



HANNA-MARI PUUSKA

Scholarly Publishing Patterns in Finland

A comparison of disciplinary groups



ACADEMIC DISSERTATION

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Preface and acknowledgements

My first touch with the topic of my PhD thesis *Scholarly publishing patterns in Finland - a comparison of disciplinary groups* took place in 2006 when I was employed in a project investigating the potential of Finland's national publication data as a basis for evaluating universities' publishing performance. Through the project I came to realize that despite the fact the disciplinary publishing patterns are considered as well known and they are often mentioned in research literature, policy statements, and public debate, there is a great gap in the empirical evidence of them. My thesis is mainly a result from the subsequent project "Disciplinary differences in publishing behavior" (JET) in 2007-2008 in which we studied this topic more specifically and collected a large corpus of empirical data on scholarly publishing in Finnish universities.

Both the abovementioned projects were conducted in the Research Centre for Knowledge, Science, Technology and Innovation Studies (TaSTI) in the University of Tampere. As a researcher in TaSTI in 2005-2010, I was involved in several projects dealing with publishing patterns, research policy, disciplinary cultures, performance-based funding, and scientific productivity of academic institutions, which provided me a wider perspective on the area. In 2010, I moved to another employer, CSC- IT Center for Science, where my work still touches on the topics very close to my research: developing publication data collection from the universities and applying bibliometric analyses on the evaluation of Finnish science.

First of all, I want to thank my three supervisors. My PhD work got a great boost when my principal supervisor, Professor Sanna Talja, fortunately caught me as a PhD student in the School of Information Sciences (former Department of Information Studies and Interactive Media) in 2008. During the whole process, Sanna has given me the most valuable support. In my few tough moments she has helped me to work out the difficulties and convinced me that the work is going to be finished some day. The same goes to my other supervisors. I have been privileged to the enormous competence on higher education and science studies of Docent Oili-Helena Ylijoki. Her encouraging and insightful comments have significantly improved my texts. My third supervisor, Professor Pertti Vakkari, has also been a great help in providing

pertinent and expert comments to my thesis. I want to thank you all three for the supervising meetings that we had among the four of us. Those fruitful conversations gave me lots of reinforcement and I got confidence that I am doing right things in my PhD work.

I will be forever grateful to TaSTI and especially its director, Dr Erkki Kaukonen, who has provided me an academic home and always supported my research activities. TaSTI has offered me facilities for the PhD work until today – even after I moved to another organization in 2010. I also want to thank Professor Jorma Sipilä and Dr Mika Nieminen who, in the very beginning of my research career, offered the initiative to my very first bibliometric project in TaSTI and kindly encouraged me to become acquainted with bibliometric studies. The world of bibliometrics has been well worth a visit.

It has also been a pleasure to work with other competent researcher colleagues during the projects. The JET-project was conducted in collaboration with Marita Miettinen and Laura Himanen who both did a great job in collecting and analyzing the data. Most of the research data used in my thesis were collected in the JET-project. Marita was the key person in analyzing the qualitative data which we got by interviewing 43 Finnish professors as regards publishing behavior in their own field. The data has been of immense value for my work by providing me a more in-depth understanding on the topic. I also want to acknowledge my other colleagues in TaSTI, especially Reetta Muhonen, Otto Auranen, and Johanna Hakala who have contributed my work by giving valuable ideas and by commenting my texts. I also thank you for your friendship and the interesting discussions on both work-related and non-work-related issues.

Besides Otto and Reetta, I also want to thank the other co-authors of the articles included in the thesis. Professor Ilkka Arminen initiated the article *Scientific productivity, web visibility and citation patterns in sixteen Nordic sociology departments* and Inari Aaltojärvi collected the data and conducted the descriptive analyses. The article was not initially meant to be part of my thesis but finally it turned out that it fitted the entity quite well. Yrjö Leino has done indispensable work in validation and computation of the data used in the article *International and domestic co-publishing and their citation impact in different disciplines*. I acknowledge Merl Storr for the precise job in proofreading the summary article of my thesis. I wish to also thank Professor Paul Wouters and Professor Terttu Kortelainen, who acted as the preliminary examiners of my thesis and gave their time and energy for it.

The earlier mentioned bibliometric and research policy projects in TaSTI have been mainly funded by the Finnish Ministry of Education and Culture. The Ministry's interest towards bibliometrics has been very essential in that I have been able to conduct research in these topics. In particular, I want to thank Dr Olli Poropudas who has had a very important role in promoting the use and development of bibliometric data and indicators in the Ministry and subsequently he has remarkably advanced the bibliometric research in Finland. My current employer, CSC, has also been a key actor in contributing bibliometric competence in Finland. CSC also deserves a great thank for enabling me to finish the PhD thesis through a part-time study-leave in the past two years. Special thanks go to my boss Dr Tuija Raaska for her flexibility and great support.

I want to thank my parents, my mom Tannu and her husband Raikku as well as my dad Matti and his wife Riitta for their endless wisdom and support. My dad has also provided priceless help in a few tricky statistical problems in my thesis. I am very grateful for having two adorable children, Lotta and Justus, who have brought joy to my life every day. Finally, thanks to my love, Siva, for your existence.

In Tampere, May 5th, 2014,

Hanna-Mari Puuska

Abstract

This thesis investigates variation in the publishing patterns of different disciplinary groups in Finnish universities. During the past two decades universities' research performance and effectiveness have become highly relevant issues for policymakers and are assessed more and more. Academic research performance is increasingly evaluated at various levels: in international comparisons, in global university rankings, as criteria for the allocation of funding between and within academic institutions, in the appointment of scholars to academic positions, and in research grant decisions.

Since publications are the major output from research, there is a demand for bibliometric indicators, that is, indicators based on the publications produced by scientists and the citations received by them. Bibliometric indicators have various shortcomings, however, and their use requires in-depth knowledge and understanding of both methodology and the studied context. One of the major problems is that academic institutions are not uniform entities but comprised of diverse academic cultures. Scientific disciplines differ both cognitively and socially, research conducted within them has different goals, tasks, audience structures and funding structures. The nature of research topics is different in different disciplines. As regards publishing, disciplines differ in terms of the typicality and status of various publication types – scientific journals, books and conference proceedings aimed at national and international, scholarly and non-scholarly audiences. What is more, views of what can be considered as a good quality publication vary from discipline to discipline. Therefore disciplines also differ in their potential to adopt science policy goals and to succeed in the competition for funding.

Disciplinary differences in publishing patterns are usually considered as self-evident, yet there is only little empirical evidence regarding them. In the research area of bibliometrics, scientific publishing patterns have been studied extensively around the world at various levels: through comparisons between countries, between institutions, and within single scientific fields. However, both internationally and in Finland there is a lack of comparative studies covering all disciplinary groups. Most bibliometric studies are based on data covering only international scientific journals indexed in the most

widely used commercial citation index databases, namely Thomson Reuters Web of Science and, more recently, Elsevier Scopus. Articles in these journals have become the established unit of analysis in bibliometric studies. The databases however give a limited picture on publishing activities in academic disciplines since they exclude books, national publications and non-scholarly publications which are important especially in social sciences and humanities.

This study is comparative, and the principal unit of analysis is a disciplinary group. These refer to groups of academic disciplines, that is, natural sciences, engineering, medicine, agriculture and forestry, social sciences and humanities. The analyses of this study are based on large-scale empirical data which cover a wide range of publication types. The thesis contributes to bibliometric research by 1) providing a comparative analysis of disciplinary groups instead of analysing only single fields, 2) using different kinds of datasets instead of relying on a limited representation provided by only one database, and by 3) including all publication types instead of analysing only articles in international scientific journals.

The study combines bibliometric methodology with a theoretical framework from science studies. The study applies Tony Becher's theory and conceptualisations of 'disciplinary cultures', which have been discussed extensively in science studies and research in higher education. The principal model for explaining disciplinary differences in publishing patterns is adopted from Svein Kyvik who has presented a range of intra-scientific and extra-scientific factors associated with publishing behaviour in academic disciplines. The results are discussed in the light of the global transformation of academic institutions and recent developments in Finland's national science policy.

The analysis focuses on the following four major aspects:

1. The typicality of various publishing types and co-publications in Finland;
2. Changes in publishing patterns during the past two decades;
3. The effects of gender and position on publishing patterns;
4. The comprehensiveness and applicability of different kinds of datasets in the assessment of publishing performance.

The results suggest three main distinctive patterns in publishing: that found in the natural sciences and medicine, that of engineering, and that of the humanities.

Publications in natural sciences and medicine are typically articles in an international journal authored by a group of scholars, and the rate of publications per researcher is high. In Kyvik's model this publishing pattern of publishing is possible due to codified communication languages and uniform symbol systems enabling results to be presented in a short and standardised format in an article. Researchers in natural sciences and medicine tend to have a high degree of dependence on the results reached in earlier studies and a shared methodology and techniques. Therefore it is necessary to make a contribution to international research, and the principal audience is the international scientific community.

The abovementioned characteristics apply to engineering as well but the audience structure is more heterogeneous. The articles in engineering are mostly published in conference proceedings instead of journals, because in a fast-developing field that is the best way for getting research results published rapidly and for reaching relevant audiences, such as national or international industry partners.

In the humanities, scholars prefer the book format and tend to write alone or in pairs. National publication forums are typical, and researchers contribute fewer publications per year. In Kyvik's terms, humanities have a low degree of codification, lack a uniform symbol system and are multi-paradigmatic in nature. More space is required for the presentation and discussion of research problems and methodologies. The lower degree of competition means that more time can be devoted to developing a comprehensive description of a research topic or problem. Monographs and edited books are better for reaching the non-scholarly audience important in many fields in the humanities. The rise in the share of articles in edited books as publishing channels can be attributed to the holistic nature of knowledge: an article compilation can provide a more comprehensive overview of the phenomenon under scrutiny than a single article in a journal. The social sciences also represent this pattern of publishing to some extent but the share of publications in journals is higher. The social sciences have a higher degree of collaboration than the humanities, and thus fall somewhere between the natural sciences, medicine and the humanities in their publishing patterns.

Despite the transformations undergone by academic institutions, the disciplinary publishing patterns have changed little and the differences remain fairly distinct. There are no signs that the dominant way of publishing research results in the natural sciences and medicine – that is, articles in international journals – has become dominant in all disciplinary groups. The monographs and book articles have retained

their status as important publishing types in the social sciences and especially in the humanities. It is noteworthy that non-scholarly publications account for almost one half of all humanities publications even though they are less rewarded in the assessment researcher performance.

This study suggests that following the global trends in science, increased internationalisation and international collaboration can be seen in all disciplinary groups also in Finland. An exception is that a great majority of humanities publications are still written alone. In almost all disciplinary groups international co-publications are more highly cited than publications from Finnish authors only. This study shows, however, that the higher average number of authors in international co-publications compared to domestic co-publications explains most of the differences in citation rates between these two types of collaboration. The number of authors has a more significant effect on citation impact than whether the authors are from different countries but in a small country such as Finland international collaboration can still be seen as a necessity: there are not enough competent research partners within the country.

Using disciplinary groups as the main unit of analysis ignores significant variations across fields within the groups, therefore, the three patterns of publishing characterise academic cultures in a somewhat simplified manner. There is great variation between disciplines, subdisciplines and specialisms, and individual scholars. The results from this study lend support to earlier studies which have repeatedly shown differences in publishing productivity between individual scholars: publishing productivity accumulates to a small group of scholars, productivity is higher for scholars in the highest positions, and men publish more than women. The results indicate that the distribution of academic productivity is as skewed in Finland as elsewhere and this applies to all disciplinary groups. The analysis does not support the view that different scholars focus on different publication types: the most productive scholars tend to be most productive in all forms of publishing.

The data were gathered from the publication data from universities' local publication registers, through a questionnaire directed to the heads of university departments, via Google Scholar and Thomson Reuters Web of Science. In the light of the results, the choice of data has a remarkable influence on results regarding publishing productivity and impact. Productivity differences between disciplines depend on which publication types are included in the analysis and the counting method applied. The inclusion of

publication types other than journal articles and the fractionalisation of publications by the number of authors almost reverse the order of the disciplinary groups in terms of productivity.

This raises the question of the meaningfulness of using uniform indicators for all disciplines. This is common at the national level. Uniform indicators often have a better fit with the natural sciences and medicine, where the publishing of articles in scientific journals with established peer review processes is fairly standardised, and there is a higher degree of consensus on what constitutes good research. In fields where a variety of approaches are applied research problems are broad, and procedures are less standardised, views on the criteria for quality of research vary. Especially in the social sciences and humanities, it is more difficult to measure quality or impact and it is even difficult to define what constitutes scholarly literature. Therefore the development of consistent indicators and the availability of uniform data present greater challenges for the measurement of publishing performance in these fields. Thus the tendency in performance measurements should be towards the use of more diverse rather than simplified indicators.

Tiivistelmä

Väitöskirjassa tarkastellaan tieteenalojen julkaisukäytäntöjä suomalaisissa yliopistoissa. Viimeisten kahden vuosikymmenen aikana yliopistoissa tehtävän tutkimuksen tuloksellisuuden ja tehokkuuden seuranta ja arvioiminen ovat alati lisääntyneet sekä Suomessa että muissa maissa. Tieteellistä tutkimustoimintaa kuvaavia määrällisiä indikaattoreita hyödynnetään yhä enemmän muun muassa maavertailuissa, kansainvälisissä yliopistorankingeissa, yliopistoille jaettavan perusrahoituksen sekä näiden sisäisen rahanjaon kriteerinä, akateemisissa virantäytöissä sekä tutkimusrahoituspäätöksissä.

Koska julkaisut ovat tutkimuksen tärkein tuotos lähes kaikilla tieteenaloilla, tieteellisiin julkaisuihin ja näiden saamiin viittauksiin perustuvien mittausmenetelmien, eli bibliometrinen indikaattoreiden, kehittäminen ja hyödyntäminen ovat olleet niin tiedepoliittikan päätöksentekijöiden, tutkimuksen rahoittajien kuin tutkimusorganisaatioiden hallinnon kasvavan kiinnostuksen kohteena. Bibliometriin indikaattoreihin liittyy kuitenkin monia puutteita ja rajoituksia, ja niiden käyttö edellyttää ymmärrystä sekä sovellettavasta metodologiasta että arvioitavasta kohteesta. Julkaisutoiminnan arvioinnissa erityistä huomiota tulisi kiinnittää tieteenalojen erilaisiin julkaisukäytäntöihin. Akateemiset instituutiot eivät ole yhtenäisiä kokonaisuuksia, vaan ne koostuvat eri tieteenalojen muodostamista akateemisista kulttuureista, jotka eroavat sekä kognitiiviselta että sosiaaliselta luonteeltaan. Tutkimuskohteiden luonne sekä tutkimuksen tavoitteet, tehtävät, yleisö ja rahoituslähteet ovat erilaisia eri tieteenaloilla. Näkemykset siitä, mitä pidetään hyvänä tutkimuksena tai korkealaatuisina julkaisuina vaihtelevat tieteenalasta toiseen. Näin ollen myös eri tieteenalojen mahdollisuudet vastata tiedepoliittisiin tavoitteisiin sekä pärjätä rahoituskilpailussa vaihtelevat.

Tieteenalojen julkaisukäytäntöjen erot tunnetaan hyvin, mutta niistä on vain vähän empiiristä tutkimusta. Bibliometriikan tutkimusalueella tieteellistä julkaisemisesta on tutkittu laajasti ympäri maailmaa, ja vertailuja on tehty eri maiden, yliopistojen sekä tutkimusryhmien välillä. Myös yksittäisten tieteenalojen julkaisutoimintaa ja kehitystä on tutkittu paljon. Kuitenkin sekä kansainvälisesti että Suomessa on puutetta kaikki tieteenalat huomioon ottavasta vertailevasta tutkimuksesta riittävän kattavilla

aineistoilla. Useimmat bibliometriset tutkimukset perustuvat kansainvälisten viitetietokantojen, Thomson Reutersin Web of Science - tai Elsevierin Scopus-tietokannan luetteloimiin julkaisuihin, jotka ovat pääasiassa kansainvälisissä tieteellisissä lehdissä julkaistuja artikkeleita. Nämä julkaisut ovatkin vakiintuneet bibliometrisen tutkimuksen perusyksiköksi. Kyseiset tietokannat antavat kuitenkin rajoitetun kuvan eri tieteenalojen julkaisutoiminnasta, sillä ne eivät kata esimerkiksi monografioita, kansallisia julkaisuja tai ei-tieteelliselle yleisölle suunnattuja julkaisuja, jotka ovat tärkeitä erityisesti yhteiskunta- ja humanistisissa tieteissä.

Tämä tutkimus vertailee julkaisukäytäntöjä kuudessa tieteenalaryhmässä: luonnontieteissä, tekniikassa, lääketieteissä, maa- ja metsätaloustieteissä, yhteiskuntatieteissä ja humanistisissa tieteissä. Analyysi perustuu laajoihin empirisiin aineistoihin, jotka kattavat laajasti eri julkaisumuotoja. Tutkimus tuo bibliometriikan tutkimusalalle uusia tuloksia 1) vertailemalla kaikkia tieteenaloja yksittäisten tieteenalojen sijaan, 2) hyödyntämällä useita erilaisia aineistoja yhden tietokannan sijaan sekä 3) huomioimalla kaikki julkaisumuodot pelkkien kansainvälisten jouliaartikkeleiden sijaan.

Tässä tutkimuksessa bibliometriset menetelmät yhdistetään tieteenkorkeakoulututkimuksessa laajasti käsiteltyyn akateemisten kulttuurien teoriaan, erityisesti Tony Becherin esittämiin akateemisia kulttuureita kuvaaviin kognitiivisiin ja sosiaalisiin ulottuvuuksiin. Lisäksi väitöskirjassa hyödynnetään Svein Kyvikin esittämää käsitteellistä mallia julkaisukäytäntöihin vaikuttavista tieteen sisäisistä ja ulkoisista tekijöistä. Tutkimuksen taustaksi esitellään lisäksi korkeakoulujen ja tiedepolitiikan viimeaikaisia muutoksia ja pohditaan niiden vaikutuksia eri tieteenalojen julkaisukäytäntöihin.

Väitöskirjassa tarkastellaan erityisesti seuraavia neljää pääteemaa:

1. Eri julkaisumuotojen ja yhteisjulkaisemisen tyypillisyydet;
2. Muutokset julkaisutoiminnassa kahden viime vuosikymmenen aikana;
3. Sukupuolen ja aseman vaikutus tutkijoiden julkaisutuottavuuteen;
4. Erilaisten aineistojen hyödynnettävyys julkaisutoiminnan arvioinnissa.

Tutkimuksen empiiristen tulosten sekä aiemman tutkimuskirjallisuuden perusteella tieteenalojen julkaisukäytännöt voidaan jakaa kolmeen päätyyppiin: luonnon- ja

lääketieteen, tekniikan ja humanististen tieteiden. Luonnon- ja lääketieteen julkaisut ovat pääasiassa artikkeleita kansainvälisissä tieteellisissä vertaisarvioituissa lehdissä, niiden tekemiseen on osallistunut useita tutkijoita, ja julkaisujen määrä tutkijaa kohti on korkea. Kyvikin esittämän teorian mukaan tätä vakiintunutta julkaisukäytäntöä selittää muun muassa se, että aloilla on usein kodifioitu kommunikointikieli ja yhtenäinen symbolijärjestelmä, jolloin tulokset voidaan esittää lyhyessä ja standardissa muodossa artikkelissa. Luonnon- ja lääketieteissä riippuvuus muiden tutkijoiden aiemmista tutkimustuloksista on korkea ja tutkimusmenetelmät ja -tekniikat ovat yhtenäiset. Siksi aloilla tutkimustulosten leviäminen ja tutkijoiden meritoituminen edellyttää, että tulokset julkaistaan oman alan kansainvälisen tiedeyhteisön seuraamissa lehdissä.

Edellä mainitut julkaisutoiminnan piirteet koskevat myös useimpia tekniikan aloja, mutta tekniikan alojen yleisö on heterogeenisempi. Useilla tekniikan aloilla tutkimustuloksista ovat kiinnostuneita tutkijakollegoiden lisäksi tutkimusalasta riippuen kansainväliset tai kansalliset yritykset. Artikkelit julkaistaan tieteellisten lehtien sijaan useammin konferenssijulkaisuissa, joka on nopeasti kehittyvillä aloilla paras kanava levittää tutkimustuloksia relevantille yleisölle.

Humanistisissa tieteissä tutkimustuloksia julkaistaan lehtiartikkeleita enemmän kokoomateosartikkeleina, ja kansallinen julkaiseminen on tyypillistä. Julkaisut kirjoitetaan useimmiten yksin, joten niitä tuotetaan selvästi vähemmän tutkijaa kohti kuin luonnon- ja lääketieteissä. Kyvikin mukaan humanistisissa tieteissä kodifikaation aste on alhainen ja tutkimuksen kieli on kirjallista ja esseististä. Tutkimus on luonteeltaan moniparadigmaattista, joten tutkimusongelman, menetelmien ja tulosten, esittely edellyttää pitkää esitystapaa. Kilpailu siitä, kuka julkaisee tuloksen ensimmäisenä, on vähäisempää kuin luonnon- ja lääketieteen sekä tekniikan aloilla. Monografiat ja kokoomateokset myös tavoittavat ei-tieteellisen yleisön, joka on tärkeä monilla humanistisilla aloilla. Kokoomateosten tyypillisyyttä selittää myös tutkimustiedon holistinen luonne: artikkelikokoelma voi tarjota kattavamman kuvauksen tarkasteltavasta ilmiöstä kuin yksittäinen artikkeli lehdessä. Useimmat yhteiskuntatieteiden alatkin edustavat humanististen tieteiden julkaisukäytäntöä, mutta lehtiartikkeleiden osuus julkaisuista on korkeampi. Niin ikään yhteisjulkaiseminen on yhteiskuntatieteissä tyypillisempää. Yhteiskuntatieteet sijoittuvat julkaisukäytännöiltään näin ollen luonnon- ja lääketieteiden sekä humanististen välimaastoon.

Vaikka akateemiset instituutiot ovat olleet merkittävien globaalien, rakenteellisten ja tiedepoliittisten ja muutosten alla viime aikoina, julkaisukäytännöt ovat muuttuneet

toistaiseksi vain vähän. Ei ole nähtävissä merkkejä siitä, että luonnontieteiden ja lääketieteen tapa julkaista tutkimustulokset artikkeleina kansainvälisissä lehdissä olisi leviämässä hallitsevaksi julkaisumuodoksi kaikille tieteenaloille. Monografiat ja kokoomateokset ovat säilyttäneet asemansa tärkeinä julkaisumuotoina yhteiskuntatieteissä ja erityisesti humanistisissa tieteissä. Merkilläpantavaa on myös, että humanistisissa tieteissä ei- tieteelliselle yleisölle suunnattuja julkaisuja tuotetaan lähes yhtä paljon kuin tieteellisiä, vaikka niitä harvoin huomioidaan virantäytöissä ja rahoituspäätöksissä.

Tutkimuksen tulokset osoittavat, että tieteen globaalit trendit - kansainvälisyys ja kansainvälinen yhteisjulkaiseminen - ovat lisääntyneet Suomessa kaikilla tieteenaloilla. Humanistiset tieteet tosin muodostavat poikkeuksen, sillä suurin osa julkaisuista kirjoitetaan edelleen yksin. Lähes kaikilla tieteenaloilla kansainväliset yhteisjulkaisut keräävät enemmän viittauksia kuin julkaisut, joissa on vain suomalaisia tekijöitä. Tutkimus kuitenkin osoittaa, että kansainvälisten yhteisjulkaisujen keskimäärin suurempi kirjoittajamäärä selittää niiden korkeampia viittausmääriä suhteessa kotimaisiin yhteisjulkaisuihin. Kirjoittajien määrällä on merkittävämpi vaikutus viittausmääriin kuin sillä, että kirjoittajat ovat eri maista. Suomessa kansainvälinen yhteistyö on kuitenkin välttämätöntä, sillä pienen maan sisältä ei ole useinkaan mahdollista löytää riittävästi yhteistyökumppaneita.

Tulee huomioida, että tieteenalaryhmien käyttäminen tämän tutkimuksen useimpien analyysien perusyksikkönä jättää huomiotta ryhmien sisäisen vaihtelun ja näin ollen yksinkertaistaa tarkasteltavaa ilmiötä. Ryhmien sisällä tieteenalat, tutkimusalat ja erikoisalajat voivat poiketa merkittävästi julkaisukäytännöiltään. Myös yksittäisten tutkijoiden välillä on eroja. Tämän tutkimuksen tulokset yksilöiden välisistä tuottavuuseroista ovat yhdenmukaisia aiemmassa tutkimuskirjallisuudessa esitettyjen tulosten kanssa: julkaisutuottavuuden jakauma on erittäin vino ja suuri osa julkaisuista kasautuu pienelle tutkijajoukolle. Tuottavimmat tutkijat ovat tuotteliaimpia kaikissa julkaisumuodoissa. Lisäksi korkeimmissa asemissa olevat tutkijat tuottavat keskimäärin eniten julkaisuja ja miehet julkaisevat keskimäärin enemmän kuin naiset. Nämä tulokset koskevat yhtä lailla kaikkia tieteenalaryhmiä.

Tutkimuksessa käytetyt aineistot kerättiin neljästä erityyppisestä lähteestä: kahden suomalaisen yliopiston omista julkaisutietojärjestelmistä, yliopistoyksiköiden johtajille suunnatulla kyselyllä, Google Scholarista sekä Thomson Reutersin Web of Science - tietokannasta. Tutkimus osoittaa, että metodologisilla valinnoilla on merkittävä

vaikutus tieteenalaryhmien julkaisutuottavuutta ja tieteellistä vaikuttavuutta koskeviin tuloksiin. Tuottavuuserot tieteenalaryhmien välillä riippuvat muun muassa käytössä olevasta aineistosta, laskentamenetelmistä sekä siitä, mitä julkaisumuotoja analyysiin sisällytetään. Muidenkin kuin kansainvälisten lehtiartikkeleiden huomioiminen sekä julkaisujen osittaminen kirjoittajien kesken tuottaa jopa päinvastaisia tuottavuuseroja tieteenalaryhmien välille kuin näiden huomiotta jättäminen. Tämä herättää kysymyksen yhtenäisten indikaattoreiden soveltamisen mielekkyydestä kaikilla tieteenaloilla. Luonnon- ja lääketieteissä on usein korkeampi yksimielisyys siitä, mikä on hyvää tutkimusta ja miten sitä voidaan mitata. Yhteiskunta- ja humanististen tieteiden aloilla puolestaan mittaaminen on haasteellisempaa, sillä tutkimusaloilla on erilaisia koulukuntia ja kilpailevia paradigmoja. Aloilla ei ole yhtä vakiintuneita tieteen tuloksellisuuden mittareita, eikä julkaisujen laatua ja vaikuttavuutta kuvaamaan sopivista mittareista tai tieteellisyyden määritelmästä ole yhtenäisiä näkemyksiä. Erityisesti näillä aloilla tutkimustoiminnan arvioinnin tulisikin yksittäisten indikaattoreiden sijaan perustua useisiin, tutkimusta monipuolisesti kuvaaviin mittareihin.

List of original articles

This thesis is based on the following four original articles:

Article I

Aaltojärvi, Inari, Arminen, Ilkka, Auranen, Otto. & Pasanen, Hanna-Mari (2008), Scientific productivity, web visibility and citation patterns in sixteen Nordic sociology departments. *Acta Sociologica*, 51(1), 5–22.

Article II

Puuska, Hanna-Mari (2010). Effects of scholar's gender and professional position on publishing productivity in different publication types. Analysis of a Finnish university. *Scientometrics*, 82(2), 419-437.

Article III

Puuska, Hanna-Mari, Talja Sanna, Ylijoki Oili-Helena (2014). A longitudinal analysis of publishing patterns in engineering and the humanities. Submitted to *Minerva*, 9 December, 2013

Article IV

Puuska, Hanna-Mari., Muhonen, Reetta & Leino, Yrjö 2014, International and domestic co-publishing and their citation impact in different disciplines, *Scientometrics*. 98(2), 823-839.

Articles I, II and IV are published with the permission of the original publishers. Article III is published as a postprint of the submitted manuscript.

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1 Introduction

Academic institutions have been seen as key economic actors in producing high standards of knowledge and providing the highest levels of education. Their performance and effectiveness in research have become highly relevant issues for policymakers, and they are increasingly assessed and evaluated (Slaughter & Leslie 1997; Etzkowitz & Leydesdorff 2000; Nieminen 2005; Hicks 2012.) Quantitative studies of science have been increasingly used as a tool for advancing the knowledge of the state and development of science in relation to society and technology (van Raan 2005). Moreover, several countries apply quantitative indicators in measuring the research performance of academic institutions for the purposes of steering, decision-making and funding allocation (Hicks 2010; Auranen & Nieminen 2010).

Since publications are the major university research output, there is a demand for bibliometric indicators, that is, indicators based on the publications produced by scientists and the citations received by them. Bibliometric indicators are applied for the evaluation of research at all levels: in international comparisons, in university rankings, as criteria for the allocation of funding between and within academic institutions, in the appointment of scholars to academic positions, and in research grant decisions. The use of bibliometrics is usually justified in terms of its objectivity and lower cost in comparison to qualitative judgments by experts.

It has often been argued that bibliometric indicators have some shortcomings, and their use requires a knowledge and understanding of methodology and context (Wallin 2005; Gläser & Laudel 2007). For example, uniform quantitative measures are criticised because they do not take into account the differences between disciplines (e.g. Weingart 2005; van Raan 2005; Hicks 2013). Academic institutions are not uniform entities, but comprise various academic cultures shaped by scientific disciplines. The disciplines differ both cognitively and socially, and their research has different goals and is aimed at different kinds of audience (Becher 1989; Ylijoki et al. 2011). These factors have a bearing on why particular publishing patterns have become established in different scientific fields. Therefore the same performance indicators are not necessarily appropriate for all. A better understanding of publishing behaviour and its

determinants in different disciplines is needed in order to evaluate the validity of bibliometric indicators and to develop more valid indicators.

1.1 Aims of the study

This study investigates how different disciplinary groups in Finnish universities vary in their publishing patterns. In information studies, particularly in the research area of bibliometrics, scientific publishing has been studied extensively around the world at various levels, through comparisons between countries, between institutions, and within single scientific fields. However, both internationally and in Finland there is a lack of comparative studies covering all disciplinary groups, for example regarding actual differences in the frequency of publication types, or average publishing productivity. There are plenty of studies confirming the accumulative nature of publishing productivity at the level of individual scholars, as well as on productivity according to gender and scholarly position (e.g. Allison & Stewart 1974; Cole & Zuckerman 1984; Kyvik & Teigen 1996; Tien & Blackburn 1996; Xie & Shauman 1998; Fox 2005; Carayol & Matt 2006; Prpić et al. 2009). However, there are only a few studies on whether these factors apply similarly across disciplines.

What is more, many of the bibliometric studies use incomplete data which exclude certain publication types and thus disregard certain disciplines. Most bibliometric studies are based on data from the international scientific journals indexed in the most widely used commercial citation index databases, namely Thomson Reuters Web of Science and, more recently, Elsevier Scopus. Articles in these journals have become the established unit of bibliometric studies. These databases provide good coverage of most fields in the natural and medical sciences, but they exclude, for example, books, national publications and non-scholarly publications, which are important in the social sciences and humanities (e.g. Kyvik 1991; Hicks 2004). Conference proceedings, which account for a significant proportion of publications in engineering, are covered only moderately (e. g. Moed 2005). Previously, comprehensive data on all publication types have been poorly available. However, the situation has considerably improved recently as many countries have developed their own national publication databases. Furthermore, the implementation in 2004 of Google Scholar, the web search engine for scholarly documents and their citations, has enabled bibliometric analyses including a wider range of publication types. This study contributes to bibliometric research by 1) making a comparative analysis of disciplinary groups instead of analysing only single

fields, 2) using different kinds of dataset instead of the limited representation provided by only one database, and 3) including all publication types instead of analysing only articles in international scientific journals.

This study combines bibliometric methodology with a theoretical framework from science studies. The topmost theoretical framework in this study is formed by the concept of disciplinary cultures, which has been discussed extensively in science studies and higher-education research. This study applies the theory and concepts presented by Tony Becher in his book *Academic tribes and territories* (1989) and by Richard Whitley (2000) in *The intellectual and social organization of the sciences*. Although academic cultures are widely discussed in scientific literature, their relationship with publishing patterns has been studied only a little. Svein Kyvik's *Productivity in academia: Scientific publishing at Norwegian universities* (1991) made the first comprehensive attempt to model differences in disciplinary publishing patterns by drawing up a conceptual framework regarding the intra- and extra-scientific factors related to publishing patterns in different disciplines.

In addition to a consideration of disciplinary cultures, the results of this study are explored in light of the global transformation of academic institutions and recent developments in Finland's national science policy. The change in the academic environment has been described through various concepts, such as 'the new mode of knowledge production' (Gibbons et al. 1994), 'academic capitalism' (Slaughter & Leslie 1997) and 'entrepreneurial university' (Clark 1998). These concepts emphasise the new focus on innovativeness in the national economy, on governance and policymaking (Hicks 2012), and on the application of the ideology of 'new public management' to the university sector (see e.g. Nieminen 2005; Ferlie et al. 2009). The design of this study does not enable a straightforward analysis of the relationship between science policy and publishing patterns, but recent changes in science policy both globally and in Finland are introduced as a background to the study.

Disciplinary differences in publishing behaviour are usually considered self-evident, but there is little empirical evidence for them, not just from Finland but also from other countries. A few studies (e.g. Kyvik 1991; Bourke & Butler 1996; Piro et al. 2013) make comprehensive disciplinary comparisons of publishing patterns, including representative data from both the natural and medical sciences as well as from engineering, social sciences and humanities. The state of Finland's publishing performance has been assessed through international comparison in numerous reports

(e.g. Luukkonen et al. 1991; Persson et al. 2000; Lehvo & Nuutinen 2006; Löppönen et al. 2009; Schneider 2010; NordForsk 2011; Ministry of Education and Culture 2012), but in the Finnish context there is a lack of comparative research on publishing patterns in different disciplines.

Our previous study (Puuska & Miettinen 2008) made one of the first attempts to provide a comprehensive description of Finnish universities' publishing patterns in terms of orientation to various publication types by analysing universities' publications and interviews with Finnish professors. The current study widens this picture and provides new empirical findings on Finland's scientific publishing performance, from several perspectives: the typicality of different publication types, co-publishing patterns, non-scholarly publishing, changes in publishing patterns, the effects of gender and scholarly position on publishing performance, and the usability of different databases for analysing Finland's publishing performance. One of the aims of this study is to provide a better understanding of the potential consequences of the use of bibliometric indicators in science policy for scientists' publishing behaviour, and of how possible disciplinary differences should be taken into account when using bibliometric indicators to assess research performance.

This study compares publishing patterns in different disciplines in Finland. The analyses are based on large-scale empirical data which cover a wide range of publication types – that is, contributions to scientific journals, books and conference proceedings aimed at national, international scholarly and non-scholarly audiences. The data are derived from publication data from universities' local publication registers, from a survey of heads of university departments, and from Google Scholar and Thomson Reuters Web of Science. The analysis focuses on the following four major aspects, with special emphasis on comparisons between disciplinary groups:

1. The typicality of various publishing types and co-publications in Finland;
2. Changes in publishing patterns occurring during the past two decades;
3. The effects of gender and position on publishing patterns;
4. The comprehensiveness and applicability of different kinds of datasets in the assessment of publishing performance.

1.2 Structure of the thesis

The dissertation is composed of 10 chapters. In addition, Appendix II includes the four original articles published in scientific journals.

The next five chapters (2–6) lay out the conceptual background of the study and review the results of relevant previous research. Chapter 2 introduces the concept of academic cultures framed by disciplines, and provides a conceptual framework regarding the intra- and extra-scientific factors related to publishing patterns in different disciplines. Chapter 3 presents bibliometrics as a research field, its best-established data sources, and the relevant bibliometric indicators for the assessment of research performance. Chapter 4 combines these two frameworks and reviews previous empirical results on disciplinary publishing patterns. Chapter 5 introduces the distribution of publishing productivity at the level of individual scholars, and previous results on productivity differences between genders and scholars in different positions. Chapter 6 outlines science policy and its recent trends, with a special emphasis on its relation to publishing patterns and the use of bibliometric indicators as a tool for decision-making, research evaluation and funding allocation.

Chapter 7 presents the specific research questions of this study. The four datasets and the methodology and indicators used in this study are described in Chapter 8. The results are presented in the four articles in Appendix II, and they are summarised in Chapter 9. Chapter 10 draws conclusions based on the results.

2 Academic disciplines and disciplinary cultures

Academic discipline refers to a scientific knowledge community. Certain shared norms and practices are common to all disciplines, and they distinguish academia from other established institutions (Becher 1994; Ylijoki 2000). For example, Merton (1973) has addressed four sets of 'institutional imperatives', that is, ideals of the common ethos of science: universalism (the validity of claims is judged in terms of universal and impersonal criteria), communism (the results of research are the common property of the scientific community), disinterestedness (scientists' work is independent of their personal interests) and organised scepticism (all claims are exposed to critical scrutiny). Nevertheless, different academic disciplines can be considered as different epistemological and cognitive domains which do not rely equally on these ideals. These domains are differentiated by, for example, their object of research, their body of knowledge, or their theories, terminologies and methods. Academic disciplines are often organised and formed around taught subjects, academic departments, professional associations or scientific journals. (Krishnan 2009.) They can also be defined as sociocultural entities within which researchers share common norms, values, work practices and modes of interaction (see Becher 1994; Whitley 2000; Ylijoki 2000). In addition to differences between disciplines, subdisciplines and specialisms also vary greatly in their cognitive and social natures (e.g. Fry and Talja 2004).

