Res	4
		Natl Board Fisheries	Danish Inst Fisheries & Marine Res	2
	NZL	Univ Otago Dunedin	Aarhus Univ Hosp	2
	THA	Phuket Marine Biol Ctr	Copenhagen Univ Hosp	3
			Danish Inst Fisheries & Marine Res	2
			Natl Environm Res Inst	
			Univ Copenhagen	3
	USA	Univ Washington	Danish Inst Fisheries & Marine Res	2
			Greenland Inst Nat Resources	2
Obstetrics & Gynecology	SWE	Gothenburg Univ	Copenhagen Univ Hosp	4
			Novo Nordisk AS	2
	GBR	Univ London	Copenhagen Univ Hosp	2
	ITA	Bari Univ Hosp	Univ So Denmark	2
	NLD	Univ Med Ctr Utrecht	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
Rheumatology	AUS	Flinders Med Ctr	Statens Serum Inst	2
Sport Sciences	CAN	Univ Guelph	Copenhagen Univ Hosp	2
			Univ Copenhagen	2
	SWE	Karolinska Univ Hosp & Inst	Copenhagen Univ Hosp	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

EXHIBIT 86 MAIN PARTNER INSTITUTIONS: THE CASE OF FINLAND (YEAR 2004)

Subject category	Country 2	INSTITUTION - Country 2	INSTITUTION - Country 1	N
Anesthegiology	AUS	Royal Melbourne Hosp	Helsinki Univ / Univ Hosp	2
	CHE	Univ Bern	Kuopio Univ Hosp	3
Dentistry, Oral Surgery & Medicine	SWE	Gothenburg Univ	Turku Univ Hosp	2
	GBR	Univ Liverpool	Oulu Univ Hosp	7
	GRC	Univ Athens	Oulu Univ Hosp	6
	IRL	Natl Univ Ireland Univ Coll Cork	Oulu Univ Hosp	7
	ISL	Univ Iceland	Oulu Univ Hosp	7
	NLD	Acad Ctr Dent Amsterdam	Oulu Univ Hosp	7
		Univ Groningen	Turku Univ Hosp	4
	NOR	Oslo Univ Coll	Turku Univ Hosp	2
	PRT	Inst Super Ciencias Saude Sul	Oulu Univ Hosp	7
	TUR	Ege Univ	Helsinki Univ / Univ Hosp	2
Ecology	CAN	Univ Alberta	Helsinki Univ / Univ Hosp	2
		Univ Toronto	Helsinki Univ / Univ Hosp	2
	CHN	Chinese Acad Sci Chengdu	Univ Joensuu	2
	DEU	Univ Bayreuth	Helsinki Univ / Univ Hosp	2
		Univ Kiel	Helsinki Univ / Univ Hosp	2
	SWE	Lund Univ	Helsinki Univ / Univ Hosp	2
		Umea Univ Hosp	Oulu Univ Hosp	2
		Uppsala Univ Hosp	Helsinki Univ / Univ Hosp	7
			Oulu Univ Hosp	2
	FRA	CNRS	Helsinki Univ / Univ Hosp	2
		INRA	Helsinki Univ / Univ Hosp	3
	NOR	Norwegian Inst Nat Res	Abo Akad Univ	2
	PRT	Univ Evora	Helsinki Univ / Univ Hosp	2
	USA	Univ Calif Riverside	Univ Jyvaskyla	3
Environmental sciences	FRA	INRA	Helsinki Univ / Univ Hosp	2
	NOR	Oslo Univ Coll	Univ Joensuu	2
Fisheries	USA	Univ Calif Davis	Kuopio Univ Hosp	2
			Univ Jyvaskyla	2
Public, Environmental & Occupational Health	GBR	Univ Liverpool	Oulu Univ Hosp	7
	GRC	Univ Athens	Oulu Univ Hosp	6
	IRL	Natl Univ Ireland Univ Coll Cork	Oulu Univ Hosp	7
	ISL	Univ Iceland	Oulu Univ Hosp	7
	NLD	Acad Ctr Dent Amsterdam	Oulu Univ Hosp	7