2.1 Disciplinary cultures

As early as 1959, C.P. Snow's essay 'The two cultures' introduced the two extremes of academic culture: that of literary intellectuals, and that of scientists, by whom he meant the humanities and applied sciences, particularly engineering. According to Snow, these two cultures differ in their 'intellectual, moral and psychological' climates. Academic cultures have subsequently been conceptualised in various studies. Janice Lodahl and Gerald Gordon (1972) found differences between disciplines related to the level of paradigmatic development in terms of teaching and research. The concept of *paradigm*, adopted from Thomas Kuhn (1970), refers to a generally accepted theory within the scientific community which is related to common techniques and methodology. Anthony Biglan (1973) developed the idea of the two cultures and made a further distinction between *hard* and *soft* knowledge domains. The hard fields (natural sciences,

medical sciences and engineering) tend to have paradigmatic consensus. They are concerned with universals, and the nature of knowledge is cumulative and atomistic. On the other hand, the soft fields (social sciences and humanities) explore particularities, and aim to understand and interpret phenomena. Biglan makes another distinction along the cognitive dimension between *pure and applied* fields of science. The third dimension introduced by Biglan, the *life/non-life system*, refers to whether the object of study (biological or social) is inanimate. Biglan emphasizes that in addition to the cognitive dimension, the disciplines differ in terms of their cultures, values and norms, which are manifested, for example, in their collaboration and publishing patterns. David Kolb (1981) investigated disciplinary cultures from the viewpoint of students' learning strategies, and found that the learning styles of different disciplines can be distinguished into two basic dimensions, abstract-concrete and active-reflective, which are fairly consistent with Biglan's dimensions of hard-soft and pure-applied. (Ylijoki 1998; Becher 1989.)

In his famous work on disciplinary cultures, *Academic tribes and territories* (1989), Tony Becher considers disciplinary groups as academic tribes which have their own sets of intellectual values and their own patches of cognitive territory. Grounded in the dimensions presented by Biglan and Kolb, Becher (1989) draws up a framework of four distinct categories, hard-pure, soft-pure, hard-applied and soft-applied knowledge domains, within which fields share certain features (see Table 1). Of the four areas in the typology of disciplines, Becher presents hard-pure knowledge as the starting point because it is the most widely discussed and scrutinised within scientific enquiry. The hard-pure territory is characterised by the cumulative growth of knowledge, that is, new findings are based on and accrete to existing knowledge.

As a counterpoint to the hard-pure, Becher considers the soft-pure knowledge domain (e.g. the humanities and pure social sciences, such as anthropology), in which the process of knowledge development is recursive rather than cumulative. Whereas the most recognised claims can be regarded as discoveries in the hard-pure domain, contributions in the soft-pure domain are regarded as reinterpretations or understandings of phenomena. In this domain, fields usually have multiple competing and developing paradigms and lack consensus over what can be considered a significant contribution. Claims are less value-free and less impersonal than in the hard-pure fields. Knowledge in soft-pure fields typically has a holistic structure, that is, research problems are considered as a totality. On the other hand, the structure of knowledge in the hard-pure fields can be characterised as atomistic: research problems

can be split into various subquestions. Furthermore, the hard-pure fields are more quantitative, whereas qualitative data are often used in the soft-pure fields. Becher (1989) argues that explanations given in hard-pure areas are strong and rely on a few controlled variables, whereas the soft-pure fields settle on weaker explanations, since the research subjects are linked to a wide range of less controllable variables. The fields representing the soft-pure knowledge domain also have looser boundaries in determining new topics of study, whereas future research problems are more predictable in hard-pure fields.

Pure and applied knowledge also differ, for example in that pure knowledge is principally self-regulating, whereas applied knowledge is more externally influenced. Pure fields are focused on basic research, whereas the applicability of results plays an important role in applied fields. Technology is described as an example of a hard-applied territory in Becher's disciplinary grouping. Hard-applied fields have a heuristic and more practical approach than those in the hard-pure domain. Hard-applied subjects are concerned with mastering the physical world, the primary outcomes being new products and techniques. They are not quite as quantitative as hard-pure fields, as typically qualitative judgments, such as purposive and functional criteria, are also involved in applications. The soft-applied fields (e.g. education and law) have a functional and utilitarian role and aim to enhance societal practices. The development of knowledge is, however, less progressive than in the hard-applied domain, since these fields are based on the reiterative development process characteristic of the soft sciences.

Table 1. Table 1. Knowledge and disciplinary groupings by Tony Becher (1994).

Disciplinary grouping	Examples of disciplines	Nature of knowledge	Nature of disciplinary culture
Hard-pure	E.g. physics	Cumulative, atomistic (crystalline/tree-like), concerned with universals, quantities, simplification, resulting in discovery/ explanation	Competitive, gregarious, politically well organised, high publication rate, task-oriented
Soft-pure	Humanities (history) and pure social sciences (e.g. anthropology)	Reiterative, holistic (organic/ river-like), concerned with particulars, qualities, complication, resulting in understanding/interpretation	Individualistic, pluralistic, loosely structured, low publication rate, person-oriented
Hard-applied	Technologies (e.g. mechanical engineering)	Purposive, pragmatic (know-how via hard knowledge), concerned with mastery of physical environment, resulting in products/techniques	Entrepreneurial, cosmopolitan, dominated by professional values, patents substitutable for publications, role-oriented
Soft-applied	E.g. education	Functional, utilitarian (know-how via soft knowledge), concerned with enhancement of (semi-)professional practice, resulting in protocols/procedures	Outward-looking, uncertain in status, dominated by intellectual fashions, publication rates reduced by consultancies, power-oriented

Becher (1989; 1994) divides the social dimension into *convergent-divergent* and *urban-rural*. Convergent academic communities manifest a sense of collectivity and shared identity, and there are uniform standards and procedures. Divergent, loosely knit communities, which are ideologically more fragmented, lack these features. The distinction between urban and rural refers to the patterns of interaction within a discipline. Urban fields are characterised by speed and a high degree of competition and prefer group work, whereas in rural fields researchers tend to work by themselves and the research work is slower and less competitive.

The culture in the hard-pure territory is urban and convergent, that is, highly competitive, fast and gregarious. The research is conducted in large, well-organised laboratories. The same subjects are usually scrutinised by several competing research groups. Conversely, the culture of scientists in the soft-pure domain is individualistic

and less structured. Since its disciplinary culture is pluralistic and its research problems diverge, there is less competition than in the hard-pure area. The culture of hard-applied fields can be characterised as entrepreneurial and competitive. They are also cosmopolitan by nature because the outcomes of their research – their products – are usually globally applicable. The fields in the soft-applied knowledge domain in their turn are outward-looking and aim for close interactions between professionals in their fields. They are, however, young fields in academic enquiry, and therefore uncertain in status. (Becher 1989; 1994.)

Another significant contribution to research on disciplinary cultures has been Richard Whitley's *The intellectual and social organization of the sciences* (2000), in which he describes scientific fields from the perspective of their organisation of work. He considers the organisation of scientific fields as 'a particular kind of work organization which structure and control the production of intellectual novelty through competition for reputations from national and international audience for contribution to collective goals' (Whitley 2000, 81). He differentiates scientific fields along two dimensions: 1) the degree of mutual dependence between scientists, and 2) the degree of task uncertainty.

Whitley's (2000) concept of *the degree of mutual dependence* refers to the extent to which members of the field are reliant on a group of colleagues with whom they compete and collaborate in order to gain reputation and access to resources. Whitley breaks down this mutual dependence into two aspects, functional and strategic dependence, which usually occur at least to some extent in tandem. *Functional dependence* refers to how strictly acceptable research methods, technologies and data are defined, as well as the extent to which research results must be in accordance with the established norms of the scientific field. Functional dependence is high in fields where task outcomes are well coordinated and contributions rely on similar techniques, methods and materials. In fields where functional dependence is weak, a variety of approaches are included, research problems are broad, procedures are less standardised, and scientists have a lesser need to persuade their colleagues of the superiority of their own approach. In fields that tend to have a lower degree of dependence, usually the soft fields, the quality or relevance of the research is not based on strictly uniform methods or views. With *strategic dependence*, Whitley (2000) refers to a more political aspect: how strictly the research goals, resource allocation, and organisation of programmes and projects are determined. Whitley refers to physics as a field where the degree of strategic dependence is high: it is hierarchically structured, and types of research differ in their

prestige. Chemistry, on the other hand, is an example of a less hierarchical field in which subdisciplines have greater autonomy and compete less with each other over reputation and resources. Whitley names certain soft fields (e.g. philosophy, early German psychology and literary studies) as examples of fields where functional dependence is low but the degree of strategic dependence is high. In these fields, researchers disagree and compete over the ranking of problems and approaches and their relevance to collective goals.

Whitley's (2000) other dimension, *the degree of task uncertainty*, refers to the degree of paradigmatic consensus: the extent to which work procedures, definitions of problems and theoretical goals are shared among the members of the field, and the extent to which new findings must fit with the existing knowledge base. Whitley makes a further distinction between technical and strategic task uncertainty. The degree of *technical task uncertainty* refers to the degree of ambiguity of the results and the variety of technical procedures. If this kind of task uncertainty is low, as in physics and chemistry, research techniques and methods are standardised, and results are more predictable, visible and replicable. High technical task uncertainty occurs in fields, mostly in the soft sciences, where technical procedures are fluid and the interpretation of results is disputable. *Strategic task uncertainty* refers to uncertainty over intellectual priorities and the importance of research topics. In fields where strategic task uncertainty is low, research problems and goals are stable and clearly ordered. If it is high, the goals vary or conflict.

Whitley's and Becher's models are built from different perspectives: Becher (1989) approaches disciplinary features from the perspective of epistemology and culture, while Whitley's (2000) model is based on an organisational management perspective. The concepts provided by the two perspectives are therefore complementary, but also overlap. Fields that would be categorised as hard, convergent and urban in Becher's typology tend to have high mutual dependence and low task uncertainty according to Whitley's model. In turn, the soft sciences, which are usually divergent and rural in culture, tend to have low mutual dependency and high task uncertainty. Indeed, the distinction between hard and soft sciences seems to encompass and embrace both Becher's social dimensions and Whitley's work organisational dimensions. Whitley's model does not consider those aspects of the pure-applied dimension which may occur in fields with both low and high degrees of mutual dependence and task uncertainty. Both Becher and Whitley, however, argue that there is a large diversity of fields within all these dimensions.

2.2 Factors in disciplinary differences in publishing patterns

The academic cultures of different disciplines have been studied extensively in science studies and higher-education research as well as in information studies. Nevertheless, differences in publishing patterns between the scientific disciplines have been little studied. A significant contribution to research on differences in disciplinary publishing patterns has been Svein Kyvik's book *Productivity in academia: Scientific publishing at Norwegian universities* (1991), which draws up a conceptual framework regarding the intra- and extra-scientific factors related to publishing patterns in different disciplines. These factors are closely related, and overlap with Becher's (1989) cognitive and social dimensions:

1. Paradigmatic status (single paradigm-multiple paradigms);
2. Communication language (codified-literary);
3. Degree of dependence between scientists (mutual dependence-independence);
4. Audience structure (specialist-general);
5. Nature of research subjects (global-local);
6. Degree of competition for priority (high-low).

Kyvik's first dimension, *paradigmatic status*, is based on Kuhn's (1970) concept of the scientific paradigm. However, instead of the division between 'paradigmatic' and 'pre-paradigmatic' fields referred by Kuhn (1970) and Lodahl and Gordon (1972), Kyvik prefers to use the concepts of *one-paradigmatic* and *multi-paradigmatic* domains. In one-paradigmatic fields, the consensus on acceptable results is usually high. In multi-paradigmatic fields there are several competing paradigms instead of a single dominant one.

Kyvik's (1991) second dimension, *communication language*, is based on the work of Zuckerman and Merton (1968), who presented the concept of *degree of codification*. This refers to the expression of research results in an unambiguous theoretical form. One measure of the degree of codification is the use of mathematics in written communication. A high degree of codification is found in medical and natural science fields, which usually have a common, consolidated communication language and symbol system, as well as a uniform format for presenting results. In fields where the

communication language is less codified, namely social sciences and especially the humanities, the reporting of research results is more literary and essayistic.

According to Kyvik (1991), disciplinary differences in the typicality of book and article publishing within a given scientific field are associated with that field's paradigmatic status and communication language. Kyvik states that research fields with a codified communication language have a uniform symbol system and make economical use of mathematical formulae, so the results can be presented in a short and standardised way in article format. Kyvik goes on to say that, since the social sciences and humanities have a low degree of codification, lack a uniform symbol system, and are also multi-paradigmatic in nature, it takes them more space to present the research problem, methodology and discussion in a satisfactory manner. Therefore books are a more common type of publishing in the social sciences and humanities than in medical and natural sciences. Furthermore, in the social sciences and humanities there is no need to publish as quickly as in the natural and medical sciences, and there is rarely competition for priority, so more time can be devoted to formulating a comprehensive description.

Kyvik's third dimension, *the degree of dependence between scientists*, refers to Whitley's (2000) definition of the extent to which researchers have to make use of each other's results (cf. Becher's distinction between convergent and divergent fields). Disciplines also differ in terms of their *audience structure*. In all fields of science, research results are reported to colleagues who represent the specialist academic audience. In certain fields, especially the social sciences and humanities, there are typically other important audiences outside one's own scientific community. In fields where *the nature of the research subjects* is global, the research concerns globally valid universalities. On the other hand, many social sciences and humanities fields have local research topics, and their research results depend heavily on geographical or cultural context, for example. In rapidly developing fields such as physics, the degree of *competition for priority* is high. The researcher who is the first to publish a result gets most of the credit. In these fields, it is therefore necessary to publish new research results immediately.

To explain the rate of international publishing in a given field, Kyvik (1991) refers to the degree of mutual dependence between researchers, the degree of competition for priority, and the nature of the research subject. In fields with a high degree of mutual dependence between researchers, that is, shared methodology and techniques as well as a dependence on the research results and perspectives of other researchers globally, it

is necessary to make a contribution to international research, and the principal audience is the international scientific community. In a rapidly developing field where the competition for priority is high, it is necessary to publish one's results rapidly for colleagues in international forums in order to gain the credit for those results. Moreover, research topics in these fields are usually universal by nature. As for social sciences and humanities, the high proportion of national and domestic-language publications derives partly from the fact that the research subjects are often somewhat local in nature, and obviously the research results can spark more interest in national forums than internationally. National publications also reach a larger audience because the audience is often wider than just specialist colleagues (Kyvik 1991).

Besides publication channels, disciplinary features are related to co-authorship practices. Kyvik (1991) argues that because the natural and medical sciences are mostly single-paradigmatic, authors usually have a higher consensus over the acceptability and form of presentation of the results. In these disciplines co-authoring is therefore easier than in the social sciences and humanities, where there are often multiple competing paradigms, where research is not based on shared and mutually agreed theories and methodologies, and where researchers often do not agree over what constitutes quality or relevance in research. Kyvik also uses the degree of dependence between scientists as one explanation for disciplinary differences in the typicality of co-authorship in publications. In fields where researchers are highly dependent on each other's results and ideas, and where they share standard techniques and methodologies, research cooperation can even act as a prerequisite for achieving new research results. In the social sciences and humanities, on the other hand, the higher proportion of single-authored publications can be explained by the lower degree of dependence between researchers, the existence of multiple competing paradigms, the relative absence of shared and mutually agreed theories and methodologies, and researchers' frequent disagreement over what constitutes quality or relevance in research. Kyvik (1991) states that social factors also have an effect on author lists: in certain areas of the social sciences and humanities, researchers' competence evaluations may disregard co-authored publications.

Most fields in the natural and medical sciences can be characterised as hard sciences and are located at one extreme in Kyvik's model (single-paradigmatic, codified communication language, high mutual dependence between scientists, specialised audience, global research subjects, and a high degree of competition for priority), whereas the soft fields, namely the social sciences and especially the humanities, can be

characterised at the opposite extreme (multi-paradigmatic, literary communication language, low mutual dependence between scientists, general audience, local research subjects, and a low degree of competition for priority).

2.3 Classification and delineation of disciplines

Becher (1994) categorises communities of scientific knowledge at four levels of generality: 1) the academic profession as a whole, 2) broad disciplinary groupings of disciplines (hard-pure etc.), 3) separate disciplines and professional groupings, and 4) subdisciplinary specialisms. The models presented by Becher, Whitley and Kyvik basically describe the second level of aggregation, the disciplinary groups. Therefore they characterise fields in very simplified terms. Each of the models presents taxonomies for grouping disciplines. However, these dimensions should not be regarded as categories but as continuums. On the other hand, differences within disciplines, in both their cognitive and their social aspects as well as in work practices and publishing patterns, may be even larger than between disciplines: a discipline may include specialisms at different extremes of the dimensions. Kekäle and Lehtikoinen (2000) present the field of biology as an example. Research in experimental biology can often be portrayed as hard, exact and convergent. By contrast, the field of ecology is rather soft, divergent and rural: the acceptability of theories can be questionable. Fry and Talja (2004) argue that specialisms within the same discipline can be distinct from each other and also share cultural similarities with specialisms in other disciplines. They give social/cultural geography as an example: it is a specialism of geography, namely the subdiscipline human geography. However, it differs greatly from the specialism in the other subdiscipline, namely physical geography. Typically, social/cultural geographers seek information from journals in anthropology and sociology, but publish their results in geography journals (Fry 2003).

There have been attempts to categorise the disciplines into broader groups. Probably the best-established standard is that in the OECD's *Frascati manual* (2002), which proposes a standard practice for surveys on research and development (R&D). The fields of science and technology are divided into six disciplinary groups (natural sciences, engineering and technology, medical sciences, agricultural sciences, social sciences, and humanities). The analysis in this study is mainly built on this categorisation of fields.

The delineation of academic disciplines or fields is awkward, however. Disciplines are partly identified by the existing organisational structures: university departments, professional associations and specialist journals (Becher & Trowler 2001). Certain disciplines have a long history, with for example a set of established journals and departments, but some new fields are pursued by only a few universities or journals. Furthermore, institutional units and people may move between fields and span different specialisms (Leydesdorff 2008). Fry and Talja (2004) emphasise that the categorisation of disciplinary cultures may apply well to mature and established fields, but it is not necessarily valid for new, emerging fields. Communication and collaboration between scholars across disciplines is on the increase, and interdisciplinary research is becoming increasingly typical (e.g. Palmer 1999). The basic fields differ from new, thematic, often multidisciplinary, transdisciplinary or interdisciplinary research fields, which disengage from the basic field, exist between or beyond several fields, bring together knowledge from several fields by merging, fusing or connecting them, and often derive from societal or practical needs. These new fields have no stable place, either in knowledge categories or in institutions (Palmer 1999). Palmer (1999) presents two examples of such hybridisations: cognitive psychology is a conglomeration of social, physiological and political psychology, behavioural pharmacology and cognitive science; biophysics integrates theoretical physics with biological studies. Within the same disciplines or even specialisms, academic cultures may also depend on different institutional, historical or geographical contexts, for example (e.g. Becher 1989).

3 Bibliometrics and the assessment of research performance

In most academic fields, research findings are principally communicated and verified through publication. Therefore quantitative indicators of publishing activity, research collaboration and publications' impact are widely used as a measure when assessing research performance. These indicators are the core research subject in the research area of bibliometrics, that is, the statistical analysis of scientific publications and citations.

3.1 Bibliometrics as a research field

The first famous bibliometric study came as early as 1926, when Alfred J. Lotka introduced his study of the frequency of publications by authors, later known as Lotka's law. Lotka found that the number of authors producing n publications is $1/nk$ of those producing one publication (where k depends on e.g. the field of science, being often close to 2). The term bibliometrics was first used by Alain Pritchard who described it as 'the application of mathematical and statistical methods to books and other media of communication' (Pritchard 1969, 349). Nowadays it is often used as a synonym for *scientometrics*. Scientometrics is a translation of the Russian term *naukometrija*, originally introduced by Nalimov and Mulchenko (1969) to refer to 'the application of those quantitative methods which are dealing with the analysis of science viewed as an information process' (cited by Glänzel 2003). Nowadays, bibliometrics particularly refers to the statistical analysis of scientific literature. The more general term informetrics deals with all aspects of the quantitative study of information more broadly: not only bibliometrics, but also the quantitative aspects of information retrieval, cybermetrics and webometrics (Glänzel 2003; Hammarfelt 2012).

In his book *Little science, big science* (1963), Derek J. de Solla Price presented ideas which have been regarded as revolutionary for the development of bibliometrics and scientometrics. Price characterised the transition from 'little science' to modern 'big science' by the exponential growth both in the number of scientists and scientific publications and in the increasing specialisation of science. What is more, in his book he introduced the idea of applying the quantitative methods of science to science itself,

that is, measuring, generalising, making hypotheses and deriving conclusions (Price 1963). It has been argued that Price's ideas laid the foundation for the quantitative analysis of science (e.g. Merton & Garfield 1986; Glänzel 2003).

Bibliometrics as a research field expanded greatly after Eugene Garfield created the Science Citation Index, an international database for scientific publications, launched by the Institute for Scientific Information (ISI) in 1964. The Social Science Citation Index followed in 1970, and the Arts and Humanities Citation Index in 1975. These three citation indexes were primarily designed for the purposes of information retrieval and the dissemination of research outputs. However, they have significantly promoted the development of bibliometric research by enabling the use of larger datasets of publications, and by linking publications to each other via citations and thus created 'a fundamentally new representation of science' (Wouters 1999, 5). Later, the development of information technology and computer sciences enabled the rapid development of bibliometrics, especially from the 1990s onwards, when the first online version of the ISI's databases was launched and provided access to large-scale bibliometric data for a wider group of users.

Wolfgang Glänzel (2003) distinguishes three levels of aggregation in bibliometric analysis which affect the choice of methodology and data: 1) the micro level, which concerns individual scholars and research groups; 2) the meso level, which refers to institutions or scientific journals; 3) the macro level, which places regions and countries under scrutiny. Glänzel (2003) offers another typology of the three main target audiences of bibliometric studies, which also frames the three sub-areas of the current bibliometric research:

1. *Bibliometrics for bibliometricians* refers to methodologically and mathematically oriented basic research.
2. *Bibliometric research for scientific disciplines* concerns the development and structure of scientific disciplines. This domain is of special concern among researchers whose interests are usually related to their own specialism.
3. *Bibliometrics for science policy and management* focuses on national, regional and institutional structures of the sciences and their comparison.

Glänzel (2003) considers the last domain the most important. In 1978 Francis Narin introduced the concept of *evaluative bibliometrics* by analysing the development of research performance at the level of institutions. The first well-known application of bibliometric indicators to the evaluation of research groups was conducted by Martin

and Irvine (1983). Since then the use of bibliometrics in research evaluation in national science policy, research administration, management and decision-making has increased heavily. This development has created some challenges for bibliometrics as a research field. Bibliometrics is facing a demand for 'transforming something intangible (scientific quality) into a manageable entity' (Wallin 2005, 261). Wouters (1999) points out that this demand on the part of scientific policymakers has created a new type of professional expert, the scientometrician, who measures science scientifically. Gläsel and Laudel (2007) argue that the rapidly increasing use of one method of evaluation, particularly bibliometric evaluation, comes at the cost of validity and reliability. Bibliometric databases nowadays provide easy access to an unlimited quantity of data. The design of the study and the choice of data and methodology, however, influence the results of bibliometric analysis. The use of appropriate methods and interpretations of results of bibliometric analyses requires a knowledge and understanding of both methodology and context. However, these are often ignored when bibliometric data are used as a basis of decision-making or political discussion. (Wallin 2005; Gläsel & Laudel 2007; Hammarfelt 2012.) What is more, just as representations of scientific knowledge are socially constructed, so bibliometric research also makes its own construction of the reality of science (Wouters 1999; Gläser & Laudel 2007).

3.2 Bibliometric data sources

Since the establishment of the Science Citation Index (SCI) in the 1960s, bibliometric research has greatly increased. Since the 1990s various other databases providing data on scientific publications have been developed for different purposes. During the last 10 years, the development of national and institutional databases in particular has been rapid, and they have been implemented by more and more countries and research organisations. This subsection presents some of the relevant sources of data for bibliometric research.

3.2.1 Citation index databases

The three databases, the Science Citation Index (SCI), the Social Science Citation Index (SSCI) and the Arts and Humanities Citation Index (A&HCI), currently provided by Thomson Reuters (formerly Thomson Scientific, formerly the Institute for Scientific Information) are the most widely used citation indexing databases. Web of

Science (WoS) is a search engine which compiles these three databases and has been available on the Internet to subscribers since 1997.

WoS contains standard information on publications and their citations in approximately 12,000 international scientific journals. In addition to its comprehensive coverage of all papers published in these journals, WoS also includes cited references from all these documents, which makes it possible to analyse citation impacts and to map co-citation networks of publications. WoS covers journals from all disciplines. However, the three databases give only a partial view of scientific publishing activities, since it does not include national publications, books or non-scholarly material. Therefore the coverage of WoS varies widely by discipline. The data give the most comprehensive coverage of publications in the natural and medical sciences, but account for only a small fraction of publications in the humanities and social sciences, where publishing is equally or even more oriented towards national publications and books (e.g. Moed 2005). Table 2 shows that this applies to Finnish universities' publications as well. Of all of the publications in the medical sciences produced by eight Finnish universities in 2010, WoS-indexed documents account for 60 per cent, whereas the corresponding figure is nine per cent for the social sciences and only four per cent for the humanities (Table 2). In 2010 Thomson Reuters also launched the Book Citation Index (BKCI) as part of WoS, indexing approximately 30,000 books and 380,000 book chapters. At this stage, however, the BKCI is biased towards commercial and English-language domains, and a variety of important publishers are absent. (Leydesdorff & Welt 2012; Torres-Salinas et al. 2012.)

WoS does not only exclude non-English or non-journal material. The analysis by Moed (2005, 124) showed that 19 per cent of the references in WoS-indexed papers were to journal literature which was not indexed by WoS. In a working group assigned by the Ministry of Education and Culture (Ministry of Education and Culture 2011), we found that Finnish universities' publishing patterns suggest that there are plenty of English-language journals that are disregarded by WoS: one third of Finnish universities' contributions to English-language journals were not to be found in WoS, this figure becoming much higher in the social sciences and humanities (Table 2).

The two proceedings citation databases, the Conference Proceedings Citation Index-Science and the Conference Proceedings Citation Index-Social Science & Humanities, include proceedings from 1990. These two databases were merged into WoS in 2008.

(Bar-Ilan 2010.) In engineering, where conference proceedings dominate, coverage by WoS is still only moderate (see Table 2).

Table 2. Coverage by WoS of different disciplinary groups in Finnish universities.

	All scientific publications*		English-language journal articles	
	Number of publications	% in WoS**	Number of publications	% in WoS**
Natural sciences (incl. agriculture and forestry)	4,558	44%	2,746	72%
Engineering	1,543	23%	545	65%
Medical sciences	2,856	60%	2,243	77%
Social sciences	3,108	9%	787	35%
Humanities	2,336	4%	349	26%
Total	14,401	31%	6,670	67%

Data source: Finnish publications in WoS, and eight Finnish universities' publication registers, in 2010 (Ministry of Education and Culture 2011).

*Articles in scientific journals, conference proceedings and edited books, and scientific monographs.

**WoS publications include all publications in the SCI, SSCI and A&HCI databases that were identified in the data reported by the eight Finnish universities under scrutiny.

For a long time, WoS was the major source for bibliometric analyses. In 2004 the publishing company Elsevier launched its own citation index database, Scopus. Elsevier's Scopus database is to some extent more comprehensive than WoS, and it covers a wider range of journals. Falagas et al. (2008) found that Scopus offers about 20 per cent more coverage for citation analysis than WoS, but it only includes publications from 1966 onwards and its citation data are limited to publications from 1996 onwards, whereas WoS goes back to 1900 (Falagas et al. 2008). Scopus has better coverage in the field of engineering in particular, but in the social sciences and humanities its coverage is weak. In addition to scientific journals, Scopus also indexes books and conference papers (Jacso 2005).

Both WoS and Scopus are available in online versions which offer access to subscribers, usually through academic institutions or libraries. These online versions, however, provide only limited opportunities for bibliometric analyses. Therefore many organisations such as ministries, national funding agencies, research councils or single research organisations have secured contracts to access the raw data, including all the metadata indexed in these databases.

Besides the multidisciplinary WoS and Scopus, several specialist databases, such as PubMed (medicine and the biomedical sciences), Chemical Abstracts, Mathematical

Reviews, the ACM Digital Library (computer sciences) and CiteSeer (computer and information sciences), are available online, and most of them provide free access to bibliometric data in their particular field.

3.2.2 Google Scholar

Google Scholar is a web search engine introduced by Google, Inc. It searches for 'scholarly literature' on the web, that is, articles, theses, books, abstracts and court opinions (Google 2014). Google Scholar is used in the same way as most other web search engines. A search word or phrase is typed into a search field, and the engine returns a set of 'hits', web pages or related documents. Google Scholar differs from other search engines in that it is designed to find scientific content. The data in Google Scholar are obtained from academic publishers, professional societies, online repositories, universities and other websites (Google 2014). An individual search result gives bibliographical information on the publication or scholarly document, the number of articles citing the document in question, a link to the document if it is online, links to documents that relate to the same topic, and links to a web search for the document.

Compared to WoS and Scopus, Google Scholar is clearly more comprehensive in terms of different publication types. Google Scholar includes a wider range of journals, conferences, books and book articles, including in languages other than English. It also includes data on citations received by the publications. Google Scholar's other advantage is that it is freely available. The quality of the data is poor, however, in that Google Scholar does not separate out non-scientific material, such as seminar presentations or working papers, from scientific literature. The number of publications is not known, because Google does not reveal the inclusion criteria or the sources from which it gets its publication data. In theory, Google Scholar includes all scientific papers in electronic sources. The major restriction on large-scale citation analyses of Google Scholar data is that the cleaning of the data is very time-consuming because of the way search results are displayed and the limited downloading capabilities (Meho & Yang 2007). Google Scholar is suitable for analysing publication and citation counts for journals and individual researchers, but organisation- or country-level comparisons are not possible because Google Scholar does not enable searches based on authors' affiliations.

3.2.3 National publication databases

Many universities and other research organisations maintain their own publication registers, but until recently the various national research assessments at both national and international levels have lacked representative data on publications from whole countries, because comprehensive data on all publication types have been poorly available. The situation has improved remarkably now that several countries are developing tools to compile exhaustive and reliable data on their publications in order to produce a valid information basis for policymaking. The coverage of these databases, however, varies in terms of disciplines and organisations, as well as in relation to the types of research output collected.

The Finnish Ministry of Education and Culture has adopted a decentralised data collection model, in which higher-education institutions maintain their own local Current Research Information Systems (CRIS systems). Finnish universities have collected data on their own publications and reported them to the Ministry since 1994. Until 2010 only publication counts were reported, and only summary statistics on the universities' publications were available. Since 2011 bibliographic data on the publications have also been harvested from the local systems and stored in a common research database. Besides international and national scientific articles and books, the current data also include non-scholarly publications produced by scholars in higher-education institutions. The data are open to public browsing on the national publications portal. So far, data collection in Finland has been limited to universities and polytechnics, whereas in Norway, for example, the publications database was extended in 2011 to cover the whole public research system, including research institutes and the health sector (Cristin 2014).

National publication databases open up new opportunities for bibliometric research, since they provide better coverage of various types of publishing in different disciplines than the widely used WoS and Scopus. They do not, however, allow analysis of the scientific impact of publications, because they do not usually include data on citations. Furthermore, since the coverage of the universities' registers is usually based on the researchers' own reporting activity, they cannot be expected to have complete lists of publications. In Finland the universities collect publication data using different methods and systems, and the quality of such data varies. International comparisons

have so far not been possible, due to the varying inclusion criteria and classifications of publications in the national databases.

3.3 Bibliometric indicators of research performance

Peer review is often applied when evaluating the quality of individual publications, researchers or research groups, for example in research grant decisions and appointments. Nevertheless, for larger units such as universities or countries, expert-based assessment is often too burdensome and expensive. Peer review is also subject to certain shortcomings, such as the subjectivity of the experts, conflicts of interest, lack of awareness, or a bias against younger scholars (van Raan 2003). Therefore there is a demand for quantitative indicators of research quality. It has often been argued that bibliometric indicators have their own shortcomings and cannot replace qualitative judgment (e.g. Wallin 2005; van Raan 2005). They can, however, provide a supplementary tool alongside peer review for decision-making and priority-setting in science policy, since their use 'forces the experts to rethink their judgments and it provides challenging new insights' (van Raan 2003, 21). Van Raan (2005) distinguishes two major roles for bibliometric indicators: 1) to describe the recent past in order to predict the future, and 2) to test theories and models of scientific development and its interaction with society. Therefore the indicators act as tools not only for science policy, but for science studies as well.

In this subsection, three types of bibliometric indicators are presented: indicators of publication activity, which are based on publication counts; citation indicators, based on the number of citations received by publications; and collaboration indicators, based on the frequency of co-publication and the number of authors. In the research area of bibliometrics, a wide variety of other indicators have also been developed, such as journal impact measures. Another important research methodology in bibliometrics is citation network mapping, which is used for example to analyse the relationships established by co-citations when two articles are cited by the same publication, or by bibliographic coupling when two articles cite the same publication (Small 1973). These journal indicators and co-citation mapping methods will be left aside here, since they are outside the scope of this study.

3.3.1 Indicators of publishing activity

In general, bibliometric indicators of publishing activity measure the number of publications published by a unit or scholar in a given period of time (e. g. Glänzel 2008). The suitable methodology depends on the level of aggregation, the scientific fields under scrutiny and the data used. The aggregation level can be either institutional (individual scholars, research groups, faculties, universities or countries) or disciplinary (scientific fields or disciplinary groups). Publishing productivity is heavily dependent on the abovementioned choices of method: which data are used, which publication types are involved, how they are weighted, and how co-publications by several units are treated.

The status and importance of different types of publication vary between disciplines. In many areas of the natural and medical sciences, articles in international refereed journals, often indexed by WoS, are the primary channel for publishing research results, and thus they cover most of the output. On the other hand, the majority of research outcomes in the social sciences and humanities lie beyond journal articles (see Chapter 5 for more detail). Different types of articles and books differ in terms of scope, length and workload. There is no consensus on standard methods for considering different publication types. Earlier studies have tried to weight monographs relative to journal articles on the basis of either expert judgment or intuition, and they report inconsistent results as to how different publication types should be weighted in different disciplines. Estimates of how many articles equal a monograph vary remarkably, from three to as many as 18 (e.g. Finkenstaedt 1990; Kyvik 1991; Clemens et al. 1995; Moed et al. 2002; Puuska & Miettinen 2008).

The two main counting schemes used in the calculation of co-publications between units are *whole counting* and *fractional counting* (see Glänzel 2003; Gauffriau & Larsen 2005). Whole counting gives full credit for a publication to all of its contributing units (authors, institutions, countries or fields), regardless of the number of units involved. In fractionalised counting, on the other hand, the credit for a publication is divided by the number of contributing units: if n units have contributed to the paper, each of them is assigned the value $1/n$. The publication can also be fractionalised in terms of the number of authors contributing from each unit. The whole counting method is non-additive, since publication counts from the lower level of aggregation (e.g. universities) do not add up those at the higher level (e.g. countries). Fractional

counting is an additive form of publication count, but it does not describe the actual number of publications produced by a unit. Furthermore, the viability of a particular counting scheme depends largely on the data used, since fractionalisation requires information on the number of authors and their affiliations. For example, WoS lists the contributing organisations for all papers, but the authors are linked to organisations only for publications since 2008; thus fractional counting based on the number of authors in each organisation is not possible with older data. (See Glänzel 2003; Ministry of Education and Culture 2012.) Local or national publication registers do not necessarily include authors' affiliations, especially with external or foreign organisations.

3.3.2 Indicators of citation impact

Indicators based on citations received by publications are often used as quantitative measures of research performance. Although there is evidence that citation indicators correlate at least moderately with results from peer-based evaluations (e.g. Aksnes & Taxt 2004; van Raan 2006;), their validity as a measure of quality is widely criticised. Bibliometricians are unanimous that citations should be used as an indicator of the impact (van Raan 1996) or reception (Glänzel 2008) of a publication, not of its quality. The latter should be reviewed by peers, while citation indicators can act as a supplementary tool for peer-based evaluation (van Raan, 1996). It must also be noted that the impact measured by citations particularly refers to the publication's international scientific influence, and that citation analyses do not capture societal impact well (e.g. Wallin 2005).

The view that a high citation count can be used as a measure of some aspects of research quality is often justified by the assumption that high-quality contributions are more likely to be used by others 'both to build upon and to extend', and that a more widely cited publication is more likely to have a greater input into subsequent research than a less-cited publication (Lindsey 1988). There are certain advantages of citation measures over peer-based assessments: citation counts are to some extent objective and hard to manipulate, since the research is assessed by the whole research community rather than being limited to the personal knowledge of a few peers (e.g. Lindsey 1988; Weingart 2005).

Citation counts are, nevertheless, subject to well-known flaws. Glänzel (2008) states that the low frequency of citations does not reveal anything about the quality of a

publication or the standing of its authors. Moreover, papers subjected to negative criticism or providing erroneous results may be highly cited simply because they provoke criticism (Lindsey 1988; Glänzel 2003). It has been argued that citation-based indicators favour mainstream research and dominant paradigms (Lindsey 1988; Weingart 2005). Lindsey (1988) goes on to say that publications that identify their methodology accumulate a large number of citations, even though they are not necessarily of the highest quality. On the other hand, research on a very complex or specialised subject may gain fewer citations because there are not many potential citers (Lindsey 1988; Weingart 2005).

The distribution of citations is extremely skewed. Most papers are cited rarely, whereas a few papers can gain even thousands of citations. Merton (1973) proposed the idea of the 'Matthew effect' in science as a form of cumulative advantage. The Matthew effect refers to the over-recognition of already recognised scholars within the scientific community. With regard to individual publications, citations tend to cumulate, and recognition adds further recognition: success in terms of citation impact improves a scholar's standing, and conversely the publications of highly reputable scholars gain more citations. Citation distribution is often skewed even for articles written by the same author (Seglen 1992).

Citing behaviour varies widely across scientific fields, specialisms and journals. Citing habits also vary according to personal traits. (Wouters 1999; Glänzel 2003) The increasing use of citation indicators in research assessments has led sociologists of science to seek a theoretical foundation for bibliometrics (e.g. Leydesdorff & Amsterdamska 1990; Luukkonen 1997; Wouters 1999). A wide variety of theories of citation have been presented. Glänzel (2008), Moed (2005) and Kärki and Kortelainen (1996) list a range of interpretations of the aspects of research that citations measure. For example, citing is referred to as 'concept symbols' (Small, 1978), 'a part of the reward system of science' (Kaplan 1965, Merton, 1973), 'a proxy of more direct measurements of intellectual influence' (Zuckerman, 1987), 'only secondarily a reward system but primarily a rhetorical system of science' (Cozzens, 1989), and 'a formalized account of the information use and a strong indicator of reception' (Glänzel & Schoepflin 1995). Leydesdorff (1990) argues that distinct theoretical perspectives also arise according to whether citations are understood as links between texts, between authors, or between authors and texts. Van Raan (1998) criticises the craving for a citation theory by arguing that all citation theories have strong limitations in explaining the phenomena.