	PRT	Inst Super Ciencias Saude Sul	Oulu Univ Hosp	7
Marine & Freshwater Biology	ESP	Univ Leon	Helsinki Univ / Univ Hosp	4
		Univ Valencia	Helsinki Univ / Univ Hosp	4
	SWE	Inst Ecol Limnol	Helsinki Univ / Univ Hosp	2
		Lund Univ	Helsinki Univ / Univ Hosp	2
	GBR	Univ Liverpool	Helsinki Univ / Univ Hosp	4
	NLD	Netherlands Inst Ecol	Helsinki Univ / Univ Hosp	4
	NOR	Oslo Univ Coll	Univ Joensuu	2
Obstetrics & Gynecology	SWE	Karolinska Univ Hosp & Inst	Helsinki Univ / Univ Hosp	3
		Linkoping Univ Hosp	Helsinki Univ / Univ Hosp	3
	FRA	INSERM	Natl Res & Dev Ctr Welfare & Hlth	2
	GBR	Univ London	Oulu Univ Hosp	2
	USA	Ctr Dis Control & Prevent	Natl Res & Dev Ctr Welfare & Hlth	2
Rheumatology	ESP	Hosp Univ La Paz	Helsinki Univ / Univ Hosp	2
	SWE	Linkoping Univ Hosp	Helsinki Univ / Univ Hosp	3
			KTL Natl Publ Hlth Inst	2
			Natl Inst Publ Hlth	2
			Natl Publ Hlth Inst	2
		Vaxjo Hosp	Helsinki Univ / Univ Hosp	2
			Rheumatism Fdn Hosp	2
	FRA	Hop Paris	Helsinki Univ / Univ Hosp	2
	GBR	Royal Natl Hosp Rheumat Dis	Helsinki Univ / Univ Hosp	2
			Rheumatism Fdn Hosp	2
	LTU	Vilnius State Univ	Helsinki Univ / Univ Hosp	2
	USA	Univ Calif San Diego La Jolla	Jyvaskyla Cent Hosp	3
		Univ N Carolina	Jyvaskyla Cent Hosp	2
		Vanderbilt Univ	Cent Hosp Jyvaskyla	2
			Jyvaskyla Cent Hosp	16
			Rheumatism Fdn Hosp	2
Sports Sciences	AUS	Edith Cowan Univ	Univ Jyvaskyla	3
	CAN	Univ Alberta	Helsinki Univ / Univ Hosp	2
	USA	Colorado Coll	Univ Jyvaskyla	3
		Penn State Univ	Univ Jyvaskyla	2
		Univ Connecticut	Oulu Univ Hosp	2
			Univ Jyvaskyla	8

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

EXHIBIT 87 MAIN PARTNER INSTITUTIONS: THE CASE OF ICELAND (YEAR 2004)

Subject category	Country 2	INSTITUTION - Country 2	INSTITUTION - Country 1	N
Dentistry, Oral Surgery & Medicine	FIN	Oulu Univ Hosp	Univ Iceland	7
	GBR	Univ Liverpool	Univ Iceland	8
	GRC	Univ Athens	Univ Iceland	6
	IRL	Natl Univ Ireland Univ Coll Cork	Univ Iceland	8
	NLD	Acad Ctr Dent Amsterdam	Univ Iceland	7
	PRT	Inst Super Ciencias Saude Sul	Univ Iceland	7
Fisheries	GBR	Univ Oxford	Univ Iceland	2
Public, Environmental & Occupationa	FIN	Oulu Univ Hosp	Univ Iceland	7
	GBR	Univ Liverpool	Univ Iceland	8
	GRC	Univ Athens	Univ Iceland	6
	IRL	Natl Univ Ireland Univ Coll Cork	Univ Iceland	8
	NLD	Acad Ctr Dent Amsterdam	Univ Iceland	7
	PRT	Inst Super Ciencias Saude Sul	Univ Iceland	7
Marine & Freshwater Biology	GBR	Univ Oxford	Univ Iceland	2
Sports Sciences	NOR	Norwegian Univ Sport & Phys Educ	Univ Iceland	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