The basic citation-based measure is the mean citation rate per publication (Glänzel 2003). This method is applied for example in the calculation of the widely used Journal Impact Factor (JIF), which measures the citation impact of journals indexed by WoS. The JIF of a journal in a given year is calculated by comparing the number of articles published in the journal in the two previous years to the number of citations received by them in that year. Citation counts, however, depend on various factors, and therefore the citation counts of two publications are not straightforwardly comparable. Glänzel (2003) lists factors that influence the citation impact of a single paper: 1) the subject matter, 2) the paper's age, 3) the author's or journal's social status, 4) the document type, and 5) the observation period. The lengths of reference lists vary greatly between scientific disciplines and even specialisms (Cozzens 1985; Moed et al. 1995). There are also differences in citation impact between theoretical/empirical and basic/applied contributions. Document types also differ: review articles cumulate more citations on average than original research articles. (Glänzel 2003.)

Older papers have had more time to gain citations than recent ones, and therefore contributions from different years are not comparable. A fixed citation window takes into account citations only from a fixed period, for example three or six years after the publication year. An open citation window, in which the cumulation period for citations is not limited and all citations after the year of publication are taken into account, is more subject to distributional effects, but gives better coverage of the citations cumulated by publications. Moreover, scientific fields differ greatly in terms of the ageing rate of publications (Glänzel & Schoepflin 1995). Macro-level citation analyses (countries or institutions) often include publications from different scientific fields, from different years, and of different document types. Different normalisation methods have been developed in order to control for the abovementioned differences in citation patterns. For example, the widely used crown indicator (Moed et al. 1995) and its variants (e.g. Lundberg 2007) normalise the citation count of a publication or a group of publications in relation to publications from the same year in the same subject area and of the same document type.

So far there is no consensus on standardised methods in the research field of bibliometrics, but rather an ongoing debate about methodology, for example on normalisation methods (Moed et al. 1995; Lundberg 2007 Opthof & Leydesdorff 2010; Waltman et al. 2011), the appropriate length of citation window (e.g. Glänzel & Schopflin 1995; Luwel & Moed 1998; Glänzel et al. 2003), the processing of authors'

self-citations (van Raan 1998; Aksnes 2003; Thijs & Glänzel 2006), and how to deal with the skew citation distributions (Katz 2002; Glänzel 2003; van Raan 2006).

3.3.3 Indicators of research collaboration

In bibliometrics, research collaboration is often measured by indicators based on the co-authorship of publications. Co-authorship reflects only certain types of collaboration. Laudel (2001) interviewed scholars in biology, chemistry and physics, and found that half of collaborations between researchers did not lead to formal communications, namely co-authorship or acknowledgements. Van Raan (1998) considers that co-publications 'function as symbols or evidence of collaboration' and that they give 'an interesting representation of important aspects of international collaboration, such as the results in terms of concrete output'. Glänzel and Schubert (2001) argue that since non-rewarded collaboration is significantly more common in intra-organisational or intra-group collaboration than in extramural collaboration (see Laudel 2001), collaboration at the extramural level can be reflected in co-authorship and can be analysed by using bibliometric methods based on co-authorship patterns.

In bibliometrics, co-publishing patterns can be explored at various aggregation levels: of individual authors, at the domestic inter-organisational level, between sectors (universities, other public research organisations and commercial companies) and internationally (Glänzel & Schubert 2001; Muhonen et al. 2012). Several studies have shown that co-publishing has increased rapidly at all levels (Narin et al. 1991; Katz & Hicks 1997; van Raan 1998, Glänzel & Schubert 2001; Schmoch & Schubert 2008; Sooryamoorthy 2009; Gunnarsson 2011; Muhonen et al. 2012). International co-publications are cited more often than publications authored by scientists from one country only; domestic inter-organisational collaboration also increases citation rates compared to articles published by authors from one organisation (Katz & Hicks 1997; van Raan 1998; Persson et al. 2004; Sooryamoorthy 2009; Must 2012).

The number of authors has a positive influence on the number of citations received by a publication (Baldi 1998; Goldfinch et al. 2003; Hsu & Huang 2011). Goldfinch et al. (2003) argue that co-publication allows access to a larger social network, leading to increased visibility which in turn is reflected in higher citation rates. The causal relationship can also work in the opposite direction: highly cited researchers and research groups are more attractive as collaborative partners (see also Schmoch & Schubert 2008). There is, however, a lack of research exploring whether the higher

citation rates of international co-publications can be explained by the higher average numbers of authors of these publications.

Co-publishing patterns vary significantly between scientific fields (see subsection 4.4). They are also heavily influenced by linguistic, cultural, political and geopolitical factors, as well as by bilateral or multilateral agreements between countries or institutions (Frame & Carpenter 1979; Schubert & Braun 1990; Larivière et al. 2006; Must 2012). For example, the scientific size of a nation determines its need for international collaboration. It has been shown that small countries are more active in international collaboration, and the proportion of international co-publications is bigger in their overall scientific output than in large countries (an Raan 1997; Glänzel 2001). Countries with lower degrees of material and intellectual resources are more likely to look for research partners outside their national borders than resource-rich countries (Frame & Carpenter 1979; Schubert & Braun 1990; Luukkonen et al. 1993). Small countries such as Finland have fewer opportunities to find collaborators inside their own country when compared to larger countries, and they have a greater need for research partners from other countries (see Narin et al. 1990). Differences in international collaboration patterns across countries can also be explained by their location at either the scientific centre or the periphery. Goldfinch and colleagues (2003) found that countries at the scientific periphery benefit from international collaboration, while domestic collaborations between institutions in these countries have a negative correlation with citation rates (see also Schubert & Sooryamoorthy 2010).

4 Publishing patterns in different disciplines

In almost all scientific fields, publications are the most important method of communication. It is by publishing that research results are made public and the scientific community is enabled to assess the quality of other scholars' research. Through publication researchers are involved in the development of their field and can take advantage of one another's results. By publishing researchers also gain ownership of their own research results. Publications have also played an important role in the reward system of science, in employment processes and in gaining merit, even before the advent of performance-based indicators as a tool of policymaking. Merton (1979) states: 'Since recognition by qualified peers is the basic form of extrinsic reward (all other extrinsic rewards deriving from it) and since that reward can be accorded only when the work is made known, this historically evolving reward system provides institutionalized incentive for open publication without direct financial reward.'

This chapter explores the following five perspectives on disciplinary differences in publishing patterns:

1. Different types of publications aimed at an academic audience;
2. National and international publishing;
3. Non-scholarly publishing;
4. Co-authored and single-authored publications;
5. Publishing productivity.

In this chapter, disciplines' publishing patterns are demonstrated by reviewing results of earlier research in other countries as well as publications data from Finnish universities in 2011–2012 (see the description of the data in Appendix I). In addition, this chapter presents some of the observations made in our previous report (Puuska & Miettinen 2008), which were based on the views of Finnish professors whom we interviewed in 2007 about publishing patterns in their fields.¹

¹ In semi-structured interviews, 44 professors from nine Finnish universities were asked about the features of their subfield: working methods, typical types of publication, workload involved

4.1 Publication types aimed at an academic audience

For the purposes of this study, publications aimed at an academic audience are defined as those publication types for which the readership mainly consists of academic colleagues. These publications are classified into four main categories: 1) articles in scientific journals, 2) scientific monographs, 3) articles or chapters in edited scientific books, and 4) articles in scientific conference proceedings. Naturally, these publications are often followed by a more general audience as well.

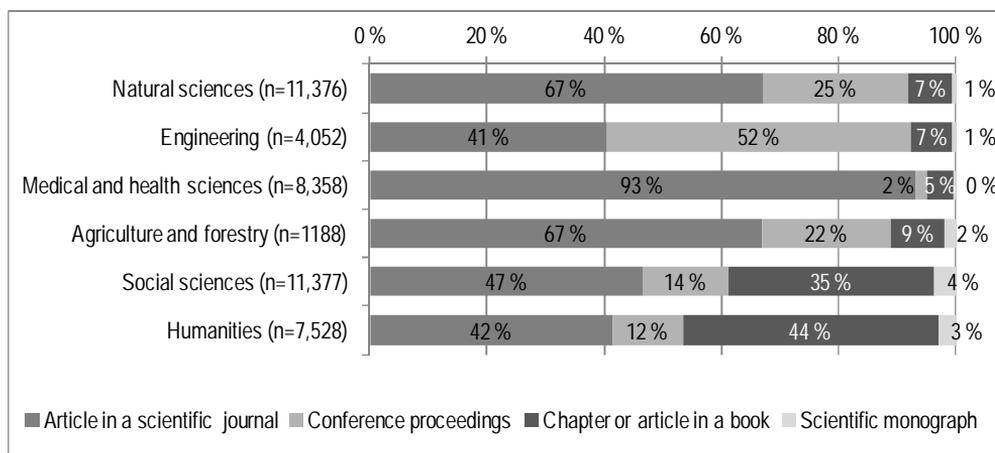


Figure 1. Percentages of different types of scholarly publication by disciplinary group in Finnish universities in 2011–2012 (see description of data in Appendix I).

Most fields in the medical and natural sciences have homogenised and established publishing patterns which are primarily regulated by the academic community itself. The dominance of one publication type, namely articles in international scientific journals, is a distinctive feature of these disciplinary groups. Among other disciplinary groups, publishing activity is more divergent and the norms of publishing are looser. In the subfields of engineering, social sciences and humanities, publishing behaviour and

in different types of publication, characteristics and measures of quality in publications, and recent changes in publication practices. The interviews were conducted in 2007 as part of a research project on 'Disciplinary differences in publishing practices', and the results are reported more precisely in *Publishing practices in different disciplines* (Puuska & Miettinen 2008).

the status of different publication types are more diverse (Puuska & Miettinen 2008). Hicks (2004) points out four literatures in the social sciences, each of which serves a different purpose: 1) journal articles, 2) books, 3) national literatures and 4) non-scholarly literatures. High publishing activity in conference proceedings is characteristic of the field of engineering (Puuska & Miettinen 2008).

In Finnish universities in 2011–2012, articles in journals account for 93 per cent of scholarly publications in the medical and health sciences, and 67 per cent in the natural sciences, agriculture and forestry (Figure 1). In the social sciences and humanities, they account for less than half of the total scholarly publication output, with chapters in books and monographs being even more common in the humanities. In engineering, papers in conference proceedings account for more than half of publication output. Parallel results on the orientation of different disciplines to different publication types have been obtained in various previous empirical studies in different countries. They attest to the validity of the insight that articles in scientific journals dominate the publishing pattern in the hard sciences, whereas books and book articles are more typical in most of the soft fields (e.g. Pestana et al. 1995; Bourke & Butler 1996; Kyvik 2003; Huang & Chang 2008; Engels et al. 2012).

Earlier research on the distribution of publication types has been either based on surveys or limited to selected disciplines. There are, however, comparative studies with comprehensive data from Norway and Australia, which have recorded data on their universities' publications for a longer period. By analysing the total scientific output of more than 11,000 Norwegian scholars in 2005–2008, Piro et al. (2013) found that journal articles account for 93 per cent of publications in medicine and 89 per cent in the natural sciences. The corresponding percentages are 49 per cent in the social sciences and 39 per cent in the humanities. The percentage of monographs is as high as 24 per cent in the humanities and 20 per cent in the social sciences. Butler (2008) differentiates four groups of fields in Australian universities based on their publication output distribution in 1999–2001. The first group includes fields (chemical, biological, physical, medical and health sciences) which are highly oriented to journal publishing, which accounts for more than 90 per cent of their total publication output. The group at the other extreme includes fields (human society, politics and policy, computing, history, management, language, education, the arts, architecture, law, journalism and library studies) which are poorly covered in WoS, and their publishing is oriented to other publication types. The percentage of books is highest in the field of history (12 per cent). Book chapters are most typical in the fields of politics and policy (37 per

cent) and languages and history (34 per cent in both). The figures cannot, however, be straightforwardly compared between countries, due to different definitions of the types of publications and different delineations of disciplinary groups.

Our interviews with Finnish professors in the natural and medical sciences (Puuska & Miettinen 2008) indicate that the international journal article is the best channel through which to contribute to scientific discussion and development in these disciplinary groups. The interviewees explained the dominance of the journal article in terms of historical tradition, its suitability in form and length, and its high prestige within the scientific community. Especially in the medical sciences, the number of articles in high-impact scientific journals has become a standardised measure of research performance, and it is widely used as a criterion for recruitment and research funding. In these fields, monographs and edited books have a different function: they collect together results on a certain research topic, while the original results are published in journals (see also Kyvik 1991, 72). The natural sciences are, however, heterogeneous in this sense. For example, mathematics and cultural geography are exceptions, with a high frequency of books (Puuska & Miettinen 2008).

In the humanities, the dominance of books over journals can be partly explained by their suitability for reaching not only scholarly colleagues but also another important audience, the non-scholarly public (Nederhof 2006; Hammarfelt 2012). Nonetheless, although books still play a significant role in the social sciences and humanities, the Finnish professors we interviewed were of the opinion that journal articles are taking over from monographs (Puuska & Miettinen 2008). Even though the interviewees underscored the significance of scientific monographs, they argued that research work has become shorter term, and hence time-consuming monographs have become rarer. According to them, this is mostly due to external factors, such as a recruitment policy which emphasises publishing in international journals. Some studies have reported that the crisis of the scholarly monograph in the humanities derives from the fact that libraries' financial resources are increasingly directed to the purchase of serial publications and electronic resources (see Thompson 2000). Kyvik (2003) found no evidence of the extinction of monograph publishing: the percentage of books remained stable among Norwegian scholars in all disciplinary groups between 1980–2000, while the percentage of articles increased and the percentage of reports declined. Nor did Engels et al. (2012) discover any significant shift away from book publishing in Flanders (the northern part of Belgium): in the humanities, the percentage of journal articles actually slightly declined between 2000 and 2010 (from 78 to 73 per cent),

whereas in the social sciences the percentage of journal articles increased from an already high level (from 90 to 93 per cent), indicating that the publication habits of these two disciplinary groups are diverging.

In engineering, contributions to conference proceedings dominate publishing. Computer science is an example of a discipline where research results are mainly published in proceedings volumes rather than journals (Moed & Visser 2007). Data for 2011–2012 from Finnish universities, where computer science is actually included in the natural sciences, show that conference contributions account for more than half of publication output in other fields of engineering as well (Figure 1). Glänzel et al. (2006) also discovered that about one half of the WoS publications in engineering were covered by the Conference Proceedings Citation Index, and engineering's share of the Proceedings database continuously increased between 1994 and 2002. The national data on universities' publications in Australia for 1999–2001 imply that conference papers account for 45 per cent of scientific publications in engineering and 62 per cent in computer science (Butler 2008). In some specific fields of engineering, especially computer and software sciences and allied fields, the top conferences with low acceptance rates and standardised review practices are rated more highly than journals (see also Ulusoy 1995; Glänzel et al. 2006). This practice is very different from the medical sciences, in which conference papers are not considered real publications, and usually only abstracts are written for conferences (Puuska & Miettinen 2008). Despite the fact that papers in conference proceedings are more common than in journals, most of the professors of engineering we interviewed emphasised the role of international journal articles as the most important channel for contributing to the scientific development of the field, and indicated that usually the most important results are published in journals. These forms of publishing are the most recognised in terms of merit and research funding.

4.2 National and international publishing

Not only is natural and medical sciences publishing highly focused on journals, but those fields' publishing activities are also characterised by a strong international orientation. National publications account for only 10 per cent of Finnish universities' scientific publications in the natural sciences and engineering, and 15 per cent in the medical and health sciences (Figure 2). On the other hand, one half of publications in the social sciences and humanities are published in domestic forums. Figure 2 shows

that Finnish-language publications are rare in the hard sciences. They are also less frequent than foreign-language publications in the social sciences and humanities. A large proportion of scientific publications are currently written in English, which has established its position as the main language in most scientific fields. These cover 93 per cent of non-Finnish-language publications. The humanities fields are an exception: 30 per cent of non-Finnish-language publications are written in a language other than English. Most of these come from the field of linguistics. In Norway in 2005–2009, disciplinary differences in publishing in domestic languages follow a similar pattern: the percentages of domestic-language publications were 55 per cent in the humanities, 50 per cent in the social sciences, 18 per cent in health sciences, and three per cent in both engineering and the natural sciences (Sivertsen & Larsen 2012).

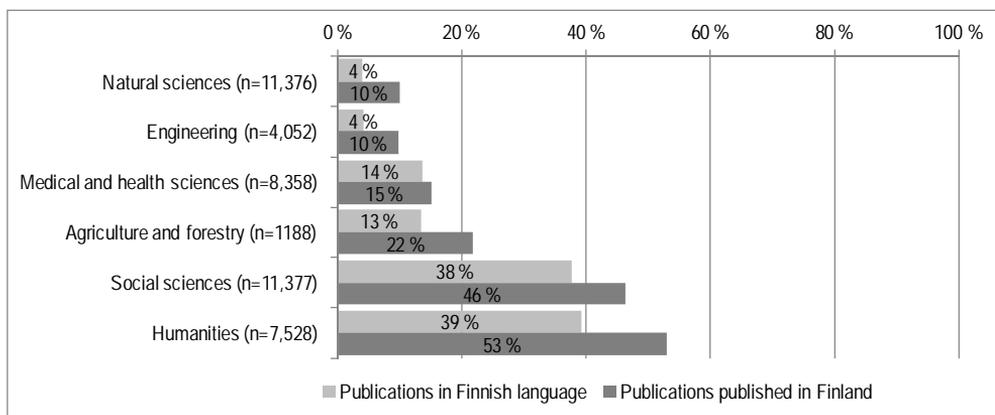


Figure 2. Percentages of Finnish-language and national publications, out of all scholarly publications by disciplinary group in Finnish universities in 2011–2012 (see description of data in Appendix I).

According to our interviews with Finnish professors (Puuska & Miettinen 2008), the high level of internationality in publishing is not questioned among scientists in the natural and medical sciences. For example, in medicine there are only a few refereed national journals, and their purpose is to disseminate research results to other professional audiences, such as medical doctors and others working in healthcare. In the social sciences and humanities, the professors we interviewed argued that through national publications one can reach not only one's colleagues but also policymakers, professionals and laypeople. For example, in education studies, education professionals and policy actors are a central audience. Certain national research topics are of great interest in Finland, but not necessarily abroad. In terms of engineering, publishing in certain fields is completely international, whereas other fields publish almost all their

results in national forums. The different publishing patterns between the fields in engineering cannot be explained by the level of applicability of the results, but more by the audience to which the results are addressed. According to professors in certain fields, the top international journals are also followed by industrial companies. By contrast, scholars in some applied fields, such as construction engineering, publish primarily for the national industry.

As in other non-English-speaking countries, in Finland there has been ongoing debate on the status of domestic languages in science. The nurturing of the Finnish language in scientific writing has been discussed, for example, in the language policy programme of the Institute for the Languages of Finland (Hakulinen et al. 2009). Writing in the Finnish language has been seen to play an important role in establishing Finnish terminology in different fields of scientific research, as well as underpinning the dissemination and popularisation of science. Other arguments supporting scientific publishing in the Finnish language have also been presented: Finnish-language publications have a stronger influence on policymaking and public debate; they are suitable for teaching material; thinking and creative work is easier in one's native tongue; junior researchers can gain publishing experience; and Finnish scientific journals can maintain their high standards (e.g. Setälä 2006; Mäntynen 2013).

There are indications that the percentage of international and English-language publications has especially increased in the soft fields. Kyvik (2003) found that among Norwegian scholars, the proportion of staff with at least one foreign-language publication increased from 65 to 80 per cent between 1980 and 2000. This trend was particularly strong within the humanities and social sciences. Ossenblok et al. (2012) studied publishing in the social sciences and humanities in Norway and Flanders, and found that publishing in English increased in almost all fields of the humanities from 2005 to 2009.

Even though the percentages of domestic publications have decreased because of the remarkable increase in international publishing, there is no evidence that the absolute number of national publications has significantly declined during the past two decades (Figure 3). Nor do the editors of Finnish scientific journals (Mäntynen 2013; Valkonen & Rantanen 2013) support the view that Finnish-language publishing is on the decline. They argue that the supply of article manuscripts has actually increased in Finnish scientific journals. National journals, however, face difficulties in the scientific journal publishing market, which is dominated by international commercial publishers. Finnish

journals are mainly published by non-profit national scientific societies, and their income is heavily dependent on the number of subscribers to those societies, which is tending to decrease.

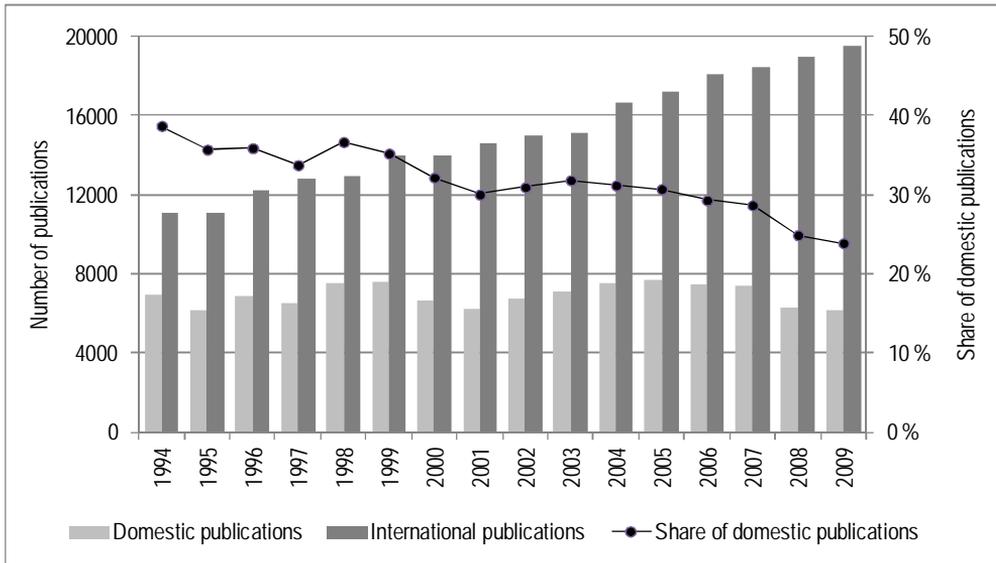


Figure 3. Numbers of domestic and international publications and percentage of domestic publications in Finnish universities, 1994–2009. Source of data: KOTA online database.

4.3 Publishing for non-scholarly audiences

Publicly funded research should benefit society, and the principal purpose of publishing is to transmit research results to the relevant audience. Although this study investigates patterns in the dissemination of research results to non-scholarly audiences, it is still limited to formally published output. The term *bibliometrics* is generally limited to quantitative studies of *scientific communication*, which refers to the dissemination of research results through formal publishing. Scientific communication can be distinguished from *scholarly communication*, which refers to means of communication other than formal publishing, such as informal discussions and presentations. (Kärki & Kortelainen 1996, 7.)

The need for usability determines the form of communication. Publishing in so-called non-scholarly publishing channels, such as research reports, textbooks, articles in professional magazines or newspapers, and popular books, is one means of

dissemination of scientific knowledge to the non-scholarly public (Nederhof & Zwaan 1991). Hicks (2004) distinguishes non-scholarly literature from national scholarly publishing: 'Where national literatures develop knowledge in the context of application, publishing in non-scholarly journals moves knowledge into application.' Besides one's own scientific community, there are also a variety of other audiences who make use of the results of scientific research. Kyvik (2005) refers to Kalleberg's (2000) description of the two roles of scientists who communicate with a general audience: 1) specialists who disseminate knowledge to people outside their own discipline, and 2) intellectuals who contribute to public debate. Based on a survey of heads of departments and research units and on interviews with academics at Finnish universities, Ylijoki et al. (2011) make a distinction between five different research markets, which have different objectives, practices, reference groups and types of research, and which consequently publish the outcomes of their research in different forms:

- The *academic market* is shaped by the academic ethos and ideals. The principal audience is the international scientific community. The emphasis is on basic research, and the aim of the research is to promote scientific knowledge in the field. Academic merit is important. Results are published in scientific journals or books.
- The *corporate market* aims to produce knowledge with economic relevance. The research is principally directed at companies, which also provide funding and are collaborated with. The research outcome might be a commercial application or patent.
- The *policy market* produces and disseminates policy-relevant knowledge to public administration and decision-makers. The research is typically published in the report series of the funding agency.
- The *professional market* aims to develop professional practice and to produce new knowledge, tools and methods for practitioners within a given field. Typical publication types are reports, guidelines and textbooks, and articles in professional journals.
- *Public market*-oriented research contributes to societal discussion and the popularisation of research to civil society. Its publications are, for example, essays, newspaper articles or popular books.

All disciplinary groups operate in several research markets. Because of the typical funding sources, research topics, collaboration partners and target audiences for each disciplinary group, they are all situated differently in terms of these five research markets. The academic market is important to all disciplinary groups, but is especially

crucial in the natural sciences, where funding, partners and choice of topic are linked to the international scientific community more strongly than in other disciplinary groups. The corporate market is characteristic mainly for the field of engineering, which has strong links to companies and where the research topics have commercial relevance. The policy market is most typical in medicine and the social sciences, where the research topics are of great interest to public agencies in healthcare, education and social problems. The professional market is typical of disciplinary groups with a close relationship to a professional field and its practitioners, such as medical doctors, teachers or lawyers. The public market has a secondary role in all disciplinary groups, due to the lack of any funding base which would provide substantial resources for this purpose (Ylijoki et al. 2010).

There is only a little empirical evidence on how much non-scholarly material is published in various disciplinary groups. In a survey of tenured staff members in Norway (Kyvik 2005), respondents were requested to specify their number of popular-science articles and contributions to public debate. The results from the survey showed that the average number of popular-science articles per scholar in the three-year period 1998–2000 varied between disciplinary groups, from 1.1 in technology fields to 2.9 in the humanities. The number of article contributions to public debate per scholar ranged between 0.8 in technology and the natural sciences and 2.2 in the humanities and social sciences. However, productivity was highly skewed and attributed to a small group of scholars: half of the popular-science articles were produced by six per cent of scholars, the corresponding figure as regards public debate contributions being only four per cent (Kyvik 2005).

Figure 4 shows that in Finnish universities in 2011, the social sciences and especially the humanities have the highest percentages of non-scholarly publications out of total publication output. In the humanities, the percentage of publications aimed at the lay public is especially high (23 per cent), while in the social sciences most non-scholarly publications are aimed at a more specific, professional audience. Kyvik (2005) states that the main purpose of research in the humanities is to disseminate knowledge about history, art, literature, and philosophy to the public whereas research in the social sciences aims at producing knowledge about social processes and to stimulate general understanding of complex social phenomena.

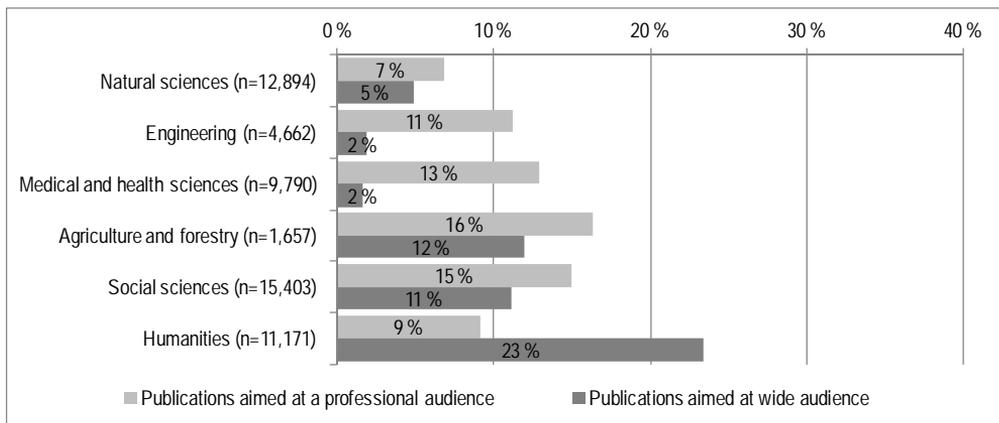


Figure 4. Percentages of non-scholarly publications out of all publications by disciplinary groups in Finnish universities in 2011–2012 (see description of data in Appendix I).

Publications aimed at professional audiences are also published quite frequently in the hard sciences, but popular texts for a wider audience are less common (Figure 4). Kyvik (2005) points out that even though the hard sciences deal with topics of common societal interest, the results are more difficult for non-specialist audiences to understand, and the high degree of codification makes it more difficult to popularise the research results. The Finnish professors we interviewed in the medical and health sciences (Puuska & Miettinen 2008) identified medical doctors and other healthcare practitioners as an important audience for their research, but these usually follow the scholarly journals. The professors interviewed in both the natural and the medical sciences pointed out that researchers themselves do not need to present their results for a non-scholarly audience, since journalists, for example, take care of this type of communication. The media are interested in their research results, and scientists are therefore interviewed in the media. In the social sciences and humanities, the dissemination of results relies more heavily on the researchers themselves. In the social sciences, the interviewees emphasised that through non-scholarly publications they can influence decision-makers and professionals and contribute to public debate on current social issues (Puuska & Miettinen 2008; see also Kyvik 2005). According to interviewees in engineering, professionals are an important audience in fields that are oriented towards national industries such as construction engineering. In these fields, national professional journals, books and reports are published frequently (Puuska & Miettinen 2008). Non-written outputs play an important role in most fields of engineering: research results are transferred to partner companies or other relevant audiences through new technical applications (Puuska & Miettinen 2008).

4.4 Co-publishing

Funding agencies and other science policy instruments increasingly support research collaboration, and group working has thus become more frequent in all scientific fields (Hakala et al. 2003; Puuska & Miettinen 2008; Kaukonen et al. 2009). The need for research collaboration depends on the nature of research in the field and the way the research work is organised. In experimental research, for example, data collection requires a lot of human resources, and the complexity of methods or use of instruments requires several types of expertise (Kyvik 1991.) In these fields, research cooperation also involves using laboratories or exchanging research materials, or the joint acquisition of expensive equipment by research groups (Laudel 2001). Research collaboration is seen as a means of access to better research equipment and technology (Kaukonen et al. 2009).

A study of co-authorship patterns by Larivière et al. (2006) showed that 90 per cent of natural sciences articles indexed in WoS in 2002 had more than one author. The corresponding figure in the social sciences was between 50 and 60 per cent. Over the 23-year period 1980–2002, both the natural and the social sciences showed a steady growth in the proportion of co-authored publications, whereas in the humanities the collaboration rate remained at about 10 per cent. Larivière et al. (2006) also found that international co-authorship patterns vary widely by both disciplinary group and country. The percentage of natural science publications in WoS in 1998–2002 with authors from more than one country varied from 19 to 54 per cent. The corresponding ranges were between nine and 45 per cent in the social sciences, and between two and 17 per cent in the humanities. Over this 23-year period, the natural and social sciences in particular showed a steady growth in the percentage of international co-publications.

In the hard sciences, more than 90 per cent of Finnish universities' scholarly publications in 2011–2012 are co-authored by several scholars (Figure 5). In the social sciences, co-publications account for more than half of publications (58 per cent), but in the humanities single-authored publications still dominate (67 per cent). Correspondingly, Ossenblok et al. (2014) explored the co-authorship of journal articles and book chapters in the social sciences and humanities in Flemish universities in 2000–2010, and found that 81 per cent of these publications were co-authored in the social sciences and 29 per cent in the humanities. They also observed an increase in the proportion of co-authored publications: in the social sciences and humanities the

proportion of single-authored publications fell from 56 per cent in 2000 to 37 per cent in 2010.

The average number of authors of Finnish universities' publications is highest in the medical and health sciences (6.7), whereas in the social sciences and humanities co-publications are usually authored by only two or three scholars, and therefore the average number of authors is only 2.3 in the social sciences and 1.8 in the humanities. These results are well in accordance with results from Norway, where Piro et al. (2013) found that the average number of authors per publication was 5.6 in the natural sciences, 4.3 in technology, 8.3 in medicine, 2.6 in social sciences, and 1.4 in humanities. The small differences probably derive from the different definitions of disciplines and publication types.

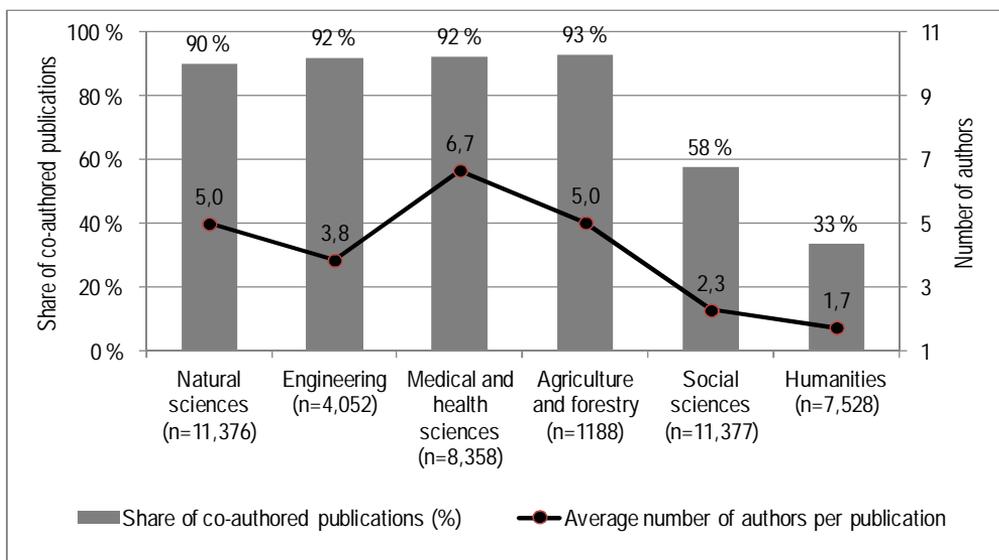


Figure 5. Percentages of co-authored publications out of all scholarly publications and average number of authors by disciplinary groups in Finnish universities in 2011–2012 (see description of data in Appendix I).

The Finnish professors we interviewed in the natural and medical sciences (Puuska & Miettinen 2008) considered collaboration and co-authoring a self-evident part of research. In many cases it would not be possible to conduct the research without specialist experts. The interviewees in experimental fields stated that collaboration even speeds up the research process. In all disciplinary groups, the interviewees were of the opinion that having co-authors increases the quality of publications. In the social

sciences and humanities, the motivation for research collaboration is rather different: the exchange of perspectives and ideas. Even if the research is conducted in collaboration, most publications are still written alone in the humanities. (Puuska & Miettinen 2008.) In a survey of Finnish university unit heads, Kaukonen and his colleagues (2009) found that in the social sciences, collaboration with foreign colleagues is often motivated by international comparative research. In the hard sciences, on the other hand, obtaining international funding and competing successfully with other units in same field were emphasised as the most important reasons for international collaboration. In addition, gaining access to research facilities abroad motivated units in the natural sciences to collaborate with foreign partners.

The interviews with Finnish professors (Puuska & Miettinen 2008) also show different practices in terms of how authors are ordered in the publication's author list and the kind of contribution that authors make to the research. In the medical and natural sciences as well as in psychology, a typical article has one principal author, usually a doctoral student, while the other authors comment on and edit the text. Some of the authors may make contributions other than writing, such as designing the study, or carrying out the data collection or statistical analysis. In many cases these are considered a scientific contribution. The last listed author is usually the group leader or a supervisor, and has an important role in the research. In the humanities, the practice of naming someone as an author even if they have not made a written contribution to the text is not used (Puuska & Miettinen 2008).

4.5 Disciplinary differences in publishing productivity

The status and typicality of different types of publication and co-authoring practices presented in the previous subsections can be linked to differences in productivity. The dominant publication types in the natural and medical sciences, particularly co-authored journal articles, are often less time-consuming per author than the monographs and single-authored articles that are typical of the social sciences and humanities. Disciplinary differences in publishing productivity have been studied very little.

Piro and his colleagues (2013) compared the mean numbers of scientific publications (journal articles, book articles and monographs) produced by Norwegian scholars in different disciplinary groups. They found that when using the whole counting method

(a publication is assigned as a whole to all its authors), the average publication count per scholar in the four-year period 2005–2008 was the highest, 6.2, in the natural sciences. The corresponding mean number of publications by whole counting was 5.3 in medicine, 5.2 in technology, 4.5 in the social sciences, and the lowest, 3.6, in humanities. When applying fractionalised counting (each publication is divided equally between its authors) and using ‘article equivalents’ as the unit of counting (monographs weighted as equal to five articles), Piro et al. (2013) found the opposite ranking of disciplinary groups in terms of productivity. The publication counts in the humanities (3.9) and social sciences (3.2) were substantially higher than in technology (1.8), natural sciences (1.6) and medicine (1.0). These results indicate that the choice of counting method has a significant effect on publishing performance in different disciplinary groups.

4.6 Citation patterns by discipline

Citing practices such as the number of references in reference lists, the typicality of references to the author’s own publications and the use of different types of publication as references (books or non-scholarly material) vary widely by discipline. For example, articles in basic biomedical research are cited six times more often than articles in mathematics (Weingart 2005). Moreover, publications within different fields need different lengths of time to accumulate citations, and they differ in terms of age when they reach peak citation impact. Glänzel and Schoepflin (1995) found that in social sciences and mathematics journals the obsolescence rate of articles is lower than in medical or chemistry journals. Consequently, average citation rates vary significantly by scientific field (see also Moed et al. 1995; Lancho-Barrantes et al. 2010).

The disciplines also differ in terms of the most cited publication types. It has been shown by various previous studies that in the social sciences and humanities, books are on average more highly cited than journals (e.g. Clemens et al. 1995; Bourke et al. 1996; Hammarfelt 2012). In many fields of the humanities, the majority of references in journals are to monographs, even though monographs are less frequent than contributions to journals (Thompson 2002; Knieval & Kellsey 2005; Hammarfelt 2012). As regards computer sciences, Goodrum et al. (2001) found that while the majority of papers are from conference proceedings, the most highly cited publications are books and book chapters, followed closely by journal articles. In addition to disciplinary differences, Leydesdorff (2008) emphasises that citing patterns within

specialisms and fields of science are also heterogeneous and even vary from journal to journal.