EXHIBIT 88 MAIN PARTNER INSTITUTIONS: THE CASE OF NORWAY (1/2) (YEAR 2004)

Subject category	Country 2	INSTITUTION - Country 2	INSTITUTION - Country 1	N
Anesthegiology	SWE	Linkoping Univ Hosp	Oslo Univ Coll	2
Dentistry, Oral Surgery & Medicine	BRA	Lutheran Univ Brazil	Univ Bergen	3
		Univ Fed Rio Grande Sul	Univ Bergen	3
	CHN	Wuhan Univ	Oslo Univ Coll	2
	SWE	Gothenburg Univ	Oslo Univ Coll	2
		Karolinska Univ Hosp & Inst	Oslo Univ Coll	2
		Postgrad Dent Educ Ctr	Univ Bergen	2
		Publ Orthodont Clin	Oslo Univ Coll	2
	FIN	Turku Univ Hosp	Oslo Univ Coll	2
	UGA	Makerere Univ	Univ Bergen	2
	USA	Temple Univ	Univ Bergen	3
		Univ Washington	Univ Bergen	2
Ecology	AUT	Int Inst Appl Syst Anal	Marine Res Inst	3
			Natl Board Fisheries	2
	DEU	Univ Kiel	Agr Univ Norway	3
		Univ Munich	Norwegian Univ Sci & Technol	3
	SWE	Forestry Res Inst Sweden	Norwegian Inst Nat Res	2
		Lund Univ	UNIS	2
			Univ Tromso Hosp	3
		Swedish Univ Agr Sci SLU	Norwegian Inst Nat Res	3
			Oslo Univ Coll	2
		Uppsala Univ Hosp	Norwegian Inst Nat Res	2
	FIN	Abo Akad Univ	Norwegian Inst Nat Res	2
	FRA	IRD	Marine Res Inst	2
			Natl Board Fisheries	2
		Univ Grenoble 1	Agr Univ Norway	4
			Oslo Univ Coll	2
		Univ Lyon 1	Norwegian Inst Nat Res	2
	GBR	Nat Hist Museum	Oslo Univ Coll	2
		Univ Liverpool	Univ Tromso Hosp	2
		Univ London	Univ Bergen	4
	USA	Arizona State Univ	Oslo Univ Coll	2
		Florida State Univ	Norwegian Univ Sci & Technol	2
		Natl Marine Fisheries Serv Woods Hole	Marine Res Inst	2
			Natl Board Fisheries	2
		Oregon State Univ Newport	Norwegian Inst Nat Res	2
		Texas A&M Univ	Univ Bergen	2
		Univ Alaska Anchorage	Norwegian Univ Sci & Technol	2
		Univ Alaska Fairbanks	Norwegian Univ Sci & Technol	2
		Univ Calif San Diego La Jolla	Norwegian Univ Sci & Technol	2
Environmental sciences	FIN	Univ Joensuu	Oslo Univ Coll	2
Fisheries	CAN	Fisheries & Oceans Canada	Norwegian Inst Nat Res	2
		Univ British Columbia	Norwegian Inst Nat Res	2
	DNK	Danish Inst Fisheries & Marine Res	Marine Res Inst	4
			Natl Board Fisheries	2
	SWE	Gothenburg Univ	Marine Res Inst	2
			Natl Board Fisheries	2
	GBR	Ctr Environm Fisheries & Aquaculture Sci	Marine Res Inst	2
			Natl Board Fisheries	2
		Univ Stirling	Marine Res Inst	3
			Natl Board Fisheries	3
	IRL	Natl Univ Ireland Galway	Marine Res Inst	5
			Natl Board Fisheries	3
	PRT	Univ Algarve	Univ Bergen	4
Public, Environmental & Occupational Health	UGA	Makerere Univ	Univ Bergen	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