Disciplinary differences in citation rates are also affected by geographical factors. Publications which have a national slant may receive fewer citations than publications which deal with universal topics. For example, Finnish WoS publications in the social sciences and humanities are on average less cited compared to the world average in these disciplines, whereas Finnish publications in the hard sciences are more highly cited than the world average (Ministry of Education and Culture 2012). This is possibly partly due to the nature of research in the social sciences, where research topics are often nationally or locally oriented.

5 Distribution of publishing productivity at the level of individual scholars

Cole and Cole (1973) have stated that predetermined differences in productivity capacities deriving from scholars' individual skills and motivation lead to unequal scientific output. An alternative perspective on individual differences has been made famous by Merton (1973). He explained the skewed productivity pattern by the principle of cumulative advantage and the 'Matthew effect', which means that recognition achieved by publishing further increases a scholar's prestige. One's previous reputation leads to success in competition for funding, improved conditions for research work, membership of networks, and better collaboration opportunities. Consequently, the preconditions for further publishing are enhanced. (Merton 1973.) As well as the highly skewed distribution of citations (see subsection 3.3.2), the skewness of scientific productivity is also a well-known phenomenon in bibliometric studies. In all fields, most scholars publish just one or a few papers, while a small group of highly productive scholars produce the field's major output. Lotka's (1926) discovery that only a small fraction of authors produce a high number of publications while a scholar typically publishes only one article has been repeated empirically in numerous successive studies (e.g. Price 1963; Pao 1986; Kyvik 1989).

5.1 Scholars' academic positions and publishing productivity

Higher-ranked scholars receive more encouragement to publish and better publication opportunities. High visibility and impact improves the scholar's chances of cooperation and co-authoring. Co-publishing enables access to larger scholarly networks and in turn leads to a higher impact of co-publications. Therefore scholars in the highest professional positions tend to be the most productive. (E.g. Allison & Stewart 1974; Tien & Blackburn 1996; Carayol & Matt 2006.) Over the course of a career, publishing is facilitated as the scholar becomes more professional and gains better familiarity with the research topic. Moreover, universities often use publishing activity as the major criterion for promotions (Tien & Blackburn 1996). Thus in order to be appointed to a professorship or some other high-level position, one has to have a long list of publications and recognition, which – according to the principle of cumulative advantage (Merton 1973) – adds further publishing opportunities. Tien and Blackburn (1996) call this a selection function. Their findings on productivity differences between scholars in different positions in the academic hierarchy showed evidence of considerably higher productivity among full professors compared to lower positions.

In addition to rank, the scholar's tasks are associated with publishing activity. In universities, teaching is an essential part of scientific work, and in several scholarly positions more time is devoted to teaching than to research. These two tasks can be seen either as complementary or as competitive and segmented by conflicting expectations and obligations (Fox 1992). Marsh and Hattie (2002) reported a zero correlation between the effectiveness of teaching and research. The zero relation is also supported by a meta-analysis of 58 earlier studies (Hattie & Marsh 1996). Fox's (1992) findings support the view that the two activities are mutually incompatible: the most productive individuals are more likely to orient themselves and devote time to research, while an orientation to teaching is not associated with high publishing activity.

In Finland, the composition of academic staff and the organisation of research training have undergone changes during recent decades (Hakala 2009; Ylijoki et al. 2011). While the total number of teaching staff remained fairly stable at around 7,700 labour years per year between 1990 and 2009, research labour years increased from 1,900 to as high as 6,500. Over the same period, the number of professors increased by 24 per cent

(from 1,800 to 2,300). (KOTA online database.) The other noticeable feature in the Finnish university system is the increased number of PhD students, and their high level of representation among academic staff (Hakala 2009). According to Statistics Finland, only 30 per cent of researchers in universities had completed a PhD in 2009. These staff mainly work on externally funded research projects, which have heavily increased (Hakala 2009). Hakala (2009) lists the consequences of this pattern: 1) supervision and support for these students demands more time from senior research staff, 2) senior staff are responsible for applying for funding for the PhD students, and 3) competition for academic posts is harder.

It can be assumed that these features have implications for publishing patterns as well, but so far there is only a little research on the publishing behaviour of staff in different academic positions, especially in terms of different publication types, both in Finland and in other countries. In our earlier study we analysed the publishing patterns of individual scholars (Puuska & Miettinen 2008), and we found that at the University of Helsinki, the biggest university in Finland, the number of all types of publications per number of research labour years decreased between 1998 and 2005, with the decrease particularly pronounced in national publishing. Productivity had declined among professors and full-time researchers, but not among full-time lecturers.

5.2 Age and publishing productivity

There is evidence that although publishing productivity increases with age, it tends to decline at a certain age, usually in the early 40s (e.g. Cole 1979; Kyvik 1990a). Kyvik (1990a) found, however, that in line with the cumulative advantage theory, those with more recognition are more likely to keep publishing frequently with increasing age than those with less recognition. He found no evidence of a decline in productivity with age due to the decreasing utility of publishing for the purposes of money and prestige: although productivity decreases with age in all ranks, professors are still the most productive as they age. Kyvik (1990a) found large disciplinary differences among Norwegian scholars in terms of the age when the scholar's publishing productivity reaches its peak. In the natural sciences productivity steadily decreases as age increases, while in the medical sciences it declines after the age of 55. In the social sciences and humanities, average productivity stays more or less the same regardless of age. One possible explanation is that in the hard fields it is harder to keep up with current

research and to cope with the rapidly developing discipline and technologies than in the soft sciences, where developments are less rapid.

In Finland, the percentage of young researchers has remained pretty stable over the past decades: in 2012 more than half (55 per cent) of researchers at Finnish universities were less than 40 years old, and the percentage had been roughly the same in the early 1990s. The percentage of young researchers among universities' research staff varies greatly between disciplinary groups. In engineering and the natural sciences, researchers under the age of 40 accounted for a large proportion (67 per cent) of Finnish university research staff in 2012, whereas in the humanities only 37 per cent of researchers were under 40. (Statistics Finland 2012.)

5.3 Gender differences in publishing productivity

Various studies have reported evidence of considerably lower publication productivity in women compared to men. Cole and Zuckerman (1984) reviewed more than 50 studies, all of which show evidence of higher publication rates for men compared to women in various time periods and scientific fields, even when age and other attributes are taken into account, and which show that women's publishing productivity is 57 per cent of that of men. Similar results have been repeated in numerous more recent studies (e.g. Kyvik 1990b; Kyvik & Teigen 1996; Zuckerman 1991; Xie & Shauman 1998; Prpić 2002; Fox 2005; Prpić et al. 2009).

Fox (2005) states that equal publication rates do not produce the same rewards for women and men. Rossiter (1993) has presented the principle of cumulative disadvantage, the so-called 'Matilda effect', which refers to the systematic under-recognition of female scholars in the academic world. Based on previous literature, Prpić (2002) identifies five major features which distinguish female scholars from their male counterparts:

1. Less frequent and slower achievement of academic degrees and the highest academic ranks;
2. A lower degree of collegial recognition in terms of prestigious or permanent scholarships and scientific awards;
3. Fewer management, supervisory or other influential positions in academic institutions;

4. Lower participation in the scientific power structure, such as national academies, scientific societies, editorial boards, or science and technology policymaking bodies;
5. Lower average salary (even for the same job).

The effect of gender-differentiated roles in household duties and childcare on the performance of female researchers has been investigated in a number of studies but it seems that the relationship between scientific productivity and marriage or parenthood is complex (e.g. Cole 1979; Luukkonen-Gronow & Stolte-Heiskanen 1983; Cole & Zuckerman 1984; Kyvik 1990b; Kyvik & Teigen 1996; Fox 2005). Gender differences in scientific productivity can also be attributed to cultural and disciplinary differences (see also Prpić et al. 2009).

The studies reviewed by Cole and Zuckerman (1984) give evidence that gender differences in productivity have not diminished but have remained constant over time. Prpić and her colleagues (2009) reviewed more recent literature on gender differences in publication productivity and citation impact. However, they concluded that the differences tend to decrease over time: in certain countries and scientific fields, there did not appear to be significant gender differences in publication productivity, or the differences disappeared when academic rank was taken into account. For example, on the basis of large surveys of US scholars, Xie and Shauman (1998) found that while the productivity of female scientists was about 63 per cent of that of male scientists in 1969, this figure was 76 per cent in 1993. Furthermore, Xie and Shauman (1998) found the direct effect of gender was low, and that gender differences could be attributed to other factors such as structural position and marital status. In several studies reviewed by Prpić et al. (2009), gender differences in citation impacts were either not found or else disappeared when the number of publications was taken into account.

Finnish women are exceptionally highly educated on the world scale: Finland ranked fourth in the gross enrolment ratio for women in tertiary education in 2010 (UNESCO 2010). However, female scholars' lower occupancy of the highest university posts can also be seen in Finland, even though Finnish women's level of education compared to men is high: 58 per cent of Masters degrees and 52 per cent of doctoral degrees were taken by women in 2010–2012 (Figure 6). Women are well represented on the teaching staff of Finnish universities, and they have accounted for more than half of lectureships and other teaching posts since the beginning of the 2000s. The female share of research labour years stayed above 40 per cent during 1995–2012. However,

although the percentage of female professors and associate professors has steadily increased during the past two decades, women comprised only 24 per cent of these highest academic positions in 2007–2009 (Figure 6). This study presents large-scale research on gender differences in publication productivity, such research having previously been lacking in the Finnish context.

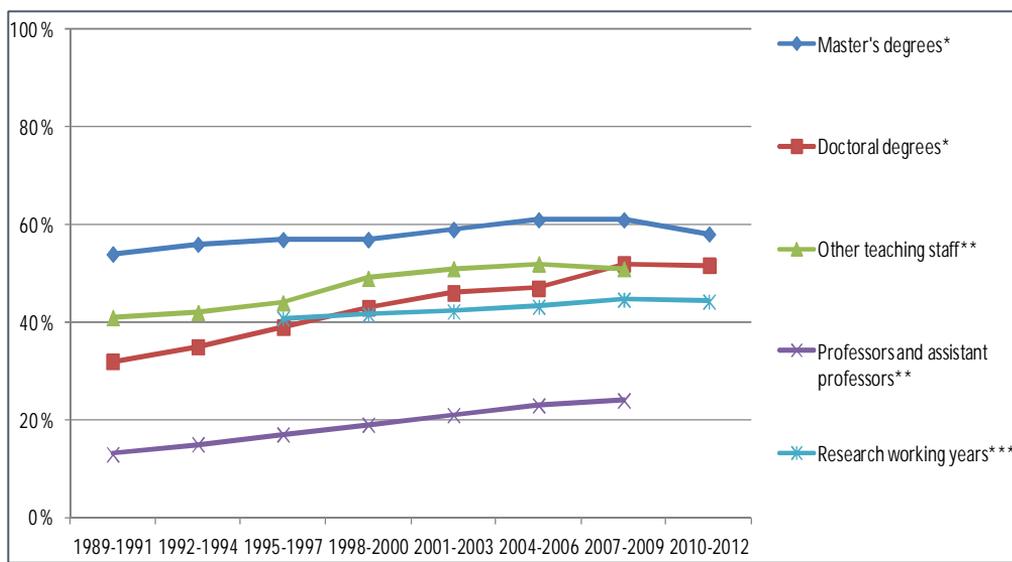


Figure 6. Percentages of women with academic degrees and positions in Finnish universities in 1989–2011. Sources of data:

*KOTA online database for 1989–2009, and Vipunen reporting portal for 2010–2012.

**KOTA online database for 1989–2009 (comparable data not available for 2010 onwards).

***Statistics Finland for 1995–2011 (comparable data not available before 1993).

Even though there are plenty of studies repeating the finding of gender differences in terms of publishing performance, there are only a few studies comparing disciplines in relation to gender. The disciplines differ greatly in terms of the percentages of women on academic staff (Fox 1999; Stack 2002). This is also the case in Finnish universities, where women accounted for more than one half of research labour years in all disciplinary groups except for the natural sciences (33 per cent) and engineering (24 per cent) in 2012 (Statistics Finland 2012). In medicine and health sciences, the proportion of women is more than 60 per cent among researchers and teachers, but still quite low among professors (25 per cent). The proportion of female professors is highest in the social sciences (34 per cent) and humanities (40 per cent). (Statistics Finland 2012.) Stack (2002) argues that one can assume that productivity differences

between genders are smaller in soft fields, where the proportion of women is high. He found no evidence of a gender gap among American scholars in research fields with a high proportion of women (criminal justice and sociology). Correspondingly, Prpić et al. (2009) found smaller performance differences between genders among Croatian scholars in the social sciences than in the natural sciences.

6 Science policy and publishing performance

The Chapters 3 and 4 presented the intra-scientific factors that potentially influence the publishing behaviour of scholars in different disciplines: academic cultures, traditions, norms and values, the organisation of research, the nature of the research subjects, and the target audience. However, the practices of research in academic institutions are heavily affected by extra-scientific factors as well. The organisation of research, research subjects and forms of research output are influenced by global changes such as economic trends, globalisation and the new tools provided by technological development. Extra-scientific factors include, among other things, social factors such as the reward systems and requirements of research funding sources (Kyvik 1991). Additionally, government science policies act as one of the major external forces shaping research (Auranen & Nieminen 2010; Hicks 2012).

This chapter concentrates on recent changes in academic research, particularly in the context of national science policies. The emphasis is on the transformation of universities. Although science policy also concerns other sectors such as state research institutes and businesses, universities are major actors in national science systems, and most public research funding is targeted at universities (Auranen & Nieminen 2010).

6.1 Transformation of universities

Academic institutions have faced notable changes during the past two decades. Since knowledge has become an important resource for countries in the global economic competition, the ability of universities to produce high-grade knowledge and information has become a matter of great interest in national innovation policies (e.g. Etzkowitz & Leydesdorff 2000). Etzkowitz (2001) claims that universities have a new entrepreneurial role, which emphasises the commercial and innovative potential of academic research and the conversion of knowledge into intellectual property.

Gibbons and his colleagues (1994) have described the transformation in terms of two modes of knowledge production, which currently coexist. In their book *The new production of knowledge: The dynamics of science and research in contemporary societies*, they state since the 1980s science systems have shifted from a disciplinary, homogenic and organisationally hierarchical mode of knowledge production (mode 1) towards a new mode (mode 2), in which research can be described as transdisciplinary, heterogenic and heterarchical. Mode 2 emphasises societal impact, usefulness and applicability as criteria of research quality, whereas the previously prevailing mode 1 stresses basic research and scientific quality. Furthermore, the mode-2 type of research is reflexive, socially accountable and often commercialised. It is typically externally funded, and it is conducted in close interaction with several actors. In mode-2 types of research, problems are defined in a specific and local context.

The change in the academic environment has been conceptualised in various other studies as well. The concept of the 'triple helix' presented by Etzkowitz and Leydesdorff (2000) refers to the university-industry-government relationship, in which knowledge is produced, transferred and applied in new institutional and social formats. According to the triple helix thesis, the boundaries between the three sectors are becoming more and more obscured, and universities are increasingly important as part of innovation in knowledge-based societies. Slaughter and Leslie (1997) have introduced the concept of 'academic capitalism', which refers to both profit-seeking in the market and competition for external research funding between universities and researchers. Dependence on resources from external actors forces universities to balance between autonomy and external demands. On the one hand, universities play a more important role as providers of educated people (Slaughter & Leslie 1997), but on the other hand they have become more entrepreneurial in that they must compete for competent people in the global market (Clark 1998; Marginson 2006). By using the concept of the 'entrepreneurial university', Clark (1998) refers to a university that is searching for more efficient ways of doing things, for example, restructuring the organisation by supporting units with stronger external links, widening the financial base by more actively seeking external funding, and strengthening steering.

Ziman's (1994) concept of 'post-academic science' refers to the weathering of the traditional, idealistic, Mertonian norms of science – communism, universalism, disinterestedness and organised scepticism (see Merton 1973) – which are now being replaced by new market-driven norms and practices, described as proprietary, local, authoritarian, commissioned and expert. Ziman (1994) argues that the objectivity of

research is endangered by, for example, the interests of external funding sources, which influence the choice of research problems and topics. Consequently, there is a risk that market-like principles make research more oriented towards technological problem-solving and more secretive, instead of producing common knowledge that is open to scientific criticism. Hakala et al. (2003) argue, however, that although values, goals and practices in academic institutions have in many respects come closer to the new knowledge production mode since the 1990s, basic research and scientific quality have maintained their position as the basic value of academic research. Moreover, societally relevant applied research is not new, and was already being conducted alongside basic research before these changes (Hakala et al. 2003).

In addition to acting as a substantial element in national innovation policy by enhancing the innovativeness of the national economy, university research as part of the university enterprise is subject to governance and policymaking (Hicks 2012). The ideology of 'new public management' has brought the values and practices of management in the private sector into the public sector, including the university sector. Under the new managerialism, the performance and cost-effectiveness of universities have been stressed by policymakers (e.g. Nieminen 2005; Ferlie et al. 2009). Whitley (2011) categorises the changes in the governance of public research institutions into three major aspects: 1) increasing the state steering of research priorities and knowledge evaluation, 2) increasing competitive resource allocation and performance monitoring, and 3) enhancing management in the public research institutes. Several countries have introduced output incentives and competition mechanisms, for example by increasingly allocating core state funding for universities on the basis of their performance in research and education (Geuna & Martin 2003; Hicks 2010; Auranen & Nieminen 2010) At the same time, the proportion of direct government funding to universities has decreased (Slaughter & Leslie 1997; Himanen et al. 2009).

Besides the stress on performance, the increasing pressure towards internationalisation is another prominent element in national science policies. Internationality has always been an obvious element of research, and the globalisation of science pushes universities to internationalise. Moreover, looking for material and intellectual resources outside national borders is seen as an important instrument for advancing national science, especially for marginal or small countries such as Finland. Governments have therefore encouraged the internationality of research, and it has been increasingly emphasised in science policies. (Frame & Carpenter 1979; Schubert & Braun 1990; Hakala 1998.)

6.2 Characteristics and recent development of Finnish science policy

Since the 1990s, Finnish national science policy has increasingly emphasised performance, productivity and the internationality of research and education conducted in universities (Hakala et al. 2003). Finland has invested heavily in research: its expenditure on higher-education research has grown remarkably during the past two decades. In 2011, Finland's R&D expenditure on the higher-education sector measured as a percentage of GDP was the third highest of all OECD countries: 0.80 per cent (OECD 2012). The research expenditure of the university sector more than tripled from 1991 to 2010, from 380 to 1,200 million euros (Statistics Finland 2012). At that time the state funding of research in universities was increasingly being distributed through the funding agencies that allocate funding by competition, namely the Academy of Finland and the Finnish Funding Agency for Technology and Innovation (Tekes). An additional funding programme in 1997–1999 channelled about 540 million euros in further external funding for research. (Hakala et al. 2003; Auranen & Nieminen 2010). Consequently, the percentage of external funding in Finnish universities' research expenditure has increased remarkably. In the mid-1990s, external funding constituted 40 per cent of the universities' research expenditure, whereas in 2012 the corresponding figure was 54 per cent. Table 3, however, shows that the percentage of external funding varies greatly among disciplinary groups, being the highest in engineering (71 per cent) and the lowest in the humanities (38 per cent). The sources of external funding vary as well. Tekes and the private sector account for more than half of external funding in engineering. For other disciplinary groups, the Academy of Finland, which aims to finance high-quality scientific research, is the major source of external funding. In the medical and health sciences, the private sector, the Ministry of Social Affairs and Health and foundations are also important (Statistics Finland 2012).

Table 3. Distribution of funding by sources in the Finnish higher-education sector by discipline in 2012.

	Total research expenditure (millions of euros)	Budget funding	External funding sources							Total
			Academy of Finland	Tekes	Ministries/other public sector	Found-ations	Private sector	EU	Other	
Natural sciences	424	41%	26%	9%	8%	3%	4%	7%	2%	100%
Engineering	270	29%	10%	23%	13%	2%	14%	10%	1%	100%
Medical and health sciences	293	35%	17%	4%	19%	7%	10%	6%	2%	100%
Agriculture and forestry	47	50%	15%	3%	13%	4%	2%	10%	3%	100%
Social sciences	319	49%	13%	8%	14%	4%	3%	8%	2%	100%
Humanities	124	62%	18%	3%	8%	3%	1%	4%	1%	100%
Total	1,475	41%	17%	10%	13%	4%	6%	7%	2%	100%

Source of data: Statistics Finland 2012.

In Finland, both the ideology of the new public management and the economic recession of the early 1990s promoted the demand for efficiency in the public sector. With regard to universities, these tendencies led in the mid-1990s to the adoption of a new, performance-based steering model. The allocation of budget funding for universities has been one of the Ministry of Education and Culture's most important science policy instruments (Hakala et al. 2003; Nieminen 2005). Since the introduction of the performance-based funding model in 1995, the main part of the funding budget has been distributed according to productivity in terms of targeted numbers of Master's and doctoral degrees, while publishing performance carried only little weight: 0.3 per cent in 2007–2009 and 1.7 per cent in 2010–2012 of total budget funding was distributed according to publication output (Ministry of Education and Culture 2009). A fundamental change was established recently: under the new funding model for the

years 2013–2016, 13 per cent of the universities' budget funding will be distributed according to publishing performance.

Finnish universities are governed by the Ministry of Education and Culture. In the 2000s, the policy statements of the Finnish Ministry of Education emphasised international competitiveness and excellence of research. The universities are expected to achieve higher quality by focusing on their strongest areas, stressing multidisciplinary, strengthening their societal importance and local impact, and developing international, national and regional collaboration networks. At the same time, alongside the increasing need for high scientific quality, science policy also highlights the importance of the societal and commercial impacts of science. According to the Ministry of Education, the universities should aim for the efficient use of the knowledge they produce and the commercial profitability of their research results. Interaction with society and the promotion of the social impact and relevance of research were included as universities' third mission in the Universities Act 2004, next to teaching and research. (Ministry of Education 2004; 2005; Finnish Government 2005.)

The internationalisation of research has been seen as a key tool for developing a competitive national innovation system, and it has been heavily stressed in Finnish science policy since the late 1980s (Hakala 1998). In 1995 Finland joined the European Union, which enabled its full participation in EU research programmes from 1996 onwards. Prior to this Finland had already strengthened European research collaborations by becoming a member of various European research cooperation networks, such as Eureka (in 1985), the European Laboratory for Particle Physics (CERN, in 1991) and the European Space Agency (ESA, associate membership in 1987, full membership in 1995) (Muhonen et al. 2012).

The new Universities Act was implemented in 2009. It further extends the autonomy of universities by making them independent legal entities, either as public corporations or as foundations. The idea is to give universities more power so that they are no longer part of state administration, but rather are run on the basis of education and research. The government, however, still guarantees the core funding of universities (Ministry of Education 2009). As part of active regional policy, the universities have been decentralised all over the country in order to provide equal opportunities in education and to support regional development. In the early 2000s, the 20 universities with their branch offices and the 29 polytechnics covered almost all of the most

important cities in Finland. However, the emphasis shifted towards the higher-level and more internationally competitive universities and their international evaluation, and consequently the network of universities was reformed in preparation for the Universities Act 2009 (Hautamäki & Stähle 2012). The number of Finnish universities therefore fell from 20 to 14.

Since the early 1990s, Finland has promoted the idea of a national innovation system and a systematic innovation policy which stresses the importance of innovation, technological research, and the connection between research and society, especially business. Not only are the higher-education institutes governed and funded by the Ministry of Education and Culture, but national research policy is also outlined by an expert body, the Research and Innovation Council (formerly the Science and Technology Council), chaired by the prime minister. The council advises the government and its ministries with regard to 'the direction, follow-up, evaluation and coordination of research, technology and innovation policy' (Finnish Government 2014). The universities, along with the state research institutes and polytechnics, are tightly integrated into the national innovation system under the Council's new national innovation strategy (2009), which highlights the increasing role of information and knowledge in society, the challenges of globalisation, and the promotion of the internationalisation of Finnish education, research and innovation.

Hautamäki and Stähle (2013) suggest that the strong integration of science policy into innovation policy sets aims that are somewhat in contradiction with research conducted in universities. The science policy implemented by the universities' principal funding source, the Ministry of Education and Culture, has a strong focus on scientific excellence and internationalisation, and the core funding model encourages universities towards more ambitious academic performance and publication in high-level scientific publishing forums. Meanwhile, the innovation policy makes demands for social impact, industrial collaboration and policy-relevant research, which are almost completely ignored in the core funding model of universities (Hautamäki & Stähle 2013).

6.3 Use of publication indicators as a tool of science policy

The need to monitor the performance of universities has motivated policymakers to actively explore tools for the assessment of research outcomes. The tendency, especially in European countries, is to apply metric indicators instead of panel-based

peer review models. For example the UK, which previously conducted a massive peer-based research evaluation called the Research Assessment Exercise (RAE), is now turning towards a more metric approach. The purpose of the RAE was to assess the quality of research in UK higher education in order to determine the allocation of funding through the four Higher Education Funding Councils. (RAE 2009.) The first RAE was conducted in 1986, and the exercise was repeated five times until the last RAE in 2008. Metric indicators were not used, but a few best publications for each assessed researcher were subjected to the qualitative judgment of expert panels. The assessments had a great impact on the publishing behaviour of UK scholars. Himanen et al. (2009) found that the effects of the exercise appear as visible peaks in the UK's publishing performance relative to other OECD countries a year before each exercise. Through bibliometric analysis, Moed (2007) showed that until 1992, when the assessment criteria of the RAE began to take equal account of both the quality and quantity of publications, UK scientists substantially increased their article production. However, from 1996 onwards, when the emphasis shifted towards quality, the number of papers in journals with a high citation impact increased. The RAE has been replaced by a new assessment system, Research Excellence Framework (REF), the first results of which will be completed in 2014. The REF applies citations as one key indicator in certain fields. One of the aims is to significantly reduce the administrative burden on institutions compared to the RAE. The other aims are to produce robust indicators to benchmark quality against international standards, to distribute funding according to research excellence, and to avoid incentives for undesirable behaviour. (HEFCE 2007.)

In recent decades, several countries have devoted a lot of attention to designing national funding systems that rely on the evaluation of research output or performance-based indicators in their universities' basic funding models (Weingart 2005; Schneider 2009; Hicks 2012). Publication and citation counts have become standard indicators in national research evaluations at the university, faculty and departmental level (Leydesdorff 2008). Among OECD countries such as Australia, Denmark, Finland, Flanders (the northern region of Belgium), Norway, Poland, Slovakia and Sweden, part of the universities' basic funding is allocated according to their publishing performance (Hicks 2012). Although the societal and commercial relevance of research has been increasingly emphasised in national science policies, the ideology of new public management, along with the development of bibliometric methods, has integrated quantitative measures of scientific excellence more tightly into science policy and decision-making. The use of bibliometric indicators has been

criticised for a lack of validity and reliability. For example, the first bibliometric-based evaluations of research institutions conducted in the UK before the RAE in the 1980s were criticised by scientists for being theoretically and empirically crude and based on imprecise data (Weingart 2005). The bibliometric-based assessments are also claimed for relying on very few methods of evaluating research performance (Gläser & Laudel 2007) and reducing a multidimensional problem into a simple number (Schneider 2009).

On the other hand, scientists are concerned about the negative consequences for research practices when publications and citations are increasingly linked to funding. For example, giving rewards for raw publication counts may lead to the production of quantity at the cost of quality and impact. Publication output was linked to university funding in Australia as early as 1995. This model of funding was an incentive for a large growth in terms of publication counts following its establishment. However, the increase in articles has been strongest among journals with the lowest impact (Butler 2003). In most countries the long-term effects are so far largely unknown, since many of them have implemented the models only fairly recently and there is not yet any empirical evidence available.

In some countries, publications data are derived from databases that index bibliographic data on articles published in international journals, usually WoS or Scopus. These databases also enable the use of citations, which in Australia, Flanders, Poland, Slovakia and Sweden, for example, are included in funding models as an indicator of research impact (Hicks 2012). In addition to Finland, Norway and Denmark also apply a model in which publication output is based on national publication registers that include not only contributions to international journals, but all publication types comprehensively.

Norway implemented a novel publication indicator in the allocation of basic funding for higher-education institutions in 2006. To avoid the unintended publishing pattern experienced for example in Australia, the Norwegian model takes into account the quality of publications, beyond merely calculating publication counts. Instead of using citation indicators, the quality of publications is considered by applying a two-level categorisation of scientific publishing channels (journals, series and book publishers). The national panels for the various disciplines have evaluated the quality of the publishing channels and classified them as either level 1 (channels recognised as

scientific) or level 2 (prestigious scientific publication channels). Level 2 accounts for roughly 20 per cent of the publication output in each discipline. The funding is allocated on the basis of 'publication points', which are weighted according to publication type and the level of publication channel. Moreover, the publications are fractionalised, so that the publication points for a publication are divided among the participating universities according to the number of contributing authors (Sivertsen 2010). Impressed by the Norwegian model, Denmark implemented a similar indicator in 2009 (Schneider 2009). Flanders has applied a corresponding indicator for the social sciences and humanities since 2010, while the publication performance of other fields is measured by publications and citations indicators based on the WoS database (Ossenblok et al. 2012).

In 2009, the Finnish Council of University Rectors suggested that Finland should follow the Norwegian and Danish examples and create 'a system to improve the quality assessment of scientific publications, based on a publication forum'. This was an answer to the widespread criticism of the previous funding model, which had been condemned for disregarding the quality of research. Besides creating a publication quality indicator for the purposes of the funding model, the objective was to provide a tool for the evaluation of the publishing performance of research organisations or disciplines at macro level. Another aim was to increase scholars' awareness of the high-level publication channels in their fields, in order to create an incentive for more ambitious publishing behaviour by researchers. (Auranen & Pölönen 2012).

The Finnish Publication Forum was launched in 2010. The 23 expert panels, comprised of 204 scientists from Finnish universities, state research institutes, scientific societies and academies, rated roughly 20,000 publication channels into levels 1 (scientific publication channels) and 2 (leading publication channels). Unlike in Norway and Denmark, the Finnish panels adopted an additional level 3, which comprises publication channels that 'represent the state-of-the-art quality in the respective field'. (Julkaisufoorumi 2011.) In Finland, the publication channel rankings will be put into operation in the universities' basic funding model from 2015 onwards. The intention is that publications at levels 2 and 3 will be assigned greater weight in the calculation of publication outputs (Ministry of Education and Culture 2012). The details of the model, such as the weighting of publication types and fractionalisation, are currently under construction. The proportion of basic funding allocated to Finnish universities for the years 2013–2016 on the basis of publication output, 13 per cent, is exceptionally high compared to other countries.

Despite the fact that publishing performance has previously had a minor role in the budget funding model of Finnish universities, there are other incentives that have encouraged researchers towards certain publication behaviours. The universities have had various internal funding systems. In addition, with regard to the medical sciences, the Finnish Ministry of Social Affairs and Health's way of allocating funding to hospital districts has had a significant impact on publishing behaviour, especially of those university faculties which collaborate with university hospitals. Funding has been primarily distributed to hospital districts according to their publishing productivity, and publications are weighted more heavily if they are published in a journal with a high Journal Impact Factor. (Puuska & Miettinen 2008.)

Moreover, the Finnish professors we interviewed (Puuska & Miettinen 2008) argued that universities' employment processes often favour applicants with certain publishing patterns, usually those who have a high level of publishing activity in prestigious international journals. Furthermore, the funding bodies have their own interests and requirements regarding the topics and output of research. Contributions to high-level scientific publishing channels carry heavy weight in the funding decisions of the biggest external funding source, the Academy of Finland. The increase in funding from the EU, Tekes and industry may encourage universities to publish in forums aimed at non-scholarly audiences, however.

Hicks (2013) points out that the hard sciences dominate the research conducted, and they account for 70–80 per cent of research expenditure in OECD countries. Therefore it can be assumed that the evaluation criteria are designed in accordance with the premises of these fields. The primary research output is contributions to English-language journals and patents, and researchers can reach a consensus as to which are the core high-quality journals in their fields. Citation analyses based on papers in these journals with a few years' time-window can offer a fair measure of the impact of research. The social sciences have to adjust their research practices in this setting (Hicks 2013).

While the citation indicators are based on data that have particularly poor coverage in the social sciences and humanities, publication points are based on data which also cover books, book chapters and national publications, which are important in the social sciences and humanities. However, in both Norway and Finland the implementation of the new funding model aroused public debate and resistance, especially from scientists in the social sciences and humanities. In Norway, 223

professors signed an objection to the use of publication points, expressing concern about the status of the Norwegian language as well as about the dissemination of research results to the general public. They also argued that these fields do not have a consensus on the best scientific journals, and that there is no reason to segregate scientific from other publications (Aftenposten 2006). Similarly, in Finland, 60 scientific societies, representing mainly the social sciences and humanities, signed a declaration entitled 'For versatile and multifaceted scientific publication activity', in which they condemned the classification as unfair with regard to the different publishing cultures in different disciplines, since it heavily emphasises international and especially English-language publication forums at the expense of other publications (Monipuolisen tieteellisen julkaisutoiminnan puolesta 2012). As a consequence, 18 Finnish-language and two Swedish-language journals or series were raised from level 1 to level 2 in 2012 (Auranen & Pölönen 2012).

The impact of the Finnish funding model is not yet visible. The effects of the use of publication indicators have been evaluated in both Norway (Aagaard et al. 2014) and Denmark (Sivertsen & Schneider 2012). These evaluations were based on surveys, interviews, bibliometric analyses and case studies of universities. The evaluation in Norway suggests that the number of publications has strongly increased since the implementation of the indicator: they grew by 82 per cent between 2004 and 2012. At the same time, the number of publishing researchers in Norwegian research institutions tripled. These patterns are partly related to increased resources, but publication output has increased more substantially. The evaluation did not, however, find significant changes in other patterns of publishing. The citation impact of Norwegian publications has stayed at a stable level. Neither the percentage of publications in the more highly rated publication channels (level 2) nor the percentage of journal publishing has increased. In the humanities and social sciences, the percentage of Norwegian-language publications has declined moderately at the expense of other languages, but the absolute number of Norwegian-language publications has nonetheless increased. (Aagaard et al. 2014.) The effects on publishing patterns in Denmark cannot yet be assessed due to the short time since its implementation (Sivertsen & Schneider 2012).

One intention of the Norwegian model was to create an indicator that was neutral across all disciplines, and hence to take into account different publishing traditions and to make them comparable using the same measurement (Sivertsen 2010). According to the evaluations in Norway and Denmark, this aim has not been fully achieved. In

Norway it has been found that the average number of publication points per researcher varies widely across disciplines, for example due to the counting method used, professors in the humanities being 2.5 times more successful in earning publication points than professors in medicine (Aagaard et al. 2014). The Danish evaluation suggests that in the humanities and social sciences the indicator was first resisted most heavily, since these disciplines were not used to being measured quantitatively. Now the developed database provides a better overview of their research activities, and the indicator has made them place more focus on research. Meanwhile, scholars in the natural sciences have shown less interest in the indicator, since some of them would prefer citation-based indicators in the assessment of their research (Sivertsen & Schneider 2012).

7 Research questions

This study addresses the four following major research questions:

1. What are the publishing patterns in various disciplinary groups in Finland?
2. Have publishing patterns changed during the last two decades?
3. What kinds of effect do the individual-level characteristics of gender and position have on publishing patterns?
4. How comparable are the results from different kinds of dataset?

These questions are answered by using empirical data, with a special emphasis on the differences between disciplinary groups. The analysis of empirical data seeks to provide a more comprehensive understanding of these four areas in the Finnish context in order to evaluate how the use of bibliometric indicators in science policy might affect publishing patterns, and which indicators and datasets are feasible in different disciplines.

7.1 What are the publishing patterns in various disciplinary groups in Finland?

As regards the first research question, the analysis of empirical data explores the typicality of different publication types. Disciplinary differences are often considered self-evident, but there is a lack of empirical evidence, especially in the Finnish context. The four articles in this study provide empirical evidence of the publication types that dominate in different disciplinary groups. More explicitly, as regards these patterns, the articles provide empirical evidence on the following issues:

- Productivity in different types of publication (journals, conference proceedings, books and book chapters) per researcher in different disciplinary groups (Article II);
- The distribution of publication types (monographs/articles, international/national publications) among the most highly cited Nordic sociologists (Article I);
- The distribution of different types of publication (journals, conference proceedings, books and book chapters, national/international publications,

scholarly/non-scholarly publications) in the humanities and engineering (Article III);

- Co-publishing patterns and citation impacts of international and domestic co-publishing in the six disciplinary groups (Article IV).

The analyses in Articles II and IV cover all six disciplinary groups, while Article I addresses similar questions in one particular field, sociology. Article III compares two disciplinary groups, the humanities and engineering.

The results are interpreted in light of Tony Becher's (1989) and Richard Whitley's (2000) theories, according to which academic disciplines are grouped into knowledge territories, within which the disciplines have a similar type of knowledge and the researchers share common norms, values, work practices and modes of interaction. Kyvik's (1991) six factors (paradigmatic status, codified or literary communication language, mutual dependence between scientists, audience, global versus local research subjects, and competition for priority) seek explanations for disciplinary differences in publishing patterns more explicitly. The findings of this study in the Finnish context reflect these models as well as previous studies from other countries. In addition to looking at potential differences, this study explores the features of publishing behaviour that are common to all disciplinary groups.

7.2 Have publishing patterns changed during the last two decades?

Publication-based indicators are increasingly used as a measure of research performance at different levels: countries, institutions, research groups and individual scholars. It is often claimed that they are designed according to the terms and conditions of the natural and medical sciences, and thus that they ignore the traditional publishing behaviours of the social sciences and humanities (e.g. Hicks 2013). This study seeks to establish whether the findings support the argument that publication behaviour in the soft sciences and engineering are shifting towards that found in the natural and medical sciences. Although the causal relationship between changes in academic institutions and publishing patterns cannot be traced through the analysis conducted in this study, Articles III and IV seek to establish whether there are signs of homogenisation in the publishing patterns of different disciplinary groups. The development of book, journal and conference publishing as well as international and

non-scholarly publishing is investigated in Article III, which focuses on two disciplinary groups, 'hard-applied' engineering and the 'soft-pure' humanities, which traditionally have distinct academic cultures and publishing patterns. In addition, the trends in international and domestic co-publishing in different disciplinary groups during the last two decades are investigated in Article IV.