EXHIBIT 89 MAIN PARTNER INSTITUTIONS: THE CASE OF NORWAY (2/2) - (YEAR 2004)

Subject category	Country 2	INSTITUTION - Country 2	INSTITUTION - Country 1	N
Marine & Freshwater Biology	CAN	Univ Montreal	Norwegian Univ Sci & Technol	2
	DEU	Univ Munich	Norwegian Univ Sci & Technol	2
	DNK	Danish Inst Fisheries & Marine Res	Marine Res Inst	4
			Natl Board Fisheries	2
	SWE	Gothenburg Univ	Marine Res Inst	4
			Natl Board Fisheries	2
		Kalmar Univ	Norwegian Univ Sci & Technol	3
		Stockholm Univ	Norwegian Univ Sci & Technol	2
	FIN	Univ Joensuu	Oslo Univ Coll	2
	FRA	IFREMER	Marine Res Inst	2
	GBR	British Antarctic Survey	UNIS	2
		CEFAS	Marine Res Inst	2
		Ctr Environm Fisheries & Aquaculture Sci	Marine Res Inst	2
			Natl Board Fisheries	2
		Environm Agcy	RF Rogaland Res	2
		Univ Coll Swansea	UNIS	2
		Univ Plymouth	RF Rogaland Res	2
		Univ St Andrews	Marine Res Inst	2
			Natl Board Fisheries	2
		Univ Stirling	Marine Res Inst	2
			Natl Board Fisheries	2
	IRL	Natl Univ Ireland Galway	Marine Res Inst	6
			Natl Board Fisheries	4
	POL	Polish Acad Sci Sopot	UNIS	2
		Polish Acad Sci Warsaw	UNIS	2
	PRT	Univ Algarve	Univ Bergen	5
	USA	Texas A&M Univ	Univ Bergen	2
		Univ Calif San Diego La Jolla	UNIS	2
Obstetrics & Gynecology	BEL	Katholieke Univ Leuven Hosp	Norwegian Radium Hosp Hlth Trust	2
		Ziekenhuis Oost Limburg	Norwegian Radium Hosp Hlth Trust	2
	SWE	Karolinska Univ Hosp & Inst	Oslo Univ Coll	2
	NLD	Univ Nijmegen	Norwegian Radium Hosp Hlth Trust	2
	TUR	SSK Ankara Matern & Womens Hosp	Norwegian Radium Hosp Hlth Trust	2
Rheumatology	FRA	Hop Paris	Diakonhjemmet Hosp	2
Sports Sciences	GBR	Univ Essex	Haukeland Univ Hosp	2
	ISL	Univ Iceland	Norwegian Univ Sport & Phys Educ	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

EXHIBIT 90 MAIN PARTNER INSTITUTIONS: THE CASE OF SWEDEN (1/2) ; (YEAR 2004)