7.3 What kinds of effect do the individual-level characteristics of gender and position have on publishing patterns?

The third research question concerns variations in publishing performance between individual scholars, which are investigated in Articles I and II. Numerous previous studies have shown that there are remarkable differences between genders and among scholars in different positions, so that men are more productive than women, and scientists in the highest positions publish more than others. The highly skewed distribution of publishing productivity at the individual level has also been demonstrated repeatedly in previous studies. The accuracy of these findings, however, has not previously been studied in the Finnish context. In addition to providing empirical evidence in the Finnish context, this study makes a novel contribution to these questions by comparing the productivity of individual scholars with regard to different types of publication, namely articles in journals, conference proceedings, book chapters and monographs.

The following questions regarding changes in publishing patterns are addressed:

- Are there differences in total publishing output between scholars in different professional positions and genders when several publication types are included (Articles I and II)?
- Are the productivity differences between individuals similar in different types of publications (Article II)?
- Does the fractionalisation of co-authored publications influence productivity differences (Article II)?
- Is the individual-level variance in publishing performance between genders and researchers in different scholarly positions evidenced in a similar way in all disciplinary groups (Article II)?
- Are there differences between genders and positions in terms of publishing output and citations among Nordic sociologists (Article I)?

7.4 How comparable are the results from different kinds of dataset?

This study applies and compares four different kinds of dataset, with a focus on evaluating their coverage, quality and applicability in the assessment of publishing performance in different disciplines. In particular, Article I compares the results of Nordic sociologists' publications and citations with a corresponding previous bibliometric study of WoS data by Bjarnason and Sigfusdottir (2002). Article III compares results as to changes in publishing patterns in the humanities and engineering from two datasets: publication data from two universities' local registers and a survey of Finnish university departmental heads. Article II compares factors of productivity in terms of different publication types, which increases our understanding of how different publication types are distributed among individual scholars. The results from Article II give evidence as to the consequences of omitting certain publication types, such as books, when making comparisons between individuals.

8 Data and methods

The principal level of this study is that of the disciplinary group, which refers to a larger group of academic disciplines. The academic disciplines in Articles I–III are categorised into disciplinary groups according to the grouping proposed in the OECD's *Frascati manual* (2002). Even though there is wide variation within the groups (e.g. Fry & Talja 2004), the focus of this study is on comparisons between disciplinary groups. Single fields are not scrutinised except in Article I, which demonstrates the publications output and impact of scholars in sociology. Publications are assigned to disciplinary groups according to the fields of the department with which the authors are affiliated (Articles I–III) or the journal's classification in the citation index database (Article IV).

The impact of Finland's co-publishing is explored by using data from WoS (Article IV). However, since the focus of this dissertation is particularly on studying disciplinary publishing patterns in terms of different types of publication, Google Scholar, Finnish universities' local publication registers and a survey of Finnish university departmental heads are also used as data sources (Articles I–III). The four types of data source are summarised in Table 4.

In principle the universities' publication registers cover all publications produced by their staff, but in practice the coverage is largely based on scholars' own reporting activity; all researchers do not necessarily report all of their publications, and the data probably include defects such as the erroneous classification of publications. Therefore they do not provide accurate counts of all publications. At the time the analyses were conducted, information was not available from all Finnish universities, since the collection of data was not implemented at a national level until 2011. In the years under scrutiny, 1997–2008, only a few Finnish universities provided reliable, publicly available bibliographic information on their publications. The data used in this study are based on publications from two case universities, the University of Helsinki (Articles II and III) and Tampere University of Technology (Article III). They do not represent the whole Finnish university sector, but they cover almost all scientific disciplines. Besides providing good coverage, local publication registers also enable the analysis of publishing productivity when publications are combined with data from the university's personnel register. Publishing output is compared to working years at the

individual level in Article IV, which analyses productivity differences between scholars in different positions and of different genders.

As regards Google Scholar, it is not possible to evaluate the coverage of the data, since Google does not disclose its selection criteria. Google Scholar provides a broad variety of types of publication, but with regard to national publications its coverage is inadequate. The data used in Article I were gathered in March 2005, when Google Scholar was at the beta-testing phase, and they have been partially remodelled since. While other databases categorise publications by organisation, it is not possible to do this in Google Scholar. In Article I the analysis was made at the level of individual scholars, namely staff members in Nordic sociology departments. The search phrase included every individual staff member's given and last name in quotation marks. The staff positions were taken from each department's web pages.

WoS and Google Scholar include data on the citations gained by publications, which allows analysis of the scientific impact of publications. The citation counts of publications in Google Scholar are studied at the level of individual scholars in Article I, but the analysis is limited only to the most cited publication of each scholar. The differences between disciplinary groups in the citation impact of Finnish publications with different types of co-authorship (international, domestic inter-organisational and domestic intra-organisational) are examined by using WoS data in Article IV.

The survey of Finnish universities was conducted in 2008 as part of the project called *Changes in research communities and academic work*, in which a questionnaire consisting of 19 sets of multi-response questions was sent to all departmental heads in Finnish universities. Since Article III focuses on publishing patterns in the humanities and engineering in particular, the responses from these two disciplinary groups were considered (n=98). The exact number of publications was not requested in the survey, but with regard to publishing activity the respondents answered the following questions:

1. How much does your unit publish in the following publication types?
(With the response alternatives 'a lot', 'to some extent' or 'not at all'.)
2. Has the number of publications changed in your unit during the last three years?
(With the response alternatives 'increased', 'as before' or 'decreased'.)

The survey reflects the general attitudes and assumptions of the departmental heads rather than the actual publishing patterns of the department. The views of respondents can be influenced by subjective presumptions. Therefore the analysis of the survey in Article III is complemented and compared with data from the two universities' publication registers in humanities and engineering.

The analyses apply basic bibliometric indicators (Table 4). All articles display publication counts and the percentages of different publication types. The data are analysed by descriptive statistical methods and linear regression models. Publication counts are analysed at the macro level in Articles III and IV, and at the level of individual scholars in Articles I and II. In Article II, the number of publications is related to working years. In addition to publication counts, citation counts are analysed in Article IV, in which field-normalised citation scores are calculated when comparing the citation impact of different types of co-authorship.

Table 4. Description of the four datasets used in the analyses.

Dataset	Articles	Description	Publication types included	Time period	Levels of analysis	Indicators
Thomson Reuters Web of Science (WoS)*	IV	Publications and their citations in the three databases: the Science Citation Index Expanded, the Social Sciences Citation Index, and the Arts & Humanities Citation Index	Articles, reviews and letters and their citations in scientific journals indexed by WoS	1990–2009	Disciplinary groups	Percentages of Finland's different types of co-publication and their field-normalised citation scores
Google Scholar	I	Search results on the web search engine by names of staff members of 16 Nordic sociology departments	All publication types included in web hits and citations of the most cited publications	From 1980 until March 2005	Individual scholars in sociology	The number of hits for the researcher and the number of citations of his/her most cited publication
Local publication registers	II&III	Complete bibliographic records in two universities' publication registers: the University of Helsinki (Articles II & III) and Tampere University of Technology (Article III). In Article II, the publications are combined with data on scholars from the University of Helsinki's personnel register	Scholarly publication types – journal articles, book chapters, conference proceedings, monographs and PhD theses (Articles II & III) and non-scholarly publications (Article III)	1997–2008 (Article III) and 2002–2004 (Article II)	Individual scholars (Article II) and disciplinary groups (humanities and engineering, Article III)	Percentages of different scholarly publication types, non-scholarly publications and international publications (Article III) and the number of publications by working years (Article II)
Survey	III	Results from a survey of the views of Finnish university departmental heads on recent changes in publishing behaviour	Scholarly and non-scholarly publications	Conducted in 2008	Disciplinary groups (humanities and engineering)	Typicality of different types of publications (published <i>a lot/to some extent/not at all</i>) and trends (<i>increased/as before/decreased</i>)

*) The analyses were carried out under contract with the Finnish Ministry of Education and Culture which has acquired the data from Thomson Reuters.

9 Summary of results

9.1 Publishing patterns

9.1.1 Types of publication

Article II shows that Finnish scholars in the natural and medical sciences are more oriented towards journal publishing, whereas those in engineering are oriented towards conference proceedings publishing, and the social sciences and humanities typically publish in books. With regard to monograph publishing, social scientists are the most active. These results are well in accordance with findings from studies in other countries (e.g. Pestana et al. 1995; Bourke & Butler 1996; Kyvik 2003; Huang & Chang 2008; Engels et al. 2012; Piro et al. 2013;) and with the more recent data from Finnish universities presented in Figure 1 (see subsection 4.1). The findings of Article I confirm the status of book publishing in the social sciences. Monographs and article collections seem to have maintained their position as an important channel for publishing results as well as for references among Nordic sociologists: monographs and edited collections gained more citations on average than journal articles. Article I further shows that international publications have a higher citation impact in sociology: the majority of the most cited Nordic sociology publications on Google Scholar were in the English language – a result corresponding to Clemens et al. (1995). Article III shows that in the humanities, articles in edited books clearly dominate. Similar results also have been obtained in Flanders (Engels et al. 2012) and Norway (Kyvik 2003; Piro et al. 2013).

In Article III, patterns of national and non-scholarly publishing were investigated with regard to two disciplinary groups, engineering and the humanities. It is noteworthy that in the humanities, non-scholarly publications account for a remarkable proportion, almost one half, of all publications output. These publications encompass mainly popular articles and books. In engineering, on the other hand, the proportion is substantially lower, and the few non-scholarly publications mostly concern research reports. Disciplinary comparisons as to the typicality and development of non-

scholarly publishing lack empirical research, but similar differences between disciplinary groups have been found among Norwegian scholars (Kyvik 2005). The results from Article III also suggest that not only are non-scholarly publications in the humanities almost entirely written in a domestic language, but also the majority of scholarly publications, particularly scientific monographs and book chapters, are published in Finnish publishing forums.

9.1.2 Patterns of co-publishing

The results from Article IV indicate that significant disciplinary differences still exist in co-publishing patterns. While in all other disciplinary groups almost half of Finland's WoS publications had international co-authors, the corresponding percentages were only 10 in the humanities and 34 in the social sciences in 2006–2008. In all disciplinary groups international co-publishing is more common than domestic collaboration between organisations. In the humanities both international and domestic co-authorship are uncommon: more than two thirds of Finland's WoS publications in the humanities were single-authored.

The positive correlation between international co-publishing and citation impact has been repeated in numerous previous studies (Narin 1991; Katz & Hicks 1997; Glänzel 2001; Glänzel & Schubert 2001; Gunnarsson 2011). Similarly, Article IV shows that in almost all disciplinary groups Finland's international co-publications are on average more highly cited than publications by Finnish authors only. The association between international collaboration and citation impact is stronger in the social sciences than in other disciplinary groups. However, only a small portion of the variation in citation rates is explained solely by international or domestic collaboration. The higher average number of authors in international co-publications when compared with domestic co-publications explains most of the differences in citation rates between these two types of collaboration. International co-publications by more than 10 authors, although quite rare, gather significantly more citations than similar publications by Finnish authors only in almost all disciplinary groups.

9.1.3 Patterns of productivity

Article II shows that there is wide variation in publishing productivity between the disciplinary groups, but the productivity differences are highly dependent on how the

output is calculated. Scholars in the medical sciences are clearly the most productive when measured by journal article counts, even when co-authored journal articles are fractionalised. Fractionalisation affects disciplinary differences considerably, improving the productivity of the soft sciences in comparison with the hard sciences. However, when the total scientific output (including books, book chapters and conference proceedings) is analysed, scholars in the medical sciences have contributed to significantly more publications than those in other disciplines. Scholars in the humanities perform most weakly. However, when co-authoring patterns are taken into account by fractionalising the output by the number of authors, the social sciences move up to the top, being significantly more productive than the hard sciences. So far, publishing productivity differences and comparisons of fractionalisation methods have not been widely studied due to a lack of comprehensive data. A recent study by Piro and his colleagues (2013) explored Norwegian scholars' publishing patterns in this regard. Their results are in accordance with the findings in Article II.

9.1.4 Changes in publishing patterns

Article III compares the views of the heads of Finnish university departments and research units with the actual numbers of publications in engineering and the humanities in two Finnish universities. The departmental heads estimated that journal article publishing had increased more than conference publishing. The publication counts do not, however, indicate that the publishing patterns in different disciplinary groups have become homogenised. These two groups, engineering and the humanities, are still very distinct from the natural and medical sciences: the percentages of the traditionally most typical publication types in engineering (conference proceedings) and the humanities (monographs and book chapters) have not dramatically decreased in favour of journal articles. In the humanities it seems, however, that book publishing is shifting from monographs to edited books. This supports the perception of the Finnish professors interviewed in a previous study (Puuska & Miettinen 2008): nowadays, it is hard to find the time to write a monograph.

Even though the data do not support the thesis of homogenisation in terms of publication types, there is evidence of internationalisation (Article III) and increased collaboration (Article IV) in the social sciences and humanities, which traditionally have been more oriented towards a national audience and where publications have typically been single-authored. Previous research has shown that international co-

publishing has increased in most countries and most disciplines during recent decades (e.g. Gunnarsson 2011, Schubert & Sooryamoorthy 2009). An analysis of Article IV shows that developments in Finland have been similar: the results indicate that Finland's international and domestic co-publishing, along with the number of authors per publication, have increased remarkably during the last two decades in all disciplinary groups. The results from Article III indicate that even though national publications still constitute the majority in the humanities, the proportion of international publishing has substantially increased. This finding is in accordance with the views of the departmental heads, which are also analysed in Article III.

9.1.5 Three patterns of publishing

The results from this study, combined with the findings of earlier studies (Kyvik 1991; Bourke & Butler 1996; Puuska & Miettinen 2008; Piro et al. 2013), tend to suggest three main distinct patterns in publishing: that found in the natural sciences and medicine, that found in engineering, and that in the humanities (Table 5). The social sciences are placed somewhere in between. At a general level, Becher's taxonomy of hard and soft disciplines applies well to these publishing patterns. Roughly speaking, publications in the disciplinary groups which represent hard fields (the natural sciences and medicine) are typically in the format of an article, are authored by a group of scholars, and are published in an international scientific forum, and the rate of publications per researcher is high. Kyvik (1991) has attributed the high rate of article publishing in the hard sciences to their codified communication language and uniform symbol systems, which enable results to be presented in a short and standardised format in an article. Kyvik (1991) also states that in the hard sciences, researchers tend to have a high degree of dependence on the research results and perspectives of other researchers as well as a shared methodology and techniques (see also Whitley 2000). Therefore it is necessary to make a contribution to international research, and the principal audience is the international scientific community.

On the other hand, the humanities prefer the book format, scholars write alone or in pairs, national publication forums are typical, and researchers contribute fewer publications per year. The social sciences also represent this pattern of publishing to some extent, but they publish more in journals (Article II) and have a higher degree of collaboration (Article IV) than the humanities, and thus fall somewhere between the hard sciences and the humanities in their publishing patterns. Kyvik (1991) argues that

since the social sciences and humanities have a low degree of codification, lack a uniform symbol system and are multi-paradigmatic in nature, they require more space to present their research problems, methodologies and discussions. According to Kyvik (1991), the lower degree of competition for priority means that more time can be devoted to presenting a comprehensive description. Monographs and edited books may also better reach the non-scholarly audience which is important to many fields in the humanities and social sciences (Nederhof 2006; Hammarfelt 2012). The dominance of edited books above journals as publishing channels of articles can be attributed to the holistic nature of knowledge in soft fields (see Becher 1989): an article compilation can provide a more comprehensive overview of the phenomenon under scrutiny than a single article in a journal.

In this study, the dichotomy between pure and applied fields (see Becher 1989) becomes concrete when publishing patterns are compared between a hard-applied disciplinary group (engineering) and hard-pure fields (the natural sciences and medicine). The abovementioned characteristics of the publishing patterns of hard fields (article format, high number of authors, internationality, high productivity) apply to engineering. In terms of Kyvik's dimensions, engineering can be characterized by a codified communication language, a high mutual dependence between researchers and a high degree of competition for priority which are typical to natural sciences. The audience structure is however more heterogeneous (see Ylijoki et al. 2011). According to our interviews with Finnish professors of engineering (Puuska & Miettinen 2008), the articles are mostly published in conference proceedings instead of journals, because in a fast-developing field that is the best way to get results published rapidly and to reach relevant audiences, such as national or international industry.

It must be borne in mind, however, that these dichotomies do not take into account the variations within the groups: both the natural and the medical sciences include highly applied fields as well. Therefore it was not possible to distinguish soft-pure and soft-applied fields in terms of their publishing patterns, because this study was limited to the level of the disciplinary group. The humanities and social sciences both include pure and applied fields, and also fields in between. Differences in publishing patterns along this dimension should be investigated further.

By presenting taxonomies, the conceptualisations referred to in this study (Becher 1989; Kyvik 1991; Whitley 2000) characterise academic cultures in very simplified terms. Similarly, the three patterns presented in Table 5 oversimplify the phenomena

of publishing patterns in different disciplines. The categorisation therefore applies at a very general level, and does not take into account the fact that disciplinary groups may include quite heterogenic disciplines, subdisciplines and specialisms (Palmer 1999; Kekäle & Lehtikoinen 2000; Fry & Talja 2004). The hard-core natural sciences of physics and chemistry as well as the medical sciences can be placed at one extreme of this dimension, whereas for example the field of history represents the opposite extreme. In our previous study (Puuska & Miettinen 2008) we found that certain disciplines categorised as natural sciences or medicine, such as cultural geography or nursing science, have characteristics of the soft sciences, as they also publish books and national publications. By limiting the focus of comparison to disciplinary groups, this study does not take into account the variations within these groups. The three patterns, however, give a context for further studies on how different subdisciplines and specialisms are placed.

Table 5. Three patterns of publishing.

Disciplinary groups	Knowledge territory (cf. Becher 1989)	Explanations for publishing pattern (cf. Kyvik 1991)	Typical scholarly publication types	Non-scholarly publishing	Co-publishing	Publishing productivity
Natural and medical sciences	Hard-pure	Codified communication language, single-paradigmatic, high mutual dependence between researchers, specialist audience, global research subjects, high degree of competition for priority	International journal articles	A few professional journals Communication and dissemination of results to a large audience, mainly through interviews and the media	High number of authors International co-publishing typical	Researchers contribute many articles, but due to the high number of co-authors the fractionalised publication count per researcher is low
Engineering	Hard-applied		Conference proceedings	Research reports, applications	High number of authors International co-publishing typical	Researchers contribute many articles, but due to the high number of co-authors the fractionalised publication count per researcher is low
Humanities (and social sciences)	Soft-pure	Literary communication language, multi-paradigmatic, low mutual dependence between researchers, general audience, local research subjects, low degree of competition for priority	Chapters or articles in edited books, and monographs	Popular articles and books	Mostly single-authored Co-publications usually by two or three authors only	Contributions per researcher are lower than in other disciplinary groups due to low degree of co-publishing Fractionalised publication counts combined with higher weighting of monographs are high

9.2 Effects of gender and position on publishing patterns

Earlier studies have repeated equivalent results on the distribution of publishing productivity at the level of individual scholars: publishing productivity accumulates to a small group of scholars (e.g. Allison and Stewart 1974; Tien & Blackburn 1996; Carayol & Matt 2004), productivity is higher for scholars in the highest positions, and men publish more than women (e.g. Kyvik and Teigen 1991; Zuckerman 1991; Xie and Shauman 1998; Prpić 2002; Fox 2005). The findings of this study indicate that these features observed in other countries also persist in Finland, in all disciplinary groups (Article II) as well as in one particular field, sociology (Article I). Data on publications in the local databases of Finnish universities (Article II) as well as Nordic sociologists' visibility and citations on Google Scholar (Article I) support this result.

Finnish science seems to follow a widely observed pattern of publishing performance at the individual level: the so-called Matthew effect of the cumulative and self-reinforcing nature of publications and their impact (see Merton 1973). The distribution of academic productivity is as skewed in Finland as elsewhere. Professors often act as supervisors or research group leaders, and in some fields of the medical and natural sciences, they are usually the last authors of their doctoral students' and research groups' publications. However, professors are also significantly more productive than other scholars in the soft sciences, where authoring practices are quite different (see Puuska & Miettinen 2008).

In all disciplinary groups, the distribution of publishing productivity is highly skewed. Analysis of Article II does not support the view that different scholars focus on different publication types: the most productive scholars tend to be most productive in all forms of publishing. In line with results from various studies (e.g. Allison & Stewart 1974; Tien & Blackburn 1996; Carayol & Matt 2004), Finnish scholars in the highest professional positions, namely professors, tend to be the most productive. Article II shows that these features apply for all types of publications. Professors are also significantly more productive than other scholars in the soft sciences, where a remarkable proportion of publications are single-authored and supervisors or research group leaders do not automatically appear on author lists, which is a common authoring practice in the hard sciences.

According to the results in Article II, the total output of male Finnish scholars is 1.7-fold greater than that of women. The gender distinction is smaller but still persists when professional position is taken into account. Article I suggests that among the Nordic sociologists 'Grey male professor panthers still dominate the faculties.' Female authors are less visible than their male counterparts on Google Scholar, and the gender differences are similar in all Nordic sociology departments. Female scholars attract far fewer citations than men; this is mostly an outcome of individual differences in visibility measured by web hits in Google Scholar.

Even though the positive effect of position and male gender apply for all publication types, there are certain curiosities. Article II shows that productivity differences between professors and other positions, as well as between men and women, are highest for monographs. Furthermore, the difference in productivity between different positions is higher for articles in edited books than for journal articles. Unlike in other disciplinary groups, female professors do better than their male counterparts in the natural sciences, where the percentage of women is very small. Thus the results do not support the assumption that the fields with a high proportion of women, that is the humanities and social sciences, will have a narrower gap in publishing productivity (e. g. Stack 2004).

9.3 Coverage and applicability of different bibliometric datasets

In light of all four articles it appears that the choice of data has a remarkable influence on results in terms of productivity and impact. All of the four datasets used have their pros and cons in terms of quality and coverage. They all have different functions, and they can be considered mutually complementary, as they describe different aspects of publishing. WoS represents only a partial picture of publishing patterns, specifically in the selected international publishing forums. The local publication registers from the universities and Google Scholar provide much better coverage in terms of various publication types and are therefore more representative, especially in the social sciences and humanities. However, their data quality is not as standardised as in WoS.

Usage of an international database that mainly covers international journal articles will give quite a different kind of result in terms of productivity than data that also cover other publication types. Article II shows remarkable productivity differences between disciplines, depending on which publication types are included and which counting

method is applied. The consideration of publication types other than journal articles and the fractionalisation of publications by the number of authors almost reverse the order of the disciplinary groups in terms of their productivity.

Article I compares its findings on Nordic sociologists' publishing performance on Google Scholar with a previous study by Bjarnason and Sigfusdottir (2002), who examined the publishing patterns of the same 16 Nordic sociology departments in WoS. It emerges that the ranking of individual departments or authors in sociology varies significantly between Google Scholar and WoS in terms of both productivity and citation impact.

WoS has an advantage in its good level of standardisation of data and its clear documentation of which particular journals and series it includes. On the other hand, Google Scholar has better coverage in many fields, but it does not disclose its selection criteria, and therefore it is difficult to assess its validity for different kinds of analysis. Despite the overwhelming coverage provided in national or local publication databases, they have certain weakness compared with the more standardised data in WoS. In practice the coverage of the national or universities' databases is largely based on scholars' own reporting activity; all researchers do not necessarily report all of their publications, and the data include defects such as the erroneous classification of publications. There is wide variation in the quality of data they provide, depending on the checking procedure used and the accuracy of instructions given. Therefore they do not necessarily provide accurate counts of all publications.

This analysis raises methodological challenges for studying the typicality of different publication types. Studies from other countries show quite varied results as to the percentages of different publication types (Kyvik 2005; Puuska & Miettinen 2008; Ossenblok et al. 2012; Piro et al. 2013). Such differential results are possibly influenced by publishing behaviour in different countries, but perhaps even more so by different determinations of publication types and various counting methods. So far there are no international databases for all types of publications with standard definitions, and thus national and local publications databases and surveys are often the primary source for research in this area. In the case of non-scholarly publications, the definitions are even more heterogeneous and the data are more difficult to obtain. When the data are based on scholars' own reporting activity, they do not necessarily provide accurate counts of all publications. The problem of definitions stands out when using surveys, which are even more open to different interpretations of what is meant by, for example, 'a

scientific journal article' or 'a research report'. The somewhat contradictory results on publishing patterns according to a survey and universities' publication data in Article III largely arise from this fact.

10 Conclusions

The results of this study, along with previous research in other countries, indicate that at least three distinct patterns of scholarly publishing can be found: that of the natural sciences and medicine, that of engineering fields, and that of the humanities. Despite the alleged transformations undergone by academic institutions, they have changed only little and still seem to remain fairly distinct. There are no signs that the dominant way of publishing research results in the natural sciences and medicine – that is, articles in international journals – will become dominant in all disciplinary groups. The continuing salience of monographs and book articles in the social sciences and especially the humanities indicates that these fields have retained a publishing behaviour that is distinct from the natural and medical sciences. Publishing in non-scholarly forums is still typical of the social sciences and especially the humanities, even though it is less often rewarded in assessments of researchers' performance (see Puuska & Miettinen 2008). In engineering, on the other hand, conference publishing dominates. These disciplinary differences can be attributed to epistemic considerations related to the nature of knowledge, theories and methodologies (Becher 1989), the organisation of work (Whitley 2000), paradigmatic status, the degree of codification of the communication language, audience structure, the degree of universality of the research subjects, and the degree of competition (Kyvik 1991), which seem to have a great impact on the form, pace and personnel with which research results are published.

Despite the differences, certain features are observed in all disciplinary groups. The skewed distribution of publishing productivity appears in all disciplinary groups in such a way that the most productive scholars perform the best in all types of publication typical of the disciplines. Gender differences in productivity are also significant in Finland, even though women's level of education, employment rates and representation in university teaching positions is at the top global level. In previous studies the gender differences in publishing productivity have been attributed to, for example, gender-differentiated roles in household duties and childcare and, either consequently or not, women's slower achievement of academic degrees and the highest academic ranks, as well as lower participation in influential positions and bodies of scientific power structure (e. g. Kyvik & Teigen 1996; Fox 2005; Prpić et al. 2009).

Such kind of hidden processes are ignored when the research performance is measured at macro level.

Another feature common to all disciplinary groups is internationalisation and increased collaboration. These can be partly seen as a result of the strong promotion of collaboration networks and of the internationalisation of research within the EU and in national science policies (Hakala 2009). Although the results of this study demonstrate that the number of authors is a more significant factor in citation impact than whether the authors are from different countries, for a small country such as Finland, international collaboration can still be seen as a necessity: there are not enough competent partners within the country (see also Frame & Carpenter 1979; Narin et al. 1990). The increase of international collaboration is, however, a global trend in science, indicating that it is related not just to national policies, which may vary from country to country, but also to the global development of science. Globalisation and technological development, which have enabled new forms of communication and made travelling cheaper and faster, have enhanced the conditions for collaboration across countries. Since other factors such as global changes in science, technological developments and economic conditions also affect the development of scientific fields, the results from this study cannot draw a direct link between changes in publishing patterns and changes in national science policy. Currently and in the near future, technological developments in electronic publishing and the tendency towards more open and easier access to scientific publications and research data will probably have a substantial influence on researchers' publishing behaviour.

Academic institutions and researchers face pressures produced by national science policies and various funding bodies. It has been argued that national policies set quite contradictory aims to those of scientific research. While Finnish national science policy emphasises the internationalisation and scientific excellence of research in universities, the national innovation policy emphasises commercial value and societal relevance. Research conducted in an international context and aiming for high scientific impact may not always meet national needs and interests. (See also Hautamäki & Stähle 2012.) On the one hand, it has been suggested that disciplinary categorisation is becoming unimportant due to the homogenisation of academic cultures, which is a consequence of, for example, the demands for increased efficiency and international excellence (Hakala et al. 2003). On the other hand, the universities have been alleged to have shifted from the mode 1 type of knowledge production stressing basic research and scientific quality towards a transdisciplinary, heterogenic and heterarchical mode 2

which emphasises societal impact and relevance (Gibbons et al. 1994). The universities' various tasks, the juggling act between the two modes of knowledge production, and the pressures to seek funding from external sources (e. g. Slaughter and Leslie 1997) place different demands on research and boost the heterogeneity of research output.

Disciplinary differences are rarely taken into consideration in science policy. In national policy guidelines and strategies, the academic institutions are treated as entities instead of as constituted by heterogeneous disciplines which differ in their tasks, audience structures, funding structures, nature of research topics or publishing patterns. The different academic cultures shaped by disciplines differ in their potential to adopt science policy goals and to succeed in the competition for funding. Disciplines do not seem to adjust to these demands in a uniform manner, but in ways that are in line with their nature. For example, the technology fields have the best potential to fulfil the top priority of science policy, namely the economic value and commercialisation of research (Ylijoki et al. 2011). The findings concerning the humanities in this study act as an example of how disciplines may have their own ways of adapting their publishing patterns to external pressures. For example, it seems that publishing is shifting from monographs to articles in books. These edited books may act as substitutes for monographs: they uphold the tradition of book publishing, but are not as time-consuming as monographs. In addition, science policies and funding bodies support research collaboration. In the humanities research is also increasingly conducted in collaboration with other researchers and research groups (Puuska & Miettinen 2008). Even so, co-authorships are not common, and humanities publications are still mostly written alone.

The usage of several types of data and multiple indicators gives a better overview of publishing activities at any level. The reduction of research performance to single measurements drowns out a large part of the phenomenon (Weingart 2005; Gläser & Laudel 2007; Schneider 2009). Single indicators are also more subject to manipulation, and can lead to undesirable consequences in publishing behaviour. The results of this study demonstrate that the results of a bibliometric analysis are heavily dependent on the data used and the methodological choices made: which publication types are involved, how they are weighted, and how co-publications contributed by several units are treated. Any analysis of publishing activity based on bibliometric data therefore needs a careful interpretation and understanding of the context. The significant differences in publication types, co-authorship patterns and productivity, along with the cognitive and social differences among different disciplines, beg the question of the

meaningfulness of using uniform indicators for all disciplines, which is especially common at the national level. Is it reasonable or even possible to compare a single-authored Finnish-language monograph in history with an article in a physics journal contributed by a large international group of researchers? Disciplinary groups seem to differ greatly in terms of productivity per researcher (see also Piro et al. 2013; Aagaard et al. 2014).

Single indicators may fit better in the hard sciences, where the consensus on quality of research is higher. In the hard sciences, the publishing pattern – that is, articles in scientific journals with established peer review and publishing processes – is fairly standardised, and there is a higher degree of consensus on what constitutes good research (e.g. Becher 1989; Kekäle & Lehtikoinen 2000). Many of these scientists would prefer citation-based indicators in the assessment of their research (e.g. Sivertsen & Schneider 2012). In such fields where variety of approaches are included, research problems are broad, procedures are less standardised, there are varying views on the criteria for quality of research (Whitley 2000; see also Becher 1989; Kyvik 1991; Kekäle & Lehtikoinen 2000; Puuska & Miettinen 2008). Especially in the social sciences and humanities, it is more difficult to measure quality or impact and it is even hard to define what constitutes ‘scholarly literature’ (see also Hammarfelt 2012). The findings of this study suggest that there is a great variety of both scholarly and non-scholarly publication types in these fields. Review processes and formats of contributions are usually not as standardised as they are in journals. This observation also applies to engineering, where most of the publications are published in conference proceedings, which have various formats ranging from short abstracts to full papers. Therefore the development of consistent indicators and the availability of uniform data present greater challenges for the measurement of publishing performance in these fields. In these fields the tendency should be towards greater diversity rather than simplified indicators in performance measurements.

Bibliometric indicators are social constructions of the reality of science (e.g. Wouters 1999). They have been often criticised for their reliability and validity, and for failing to relate methodology to context (e.g. Wallin 2005; Weingart 2005; Gläser & Laudel 2007). Instead of allowing the targets of science policy to determine the measurements used, the availability of data often determines the indicators that are used (Lindsey 1988; Gläser & Laudel 2007). Important aspects of research outcomes, such as non-scholarly literature and societal impact, are often neglected in research assessments and funding models because it is hard to get standardised information on them (e.g. Hicks

2013). That is, the development of bibliometric indicators has influenced the aims of science policy, instead of the indicators supporting the achievement of policy aims. Bibliometric indicators, however, have an important role in the assessment of research, which would otherwise be based on sometimes subjective impressions (e.g. van Raan 2003). This is well demonstrated by this study, where the results from a survey of Finnish departmental heads suggested that the humanities and engineering were increasingly approaching the publishing practices of the natural and medical sciences, but the actual statistical data went somewhat against those perceptions. Bibliometric indicators can serve well as a supporting tool alongside peer review for decision-making, and they should be developed further in relation to the various publishing practices in different disciplines.

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Appendix I: Description of data on Finnish universities' publications in 2011–2012

All 14 of the Finnish universities report bibliographic data on all their publications annually to the Finnish Ministry of Education and Culture. The data have been gathered since 2011. In this study, the data from the years 2001 and 2012 were analysed in order to describe disciplinary publishing patterns in Finland (Chapter 4).

The universities categorise their publications from one to six scientific fields according to a 67-item classification authorised by the Ministry. Only the primary field was used for the purposes of this study. The scientific fields are further classified into six main disciplinary groups: the natural sciences, engineering, medicine and health sciences, agriculture and forestry, the social sciences, and the humanities. One university was excluded from this study, since it uses a method of classifying disciplines that differs from other universities and is thus not comparable.

The publications reported by the universities are also categorised by publication type according to the Ministry's 16-item publication type list. For the purposes of this study (see Figures 1–4 in Chapter 4), these publication types were combined as follows:

Publication type	Publication type in the Ministry's categorisation list
Article in journal	A1 Original research article in a journal, peer-reviewed A2 Review article in a journal, peer-reviewed B1 Article in a journal, non-peer-reviewed
Article in conference proceedings	A4 Article in conference proceedings, peer-reviewed B3 Article in conference proceedings, non-peer-reviewed
Chapter or article in edited book	A3 Chapter or article in an edited book, peer-reviewed B2 Chapter or article in an edited book, non-peer-reviewed C2 Edited book (editorial work including a general introduction or epilogue)
Scientific monograph	C1 Scientific monograph
Publication aimed at professional audience	D1 Article in a professional journal D2 Article in a professional book D3 Professional conference proceedings D4 Published development or research report D5 Textbook, professional manual or guide
Publication aimed at wide audience	E1 Popular article, newspaper article E2 Popular monograph

Duplicates were removed, that is, each publication was included only once, even if it was reported by two or more universities. Some of the edited books are anthologies which consist of very short articles by the same authors. If an author had several chapters or articles in one edited book, they were counted only as one in order to avoid an overestimation of the frequency of contributions to edited books in relation to other publication types.

Appendix II: Author contributions in co-authored articles.

Articles I, III and IV in this study were co-written with other authors. The contributions of each author are described below.

Article I

Aaltojärvi, Inari, Arminen, Iikka, Auranen, Otto & Pasanen, Hanna-Mari 2008, 'Scientific productivity, web visibility and citation patterns in sixteen Nordic sociology departments', *Acta Sociologica*, vol. 51, no. 1, pp. 5–22.

Iikka Arminen and Otto Auranen initiated the study and drafted the original research design. Inari Aaltojärvi collected the data and conducted the descriptive statistical analysis. Hanna-Mari Puuska (formerly Pasanen) developed the statistical regression model and conducted more advanced analyses based on the model. Auranen made the additional analysis of the researchers' web visibility and wrote the article's introductory section. The authors had an equal share in the interpretation of results, the development of the research design and the writing of the article.

Article III

Puuska, Hanna-Mari, Muhonen, Reetta & Leino, Yrjö 2013, 'International and domestic co-publishing and their citation impact in different disciplines', *Scientometrics*, online first.

Hanna-Mari Puuska and Reetta Muhonen designed the study. Yrjö Leino conducted the validation of the bibliometric data as well as the calculation of publication counts and citation scores. Puuska designed the statistical regression model and conducted the statistical analyses and the interpretation of results. Puuska and Muhonen wrote the article, Puuska being the main responsible author.

Article IV

Puuska, Hanna-Mari., Muhonen, Reetta & Leino, Yrjö 2014, International and domestic co-publishing and their citation impact in different disciplines, *Scientometrics*, 98(2), 823-839.

Hanna-Mari Puuska designed the study and collected and analysed the data. Puuska wrote the article for the most part. Sanna Talja and Oili-Helena Ylijoki participated in the interpretation of the results, and in writing the introduction and conclusion.

Scientific Productivity, Web Visibility and Citation Patterns in Sixteen Nordic Sociology Departments

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abstract: Science is being published increasingly on the web. In this article, we explore how Nordic sociology is represented on Google Scholar (GS), what its output and impact is, and what factors explain it. Our data consist of faculty in 16 Nordic sociology departments in March 2005. The distribution of their publications and citations is skewed. Thirteen per cent of scholars do not appear on GS, whereas only 15 per cent have more than 5 publications. Of scholars with at least 1 publication ($n = 240$), 75 per cent have at most 10 citations. Both the number of web hits (web visibility) and citations are influenced by the gender of the faculty member, type and age of publication. Web visibility, citations and position are mutually reinforcing. Departmental effect is greater in web visibility than citations. International publications have started to dominate the social sciences, international monographs being particularly frequently cited. The remaining salience of books shows that sociology is still a distinct form of knowledge. The exclusive use of refereed articles and direct comparisons with the natural sciences ignore important aspects of the social sciences. In all, while GS produces findings similar to those in citation databases such as the SSCI, some systematic differences exist. No individual method for measuring scientific output is objective.

keywords: citation ♦ Google Scholar ♦ Nordic sociology ♦ scientific output ♦ scientific productivity ♦ Thomson scientific ♦ web visibility

1. Introduction

The World Wide Web has become an important source of information in developed countries, and its importance is also growing in the developing world. Scientific communities are part of this development. Dissemination of scientific publications via the web is becoming more common, and scholars in information science have already been discussing the possibility of a web mention being comparable to a research citation for evaluating the impact of academic activity (Vaughan and Shaw, 2003: 1314–15; Kousha and Thelwall, 2007: 1056). During the history of the web, several search engines have been developed to help users find the information they need. In recent years, the Google search engine has held a leading position among web search engines because it covers more text documents on the web than other engines and is now the most popular among internet users (Notess, 2003; Sullivan, 2006). One of the latest applications introduced by Google Inc. is Google Scholar (GS) (<http://scholar.google.com/>),

which searches for 'scholarly literature' on the web (Google, 2005). GS also shows how many and which publications have cited the publications found in a search.