Subject category	Country 2	INSTITUTION - Country 2	INSTITUTION - Country 1	N
Anesthegiology	ITA	Bari Univ Hosp	Gothenburg Univ	2
			Uppsala Univ Hosp	2
	NOR	Oslo Univ Coll	Linkoping Univ Hosp	2
Dentistry, Oral Surgery & Medicine	CAN	Dalhousie Univ	Malmo Univ Hosp	2
	CHE	Univ Bern	Kristianstad Univ	2
		Univ Geneva	Gothenburg Univ	3
		Univ Zurich	Gothenburg Univ	2
	DNK	Copenhagen Univ Hosp	Gothenburg Univ	3
			Umea Univ Hosp	2
		Univ Copenhagen	Gothenburg Univ	2
			Umea Univ Hosp	2
	FIN	Turku Univ Hosp	Gothenburg Univ	2
	GBR	London Med	Gothenburg Univ	2
	GRC	Univ Athens	Karolinska Univ Hosp & Inst	2
	JPN	Kyushu Univ	Karolinska Univ Hosp & Inst	2
	NLD	Acad Ctr Dent Amsterdam	Karolinska Univ Hosp & Inst	2
	NOR	Oslo Univ Coll	Gothenburg Univ	2
			Karolinska Univ Hosp & Inst	2
			Publ Orthodont Clin	2
		Univ Bergen	Postgrad Dent Educ Ctr	2
	SAU	King Faisal Specialist Hosp & Res Ctr	Umea Univ Hosp	3
	USA	Forsyth Inst	Gothenburg Univ	2
		Univ Texas San Antonio	Karolinska Univ Hosp & Inst	4
		Univ Washington	Kristianstad Univ	2
Ecology	AUS	Univ Sydney	Gothenburg Univ	4
		Univ Tasmania	Gothenburg Univ	2
		Univ Wollongong	Gothenburg Univ	3
	CHE	ETH Kastanienbaum	Umea Univ Hosp	2
	DEU	Max Planck Inst Biogeochem	Swedish Univ Agr Sci SLU	2
		Univ Hamburg	Lund Univ	2
	FIN	Helsinki Univ Hosp	Lund Univ	2
			Uppsala Univ Hosp	7
		Oulu Univ Hosp	Umea Univ Hosp	2
			Uppsala Univ Hosp	2
	FRA	INRA	Swedish Univ Agr Sci SLU	2
		Univ Paris 06	Gothenburg Univ	3
		Univ Rennes 1	Umea Univ Hosp	2
	GBR	Univ Edinburgh	Lund Univ	3
		Univ Oxford	Uppsala Univ Hosp	2
		Univ Sheffield	Umea Univ Hosp	3
	IRL	Natl Univ Ireland Univ Coll Cork	Umea Univ Hosp	3
	NLD	Univ Amsterdam	Umea Univ Hosp	3
		Vrije Univ Amsterdam	Royal Swedish Acad Sci	2
	NOR	Norwegian Inst Nat Res	Forestry Res Inst Sweden	2
			Swedish Univ Agr Sci SLU	3
			Uppsala Univ Hosp	2
		Oslo Univ Coll	Swedish Univ Agr Sci SLU	2
		UNIS	Lund Univ	2
		Univ Tromso Hosp	Lund Univ	3
	USA	Montana State Univ	Uppsala Univ Hosp	2
		Rutgers State Univ	Umea Univ Hosp	2
		Univ Calif Davis	Swedish Univ Agr Sci SLU	2
Environmental sciences	NLD	Vrije Univ Amsterdam	Royal Swedish Acad Sci	2
Fisheries	NOR	Marine Res Inst	Gothenburg Univ	2
		Natl Board Fisheries	Gothenburg Univ	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

EXHIBIT 91 MAIN PARTNER INSTITUTIONS: THE CASE OF SWEDEN (2/2) ; (YEAR 2004)