With GS, the web becomes an even more viable alternative for scientific publication and citation databases. Scientists and policy-makers in many countries regularly use the databases of Thomson Scientific (the Science Citation Index, the Social Sciences Citation Index, and the Arts & Humanities Citation Index) to determine the productivity and impact of research. Publications covered by these databases are sometimes regarded as equivalent to 'science' or 'scientific publications', although databases include mostly English language articles published in Anglo-American based journals (Paasi, 2005). The original use of the databases provided by the International Scientific Institute was more innocent, these being tools by which to analyse the use of knowledge and research networks. Thomson Scientific has since developed products that appear to be easy to use in distinguishing productive and frequently cited scholars from others (Weingart, 2005: 119–20; van Raan, 2005: 140–1).

Compared to Thomson Scientific, the web search based GS can provide a more extensive picture of scientific activity that covers a broader scale of scientific output than traditional databases. Despite this, web and developed search engines such as GS give a particular picture of scholarly activity: what is scientific literature? who is a productive researcher? and who does frequently cited research? Given the popularity, cost-free use and coverage of Google, it has the chance to develop a dominant position in determining scientific output and impact similar to what Thomson Scientific has now.

Different publishing cultures in science

Scientific disciplines and research fields differ from each other in their values and practices (Becher and Trowler, 2001), differences which have also traditionally affected publishing behaviour. Journal publishing has been more common in the natural sciences, medicine and technology than in the social sciences and humanities. Social scientists and humanities scholars tend to publish extensively in books and in their national languages. In the natural sciences, medicine and technology, international publishing, mainly in English, is dominant (Kyvik, 1991: 45–51). Differences in publishing behaviour are not necessarily linked to the number of international contacts researchers have. International contacts and publishing have been a necessity for small science systems such as in the Nordic countries, since they have had to import theories and methods from the centres of international academic communities. To create contacts with such centres, one needs to be attractive. Visibility, the precondition for attractiveness, can be created by publishing internationally. Social scientists in small countries have nevertheless used their international contacts largely for purposes other than international publishing (Kyvik and Larsen, 1997: 240–2, 248–50).

Recent studies suggest that publication behaviour in 'book-publishing disciplines' may be undergoing change. Publishing in books and in national languages has been decreasing over the past 10 or 20 years in Norway and Finland, both of which are small science systems (Kyvik, 2003: 39–41; Oksanen et al., 2003: 101–5). It has also been argued that academic researchers in the UK, a much larger science system, nowadays concentrate on publishing in journals across disciplines (Bence and Oppenheim, 2004). The origins of the demand for 'international publishing' can be found in the emerging academic capitalism and current science and technology policy priorities in developed countries. In the global economy, these countries cannot compete by offering inexpensive labour to firms. Instead, the developed countries aim to create knowledge-intensive economies in which highly skilled and highly educated labour does R&D work, develops technological and other innovations, sells processed services (e.g. knowledge-intensive business services), and so forth. In this effort, knowledge infrastructures such as universities have become important players for developed countries (Slaughter and Leslie, 1997).

Development of the knowledge-intensive economies has had two consequences that are relevant in regard to scientific publishing cultures. The first is the demand for a more effective higher education system. In many countries, state instruments directing and funding universities have become more performance oriented since the end of the 1980s (Nieminen, 2005: 39). The performance orientation of science and higher education policies is part of the persistent shift of public management from rules and regulations towards incentives and monitoring, i.e. from government (of science) to governance (of science) (Féron and Crowley, 2003: 371–5). Some have argued that governance of science contains a model of uniform science based on the practices and functions of the natural sciences and technology which policy-makers consider relevant and ‘useful’ for knowledge-intensive economies (Demeritt, 2000; Donovan, 2005). There are also indications that current science policies are steering human sciences, including sociology, towards a new mode of scientific publishing. At least Australia, Norway and indirectly the UK use the number of scientific publications as a measure of the research performance of the university system. These funding systems value international (journal) publishing typical for natural sciences and technology. The second consequence of the rise of the knowledge-intensive economy is the increasing need to internationalize the developed but peripheral science systems such as in the Nordic countries. International activity, for example research collaboration with foreign partners and publishing internationally, is thought to give smaller science systems access to knowledge and raise the quality and visibility of their research activity (Hakala, 2002: 12).

However, demands for effectiveness and internationalization are mediated by existing academic and disciplinary cultures (Hakala, 2002; Ylijoki, 2003). It is not self-evident that science publishing will become completely uniform across disciplines. Scholarly practices and uses of research findings may vary between disciplines and research, which means that social scientists will continue publishing and referring to extended prose, and targeting national audiences in their own languages. Furthermore, national science policies differ in respect of generality and depth of instruments of science governance. Development in one country does not necessarily repeat itself in another (Féron and Crowley, 2003: 383–4).

Research questions

We need answers to the following research questions:

1. Web visibility: How visible is Nordic sociology on the web?
2. Publication productivity and impact: What are the patterns of publication output and impact of Nordic sociology according to GS?
3. Explaining factors: Which factors explain web visibility and impact of Nordic sociologists?
4. Publication behaviour and possible policy impact: Do the findings support the ‘single model’ argument that science policies are changing publication behaviour in the human sciences, including sociology?
5. Coverage of GS and Social Sciences Citation Index: Is the analysis of web visibility and publication productivity with GS comparable with analyses based on the data from the publication and citation databases, especially the much used Social Sciences Citation Index?

We define a researcher’s web visibility as the number of hits received in a GS search. Publication productivity is the number of scientific publications obtained in the search, and impact refers to the number of citations received by the author’s most cited publication. This operationalization of impact is widely used, but also highly debatable (see Warner, 2000). In information science and webometrics, the term ‘web visibility’ usually means the number of external web links received by an individual web domain or site (Thomas and Willett, 2000; InternetLab, 2005). We use the term differently, since we are interested in sociologists and departments of sociology ‘outside’ the Internet, not sites or domains ‘inside’ it. There is some

research on academic web visibility as we use the term, and the term 'web citation' is also used (see, e.g., Vaughan and Shaw, 2003, 2005; Kretschmer and Aguillo, 2004). These studies concentrate on academic units or scientific publications. We analyse the web visibility of both individual researchers and academic departments.

2. Methods and data

GS is used in the same way as most of the other web search engines. A search word or phrase is typed in a search field, and the engine returns a set of 'hits', web pages or related documents. GS differs from other search engines in that it is designed to find scientific content. An individual search result (Figure 1) gives the bibliographical information on the publication or other scholarly document, the number of articles citing the document in question, a link to the document if it is online, links to documents that relate to the same topic, and links to a web search of the document. The 'group of' link lists other documents that are part of this search result (e.g. a preprint of the document searched for) (Google, 2006). GS follows the general principles of Google, which are presented elsewhere (Brin and Page, 1998). The data in GS are obtained from the databases of scientific publishers and their digital hosts, scholarly organizations, government agencies and preprint/reprint servers. However, it is not possible to evaluate the coverage of the data, since Google does not disclose the exact sources (Jacsó, 2005). The relevance ranking used by the engine 'takes into account the full text of each article as well as the article's author, the publication in which the article appeared and how often it has been cited in scholarly literature' (Google, 2005). The most relevant results are placed at the top of the results list.

Our data, consisting of faculty in the 16 Nordic sociology departments, and also studied by Bjarnason and Sigfusdottir (2002), was gathered in March 2005 when the GS was in the beta-testing phase, and it has been partially remodelled since. We used every individual faculty member's given and last name in quotation marks as a search phrase. Names and positions of the faculty were drawn from each department's web pages. If the individual's name contained Scandinavian letters, these were transformed to suit English alphabet standards; å and ä were transformed to a, ö and ø to o, æ to ae and ü to u. To achieve valid results, the researchers whose names contained Scandinavian alphabets were also searched for using phonetic forms. Furthermore, the search was done with and without the faculty member's middle name. In some cases, the various search results differed a little from each other. This inconsistency is a known technical problem in search engines and databases, which we resolved by using the best search result for the researcher.

The various academic positions were classified under three categories: 'Professor' referring to the highest faculty position in the department; 'Emeritus professor' to retired staff with

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ABSTRACT . The study of institutional interaction explicates the verbal activities and interactional arrangements through which institutional ...

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Figure 1 An individual search result in Google Scholar

continuing ties to the home department; 'other teaching position' to a large class containing researchers at PhD level, i.e. with a PhD, and other staff with teaching responsibility. For example, the 'adjunkt', '(universitets)lektor', 'førsteamanuensis', 'assistant professor', 'associate professor', 'professor II', and '1. amanuensis' positions were put in this category. A lack of data reliability prevented us from using the 'affiliated faculty'. The departments seemed to have different definitions of 'affiliated faculty', which does not enable us to compose a stable category.

In 31 cases the search result contained scholars from other disciplines with the same name as the sociologist searched for. If the number of hits was at most 30, all were examined and the wrong people were omitted. In the cases of more hits, the proportion of correct hits was calculated from the first 10. The right number of hits was then calculated using the proportion of correct hits on the first page. To ensure reliable data, one unclear search result was removed entirely.

Because of the sorting techniques of the GS search engine, this is enough to study the most relevant and influential publications, i.e. those that are the most visible on the web have been put in the highest places on the search results list. Working papers, abstracts of conference papers and master's theses were not considered as publications. The age of the most cited publication was limited to a range of 0–25 years; hence, the oldest publication in our data is 23 years old. The number of citations was drawn from the most cited publication of the researcher because of our research interest in the most visible work of these scholars. The first 10 hits from every scholar were subjected to closer study, thus limiting the maximum for an individual researcher to 10.

Because of GS's technical application, a hit does not necessarily represent a publication (see Table 1). Among the researchers with 10 hits at most, 37 per cent of hits were publications. We estimated that this proportion of publications also applied in the case of more than 10 hits. Furthermore, scientific references that come up as hits seem to be coding errors or malfunctions of the search engine because they are supposed to be represented in the list of citations hyperlinked to each publication in the search results list in GS. Table 1 gives the distribution of types of hit. We can see that 47 per cent of hits are some form of research output produced by the sociologists in question. However, our analysis concentrates on the published research output and its impact. When scientific references are excluded, acknowledgements and other references are clearly the largest category of 'other hits'.

Table 1 *Estimated distribution of hits in Google Scholar, based on researchers with a maximum of 10 hits*

	% of hits	% of hits (without publications)	% of hits (without publications and scientific references)
Publications	37	–	–
Conference papers, working papers, etc.	10	15	21
Scientific references to the person searched for	17	28	–
Other references to the person searched for (e.g. acknowledgements)	25	39	54
Others (e.g. person searched for mentioned on the web page or in a publication)	11	18	25
Total	100	100	100

3. Descriptive results

Judging by the figures in Bjarnason and Sigfusdottir's (2002) study, the number of sociologists in the Nordic countries has increased during the past few years. There were 271 faculty members in 2000, whereas in March 2005 the same departments' total faculty was 353 (Table 2). Thirteen per cent did not show up on GS. A third did not have publications in GS (excluding conference papers, working papers, etc.). By the same token, the proportion of faculty with no publication in SSCI or CSA's Sociological Abstracts (SA) in 2000 was 31 per cent (Bjarnason and Sigfusdottir, 2002). Because our research interest is to consider scholars with publications, the final multi-level analysis consists of faculty with at least one publication ($n = 240$).

Sociology departments in Sweden are the biggest on average, while Finland's and Iceland's departments are the smallest. Table 2 also shows that Iceland has the biggest proportion of faculty with publications and Norway the smallest. However, these publication numbers should be treated with caution, as they do not take into account the amount of resources; in terms of effective use of resources the figures do not necessarily represent 'good' and 'bad' departments, because the resources available and the composition of personnel differ from one university to the next. Only output is measured; input is omitted from the analysis, which is often the case in the so-called university quality rankings. The highest proportion of professors among the faculty can be found in Iceland, where 4 members out of 7 are professors. The figure is quite different in Sweden, where 33 members out of 163 have professorial status. Professor emeritus is also a position that varies in Nordic countries. In Denmark and Iceland it is not used at all, whereas in Sweden, Finland and Norway the emeritus professor proportion is almost the same (5–6 per cent of the total faculty).

Table 3, which portrays our data as a whole, indicates that Iceland has most publications per faculty (4.3). However, this success does not persist in terms of impact and web visibility, where Iceland's placing is below the average. Denmark is the most powerful country when impact (8.3 citations per faculty) and web visibility (15.4 hits per faculty) are considered. Sweden is also strong in terms of impact and web visibility.

Considered at the departmental level, Umeå University, the University of Helsinki and the University of Stockholm almost reach the publication level of the University of Iceland (4.3). Umeå University contrasts considerably with Bjarnason and Sigfusdottir's (2002) study, in which it was among the universities with the least publications. The universities with fewer than two publications per faculty are the University of Tromsø, the University of Bergen, Åbo Academy, the University of Turku and Lund University. Like Umeå, Åbo Academy's ranking differs between the SSCI or the SA and GS: in Bjarnason and Sigfusdottir's article (2002), Åbo Academy's publication number per faculty was above average. Differences in the order of rankings show that the criteria (or inclusion mechanisms) for measuring scientific output differ between GS and Thomson Scientific or CSA. Consequently, different research profiles amount to different outcomes.

As in Bjarnason and Sigfusdottir's data, the University of Stockholm shows its strength in impact (9.7 citations per faculty). The Copenhagen Business School, which had a low position in Bjarnason and Sigfusdottir's (2002) research, also has 9.7 citations per faculty member in our data. In addition, the University of Oslo and Umeå University are strong in citations. As with publications, small sociology departments have the lowest impact, the Universities of Turku, Jyväskylä and Bergen having fewer than three citations per faculty.

Umeå University is above other departments with 22.9 hits per faculty in web visibility, the Universities of Stockholm and Helsinki coming second and third. Below the average level for hits are the University of Tromsø and the University of Turku.

Table 4, which includes scholars with at least one publication and represents the data used in the multi-level analysis, demonstrates that women are a minority group in Nordic sociology

Table 2 Faculty at 16 sociology departments in five Nordic countries

	Professor	Other faculty	Professor emeritus	Total faculty	Faculty with publications in GS*	Faculty with publications out of total faculty (%)
Nordic countries						
Sweden	33	121	9	163	108	66
Finland	20	50	4	74	52	70
Norway	30	29	4	63	41	65
Denmark	14	32	0	46	34	74
Iceland	4	3	0	7	6	86
Nordic sociology departments						
Åbo Academy	1	4	0	5	3	60
Copenhagen Business School	11	20	0	31	22	71
Göteborg University	4	24	3	31	20	65
Lund University	9	28	0	37	21	57
Umeå University	6	24	0	30	24	80
University of Tromsø	4	5	0	9	5	56
University of Bergen	8	12	2	22	14	64
University of Copenhagen	3	12	0	15	12	80
University of Helsinki	8	18	2	28	19	68
University of Iceland	4	3	0	7	6	86
University of Jyväskylä	2	7	0	9	7	78
University of Oslo	18	12	2	32	22	69
University of Stockholm	7	24	1	32	23	72
University of Tampere	7	16	0	23	18	78
University of Turku	2	5	2	9	5	56
Uppsala University	7	21	5	33	20	61
Total	101	235	17	353	241	68

* Because of missing data, one case was removed from multilevel regression analysis.

Table 3 Total and mean number of publications, citations and hits in Google Scholar at 16 sociology departments in five Nordic countries (n = 353)

	Publications ¹		Citations ²		Hits ³	
	Total	Per faculty	Total	Per faculty	Total	Per faculty
Country						
Sweden	499	3.1	1105	6.8	2308	14.2
Finland	214	2.9	385	5.2	768	10.4
Norway	164	2.6	383	6.1	679	10.8
Denmark	131	2.9	380	8.3	707	15.4
Iceland	30	4.3	27	3.9	55	7.9
Department						
Abo Academy	8	1.6	18	3.6	34	6.8
Copenhagen Business School	85	2.7	299	9.7	503	16.2
Göteborg University	79	2.6	141	4.6	362	11.7
Lund University	71	1.9	143	3.9	275	7.4
Umeå University	120	4.0	278	9.3	688	22.9
University of Tromsø	9	1.0	29	3.2	24	2.7
University of Bergen	35	1.6	61	2.8	162	7.4
University of Copenhagen	46	3.1	81	5.4	204	13.6
University of Helsinki	107	3.8	192	6.9	455	16.3
University of Iceland	30	4.3	27	3.9	55	7.9
University of Jyväskylä	27	3.0	24	2.7	65	7.2
University of Oslo	120	3.8	293	9.2	493	15.4
University of Stockholm	124	3.9	309	9.7	545	17.0
University of Tampere	58	2.5	131	5.7	178	7.7
University of Turku	14	1.6	20	2.2	36	4.0
Uppsala University	105	3.2	234	7.1	438	13.3
Total	1038	2.9	2280	6.5	4517	12.8

¹Maximum number of publications is limited to 10.

²Maximum number of citations is limited to 100. Citation number has been drawn from the individual's most cited publication.

³Maximum number of hits is limited to 100.

departments, men being 63.5 per cent of the total. In fact, the same holds true for the whole faculty (353), in which 62.9 per cent are male.

Monographs, edited collections and articles in international refereed journals seem equally strong in attracting citations. International refereed articles are the most cited individual publication type with 40 per cent, while monographs and article collections, both in national languages and in English, comprise together over 40 per cent of the most cited publications. Other international and national articles are clearly less prominent among the most cited publications.

According to Table 4, the distribution of publications and citations among researchers is skewed, which is a typical finding in bibliometric measurements, deriving from the cumulative nature of science. The more one has published, the easier it is to publish one more, and the more visible one is – measured by citations – the easier it is to be cited (see, e.g., Cole and Cole, 1973: 119–20; Price, 1986: 38–45). The skew pattern of publishing productivity was first noticed by Lotka (1926) and has been repeated in a number of studies in all disciplines, also in social sciences (e.g. Cole and Cole, 1973; Kyvik, 1991; Phelan, 1995). Of those scholars with publications, 67 per cent have at most 5; only 10 per cent have at least 10. The average is 4.3

Table 4 Descriptive statistics. *Faculties without publications are excluded (n = 240) in March 2005*

	%	Mean	SD	Range
Position				
Professor	37.3			
Other faculty	58.5			
Emeritus professor	4.1			
Sex				
Female	36.5			
Male	63.5			
Type of most cited publication				
International monograph/ed. collection	18.6			
National monograph/ed. collection	23.7			
Article in international refereed journal	40.3			
Other international article	13.1			
National article	4.2			
No. of publications ¹				
1–5 publications	67.6	4.2	3.2	1–10
6–9 publications	22.0			
10 or more publications	10.4			
Age of most cited publication				
0–10 years old	75.9	7.9	4.5	0–23
11–23 years old	24.1			
Citations ²				
No citations	9.8	9.0	14.5	0–100
1–5 citations	49.3			
6–9 citations	18.3			
10–49 citations	20.0			
At least 50 citations	2.6			
Hits ³				
1–5 hits	29.5	17.4	20.6	1–100
6–9 hits	18.4			
10–49 hits	44.4			
At least 50 hits	7.7			

¹Maximum number of publications is limited to 10.

²Maximum number of citations is limited to 100.

³Maximum number of hits is limited to 100.

when the maximum is limited to 10 publications. Twenty-three per cent of scholars have at least 10 citations, 10 per cent of scholars with at least one publication being left without citations. An average value for citations is 9 where the maximum is limited to 100 citations. In terms of web hits, the average visibility is 17 hits per scholar, with the maximum limited to 100 hits.¹ The mean age of the most cited publication is 8 years.

4. Multi-level explanations of web visibility and citation patterns

Through the multi-level analysis, we trace the relations of various potentially influential factors of web visibility of Nordic sociologists; the position and sex of the author, productivity, the age and type of the most influential publication and the effect of the departmental level. The data

have been subjected to multi-level analysis, which takes into account the nested structure of the data and allows variation to be examined at two levels: 1) author and 2) departmental. The multi-level linear regression model is fitted separately for the web hits and the citations on GS.

The separate models of citations and web hits allow us to determine whether similar factors influence citations and web visibility. The relationship between web visibility and impact is also examined. Furthermore, we consider the degree to which citation patterns in publications available on the web are similar to those in international refereed articles in the databases. Analysis of the impact of publication type is difficult, however, as we have no standard impact factors on other types of publication. We compare the citation frequency of the most cited publication types to estimate its impact on citations and web hits. Since the Nordic countries' science systems have their own characteristics as small, rather peripheral, systems on the global scale, we cannot determine the validity of our findings beyond Nordic countries.

The descriptive statistics for the data in these analyses are given in Table 4. The analysis concerns 240 faculty members for whom GS found 4295 hits in March 2005. The multi-level Poisson regression model was fitted because of the skew distribution of the explanatory variables, but since the findings did not differ markedly from the multi-level linear regression model, only the normal linear models are reported in Tables 5 and 6. The distortion of dependent variables was corrected by limiting the high end of hits and citations to 100. This affected the two most cited publications with 198 and 1328 citations and the four authors with most hits, ranging from 121 to 378.

Patterns of web hits

At the author level, a number of factors are statistically related to the number of hits on GS. Female scholars have far fewer hits than men. Position is closely linked with hits, such that emeritus professors have the most and professors almost as many. The type and, in particular, the place of publication are predictors of the number of hits, i.e. authors whose most influential publication is international gain more hits than those whose top publication is a national one. The age of the most cited publication is also positively associated with the number of hits. The multivariate model shows that controlling the effects of the others slightly weakens the effects of all these factors.

The variation in the number of GS hits is not only between individual researchers but to some extent between departments as well. Since the departmental level explains 4.1 per cent of the variance in web hits, some activities seem to be departmentally bound such that particular departments are slightly preferred in activities visible as GS hits. Variation between these departments is partly explained by the department's number of faculty, bigger departments producing significantly more hits than smaller ones, even when the effects of the author-level factors are taken into account. The countries do not differ significantly from each other.

According to the random coefficient model (see Table 5), the differences between females and males are similar in all departments, but the effect of position varies significantly across departments. A more detailed examination shows that individual top scholars tend to increase the difference in the visibility between professors and other faculty. The top performers' achievements do not impact equally with other researchers' performance at the department. This suggests that individual top performers do not necessarily enhance the level of the entire department (Smeby and Try, 2005).

Citation patterns on the web

The bivariate relations between author level factors and the number of citations follow a similar pattern to web hits. First, women are cited significantly less often than men are. Professors and emeritus professors are cited significantly more than other staff. The type of the most cited publication predicts the number of citations, such that international monographs

Table 5 Multi-level linear regression analysis of hits on Google Scholar. Faculties without publications are excluded (n = 240)

	Bivariate model		Multivariate model*	
	Coefficient estimate	p-value	Coefficient estimate	p-value
Fixed effects				
Author level (level 1)				
Sex ^a		<0.001		0.060
Female	-9.4		-6.6	
Position ^b		<0.001		0.025
Professor	13.3	<0.001	9.1	0.014
Emeritus professor	16.1	0.016	12.0	0.143
Type of most cited publication ^c		0.002		<0.001
International monograph/ed. collection	19.0	0.003	12.2	0.000
National monograph/ed. collection	3.9	0.534	1.9	0.395
Article in international refereed journal	12.5	0.036	11.2	0.006
Other international article	12.1	0.071	4.4	0.336
Age of most cited publication	1.4	<0.001	0.9	0.004
Department level (level 2)				
Country ^d		0.270		-
Sweden	11.7	0.192	-	
Finland	5.4	0.458	-	
Norway	6.9	0.554	-	
Denmark	11.7	0.215	-	
No. of faculties	0.5	0.005	0.5	0.010
Random effects				
Variance at level 2				
Intercept		0.064		0.124
Sex		0.393		
Position		0.039		

^aMales are contrast.

^bEntered as a block, other faculties are contrast.

^cEntered as a block, national articles are contrast.

^dEntered as a block, Iceland is contrast.

*Only significant fixed effects ($p < 0.05$) in the bivariate model are included in the multivariate model.

draw far more citations than any other kind of publication. International refereed journals, only the second most cited type of publication, are to some degree more cited than other international articles or national publications. Not surprisingly, the age of the publication correlates strongly with the number of citations, each year adding one citation on average.

However, the effects of sex, position and age of publication largely vanish when the effect of individual visibility on the web is added to the model. Although female scholars seem to attract far fewer citations, this difference turns out to be mostly an outcome of the individual differences in visibility indicated in Table 5. Both individual web visibility and productivity are strongly associated with web impact. Each new publication adds more than two new citations to the most cited publication. Similarly, web visibility and citations go almost hand in hand. According to the model, the greater the GS visibility, the more citations the author draws. An active publishing history increases the probability of citations. In the multivariate model, only individual visibility and type of the most cited publication remain significant predictors of the probability of citations. The fact that monographs are cited on average more

Table 6 Multi-level linear regression analysis of citations on Google Scholar. Faculties without publications are excluded (n = 240)

	Bivariate model		Multivariate model*	
	Coefficient estimate	p-value	Coefficient estimate	p-value
Fixed effects				
Author level (level 1)				
Sex ^a		0.001		0.155
Female	-6.3		-1.3	
Position ^b		<0.001		0.878
Professor	8.3	<0.001	0.5	0.625
Emeritus professor	9.0	0.051	-0.7	0.861
Type of most cited publication ^c		0.002		0.002
International monograph/other book	13.3	0.003	3.5	0.137
National monograph/other book	3.5	0.412	1.5	0.102
Article in international refereed journal	8.8	0.032	2.9	0.006
Other international article	5.5	0.231	-0.5	0.753
Age of most cited publication	1.0	0.001	0.3	0.146
No. of hits	0.5	<0.001	0.5	<0.001
No. of publications	2.7	<0.001	**	
Department level (level 2)				
Country ^d		0.739		-
Sweden	5.0	0.417	-	
Finland	3.0	0.636	-	
Norway	4.9	0.447	-	
Denmark	6.7	0.306	-	
No. of faculties	0.2	0.254	-	-
Hits per faculty member	0.5	0.004	-0.07	0.519
Publications per faculty	2.5	0.021	**	
Random effects				
Variance at level 2				
Intercept		0.608		0.891
Sex		0.972		
Position		0.102		
No. of hits		<0.001		

^aMales are contrast.

^bEntered as a block, other faculties are contrast.

^cEntered as a block, national articles are contrast.

^dEntered as a block, Iceland is contrast.

*Only significant fixed effects ($p < 0.05$) in the bivariate model are included in the multivariate model.

**Because of the dependence of number of publications and number of hits, only the number of hits is included in the multivariate model.

than articles in both international and national journals suggests the salience of the monograph format as references in the social sciences. Controlling for the effect of web visibility diminishes the impact of international publication types compared to national ones, which might reflect the fact that productive authors also tend to write the types of publication that produce the most citations.

Unlike the case of web hits, departmental level explains only a small proportion of variation (0.3 per cent) in the number of citations in our data. In other words, compared to the variation across individual authors, the variation between departments in terms of citations is almost non-existent. The differences between countries do not appear to be statistically significant.

Since the average number of hits is the only departmental factor that is significantly related to the number of citations, the productive departments also attract significantly more citations. However, this is only due to the author-level relation between web hits and citations, since the departmental-level effect disappears when the author-level effect is taken into account.

The correlation between hits and citations varies significantly across departments. In some departments (Göteborg, Lund, Turku and Åbo), the most cited authors are among the least visible authors within the department measured by GS hits.

5. Discussion

Citations appear to be more closely tied to individuals, while hits are more related to positions and departments. Academic recognition turns out to be individual and science an individualistic institution. The author's position correlates heavily with web hits. Position, along with age, seems to bring web visibility. The connection between position and web visibility is probably explained by the fact that professorships are gained through an academic evaluation process in which productivity in publishing is a central criterion. Furthermore, some activities and some forms of acknowledgement are position bound. Higher-ranked scholars gain more encouragement to publish, and better publication opportunities, despite anonymous refereeing practices. They may also improve the chances of cooperation and co-authoring of publications that may enhance visibility and impact. Furthermore, students tend to acknowledge professors in their publications. Female authors are less visible on the web, which also explains most of the gender differences in the number of citations. Gender differences in productivity have been found in various studies in several countries, the lower publication frequencies of women being attributed to marital status, child care, structural location and lack of scientific collaboration, and so on (Kyvik, 1991; Kyvik and Teigen, 1996; Xie and Shauman, 1998; Prpic, 2002). Our data do not allow us to trace where the gender difference comes from, but the smaller number of women in the faculties supports the view that they are still marginal in academia, which perhaps keeps them underrepresented among gatekeepers in publication, web and GS activities. It seems likely that structural historical reasons still explain the poorer visibility and impact of women in the current academic world. Grey male professor panthers still dominate the faculties and web visibility.

Since the relationship between web visibility and citations is probably mutually reinforcing, active publishing increases the likelihood of citations which, as a form of recognition, improve the chance of further publications. However, the causality of the relationship between citations and hits cannot be examined through the cross-sectional data and regression model techniques used in this article. Thus, only hypothetical arguments about mutual dependence can be advanced. It is obvious that without publications there cannot be citations. On the other hand, recognition brings publication opportunities that add further recognition. This self-reinforcing and cumulative nature of scientific recognition, sometimes called the Matthew effect, has been found early on in science studies (Merton, 1973: 443–7). Individual recognition translates into visible activities like those of GS hits. A strong correlation between position and web visibility suggests that a similar kind of circle may exist between web visibility and position. In all, a mutually reinforcing configuration between web visibility, citations and position seems to prevail, so that web visibility, citations and position mutually influence each other. Networking and co-authorships may be the intertwining factors that tie the visibility, impact and position together. Both networking and co-authorship would merit closer study.

Nordic departments of sociology also vary in terms of average web visibility. The size of the department correlates strongly with web visibility. Bigger departments are more visible because of their better resources or more powerful networks. However, departments do not seem to support individual impact; although they increase web visibility, they do not boost

the citations of their members. The departments themselves may differ critically in terms of their average productivity and recognition of their faculty members, as shown in the descriptive results, but the departmental level does not have explanatory potential for citations for individuals on GS. The best departments may be able to recruit the most productive researchers, but the departments as such do not attract more citations of their staff. In other words, there are no centres of excellence among Nordic sociology departments. Interestingly, contrary conclusions can be drawn from this fact. First, the science policy which attempts to develop stronger units, or even centres of excellence, does not seem to have succeeded in sociology in Nordic countries. We may note either that policy supporting the facilitation of stronger units has not been sufficient, or that direct support to individual researchers may turn out to be the more efficient way to influence the increase of scientific productivity as a whole.

Monographs and article collections seem to have maintained their standing as references in the social sciences. Sixty per cent of the most influential publications of the Nordic sociology departments' staff on GS are other than international refereed articles. International monographs and edited collections attract more citations on average than other types of publication. As far as the number of citations per publication goes, international refereed articles have not become the dominant type of publication in sociology. However, they have become the most cited publication type in Nordic sociology, attracting the majority of the citations in our data. Nevertheless, the number of references to international books in particular shows that publication types other than refereed articles have not lost their significance. Consequently, studies concerning citation patterns of refereed articles do not cover the full range of recognition given in citations. This is particularly salient given that the publication types are not distributed evenly between scholars, i.e. the individual research profiles may vary such that some researchers are more prone to produce other types of publications than refereed articles, such as monographs that social scientists seem to value more than refereed articles.

The remaining salience of books and extended prose in sociology suggests that practices and functions of sociology have remained different from the natural sciences. It also shows that current science policies arguably favouring certain fields of science over others have not standardized publishing behaviour in the case of Nordic sociology – at least not yet. Lack of uniform mode of scientific publishing does not necessarily mean that policy pressures for publishing in journals do not exist. Still, perhaps the strongest incentive for doing so seems to be lacking, namely funding. Most of the systems for university core funding in Nordic countries lack the element of rewarding universities for journal publications (Auranen et al., 2005: 34–8). The system in Norway contains such an element, but it was implemented only after our data were collected.

There are also other reasons for the persistence of books as publication format in sociology. Sociology is still and perhaps permanently a distinct form of knowledge, a hybrid of the scientific and literary traditions (Lepenies, 1988). It may have functions other than technical interest, such as (hermeneutical) understanding of social phenomena and criticism of undesired forms of social development, which are served best by forms of prose other than scientific articles (Habermas, 1971; von Wright, 1971). Following Kyvik's (1991: 71–2) line of argument, we can point out three explanations for the persistent differences between the publication patterns in the social and natural sciences. The social sciences do not provide mechanical explanations of facts; they account for historical, context-bound phenomena that cannot be purified from a certain degree of hermeneutic understanding. Sociological accounts cannot become value-free, which makes rhetorical persuasion of the audience an inescapable part of the sociological trade. Second, sociology is not a science of discovery where competition for priority in publishing makes shorter formats a necessity. Third, sociological publications are often intended for policy processes requiring extensive argument. The communal values and norms of sociology may also have supported longer prose as its jewel (Becher and Trowler, 2001: 75–6). If writing

books is valued among sociologists and they are rewarded for it (e.g. in recruitment), they will keep on writing books, despite possible external pressures for article publishing. For these reasons, the exclusive use of refereed articles or direct comparisons with the natural sciences may ignore important and constitutive aspects of the social sciences. Furthermore, individual authors are likely to vary in terms of their scholarly output styles. Even the most productive and recognized scholars of social sciences may be neglected if article productivity is the only measurement technique used.

On an aggregate level, GS seems to amount to findings largely similar to those in citation databases, although the beta version of GS covered an estimated half of the articles available in citation databases. For instance, both SSCI or SA and GS showed no publications for about one-third of the teaching staff in Nordic sociology departments, although we may expect that they do have some. There are also some systematic differences. The success of individual departments or authors may vary significantly between GS and citation databases. Kousha and Thelwall (2007) found that fields of science are unequally represented in GS and citation databases. Likewise, individual publications or publishers may be completely absent, amounting to systematic differences between GS and citation databases (Jacsó, 2005). Inclusion criteria of what is considered reportable scientific product vary between citation databases and GS. Consequently, different media produce different outcomes depending on how well the activities by an individual author or department fit within the set of parameters applied. It seems likely that new, less conventional fields of research are better represented in GS, because the providers of citation databases tend to be slow and 'cautious' in accepting new journals. Within Nordic sociology departments for instance, Umeå seems to be publishing widely in new areas that are well covered in GS, but considerably less in SSCI or SA. Åbo, in contrast, tends to publish in areas represented well in SSCI or SA, but not in GS (at least in the beta-testing phase in 2005). At the level of individual researchers, differences in outcomes can be even greater. Some research profiles simply fit better within the set of parameters applied in the media in question. In all, citation indexes give a more stable picture of academic work. Without further analysis, no individual method for measuring scientific output should be accepted as neutral and objective. A combination of measures or an adapted measurement whose criteria have been purposefully selected would yield a more balanced outcome. A form of capture–recapture method might be used to estimate the overall productivity that would not be dependent on any single set of inclusion criteria (cf. Fienberg, 1992).

This study supports the view that internationalization of the social sciences is growing. Although international refereed articles have not yet become dominant, international publications dominate the scene on GS. International monographs are particularly frequently cited; refereed and other international articles being cited almost as often. National publications produce considerably fewer citations. National monographs may also gain some recognition in terms of citations, but articles published nationally do not seem to draw significant numbers of citations; obviously so, considering the fact that the international audience is usually much larger than the national one. These findings do not seem to differ between citation indexes and GS.

6. Conclusions

Research findings are increasingly available on the web, which offers enhanced opportunities for web-based measurement of academic productivity. Individual systems of measurement differ in their inclusion criteria, amounting to significantly different representations of individual researchers and departments. GS may be more open to new research fields than established citation indexes, which are slow and cautious in accepting publishing outlets into their databases. Differences in the inclusion criteria mean that the serious measurement of scientific

productivity should be based on several sets of criteria, and that the consequences of the selection of criteria should be discussed. GS does not differ from citation indexes in its emphasis on international publishing. On the contrary, the growing importance of the web emphasizes international publishing and wider international networks that have sufficient mass to make them visible. Nordic sociology has met the challenge of internationalization. Seventy per cent of the most cited Nordic sociology publications in GS are international. The remaining salience of monographs and other books shows that sociology has not become solely an article production industry, but has retained a style distinct from the natural sciences. In many other respects, Nordic sociology seems to follow the patterns of general scholarly development. The distribution of academic productivity is skewed in Nordic sociology, as elsewhere. Bigger departments produce significantly higher web visibility that may become increasingly salient in the future. However, departmental affiliations do not explain the differences in citations between individuals. There do not seem to be any Nordic sociology centres of excellence that attract recognition to their faculty.

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1. Note that figures refer to the results in March 2005. Subsequent development of the Google Scholar database has generally led to some degree of increase in hits and citations.

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Effects of scholar's gender and professional position on publishing productivity in different publication types. Analysis of a Finnish university

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Abstract This paper examines the effects of a scholar's position and gender on publishing productivity in several types of scientific publications: monographs, articles in journals, articles in edited books, and articles in conference proceedings. The data consist of 1,367 scholars who worked at the University of Helsinki, Finland, during the period 2002–2004. The analysis shows that professors are the most productive, PhDs publish more than non-PhDs, and men perform better than women, also when other scholarly characteristics are controlled for. These differences are greater for monographs and articles in edited books than for articles in journals. In terms of conference proceedings, no remarkable productivity differences were found.

Keywords Publishing productivity · Gender · Academic position · Faculty rank

Introduction

A large body of literature describes the determinants of scholars' publishing productivity. The effects of scholars' professional position and gender have been studied widely in different contexts, in different countries, in different organisational cultures, and in different scientific fields. Most of these studies, however, have concentrated on papers in international scientific journals, particularly those that are indexed by Thomson's SCI, SSCI and A&HCI databases. So far, there is very little research using large data sets on how these individual determinants are associated with productivity in other types of publishing. Especially in the social sciences and humanities, the studies on publishing productivity are limited since these databases do not include scientific books which form an essential part of their scholarly activity.

By using the complete bibliographic data of a Finnish university, this paper analyses patterns of productivity in several types of scientific publications: monographs, articles in journals, articles in edited books and book chapters, as well as articles in conference

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proceedings. Particularly, the effects of a scholar's professional position and gender are examined. The specific questions are:

1. Are there differences in total publishing output between scholars in different professional positions and genders when several publication types are included?
2. Are the productivity differences similar in different types of publications?
3. Does fractionalization of co-authored publications influence productivity differences?
4. Are there differences between disciplines in the effects of position or gender on publishing productivity?