Public, Environmental & Occupational Health	GBR	Univ Coll Swansea	Karolinska Univ Hosp & Inst	2
Marine & Freshwater Biology	CEI	Russian Acad Sci St Petersburg	Uppsala Univ Hosp	2
	DEU	Univ Duisburg Essen	Swedish Univ Agr Sci SLU	2
	ESP	Univ Leon	Inst Ecol Limnol	2
			Lund Univ	2
		Univ Valencia	Inst Ecol Limnol	2
			Lund Univ	2
	FIN	Helsinki Univ Hosp	Inst Ecol Limnol	2
			Lund Univ	2
	FRA	Univ Paris 06	Gothenburg Univ	2
	GBR	Univ Liverpool	Inst Ecol Limnol	2
			Lund Univ	2
	NLD	Alterra Green World Res	Swedish Univ Agr Sci SLU	2
		Netherlands Inst Ecol	Inst Ecol Limnol	2
			Lund Univ	2
	NOR	Marine Res Inst	Gothenburg Univ	4
		Natl Board Fisheries	Gothenburg Univ	2
		Norwegian Univ Sci & Technol	Kalmar Univ	3
			Stockholm Univ	2
Obstetrics & Gynecology	AUS	Queensland Inst Med Res	Karolinska Univ Hosp & Inst	2
	BEL	Free Univ Brussels	Gothenburg Univ	2
	DNK	Copenhagen Univ Hosp	Gothenburg Univ	4
		Novo Nordisk AS	Gothenburg Univ	2
	FIN	Helsinki Univ Hosp	Karolinska Univ Hosp & Inst	3
			Linkoping Univ Hosp	3
	GRC	Univ Athens	Karolinska Univ Hosp & Inst	2
	NOR	Oslo Univ Coll	Karolinska Univ Hosp & Inst	2
Rheumatology	AUT	Univ Vienna	Karolinska Univ Hosp & Inst	2
	BEL	Univ Hosp Brussels	Gothenburg Univ	2
	CEI	Mechnikov Res Inst	Karolinska Univ Hosp & Inst	3
	FIN	Helsinki Univ Hosp	Linkoping Univ Hosp	3
			Vaxjo Hosp	2
		KTL Natl Publ Hlth Inst	Linkoping Univ Hosp	2
		Natl Inst Publ Hlth	Linkoping Univ Hosp	2
		Natl Publ Hlth Inst	Linkoping Univ Hosp	2
		Rheumatism Fdn Hosp	Vaxjo Hosp	2
	FRA	Hop Paris	Gothenburg Univ	2
	GBR	Univ Cambridge	Karolinska Univ Hosp & Inst	2
	USA	Mayo Clin	Malmo Univ Hosp	3
		Univ Pittsburgh	Karolinska Univ Hosp & Inst	2
Sports Sciences	CAN	Glenrose Hosp	Karolinska Univ Hosp & Inst	2
			Uppsala Univ Hosp	2
		Univ Alberta	Karolinska Univ Hosp & Inst	9
			Royal Inst Technol KTH	2
			Uppsala Univ Hosp	5
	DNK	Copenhagen Univ Hosp	Karolinska Univ Hosp & Inst	2
			Orebro Univ Hosp	2
		Univ Copenhagen	Karolinska Univ Hosp & Inst	2
			Orebro Univ Hosp	2
	GBR	Univ Cambridge	Orebro Univ Hosp	2
		Univ Coll Swansea	Karolinska Univ Hosp & Inst	2
		Univ Manchester	Karolinska Univ Hosp & Inst	2
			Uppsala Univ Hosp	2
	USA	Ctr Dis Control & Prevent	Karolinska Univ Hosp & Inst	2
		Univ Calif Los Angeles	Karolinska Univ Hosp & Inst	2
		Univ Iowa	Karolinska Univ Hosp & Inst	7
			Uppsala Univ Hosp	6
		Univ Vermont	Lund Univ	2
		Univ Washington	Karolinska Univ Hosp & Inst	2

Sources: OST – ISI-Thomson, Calculations OST and Technopolis Group.
Note: N: Number of publication (full counting). N>2 and strictly intra-institutional and intra-national scientific collaborations excluded.

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APPENDIX J

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ENDNOTES

1 Nordforsk, *NordForsk strategy 2006-2009*, Oslo: NordForsk, 2006

2 Based on the following population estimates: Denmark 5.5m; Finland 5.25m; Sweden 9.0m; Norway 4.5m; Iceland 0.3m

3 The Exhibit is illustrative, in the sense that the absolute numbers of publications are based on full counting while the shares are based on fractional counting

4 Of course, from a **relevance** perspective there may be quite different reasons to raise investment in medical research, but they are not considered in this analysis

5 Hinze (2005) has used the so-called Revealed Literature Advantage (RLA) Indictor to identify the countries' specialisation profile. This measure indicates whether within a country's publication activities a particular field has a higher share than its share in total world production. The indicator shows whether a country engages in a particular sub-field to an extent below or above average relative to its other publication activities (Hinze 2005:8).

6 Karlsson & Wadskog (2006), see Table 3, page 27.

7 Based on the ISIs classification system of scientific fields, Aksnes has in his report constructed a number of aggregated categories (Clinical Medicine, Psychology/Psychiatry, Biomedicine/Biochemistry, Biology, Geoscience, Chemistry, Physics, Mathematics, Computer Science, Engineering, Agronomy, Social Science and Humanities). The category Biology includes the following sub-fields: Biology General, Experimental Biology, Environment/Ecology, Microbiology, Animal & Plant Sciences, Animal Sciences, Aquatic Sciences, Entomology/Pest Control, Plant Science (Asknes 2005: 15).

8 Relative citation impact = Impact factor for Finland in certain field of science (number of citations / number of publications) / impact factor for OECD in the same field. Relative citation impact for OECD is one.

9 See footnote above on the measure of relative citation impact.

10 Science Citation Index Expanded™, Social Sciences Citation Index®, Arts & Humanities Citation Index®, Index Chemicus®, Current Chemical Reactions®

11 The presence in the perimeter of journal inclusion of a sub-population of nationally-oriented journals creates large irregularities. This can lead to an over-estimation of share and an under-estimation of the impact, for countries with national editorial tradition, while the impact of a few mainstream countries arguably benefits from the presence of this sub-population. MICHEL ZITT, SUZY RAMANANA-RAHARY, ELISE BASSECOULARD, Correcting glasses help fair comparisons in international science landscape: country indicators as a function of ISI database delineation., Scientometrics 56, 2, 2003, 259-282

12 This can be attributed to differences in the practice of referencing, to phenomena linked to the dynamics of certain fields ("age" of citations and growth), and to the position compared to other fields from which it can receive a flow of citations.

13 It is also, for the actor, the ratio of its part of the citations market to its part of the publications market in this field.
impact actor = cit(actor) / pub(actor)
impact relatif actor = (cit(actor) / pub(actor)) / (cit(ref) / pub(ref)) = (cit(actor) / cit(ref)) / (pub(actor) / pub(ref))
For a particular actor whose articles are not very visible, for reason of choice of journal or research theme, this system will have quite different consequences on "market share of citations" and on the impact indicator. Adding an article of low visibility to a corpus of research articles published will have little effect on the "citations market share", but will tend to lower the indicator impact.

14 The impact of each journal here is calculated differently from the "impact factor" of the ISI-JCR (where the type of document is taken into account, the calculation for each article is done for "year of citation", time spans are accounted for, etc.) The "hoped-for" impact used here follows the same logic than the "impact factor" by actor. There are variant forms of RCR in use, especially ones that include supplemental normalisations, and in particular by "type of document" (article, syntheses, letters, etc.):

15 See http://scientific.thomson.com/products/ahci/

16 See http://scientific.thomson.com/products/ssci/

17 See http://scientific.thomson.com/free/essays/selectionofmaterial/journalselection/

Based on bibliometric analysis, this report identifies areas of Nordic strength in research and suggests funding priorities. The authors have taken something of an investor's perspective in the analysis, aiming to focus resources on selected areas of established or likely strength.

At the level of large scientific fields, the report suggests that the major Nordic funding opportunities exist in

- **Applied Biology and Earth and Space Sciences**
- **Fundamental Biology**
- **Mathematics**

The report also identifies the ten strongest sub-fields of Nordic science:

- Fisheries
- Obstetrics and Gynaecology
- Anaesthesiology
- Marine and Freshwater Biology
- Ecology
- Sports Sciences
- Dentistry, Oral Surgery and Medicine
- Rheumatology
- Public, Environmental and Occupational Health
- Environmental Sciences

All ten sub-fields are interesting potential investments, in so far as they have passed a rather rigorous selection process. The report, however, also looks in more detail at performance and network characteristics of these ten sub-fields, comparing **them** with each other.

A bibliometric study is, on its own, no basis for setting Nordic policy priorities for cooperation in researcher-driven research. However, it is very useful as a way to inform a discussion of common priorities among Nordic funders, providing a set of hypotheses about potentially attractive areas for funding.

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