Earlier research

Variation in publishing productivity among individual scholars

Highly skewed distribution of scientific productivity is a well-known phenomenon in bibliometric studies. Lotka discovered as early as in 1926 that the number of authors producing n publications is $1/n^k$ of those producing one publication (where k depends on e.g. field of science, being often near to 2). That result has been repeated empirically in numerous successive studies (e.g. Price 1963; Pao 1986; Kyvik 1989). In all fields, most scholars publish only one or just a few papers while a small group of highly productive scholars produce the major output of the field.

Cole and Cole (1973) have stated that the predetermined differences in productivity capacities deriving from scholars' individual skills and motivation lead to unequal scientific output. The other perspective on individual differences has been made famous by Merton (1973). He explained the skewed productivity pattern by the principle of cumulative advantage, which means that recognition achieved by publishing increases a scholar's further prestige. Previous reputation leads to success in competition for funding, improved conditions for research work, memberships of networks, and better collaboration opportunities. Consequently, the preconditions of further publishing are enhanced. Merton (1973) has also evinced the idea of the 'Matthew effect' in science as a form of cumulative advantage. The Matthew effect refers to over-recognition of already recognized scholars within the scientific community (see also Allison and Stewart 1974; Allison 1980)

Professional position as a determinant of publishing performance

Scholars in the highest professional positions tend to be the most productive (e.g. Allison and Stewart 1974; Tien and Blackburn 1996; Carayol and Matt 2004). On the individual level of scholars, knowledge is cumulative. Over the career course, publishing is facilitated as the scholar becomes more professional and gains a better familiarity with the research topic. Moreover, universities often apply publishing activity as the major criterion for promotions (Tien and Blackburn 1996). Thus, to be appointed to a professor or to some other high level position, one has to have a long list of publications and recognition, which—according to the principle of cumulative advantage—adds further publishing opportunities. Tien and Blackburn (1996) called this a selection function when they studied productivity differences between scholars in different positions in the academic hierarchy. Their findings showed evidence of considerably higher productivity among full professors compared to lower positions, but no difference was found between the lower academic ranks, namely associate and assistant professors.

There is evidence that although publishing productivity increases with age, it tends to decline at a certain age, usually in the early forties, even though the productivity peak varies between fields (e.g. Cole 1979; Kyvik 1990a). Kyvik (1990a) found, however, that in line with the cumulative advantage theory, those with more recognition are more likely to keep publishing frequently with increasing age than those with less recognition. Kyvik (1990a) also studied the accuracy of the utility maximizing theory, which refers to senior researchers expending less effort on research compared to their younger colleagues for whom publishing is still advantageous to their further careers. However, he found no evidence of a decline in productivity with age due to the decreasing utility of publishing in order to gain money and prestige—even though productivity decreases with age in all ranks, professors are still the most productive as they age. Tien and Blackburn (1996) examined the effects of promotion on motivating high publishing performance. Nevertheless, they found no systematic evidence of a decrease in productivity in the early years of an appointment to a post, or of an increase in publishing prior to a subsequent appointment.

In addition to rank, the scholar's tasks are associated with publishing activity. In the universities, teaching is an essential part of scientific work and in several scholarly positions more time is devoted to teaching than to research. These two tasks can be seen either as complementary or as competitive and segmented with conflicting expectations and obligations (Fox 1992). Marsh and Hattie (2002) rationalize these two perspectives: Involvement in research helps a teacher to be more aware of the new topics and methodologies of the discipline, which enriches the content of teaching. For its part, teaching contributes to research by offering a broader perspective on the research area and revealing gaps in the knowledge base. On the other hand, the time-demand of one activity limits the other. Moreover, researchers are required to specialize while teachers are required to take a broad view. Differential personal characteristics are involved in teaching and in research (Marsh and Hattie 2002).

Earlier research presents contradictory results on the association between publishing productivity and orientation towards teaching and research. Marsh and Hattie (2002) reported a zero correlation between effectiveness of teaching and research. The zero relation is also supported by a meta-analysis of 58 earlier studies (Hattie and Marsh 1996). Fox's (1992) findings support the perspective in which the two activities are incompatible with each other: most productive individuals are more likely to orient and devote time to research, while the orientation to teaching is not associated with high publishing activity.

Gender and publishing

Numerous studies have reported evidence of considerable productivity differences between male and female scholars. In various scientific fields, male scholars tend to be more productive than their female counterparts (e.g. Cole and Zuckerman 1984; Kyvik 1990b, Xie and Shauman 1998; Prpic 2002). Gender differences have been attributed to women's low occupation in the highest academic posts and lower integration of women into the scientific community, such as influential posts in scientific associations or memberships of editorial boards of journals (e.g. Luukkonen-Gronow and Stolte-Heiskanen 1983; Cole and Zuckerman 1984; Bentley and Blackburn 1992; Xie and Shauman 1998; Prpic 2002).

Female scholars' low occupancy of the highest university posts can also be seen in Finland. Finnish women's level of education is high: 60.8% of Master's degrees and 45.2% of doctoral degrees were taken by women in 2004. Both figures have grown remarkably since 1989 when they were 53.8% and 33.3%. (Kota Database) The employment rate of

Finnish women is also high, being the third highest, 65.4%, in the EU in 2001 (European Commission 2002). Women are well represented in university teaching positions comprising 59.7% of lecturers and other teaching posts in the Finnish universities in 2004. However, the representation of women in the highest ranks is much lower. In 2004, they comprised only 22.1% of professors and 39.3% of associate professors. The share of women among people holding doctorates and in lower academic positions has grown steadily at Finnish universities in recent decades. This has also reflected the proportion of women in the higher ranks, which has likewise constantly increased since 1989, when women comprised only 12.7% of professors and 22.1% of associate professors. (Kota Database)

Ward and Grant (1996) have reviewed international research on female scholars' lower performance which suggests that male and female scholars are engaged with different kinds of activities and make different choices in their allocation of time: women devote more time to teaching and administrative work while men have more students under their supervision. It has also been stated that the organization of research training and scientific careers is principally based on a male role model, which hampers women's progress in academic careers.

Rossiter (1993) presented the principle of cumulative disadvantage, the so-called 'Matilda effect', which refers to systematic under-recognition of female scholars in the academic world. Some studies reviewed by Ward and Grant (1996) suggest that women are less likely to get mentoring, socialization into the scientific community and preparation for research and publishing practices. For example, women have fewer opportunities to participate mentors' research groups, for co-authoring with mentors, for collaboration with supervisors in funding proposals, and poorer access to funding, as well as sharing laboratories and equipment. (Ward and Grant 1996) Research collaboration is often associated to higher productivity, but women do not easily access in male-dominated research networks (Cole 1979; Fox 1991). Kyvik and Teigen 1991 found that the lack of collaboration has a significantly negative impact on productivity among women but not among men. As a possible explanation, they propose that women may be professionally less confident and need more support from colleagues.

Many studies have examined whether gender-differentiated roles in household duties and child care explain the lower performance of female researchers, but most of the research does not support the explanation. Being married has been shown to be positively associated with scientific performance (e.g. Cole 1979; Luukkonen-Gronow and Stolte-Heiskanen 1983; Kyvik 1990b; Fox 2005). Women who have children seem to be equally or even more productive in publishing than childless women (e.g. Fox and Faver 1985; Cole and Zuckerman 1984). The results of Kyvik 1990a, b and Kyvik and Teigen (1991) are somewhat contradicting and support the negative effect of child care on women's productivity when the children are small. Women with young children are less productive than men and other women, but there are no gender differences between male and female scholars with children older than 10 years.

Publishing patterns by disciplines

The academic world includes a variety of disciplinary cultures. According to Becher (1989), disciplines differ both cognitively and socially. The cognitive dimension refers to disciplines having their own traditions in applying theories, methods, techniques and problems. The social dimension entails shared norms, values, and modes of interaction within a research field (see also Ylijoki 2000). These disciplinary characteristics are also

related to what is published in different fields, and they cannot be ignored when the effects of scholars' publishing productivity are studied. The most distinctive patterns are the orientation towards books or journals on the one hand, and the orientation towards national or international publishing on the other. The publishing activity of the hard sciences, i.e. natural sciences and medical sciences, focuses primarily on articles in international scientific journals. In the soft sciences, i.e. social sciences and the humanities, books and national publishing forums are also important. Differences can also be found, for example, in publishing to non-scientific audiences, but that issue has been left outside the scope of this article. (e. g. Kyvik 1991; Katz 1999; Hicks 2004)

Co-authoring practices also vary between scientific fields. Multi-authored publications are much more common in the hard sciences, where several people are needed to cope with complex methods and equipment. Moreover, the trend towards interdisciplinary research subjects requires specialised expertise from several fields. (Kyvik 1991; Laudel 2001) In some fields, expensive facilities are required and it is necessary to combine the resources and data of different laboratories (Sampson 1995). Soft sciences are more individualistic, the researchers are less dependent on each other, and their independent contribution is more important. Therefore in the soft sciences, publications are often single-authored or authored by only a few scholars. (Kyvik 1991; Whitley 2000)

Due to different multi-authoring practices, scholars in natural sciences and medical sciences typically have a longer list of published papers. An interview study of Finnish professors (Puuska and Miettinen 2008) showed that in hard sciences, a scholar's name may appear in the list of authors with even a small contribution to the research. Professors, supervisors, or research group leaders usually have their names as authors, which is not a common practice in social sciences and the humanities. In soft sciences, the authors are usually required to have their own text in the paper. (Puuska and Miettinen 2008)

As co-authoring practices vary, the disciplinary differences in publishing productivity depend on the calculation method for co-authored publications. The most typical practices are either counting all of a scholar's publications as total publications if the scholar has his/her name on the list of authors, or factorizing each publication by the number of authors. Another method is to give differential weights to authors according to their order on the list of authors, for example, by giving greater weight to the first author. This, however, is not an appropriate method when analysing the productivity of individual scholars, since the disciplines have differing practices in ways of listing the authors and the order does not always reflect the authors' input.

In addition to co-authoring practices, the frequency of different publication types is associated with disciplinary differences in publishing productivity. Some forms of publishing are more time-consuming than others. Namely in social sciences and the humanities, extensive monographs are often an output of several years of work, while scholars in hard sciences may produce quite a few articles in a year. Earlier studies, however, report inconsistent results on how different publication types are weighted in different disciplines. In the literature, estimates of how many articles equal a monograph vary from a few articles to as many as 18 articles (see Finkenstaedt 1990; Kyvik 1991; Clemens et al. 1995; Puuska and Miettinen 2008).

Data and method

The data consist of 1,367 scholars in teaching or research posts at the University of Helsinki (UH) in 2002–2004. UH is clearly the biggest university in Finland with more

than 7,000 working years on research and research expenditure of about 226 million Euros in 2004. It accounts for almost one fourth of the Finnish university sector's personnel and funding. The budget funding is allocated to the University by the Ministry of Education and comprised 48% of the UH's total funding in 2004. Most of the external funding (53%) came from the national funding agencies, namely the Academy of Finland and the Finnish Funding Agency for Technology and Innovation. (Statistics Finland 2004) The data used in this article combine complete bibliographic records from the UH's publication register and data on scholars' backgrounds from the University's personnel register.

Bibliographic data

The bibliographies of UH are publicly available on the web and cover all types of publications—scientific books and articles as well as non-scholarly publications. The register provides bibliographic notes on each publication by the University staff. It covers only the output that has been published during the scholars' affiliation with the UH. The scholars or departments report their publications to the library, which maintains the register. The scholars are requested to supply copies of their publications to verify the authenticity.

In this paper, the focus is on scientific publications. These are defined as written texts that have been published in forums intended for an academic audience, namely articles in scientific journals, monographs published by a scientific publisher, articles in edited scholarly books or chapters in scholarly books, and full papers in published conference proceedings. The monographs do not include doctoral dissertations which are, however, counted when quantifying the total output of scholars. In Finland, doctoral dissertations are nearly always scientific monographs or article collections published by a university or other scientific publisher. In those rare cases in which a doctoral thesis had been republished as a monograph by a different publisher afterwards, they were counted only as a doctoral dissertation, but not as a monograph. Other publications, such as articles in non-academic journals, non-refereed or short review articles and book-reviews, short introductions, editorial material, discussion papers, working papers, and conference abstracts were omitted from the analyses.

The representativeness of the bibliographic data was compared with four other publication data sources (ISI Web of Knowledge, Google Scholar, and two Finnish national reference databases). A random sample of 166 scholars with a total of 1,156 registered items showed that 0.6 missing scientific publications per person were found in the other sources. Per 100 registered publications, 5.4 missing publications were found. Most of these were found in national sources, ISI publications comprising only 5.6% and Google Scholar publications 25.2% of missing papers. The coverage of the data is highly satisfactory being based on the scholars' own reporting activity.

Data on scholarly background characteristics

The background data were received from the personnel administration unit of the University of Helsinki. The personnel register provides data on scholars' names, titles, gender, host departments, funding sources, the date of commencing and termination of employment, and leaves of absence. In this paper, the inclusion criterion for a scholar is that he/she was continuously employed by the UH in 2002–2004. Brief absences of less than 6 months were not taken into account if the employment was uninterrupted for the rest of the period. Given that due to the lag between research work and publishing the scholars do not

Table 1 Descriptive statistics of scholars' degree and gender by scholar's position (% of working years)

	Working years in total	Position						Total
		Professor	Lecturer	Associate professor	Assistant	Researcher, budget funding	Researcher, external funding	
Working years in total		1,417	1,064	145	312	217	946	4,101
Degree								
Non-PhD	1,444	0.9%	33.2%	19.3%	73.1%	81.6%	67.9%	35.2%
PhD	2,657	99.1%	66.8%	80.7%	26.9%	18.4%	32.1%	64.8%
Total	4,101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Gender								
Male	2,544	79.7%	53.0%	62.8%	51.3%	44.7%	53.2%	62.0%
Female	1,557	20.3%	47.0%	37.2%	48.7%	55.3%	46.8%	38.0%
Total	4,101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

necessarily have anything to publish in the very first months of the affiliation, one inclusion criterion was that the scholar had been affiliated to UH at least since July 2001.

The discipline is defined by the scholar's host department. Most fields of science are represented at UH. Of the major fields, only fields of engineering and technology, sports sciences, and arts are not covered by the data. The scholars were classified into five disciplinary groups based on the OECD (2002) categorization of scientific fields. To avoid misinterpretation of the results, a few fields were reclassified on the basis of a previous study on UH's disciplinary publishing patterns (Puuska and Miettinen 2008).¹

The scholars are classified into six categories describing their position and duties (see Table 1). Information on the total length of scholars' research careers could not be traced since data on employment and publishing history was available only for their affiliation with the particular university (UH) and scholars often move between organisations. In addition to the scholarly position, the scholar's degree is used as an indicator of research experience.

Professor is the highest academic position in the Finnish universities. Both professors and associate professors are senior scholars with a combination of teaching, research, and administrative responsibilities. Associate professors usually have less teaching duties than professors and their posts are more focused on research. Furthermore, associate professor's post is usually for a term of 5 years, while the majority of professors are tenured staff. A doctoral degree is principally required for professors and associate professors, but there are some exceptions. In the data, 0.9% of professors and one-fifth of associate professors do not have a doctoral degree (Table 1).

An academic assistant's post is normally for 5 years. It is primarily intended for those pursuing doctoral studies, but usually includes some minor administrative and teaching duties as well. Nowadays many assistants already have a doctoral degree (26.9% of their working years in the data).

¹ Psychology and veterinary medicine at UH have a publishing profile that is similar to that in the medicine. Therefore, they were categorised as fields of medical sciences. Correspondingly, geography was included in social sciences.

The lecturers' posts focus primarily on teaching but some of them also include minor research or administrative duties. Most lecturers are senior scholars with a tenured post. A doctoral degree is required for many of the teaching positions; PhDs comprise 66.8% of lecturers in the data.

Professors, associate professors, assistants, and lecturers are mainly paid for by the budget funding, while most researchers' posts in UH (77.8%) are funded by an external source. The Academy of Finland is clearly the most common source of funding covering 48.5% of working years of researchers who are not funded from the UH budget. The researchers funded by an external source usually work full-time on research projects that are fixed for a term from a few months to a few years. The proportion of PhDs is 32.1% in this group. The researchers who are funded by the UH budget may have some teaching and administrative duties, but usually for only a very small proportion of their total working time. In the data, only 18.4% of these researchers have already taken a doctoral degree. Many of them are pursuing their doctoral studies full-time as doctoral students in the graduate schools.

Male scholars comprise 62.0% of all scholars. Table 1 shows that men and women are quite equally represented in other positions, but male scholars clearly dominate in the highest positions comprising 79.7% of professors' and 62.8% of associate professors' working years, which corresponds well to the situation in the whole country (Kota Database). As male scholars dominate in the highest ranks, the proportion of PhDs is higher among men (72.8%) than among women (51.7%).

In the data, researcher positions are much more common in natural sciences and agricultural sciences (Table 2). In other disciplines, foundations account for a considerable proportion of research funding (Statistics Finland 2004), but scholars with a scholarship from a foundation are not always registered as university personnel and thus not covered by the data. Moreover, doctoral graduate school positions in Finland are focused more heavily on the fields of natural sciences and technology (Academy of Finland 2003). Table 2 shows that the proportion of PhDs is the highest in medical sciences (73.3%) and lowest in the humanities (59.4%). Females are less represented in natural sciences (22.0%) and medicine (38.6%) while the gender distribution is nearly equal in other disciplines.

The scholar's discipline, degree, and position are defined as the scholar's situation on 1 January for each year 2002–2004. During the period 2002–2004, the professional position had changed for 339 scholars (24.8%) in the data. Of the scholars, 104 (7.6%) had completed their doctorates, and 29 (2.1%) had moved to a department representing a different discipline.

Statistical analysis

In addition to descriptive results on average publication counts, Poisson multilevel regression models are used to analyse determinants of scholars' productivity in different types of publications. In descriptive analysis, both non-fractionalized and fractionalized counts are analysed. Fractionalized counts are calculated by dividing each publication by its number of authors and then summing up the scholar's fractionalized publications. The dependent variables in the Poisson multilevel regression models are:

1. Fractionalized number of monographs.
2. Fractionalized number of articles in journals.
3. Fractionalized number of articles in edited books.
4. Fractionalized number of articles in conference proceedings.
5. Fractionalized total output.
6. Non-fractionalized total output.

Table 2 Descriptive statistics of scholars' position, degree, and gender by discipline (% of working years)

	Working years in total	Discipline					Total
		Natural sciences	Agricultural sciences	Medical sciences	Social sciences	Humanities	
Working years in total		1,075	488	873	872	793	4,101
Position							
Professor	1,417	27.6%	34.6%	40.9%	38.1%	33.0%	34.6%
Lecturer	1,064	18.0%	17.8%	21.9%	30.0%	41.7%	25.9%
Associate professor	145	4.7%	5.1%	4.1%	2.8%	1.1%	3.5%
Assistant	312	8.6%	3.7%	7.4%	8.6%	7.8%	7.6%
Researcher, budget funding	217	6.5%	8.6%	5.3%	3.2%	3.9%	5.3%
Researcher, external funding	946	34.6%	30.1%	20.4%	17.3%	12.4%	23.1%
Total	4,101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Degree							
Non-PhD	1,444	38.9%	39.5%	26.7%	31.9%	40.6%	35.2 %
PhD	2,657	61.1%	60.5%	73.3%	68.1%	59.4%	64.8 %
Total	4,101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Gender							
Male	2,544	78.0%	52.5%	61.4%	55.8%	53.8%	62.0 %
Female	1,557	22.0%	47.5%	38.6%	44.2%	46.2%	38.0 %
Total	4,101	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Total output is calculated by multiplying monographs and doctoral dissertations by coefficient 4 and then summing up the scholar's publications. The coefficient 4 for books was chosen since in an interview study, it was the most typical assessment of Finnish professors in social sciences and the humanities on how many articles equal a monograph (Puuska and Miettinen 2008). It is also a typical number of articles required to constitute a Finnish doctoral dissertation instead of a monograph. Even though in the hard fields, monographs are not necessarily more valued than journal articles, they are still time-consuming output and thus included in the total output of scholars. In the data, the number of monographs, however, was very low in natural sciences (10 in total) and medical sciences (6).

In some scientific fields, national publications are considered less prestigious than publications in international forums. An interview study of Finnish professors (Puuska and Miettinen 2008) showed, however, that many national scientific journals and publishers are equally valued as international forums in several fields of soft sciences. In the data, national publications are common in social sciences and the humanities, but in the hard fields, they are very infrequent. As the data is restricted only to publications in scientific forums, the national publications were also considered scientific contributions, and in the analyses, national and international publications were given equal weight.

Since scholarly characteristics have changed from year to year, the first level unit of the statistical analyses is 1 year of work ($n = 4,101$). As mentioned earlier, there are usually

great differences between individual scholars, thus the working years of a single scholar are not independent. Therefore, the variation between scholars was also taken into account by using a two-level (hierarchical) regression model. Working years are nested to scholars so that each level-2 unit (scholar, j) has three level-1 measurements (years, i).

The two-level Poisson regression model for non-fractionalized counts is of the following form:

$$\text{Ln}[L_{ij}] = \beta_{0j} + \beta_1 * X_{1,ij} + \beta_2 * X_{2,ij} + \beta_3 * X_{3,ij} + e_{ij}, \quad (1)$$

where the intercept β_{0j} is random at level-2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01} * Z_{1,j} + u_{0j}, \quad (2)$$

In the model, L_{ij} is the number of publications that scholar j has contributed in the year i . The four vectors of explanatory dummy variables are: X_1 = discipline, X_2 = position, X_3 = degree, Z_1 = gender. In the Poisson model, the dependent variable can only have integer values. To be able to analyse fractionalized counts, an offset variable $\text{OFF}_{ij} = L_{ij}/F_{ij}$ was set. F_{ij} is the fractionalized publication count of scholar j in year i . If the scholar j had no publications in year i , i.e. $L_{ij} = 0$, OFF_{ij} was set at 1. In the analysis of the fractionalized publication output, the regression model (1) is of the following form:

$$\text{Ln}[L_{ij}] = \beta_{0j} + \ln(\text{OFF}_{ij}) + \beta_1 * X_{1,ij} + \beta_2 * X_{2,ij} + \beta_3 * X_{3,ij} + e_{ij}. \quad (3)$$

Results

Articles in scientific journals are the most common publication type in the data. On average, the scholars contributed 6,101 journal articles, which equal 1.49 journal articles per working year (Table 3). Correspondingly, 1,808 articles in edited books, 795 conference articles, 168 monographs, and 104 doctoral theses were contributed during the study period. In total, 72% of the publications were co-authored and there were on average 3.2 authors per publication. In total, 31% of publications were published in a national forum.

Professional position and publishing

Professors are clearly the most productive and the researchers funded from the budget are the least productive in all types of publishing except conference papers (Table 3). There is also a wide disparity between PhDs and non-PhDs in all publication types, which yields a 2.3 times higher total output for PhDs than for non-PhDs. The effect of a doctoral degree is a little smaller when the publication counts are fractionalized.

The difference between professors and scholars in other positions is the greatest in medical sciences, where professors have 3.2 times higher total output than other scholars (2.8 in fractionalized counts). The data show significant productivity differences between professors and those in lower positions in all other disciplinary groups as well (Sig. < 0.001 in Student's t test, non-adjusted for other variables). The productivity of professors compared to other scholars is 2.6-fold in the humanities (non-fractionalized counts), 2.1-fold in social sciences, 1.9-fold in natural sciences, and 1.7-fold in agricultural sciences. In all disciplines, the relative differences are a little smaller, but still significant (Sig. < 0.001) when the publication counts are fractionalized (see also Figs. 1–2).

Adjustment for the effects of doctoral degree, gender, and discipline, likewise taking into account the variation in productivity between scholars by two-level modelling affects

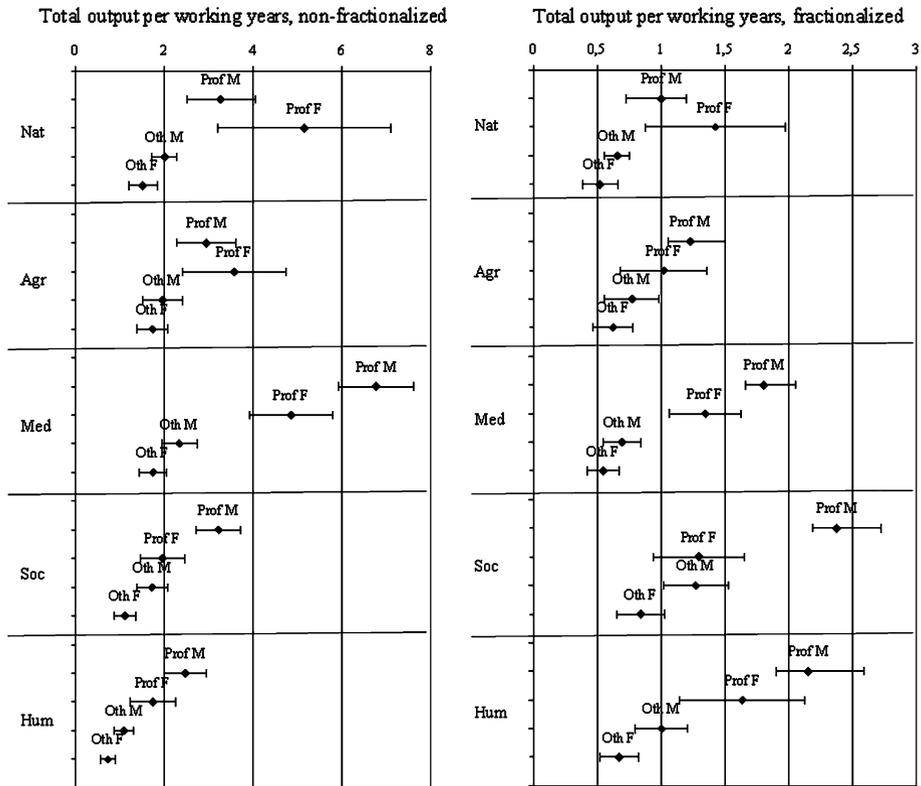
Table 3 Average publication counts per year by background characteristics (non-fractionalized/fractionalized publication counts)

	Monographs	Articles in journals	Articles in edited books/book chapters	Articles in conference proceedings	Doctoral dissertations	Total output ^a
Discipline						
Natural sciences	0.01/0.00	1.69/0.44	0.18/0.08	0.26/0.10	0.03	2.28/0.75
Agricultural sciences	0.06/0.02	1.04/0.28	0.35/0.16	0.52/0.21	0.02	2.27/0.86
Medical sciences	0.01/0.01	3.38/0.75	0.27/0.16	0.10/0.04	0.03	3.89/1.08
Social sciences	0.10/0.06	0.68/0.43	0.73/0.60	0.13/0.07	0.02	2.03/1.43
Humanities	0.04/0.03	0.29/0.27	0.71/0.66	0.07/0.06	0.03	1.34/1.22
Position						
Professor	0.08/0.05	2.50/0.77	0.78/0.60	0.26/0.11	0.00	3.86/1.68
Lecturer	0.02/0.02	0.85/0.25	0.25/0.18	0.13/0.06	0.02	1.38/0.62
Associate prof.	0.02/0.01	1.33/0.36	0.23/0.12	0.22/0.13	0.03	1.97/0.76
Assistant	0.01/0.01	0.69/0.22	0.23/0.19	0.10/0.04	0.06	1.32/0.74
Researcher budg.	0.01/0.01	0.69/0.23	0.15/0.11	0.26/0.16	0.05	1.34/0.74
Researcher ext.	0.03/0.01	1.22/0.36	0.34/0.23	0.20/0.07	0.05	2.07/0.91
Degree						
Non-PhD	0.01/0.01	0.61/0.19	0.19/0.13	0.16/0.07	0.07	1.29/0.70
PhD	0.06/0.03	1.97/0.60	0.58/0.43	0.21/0.10	-	2.98/1.26
Gender						
Male	0.05/0.03	1.81/0.56	0.50/0.37	0.22/0.10	0.02	2.82/1.24
Female	0.02/0.01	0.96/0.28	0.35/0.25	0.15/0.07	0.03	1.68/0.78
Total	0.04/0.02	1.49/0.45	0.44/0.33	0.19/0.09	0.03	2.39/1.07

^a Total output number of monographs, doctoral dissertations, and articles in journals, edited books and conferences (monographs and doctoral dissertations weighted by coefficient of 4)

the productivity differences between scholars in different positions. The results in Table 4 imply that the low productivity of researchers with budget funding is explained by the large number of doctoral students and women in this group, and when they are considered, the researchers publish in journals as much as professors. Their total output is also almost as high as that of professors. After adjustment for other scholarly characteristics, the researchers with budget funding still have low productivity of monographs and articles in edited books, while the researchers with external funding have relatively high productivity in these forms of publishing. In fact, only four budget-funded researchers (3.4%) had published a monograph.

The low performance of lecturers is not explained by the number of non-PhDs in these groups. Lecturers have the lowest productivity of journal and book articles as well as in total output also when other scholarly characteristics are controlled for (Table 4). Even though associate professors show high publishing counts in Table 3, the probability of publishing is significantly lower than that of researchers when other variables are controlled for, particularly the scholar's degree. The productivity differences of both lecturers and associate professors are significantly lower when compared to professors and researchers. This implies that they do not perform as well as researchers considering the predominance of PhDs in these positions.



Figs. 1–2 Average yearly total output by discipline, gender and professorship (non-adjusted mean and its 95% confidence interval). *Total output* number of monographs, doctoral dissertations, and articles in journals, edited books and conferences (monographs and doctoral dissertations weighted by coefficient of 4). *Prof* professor, *Oth* other, *M* male, *F* female

In the case of monographs, the effect of the scholar’s position is not statistically significant, while the doctoral degree has a more powerful effect (Table 4). By contrast, the total output is more dependent on position, and when the effects of other determinants are taken into account, the doctoral degree does not have a significant effect on total publishing productivity. As an interesting curiosity, the small group of professors and associate professors without a doctoral degree are more productive in all types of publications than their PhD counterparts, even though the difference between PhDs and non-PhDs in other positions is the other way around. This indicates that only truly outstanding scholars can be appointed to the highest positions without a doctoral degree.

Gender and publishing

Male scholars are more productive than female scholars in all types of publications (Table 3). The non-fractionalized total output of men is 1.7-fold compared to women. The differences in all publication types are slightly larger when publications are fractionalized, which indicates that women’s publications are authored by larger groups of people. The gender differences in the data are partly explained by the greater proportion of men in the

Table 4 Publication productivity by background characteristics

	Monographs, frac.		Articles in journals, frac.		Articles in edited books/book chapters, frac.		Articles in conference proceedings, frac.		Total output ^a , frac.		Total output ^a , non -frac.	
	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)
Discipline	***		***		***		***		***		***	
Natural sciences	1 ^b		1 ^b		1 ^b		1 ^b		1 ^b		1 ^b	
Agricultural sciences	5.78	(2.17;12.35)	0.96	(0.78;1.17)	2.17	(1.60;2.95)	1.26	(1.84;1.89)	1.36	(1.12;1.65)	1.20	(0.96;1.49)
Medical sciences	0.71	(0.26;2.00)	1.58	(1.35;1.85)	1.38	(1.04;1.83)	0.50	(0.34;0.75)	1.37	(1.17;1.60)	1.72	(1.44;2.06)
Social sciences	8.46	(4.25;16.88)	0.99	(0.83;1.19)	5.75	(4.44;6.43)	0.58	(0.39;0.87)	2.09	(1.77;2.46)	1.00	(0.83;1.21)
Humanities	5.13	(2.45;10.75)	0.67	(0.55;0.83)	6.02	(4.61;7.86)	0.54	(0.36;0.83)	1.86	(1.55;2.22)	0.70	(0.57;0.87)
Position	ns.		***		***		***		***		***	
Professor	1 ^b		1 ^b		1 ^b		1 ^b		1 ^b		1 ^b	
Lecturer	0.51	(0.35;0.84)	0.71	(0.62;0.81)	0.56	(0.39;0.58)	0.82	(0.67;1.00)	0.55	(0.48;0.62)	0.63	(0.55;0.72)
Associate prof.	0.57	(0.17;1.88)	0.74	(0.60;0.92)	0.66	(0.37;0.88)	0.86	(0.67;1.12)	0.60	(0.47;0.76)	0.60	(0.48;0.74)
Assistant	0.47	(0.16;1.40)	0.84	(0.68;1.06)	0.77	(0.50;0.97)	0.78	(0.55;1.10)	0.67	(0.54;0.84)	0.73	(0.60;0.91)
Researcher budg.	0.43	(0.10;1.89)	1.07	(0.85;1.38)	0.73	(0.40;0.93)	1.89	(1.39;2.57)	0.75	(0.58;1.96)	0.90	(0.72;1.12)
Researcher ext.	0.89	(0.56;1.56)	1.03	(0.90;1.19)	1.08	(0.77;1.18)	1.01	(0.80;1.27)	0.73	(0.63;0.85)	0.84	(0.73;0.96)
Degree	**		***		***		ns.		ns.		ns.	
Non-PhD	1 ^b		1 ^b		1 ^b		1 ^b		1 ^b		1 ^b	
PhD	2.24	(1.25;4.01)	1.67	(1.44;1.92)	1.79	(1.49;2.16)	0.99	(0.83;1.18)	1.03	(0.90;1.18)	1.03	(0.91;1.17)

Table 4 continued

	Monographs, frac.		Articles in journals, frac.		Articles in edited books/book chapters, frac.		Articles in conference proceedings, frac.		Total output ^a , frac. non -frac.		
	RR (95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)	RR	(95% C.I.)
Gender	**	***		**		ns.		***		***	
Male	1 ^b	1 ^b		1 ^b		1 ^b		1 ^b		1 ^b	
Female	0.52 (0.34;0.81)	0.70 (0.62;0.80)	0.75 (0.62;0.90)	0.87 (0.68;1.12)	0.72 (0.64;0.82)	0.70 (0.61;0.81)					

Results from a two-level Poisson regression analysis

^a *Total output* number of monographs, doctoral dissertations, and articles in journals, edited books and conferences (monographs and doctoral dissertations weighted by coefficient of 4)

^b Reference group

RR Event Rate Ratio estimate for group. RR implies relative amount of publishing compared to reference group. RR of 1 implies that publishing productivity in group examined is equal to reference group. RR greater (less) than 1 implies that publishing productivity is higher (lower) in group examined than in reference group

ns. non-significant

* Sig. < 0.05; ** Sig. < 0.01, *** Sig. < 0.001

Note: all the models are corrected for overdispersion, except that explaining monographs

highest positions. When other effects are controlled for, scholarly position in particular, the differences clearly decrease (Table 4). Nevertheless, there is a remarkable distinction, men publishing on average 1.9 times more monographs, and 15–42% more articles than women. In both fractionalized and non-fractionalized total output, the publishing productivity of male scholars is about 1.4 times higher. Only in the case of conference paper productivity is there no statistically significant difference between genders.

The difference between genders is greatest among professors in medical and social sciences (Figs. 1–2). A disciplinary comparison discloses, however, that in natural sciences and agricultural sciences the gender effect is non-significant. In natural sciences, the small group of female professors ($n = 32$) is even more productive than their male counterparts ($n = 245$). In other disciplines, the analysis shows that male scholars are significantly more productive both among professors and other positions (Sig. < 0.05 in Student's t test).

Disciplinary differences in publishing

Table 3 shows remarkable differences in publishing productivity between disciplinary groups. Scholars in medical sciences are clearly the most productive when measured by journal article counts even when co-authored journal articles are fractionalized. In other types of publishing, the productivity of medical sciences is low. With regards to monograph publishing, scholars in social sciences are the most active. Social sciences and especially humanities scholars have a higher frequency of articles in edited books than in journals. Conference articles are most typical in agricultural sciences, whereas they are very infrequent in medical sciences and humanities. Controlling for the effects of scholar's position, degree and gender does not remarkably affect on the disciplinary differences, which are statistically significant (Sig. < 0.001) in all types of publishing (Table 4).

Table 4 shows that when the total scientific output is analysed, scholars in medical sciences have contributed to significantly more publications than those in other disciplines. Scholars in the humanities perform most weakly. However, when taking into account the co-authoring patterns by fractionalizing the output by the number of authors, social sciences move up to the top, being significantly more productive than the hard sciences.

Accumulation of publishing productivity

In line with previous research, the distribution of publishing productivity is very skewed in the data studied. A remarkable number of scholars, 324 (23.7%), had not published anything during the three-year period whereas 11.3% of scholars had contributed to one half of the total output. The proportion of non-publishers is the highest in the humanities (35.8%) and lowest in medical sciences (14.6%). In other disciplinary groups, the proportion is about one fourth.

The accumulation effect of publishing productivity occurs in all positions. The lowest proportion of non-publishing scholars can be found among professors and researchers (both 16.0%), whereas the corresponding figure among lecturers is double (34.5%). The leading group that produces half of the total output varies from 12.1% out of lecturers to 15.8% of professors. These figures indicate that the inequality in publishing is the highest for lecturers and lowest for professors and researchers. The proportion of non-publishers is a little higher for women (26.8%) than for men (21.8%), but women are more represented in the disciplines and positions of the highest proportion of non-publishers.

Monograph is undoubtedly the most time demanding type of publishing. Therefore, the vast majority of researchers (91.6%) had not published a monograph in the period

2002–2004. The corresponding percentage is 36.8% for journal articles, 59.7% for articles in edited books, and 79.0% for conference papers. The data show some evidence that the most productive individuals are the most productive in different types of publications. Moderate positive correlations were found between a scholar's 3-year article counts in journals and edited books in the humanities (Spearman's $r = 0.576$ for non-fractionalized counts; Sig. < 0.001), social sciences ($r = 0.464$; Sig. < 0.001), and medical sciences ($r = 0.437$; Sig. < 0.001). Correlations in agriculture ($r = 0.342$; Sig. < 0.001) and natural sciences ($r = 0.311$; Sig. < 0.001) were weak but statistically significant.

In the humanities, the scholars who had published a monograph, had on average four times higher productivity in journal articles and 3.3 times higher productivity in articles in edited books compared to the scholars without a published monograph. Monograph publishing also had a significant association in social sciences (Sig. < 0.001 in Student's t test) indicating 2.2-fold productivity in journal articles and 1.7-fold in articles in edited books compared to scholars without a monograph. Activity in conference publishing had a significant correlation on other types of productivity only in agriculture, where the correlation was 0.428 (Sig. < 0.001) between book article and conference paper counts.

Conclusions

Earlier research has shown that publishing productivity accumulates in a small group of scholars, that the productivity is higher for scholars in the highest positions, and that men publish more than women. This article shows that these features also persist when different types of publications are counted. They also remain true when these determinants are taken into account simultaneously.

Professors are the most productive in all disciplines. Professors often act as supervisors or research group leaders, and in some fields of medical and natural sciences, they are usually the last authors of their doctoral students' and research groups' publications. Nevertheless, professors are significantly more productive than other scholars in soft sciences, too, where authoring practices are quite different. Fractionalization of publication counts does not greatly influence the effects of scholarly level determinants. Fractionalization, however, affects disciplinary differences considerably, improving the productivity of soft sciences in comparison with hard sciences.

Scholars in teaching positions, except professors, are less productive than researchers. This supports the theory that teaching and researching are more distinct than mutually supporting activities. It must be noted that researchers have only minor teaching responsibilities or no teaching at all, thus, more time can be devoted to publishing. In lecturers' positions, there is not much time for research. The productivity, however, is almost as low for associate professors and assistants whose posts are more oriented to research than teaching. It was found that distribution in publishing productivity is wider among lecturers than researchers. In other words, even though the average productivity of lecturers is low, there are some highly productive lecturers who have been able to combine the two activities.

There is a great gap between Finnish male and female scholars' publishing performance in all types of publishing except conference papers. The gender distinction is smaller, but still persists when the professional position is taken into account. This implies that in addition to women's low occupancy of the highest positions, other factors such as different personal characteristics and dedication to different kinds of activities are also involved in the productivity difference between men and women (see Ward and Grant 1996).

Furthermore, the recent increase of female professors in Finland indicates that they are younger than male professors on average, which may partly explain their lower publishing productivity.

The analysis shows also evidence that female professors are even more productive than their male counterparts in natural and agricultural sciences, even though men form the majority of research personnel. This may indicate that in these male-dominated fields of science, only exceptionally prominent women can be appointed to professors, whereas in other disciplines, less merit in research is required for women. In other disciplines, the female scholars' merits in teaching may have a greater impact in the filling of professorial posts.

Although the findings in total publishing productivity are in line with earlier research, small differences between different types of publication can be seen. The distinction between the groups examined, namely between professors and other positions, between PhDs and non-PhDs, and between men and women, is the highest in terms of monographs. Higher productivity of monographs is related especially to doctoral degree, which indicates that they require more experience. Furthermore, the non-PhDs may be working in such projects in which there is no call for extensive monographs. On the other hand, doctoral students do not have opportunities to concentrate on long-term book writing besides writing a doctoral thesis, which may also be in the form of a monograph.

The distinction in productivity between different positions is higher for articles in edited books than for journal articles. This can partly be explained by the expertise often associated with edited books. In the natural sciences and medicine, they are often extensive reviews of a research area, and written by the most experienced scholars. In soft sciences, editors of article collections often request contributions from their colleagues, and junior researchers are not necessarily yet involved in such networks (Puuska and Miettinen 2008). With regard to conference publishing, the scholars' position and degree do not have a remarkable effect. This is probably because in many fields, the threshold for publishing in a conference is lower than in other publishing forums and conferences often serve as a training ground for junior researchers. The data shows that the productivity of conference papers differs between disciplines. It must be noted that in some fields, such as computer science, publishing focuses primarily on conferences and certain conferences are even more valued publishing channels than scientific journals (e.g. Glänzel et al. 2006).

Some evidence of accumulation of all types of publications to a group of scholars was found. In social sciences and humanities, where monographs, edited books as well as journal articles are common, the most productive scholars tend to be most productive in all these three forms of publishing. On individual level, however, this kind of investigation would need data from a longer period.

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A longitudinal analysis of publishing patterns in engineering and the humanities

Introduction

Science policy emphasises innovations as a key to economic growth, and universities' increased collaboration with enterprises and competition for external funding poses new challenges for conducting research within academic institutions (e. g. Etzkowitz 2001, Nieminen 2005, Himanen et al. 2011). The call for new innovations with societal and economic impact, with simultaneous requirements of international competitiveness and excellence of research, pose challenges especially as measuring the performance and cost-effectiveness of universities is stressed more and more in public funding and by policy-makers. (Slaughter and Leslie 1997, Auranen & Nieminen 2010). Research evaluation is a central topic in the science policy of most European countries. Performance measurement and performance-based research funding systems are increasingly using publishing output as a criterion. This acts as an incentive toward a particular publishing pattern (Hicks 2010, Schneider 2009, Weingart 2005). Among researchers,

there is some concern that via current performance measures the publication practices of natural and life sciences, that is aiming at publishing in international journals with a high impact factor, are becoming to some degree something of a standard for other disciplines as well (e. g. Puuska & Miettinen 2008).

Scientific disciplines differ in their potential to adopt the goals of national innovation policies, and to compete for the funding that is distributed on the basis of publishing outcomes. Publishing patterns are influenced by factors and considerations such as the intended audiences for the outcomes for research, the range of funding sources available for research, and the importance of international versus national visibility for scholars (e. g. Kyvik 1991). More intra-scientific concerns such as the nature of knowledge of a field also influence scholars' publishing practices (Becher 1989, Swales 1990). For example, the degree of theoretical and methodological pluralism within a field is related to the approaches and arguments to convince the audience that the research is an important contribution to the field and, consequently, need for elaborate and lengthy presentation of research ideas. These features are related to both what forms of publishing are preferred - journal articles, conference papers or books - and in which forums the results are published - national or international, scholarly or non-scholarly.

The study analyses the developments in publishing patterns in two disciplinary groups, humanities and engineering, whose academic cultures are traditionally very distinct. Already in 1959, Snow introduced in his essay "Two Cultures" two extremes of academic cultures, those of literary intellectuals and scientists, referring to humanities and applied sciences, engineering in particular. According to Snow (1993), these two cultures are embedded in a fundamentally different "intellectual, moral and psychological" tradition and climate. From this basis, humanities and engineering were chosen for this study in order to see whether the publishing patterns of these "opposite" disciplinary groups have moved closer to each other and become homogenized or whether their traditional publishing patterns still prevail. In the humanities, monographs are an important publication channel and the national audience plays an important role (e. g. Nederhof 1989, Kyvik, 1991, Thompson 2002, Puuska & Miettinen 2008, Hammarfelt 2012). In engineering, conference articles are an important publication form and distinguish it from the

natural and life sciences, where research results are mainly published in international scientific journals (Ulusoy 1995, Glänzel et al. 2006, Puuska & Miettinen 2008).

The other reason for selecting humanities and engineering was that the publication types typical for them are covered weakly in earlier research. The fact that there is little research on changes in the shares of various publication types is mostly due to the lack of comprehensive data (see however Piro et al. 2012, Ossenblok et al. 2012, Puuska & Miettinen 2008, Kyvik 2005). Most of the research exploring development of publishing patterns is based on the citation index databases Thomson Reuter's Web of Science and Elsevier's Scopus. The basic unit in analyses is typically an article in an international refereed journal. This covers most of the research output in natural and life sciences but excludes books, national publications and non-scholarly publications which are important in the humanities. They cover conference proceedings, typical to engineering, only moderately. (e. g. Moed 2005, Finnish Ministry of Education and Culture 2012a). By using empirical data gathered from two Finnish universities publication registers, changes in publishing patterns between 1997 and 2008 in engineering and the humanities are examined. More recent potential changes are explored through a survey questionnaire targeted at department heads and covering all Finnish universities. We address the following specific questions:

- 1) Has the typicality of different types of scientific publications (scholarly journal articles, monographs, conference publications) changed?
- 2) Has the typicality of non-scholarly publishing (publications aimed at professionals, decision makers or public audience) changed?
- 3) Has the share of international publications changed?

Academic cultures and publishing patterns

Publishing practices are largely associated with the cultures and nature of knowledge production within disciplines. Each academic discipline has its own distinctive set of epistemic and social considerations (Becher 1989, Whitley 2000). Becher (1989: 35–36) argues that reasonably clear differences exist between disciplines in the following:

- characteristics of the objects of enquiry (stable and agreed-upon or subject to competing definitions)
- the nature of knowledge growth (cumulative vs. non-cumulative and based of differing theories)
- the relationship between the researcher and knowledge (non-personal or interpretive);
- standardisation of enquiry procedures;
- extent of truth claims and criteria for making them;
- the nature of the results of research.

Becher (1989) makes a distinction into hard and soft knowledge domains. Hard fields are concerned with universals and the knowledge produced is cumulative. Hard fields tend to have a paradigmatic consensus. Soft knowledge domains explore particularities, and aim at the understanding and interpretation of phenomena. Soft domains usually have multiple competing paradigms and lack consensus on what can be considered as a significant contribution to the current body of knowledge.

Becher makes another distinction into pure and applied scholarly domains. Pure and applied domains differ in that pure fields' knowledge production is more self-regulated, whereas applied domains' knowledge production is influenced more by externally defined goals and concerns.

Using Becher's terms, engineering can be categorized in the hard applied territory. The hard applied fields have a heuristic approach, are concerned with mastering the physical world. The primary outcomes of research are new products and techniques. Hard applied domains tend not to be quite as quantitative as hard pure fields (e.g. natural sciences) since typically also qualitative judgment is involved in applications. (Becher 1989.)

The humanities are typically characterised as soft pure knowledge domains since they are usually concerned with particulars, research is often qualitative, and the boundaries for choosing issues and topics are less tight than in hard pure fields. Humanities are usually more oriented toward basic research than soft applied fields (e.g. social work, education, law) which have a functional and utilitarian role and aim at enhancement of societal issues. (Becher 1989, Becher and Trowler 2001.)

Becher's concepts bring into view some essential disciplinary differences that help in understanding publishing patterns. Becher's theory is similar to Whitley's (2000) theory stressing that epistemic considerations - the nature of research within a field - and social dimensions, funding patterns, reputation and reward systems, are interlinked. We do not know to what extent publishing patterns of different disciplines are persistent, due to differences in epistemic cultures, or changeable due to social considerations and external pressures.

Previous research on publishing patterns in engineering

Fields of engineering are typically fast-developing, and therefore, the competition for priority in publishing new results and innovations is essential. More typically than in other disciplines, research in engineering usually aims at producing applied knowledge with economic relevance (Ylijoki et al 2011). Research is often conducted for enterprises which also provide funding and are collaboration partners in research projects. The outcome of research can be a commercial application or a patent. In fields where it is important to be the first to make the results public, it is necessary to publish the results rapidly in short format in international forums (see Kyvik 1991).

The level of competition in engineering is high in several ways: in getting priority of being the first who publishes and gains recognition for a novel innovation, getting research funding and recruiting the best partners (Puuska & Miettinen 2008). According to interviews of Finnish professors in engineering, publishing articles in top journals convinces co-operating companies of the competitiveness of a unit (ibid.). The main audience for research is often the global companies of the field, and therefore the ambition is to publish in the top international journals followed by the industrial companies (ibid.). There are differences between fields within engineering, however, and cooperation with companies can take many different forms. Some fields in engineering like computer science, biotechnology, and electronics are nearly completely international. Fields like civil engineering and construction engineering mostly cooperate with national industry and publish almost entirely in national forums (Puuska & Miettinen 2008).

The high degree of publishing in the form of conference articles is characteristic for engineering and makes it exceptional in comparison to other disciplinary groups. A study based on national

data of universities' publications in Australia from 1999-2001 showed conference papers to account for 45% of scientific publications in engineering. The share of conference papers was even higher, 62%, in computing sciences (Butler 2010). A recent research by Zhang and Glänzel (2012) confirmed that almost half of the journal publications in computer science and information technology in Web of Science between 1999 and 2008 were indeed conference proceedings.

Despite the dominating position of conference publications, interviewed Finnish professors in engineering emphasised the role of international journal articles as the most important channel in contributing to the scientific development of the field (Puuska & Miettinen 2008). Journal articles were also regarded as more important for getting research funding and gaining merit. Conference articles were thus seen as having a lower status than journal articles. Godin (1998) lists three reasons for the lower status of conference proceedings compared to journals: 1) they are often first drafts of results that will be modified and improved to be published in a journal, 2) they are more difficult to obtain, 3) there are numerous conferences with varying prestige in applied fields. In other disciplines, conference proceedings are mainly a venue for publishing preliminary results from research projects and a means of sharing information about ongoing research. The final synthesized results will be published in a journal or as a monograph or monograph article. Journal articles are often preceded by conference papers, and selected papers from conferences are often subsequently developed into articles to be published in special themed issues of journals (Glänzel et al. 2006).

In computer sciences conference papers are not merely predecessors of journal articles however (Goodrum et al. 2001). In computer sciences, information system sciences and allied fields, top conferences are highly prestigious: they have low acceptance rates and apply standardised peer review procedures that are even more rigorous than in journals (Ulusoy 1995, Glänzel et al. 2006, Puuska & Miettinen 2008).

Previous research on publishing patterns in the humanities

Publishing patterns in the humanities differ from natural sciences in the high degrees of monograph publishing, national publishing and publishing for a non-scholarly audience (Kyvik 1991, Nederhof 1989, Hicks 1999, Huang & Chang 2008, Thompson 2002, Nederhof 2011, Ochsner et

al. 2013). Many humanities fields have a low degree of codification, lack a uniform language and are multi-paradigmatic in nature. Therefore it takes more space to state research problems, theoretical groundings and methodology in a satisfactory manner (Whitley 2000, Kyvik 1991). In many humanities fields the extent to which work procedures, problem definitions, and theoretical goals are shared between scholars is low and research topics are often particularistic, unique or idiosyncratic (Talja & Maula 2003, Fry & Talja 2007). There is no need to publish quickly when there exists no competition for priority. Consequently, more time can be devoted to presenting the arguments and positioning the research in a comprehensive and convincing manner (Kyvik 1991).

Scientific monographs and edited books are important publishing channels in the humanities and not many comprehensive quantitative studies on publishing in the humanities exist due to lack of data on publishing in books and domestic forums. The most widely used international publication databases, the Thomson Reuters' Web of Science and Elsevier's Scopus have contained data mainly on international scientific journal publishing. Studies involving also other publication types must use data from national publication databases or surveys or universities' publication registers.

A research conducted in Norwegian universities (2005-2009) showed that books accounted for 7% and book chapters for 46% of the total scientific output in the humanities (Sivertsen & Larsen 2012). Huang and Chang (2008) found that in the University of Hong Kong the share of monographs of written scholarly output ranged in different humanities fields from 3% to 17%. The share of book chapters ranged from 9% to 39%.

Some studies have talked about a crisis in scholarly monograph publishing in the humanities, deriving from the fact that libraries' financial resources are more and more limited due to the need to purchase e-journals and e-journal databases (see e. g. Thompson 2002, Lancaster 1995). However, in an interview study (Puuska & Miettinen 2008), Finnish humanities professors emphasised that international monographs are the most prestigious forms of publications, followed by international journal articles. The humanities professors underlined the importance of publishing scientific monographs, but stated that research work has become more and more short-

term and conducted in projects. It is harder to find the time for writing a monograph and some Finnish professors assessed that monograph publishing becomes rarer and that journal article publishing increases due to external factors such as the criteria of recruitment policy and research grants which emphasize publishing in international forums. (Puuska & Miettinen 2008).

There are, however, results that do not support the prediction regarding the decline of monograph publishing. Kyvik (2003) found that the proportion of books in the total number of publications has remained stable from 1980s to 2000s in the humanities in Norway. The share of articles has increased and the publishing of research reports has decreased. The significance of monographs is also reflected in the citing behaviour of humanities scholars. For example, Thompson (2002) found that majority of both primary (79%) and secondary sources (67%) in the field of nineteenth century British and American literary studies were books. Knievel and Kellsey (2005) found that on average 74% of citations in journal articles in humanities were to books.

In many humanities fields, the nature of research subjects is national, research questions are related to a specific cultural context. A publication in a domestic forum may reach a wider audience than an international publication (Kyvik 1991). In Norway in 2005-2009, 55% of scientific publications in humanities were written in a domestic language (Sivertsen & Larsen 2012). However, Engels and Ossenblok (2012) found that publishing in English had increased in almost all humanities fields both in Norway and Flanders between 2005 and 2009.

Humanities fields are heterogeneous. Disciplines like religion, philosophy, and literature are book based disciplines whereas journal articles have more importance in history and linguistics (Hammerfelt 2012). Fields such as corpus-based linguistics partake in research projects aimed at applications and their publishing profiles can approach that of natural sciences more than traditional humanities (Nederhof et. al. 1989, Nederhof 2006, Fry & Talja 2004). Puuska and Miettinen (2008) found variation in Finnish humanities professors' attitudes towards publishing in domestic forums. Professors in philosophy and English philology considered contributing to international discussions in international publishing channels to be most the most important form of communication. Professors representing history and Finnish language studies, in turn, emphasised the importance of publishing for the national academic community. For linguists,

communication with the public, the users of the Finnish language, is important. This is also the case for general history where popularising is seen as an important task for researchers and publications are usually aimed at both scholarly and non-scholarly audiences (Puuska & Miettinen 2008). Literary studies is another field where language and its refined use are important and serving the national public of the object language is often seen as a core task (Nederhof 2011; Hammarfelt 2012).

In the humanities, the application of the results of research, societal impact, can be understood as contributing to ongoing debates about social and cultural issues (see e.g. Kyvik 2005). Publication channels used for this purpose are, for instance, newspaper articles, essays, and popular books. (Puuska & Miettinen 2008, Ylijoki et al. 2010) Kyvik (2005) noted that also the hard sciences often deal with societal important questions and issues but their high degree of codification makes it difficult for scholars to write for lay people. Scholars in the humanities and social sciences are more active in writing themselves about scientific results in popular publishing channels. Kyvik (2005) found that about 70% of Norwegian scholars in the humanities and social sciences had written popular science articles during the period 1998-2001. The corresponding share was about 50% in the natural and medical sciences and technology. Nederhof (2011) found that the share of the total written output directed at general public ranged from 26% to 73% in literature fields and from 8% to 44% in language and linguistics fields.

Finnish science system and publishing

Finland is a small country but it has heavily invested in research and steadily increased its expenditure on research during the past two decades. In 2010, Finland's R & D expenditure, measured as percentages of GDP, was the second highest among all OECD countries: 3.9 percent (OECD). The research expenditure of universities more than tripled from 1991 to 2010: from 380 to 1,200 million euros (Statistics Finland 2012). Moreover, Finland's per capita ratio of publications in the Web of Science in 2006-2009 was higher than that of any other OECD country (Finnish Ministry of Education and Culture 2012a).

Finland's science policy has since 1991 been based on the idea of a national innovation system and the aim of cultivating a systematic innovation policy. This stresses the importance of technological research, and the relevance of research for society. Internationality has been seen as an especially important instrument in advancing Finnish science and has been heavily stressed in the Finnish science policy from the late 1980s. (Hakala 1998.) Currently the main policy objective is to strengthen the quality, effectiveness and international competitiveness of research and higher education (<http://www.minedu.fi>). In addition to conducting international top-quality research, the universities are expected to produce societal impactful research. Interaction with society and the increasing societal relevance of research are included in the 2004 Universities Act as the third mission of universities in addition to research and education.

Finland's earlier performance-based funding model from 1995 distributed funding for universities based on the number of master's and doctoral degrees. Publications carried little weight since only 0.3% in 2007-2009 and 1.7% in 2010-2012 of the total budget funding were distributed according to publication output (Finnish Ministry of Education 2009). However, other incentives influenced publishing practices too (Puuska & Miettinen 2008). The universities have had various internal funding systems. Publications in international high-level journals have weight in the funding decisions of the biggest external funding source, the Academy of Finland. What is more, employment processes of universities favour applicants with a record of publishing in international refereed journals.

The Finnish science system was changed recently (The Universities Act 2009). The university network was restructured and the number of Finnish universities was reduced from 20 to 13. Although the universities now have an autonomous position and unlike earlier, have an independent legal personality either as public corporations or as foundations, the government still guarantees the core funding of universities. A fundamental change of the funding model entails that 13% of universities' budget funding from 2013 on will be distributed according to publishing performance. The new model introduced a system of classification of scientific journals, series and publishers into 3 levels according to their quality and centrality in the field. This means that those publications published at the channels of higher quality receive more credit (Finnish Min-

istry of Education and Culture 2012). Although the time scope analysed in this article covers the period 1997-2008, before the changes in the university system and funding models, the discussions regarding evaluation of research performance, the funding system and assessment of researchers started much earlier and have been ongoing since late 20th century.

Data and methods

Although departments and individual researchers are evaluated by the quantity and quality of publications, and reputation and reward systems provide incentives for a particular model of publishing, definitions of what counts as a high quality publication or even "scholarly" publication still remain variable within and across scholarly fields. An interview study with Finnish professors showed that there exists no consensus across fields on what is the most important research output. Applied research not necessarily resulting in publications or publications aimed at non-scholarly audiences is in many fields highly rated (Puuska & Miettinen 2008).

To shed light on potential changes in publishing patterns, this article analyses trends in engineering and the humanities based on two data sets:

- 1) Data gathered from two Finnish universities' publication registers covering three time periods, 1997-1998, 2002-2003, and 2007-2008,
- 2) A questionnaire conducted in 2008 covering all Finnish universities, targeted at heads of Finnish university departments and research units.

The first data allows the analysis of the exact shares of different publication types in the two disciplinary groups in the time periods under scrutiny. The second data, the survey, gives information about the universities not included in the first data set. The questionnaire responses are not as exact regarding publication types and patterns, but we can assume that heads of departments are well informed regarding the actual publishing patterns of their departments. Although the views of respondents can be influenced by the goals and expectations targeted to the departments, this does not make the data less valuable, because it gives a complementary perspective: the department heads' assessment of current trends and developments.

Publication data

The publications analysis in engineering is based on the publication register of one Finnish university, the Tampere University of Technology (TUT). TUT is a middle size university conducting research on all major fields of engineering. Publications in natural sciences fields (physics, mathematics and chemistry) were omitted from the analysis. During 1997-2006, TUT covered 22% of the overall research labour years in engineering (Statistics Finland). The share of external funding in research expenditure is of Finnish average level, 53% in 2010.

Publishing in the humanities is analysed from data collected from the publication register of the University of Helsinki (UH). UH is by far the largest university in Finland. UH covered 41% of the overall research labour years in humanities at Finnish universities during 1997-2006 (Statistics Finland). The Faculties of Humanities and Theology at UH represent a wide range of humanities fields: languages and literature, cultural studies, art studies, philosophy, history, and theology.

These two universities were selected because they provide reliable, publicly available data on publications. Their publication registers provide complete bibliographic information on publications authored by their staff. In both universities, publications are reported and registered by the scholars themselves or, in some cases, by department secretaries. Both universities apply a checking procedure: university libraries' staff goes through the reported publications and corrects possible categorization errors. The registers are based on scholars' own activeness in reporting their publishing activities; therefore they do not provide a completely accurate overall figure. The analysis focuses on the shares of different publication types and it is likely that the publication types which are less recognized and important in gaining merit and funding such as non-scholarly publications are the ones that are underrepresented. Their share is probably slightly higher than that shown by publication registers.

To be able to follow trends in publishing patterns, publication data were collected in three two year periods 1997-1998, 2002-2003 and 2007-2008. All publications that had at least one author affiliated with TUT or UH were counted as one regardless of how many authors or departments had contributed to it. Both peer reviewed and non-peer reviewed publications in scientific publication forums were included as scholarly publications. Book reviews and such were thus in-

cluded in scholarly publications. The division between scholarly and non-scholarly publications was made on the basis of the intended audience of the publication. The non-scholarly publications authored by scholars are based on research but published in forums which show that they were principally aimed at audiences outside academia (such as non-scholarly journals or newspapers).

Publications were categorised as either domestic or international on the basis of publishing country. Hence, an international publication was defined as a publication that was not published in Finland, even though also Finnish publishing forums may be international and on the other hand a publication may be published in a domestic forum abroad.

TUT and UH both universities have their own system for classifying of publications. In this study, the two classification systems were combined into the following categories:

Scholarly publications

- articles in refereed scientific journals (e. g. articles, reviews, letters, and editorial material in journals aimed at academic audience)
- articles in conference proceedings (full papers only; plain abstracts were excluded)
- articles in edited books (book chapters and articles in books)
- monographs (books published by academic publishers - also PhD theses are included since they are usually published as scholarly monographs in Finland)

Non-scholarly publications

- research reports (reports in series published by e .g. ministries, universities, research institutes or other organizations)
- non-scholarly articles (articles in non-scholarly journals and newspapers, articles in popular books)
- textbooks
- patents (only accepted patents)

The statistical significance of change in shares of publication types are analysed by applying χ^2 test for independence which shows whether the three time periods 1997-1998, 2002-2003, and 2007-2008 differ from each other statistically significantly.

Questionnaire data

Since the publication data covers only two universities, it is complemented by a questionnaire covering all Finnish universities. The survey *Changes in Research Communities and Academic Work*, funded by the Finnish Ministry of Education, was conducted in 2008 as a collaboration among three research units (Unit for Science, Technology and Innovation Studies and Higher Education Group, University of Tampere, and the Finnish Institute for Educational Research, University of Jyväskylä) (Aittola & Marttila 2010). The questionnaire was sent to heads of departments and research units in Finnish universities (N=627). With 255 responses the total response rate was 41%. Out of all respondents, 46 respondents represented fields of engineering (response rate 40%) covering eight Finnish universities. Correspondingly, 52 respondents represented humanities (response rate 41%) in 10 Finnish universities.

The survey included 19 sets of structured multi-response questions about current research practices and their changes during the last three years. Results from the study have been reported earlier elsewhere (e.g. Ylijoki et al. 2011, 2012, Ylijoki & Ursin 2013, Ylijoki forthcoming 2014). In this article, two so far unreported questions concerning publishing activities are analysed in detail:

1. How much does your unit publish in following publications types?
2. Has the amount of publications changed in your unit during the last 3 years?

The above questions were asked both about international and national publications. Both questions included the following publication types:

- Articles in scientific journals
- Scientific monographs
- Articles in books
- Conference publications
- Textbooks/other teaching materials
- Popular publications
- Patents or licenses.

Respondents were not asked to give statistical data on the typicality of different types of publishing in their own department but it is possible that some of them have kept their department's publication data available in answering the questions. The responses can be considered as well-informed assessments of the current situation and developments in the respondents' departments and units rather than exact facts.

Results

Changes in publication types

The analysis of publication data in engineering shows that conference papers are published much more than journal articles: they are still twice more typical (61% vs. 30%) in the last study period 2007-2008 (Table 1). A more detailed examination of the publication data shows that out of 32 engineering departments in TUT, only 7 (23%) had produced more journal articles than conference articles in 2007-2008. Five of these departments represented fields of civil engineering, where it was more common also to publish in edited books than in conference proceedings. In the questionnaire, 70% of the department heads in engineering assessed that articles in journals are published a lot. The corresponding percentage on conference papers is not much higher (76%) (Table 2). The publication data confirms that between the periods 2002-2003 and 2007-2008, the share of journal articles among all scientific publications has increased. (Table 1). According to the questionnaire responses, as well, journal publishing has increased in more units (66%) than conference publishing (40%) (Table 2).

In the humanities, the 10-year pattern indicates that articles in edited books have strengthened their already leading position, forming 71% of the scholarly publishing output (Table 1). The proportion of monographs has decreased remarkably during the period (from 10% to 6%). Articles in conference proceedings are secondary publication types in the humanities and seem to be almost disappearing (from 9% to 2%). In the questionnaire, however, 44% of the humanities department heads assessed that publishing in conferences has increased. The inconsistent result probably means that the results from research in the humanities are actively presented in conferences, but this does not show in the publication registers, because these publications are

short abstracts. These are not counted as publications until abstracts are developed into articles in edited books or special issues of journals.

Table 1. Shares of different scholarly publication types according to the publication registers (% of publications).

	1997-1998	2002-2003	2007-2008
Shares of scholarly publication types (% out of scholarly publications)			
<i>Engineering</i>	<i>n=1,297</i>	<i>n=2,446</i>	<i>n=3,100</i>
Article in a refereed journal	24%	26%	30%
Article in an edited book/book chapter	8%	7%	6%
Article in conference proceedings	65%	64%	61%
Scientific monograph	3%	3%	3%
Total	100%	100%	100%
<i>Humanities</i>	<i>n=2,068</i>	<i>n=2,423</i>	<i>n=2,068</i>
Article in a refereed journal	26%	22%	21%
Article in an edited book/book chapter	56%	67%	71%
Article in conference proceedings	9%	1%	2%
Scientific monograph	10%	10%	6%
Total	37%	22%	13%

Note. The differences in the shares of different publication types between the three periods are statistically significant both in engineering and the humanities ($p < 0.001$ in χ^2 test for independence).

Table 2. Publishing activity and changes in different scholarly publication types according to the survey on heads of departments (% of respondents).

Scholarly publication types*	How much does your unit publish in following publications types?			Has the amount of publications changed in your unit during the last 3 years?		
	a lot	to some extent	not at all	increased	as before	decreased
<i>Engineering (n=41-46)</i>						
Scientific journals	70%	30%	0%	66%	30%	5%
Scientific monographs	16%	80%	4%	19%	77%	5%
Edited books	9%	80%	11%	7%	85%	7%
Conference publications	76%	24%	0%	40%	53%	7%
<i>Humanities (n=48-51)</i>						
Scientific journals	53%	47%	0%	48%	52%	0%
Scientific monographs	43%	49%	8%	47%	51%	2%
Edited books	38%	62%	0%	38%	58%	4%
Conference publications	32%	68%	0%	44%	54%	2%

The publication data does not show an increase of journal article publishing in the humanities. Despite the dominant position of articles in edited books in the humanities publications, the questionnaire responses among the humanities hint to an increasing diversification in publishing types. In the questionnaire responses, 53% of respondents answered that journal articles are published "a lot." According to the humanities department heads' assessments, all the four types of academic publications are more becoming almost as typical (Table 2).

Changes in non-scholarly publishing

The publication data show that the production of non-scholarly publications in relation to academic publications has decreased in both disciplinary groups (Table 3). In engineering, the decline has been remarkable. The proportion of non-scholarly publications in the total publication output was almost three times higher in 1997-1998 (36%) than in 2007-2008 (13%).

Table 3. Shares of different non-scholarly publication types according to the publication registers (% of publications).

Shares of non-scholarly publication types (% out of all publications)			
<i>Engineering</i>	<i>n=2,072</i>	<i>n=3,140</i>	<i>n=3,569</i>
Patent	2%	2%	1%
Research report or non-scholarly book	15%	14%	11%
Other article	18%	5%	2%
Textbook	1%	1%	0%
Total	36%	22%	13%
<i>Humanities</i>	<i>n=4,310</i>	<i>n=4,464</i>	<i>n=3,690</i>
Patent	-	-	-
Research report or non-scholarly book	2%	1%	1%
Non-scholarly article	49%	48%	42%
Textbook	1%	1%	1%
Total	52%	50%	44%

Note. The differences in the shares of different publication types between the three periods are statistically significant both in engineering and the humanities ($p < 0.001$ in χ^2 test for independence).

The publication data in the humanities also indicates a decrease in the share of non-scholarly publications. However, in 2007-2008, they still formed nearly a half (45%) of the total publica-

tion output (Table 1). This is in line with results from Norway obtained by Sivertsen and Larsen (2012).

Table 4. Publishing activity and changes in different non-scholarly publication types according to the survey on heads of departments (% of respondents).

Non-scholarly publication types	a lot	to some extent	not at all	increased	as before	decreased
<i>Engineering (n=41-46)</i>						
Department series	4%	50%	46%	0%	51%	49%
Textbooks/other teaching materials	5%	84%	12%	12%	88%	0%
Popular publications	2%	64%	33%	12%	83%	5%
Patents or licenses	2%	60%	38%	17%	80%	2%
<i>Humanities (n=46-51)</i>						
Department series	16%	49%	35%	12%	63%	24%
Textbooks/other teaching materials	8%	80%	12%	14%	72%	14%
Popular publications	8%	86%	6%	30%	67%	2%
Patents or licenses	0%	2%	98%	0%	84%	16%
Publishing country	a lot	to some extent	not at all	increased	as before	decreased
<i>Engineering (n=44-46)</i>						
International publications	74%	26%	0%	68%	30%	2%
Domestic publications	7%	73%	20%	0%	82%	18%
<i>Humanities (n=51)</i>						
International publications	39%	61%	0%	71%	29%	0%
Domestic publications	53%	47%	0%	49%	49%	2%

However, the majority of the respondents in humanities (86%) assessed that popular publications are published only "to some extent" in their unit. Only a few department heads assessed that non-scholarly publications are published "a lot" (Table 3). Results from the questionnaire indicate the lower prestige of publishing in non-scholarly publication channels. The lowered prestige does not, however, mean that the role of non-scholarly publishing be changing in the humanities. Neither department heads in engineering nor those in the humanities assessed that non-scholarly publishing would be increasing, most heads assessed that the numbers are the same as before. In engineering, third of unit heads in answered that non-scholarly publication are not published at all. In engineering, patents are prestigious publication types. 60% of respondents assessed that patents are published in their units (Table 4). The publication data

shows that TUT registered 20 patents per year on average. However, the amount of patents has decreased to 2007-2008 both in absolute numbers and in relation to the total publication count.

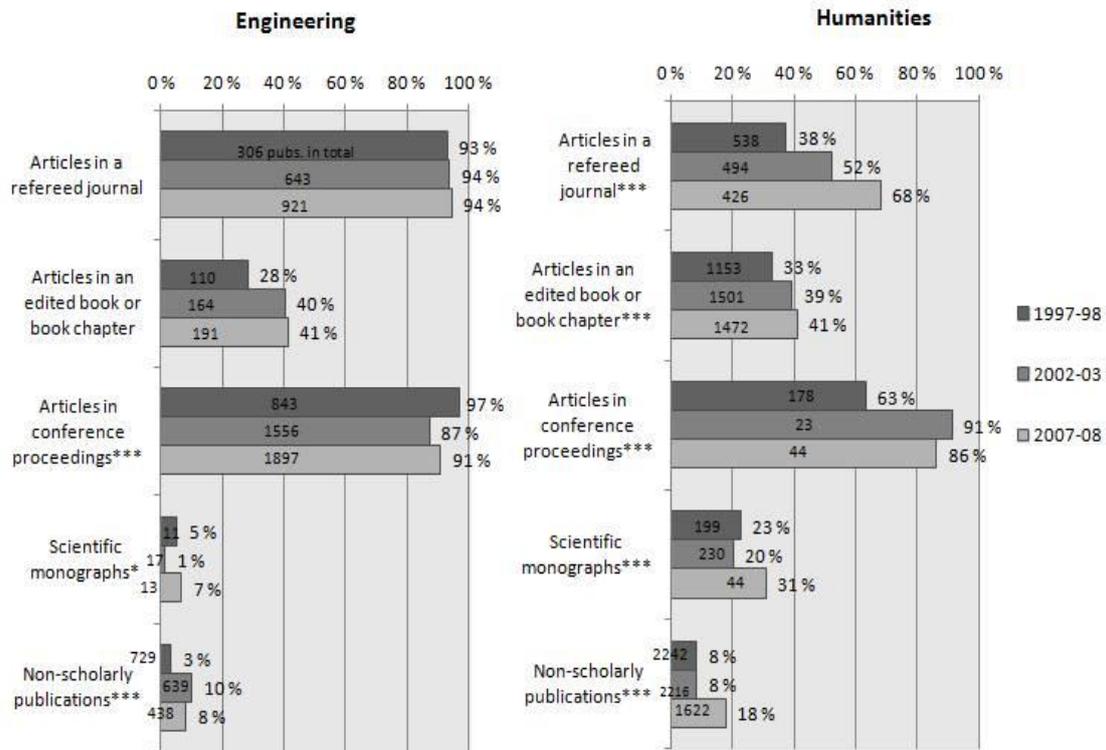
Internationality of publishing

The questionnaire responses in engineering suggest that international publications are far more common than domestic publications. The publication data confirms that journal and conference articles have been highly international in engineering already in the first period studied (1997-1998), and that there is no significant change in the typicality of international publishing (Figure 1) except the increase as regards books and book articles, although their numbers are quite small. Also according to the survey, the share of international publications has increased in most of the engineering units (68%). (Table 5). The publication data shows that the share of international publications in the total publication output has increased in 81 percent of engineering departments in TUT from 2002-2003 to 2007-2008.

Table 5. Publishing activity and changes in domestic and international publications according to the survey on heads of departments (% of respondents).

Publishing country	a lot	to some extent	not at all	increased	as before	decreased
<i>Engineering (n=44-46)</i>						
International publications	74%	26%	0%	68%	30%	2%
Domestic publications	7%	73%	20%	0%	82%	18%
<i>Humanities (n=51)</i>						
International publications	39%	61%	0%	71%	29%	0%
Domestic publications	53%	47%	0%	49%	49%	2%

In the humanities, the publication counts from UH show an increase in proportion of international publications in all publication types from 1997-1998 to 2007-2008 (Figure 2). In different publication types, the share of international publications is the highest in journal articles and conference papers. However, domestic publications are still more typical. National publications comprise 66% of all publications and 52% of scholarly publications in humanities in 2007–2008. Again this result is similar those reached in Norway and Flanders (Sivertsen & Larsen 2012, Ossenblok et al 2012).



Figures 1-2. Shares of international publications by publication type.

*) $p < 0.05$, ***) $p < 0.001$ for the differences between the three periods in χ^2 test for independence.

Also according to the responses of the heads of departments in the humanities, domestic publications still play an important role. The questionnaire responses indicated that they are published "a lot" in 53% of the units. (Table 5). The number of international publications has, however, increased in more units than domestic publications (71% vs. 49%), and according to the survey responses, international publications are published "a lot" in 39% of the units.

Conclusions

This paper examined changes in publication patterns in engineering and humanities. Neither the actual publication counts nor the survey shows a homogenization of publishing practices between these disciplines. Results indicate that the publishing patterns of the two disciplinary groups are still distinct and differ from that of natural and health life sciences where research is typically published in the form of international scientific journal articles (see e.g. Kyvik 1991, Puuska & Miettinen 2008, Moed 2005). Engineering is a hard applied discipline and its publishing pattern of engineering resembles that of natural and life sciences in certain aspects. The great majority of publications in engineering are published in scholarly international forums in an article format. Conference proceedings still dominate according to the publication data although the share of journal articles has slightly increased. Conferences enable the publishing of results rapidly which is important in the quickly developing fields of engineering. Furthermore, research in engineering is often more externally influenced than in the pure hard sciences. Conferences reach better the target audience, those who apply the new products or techniques which are typical outcome of research in engineering.

In the humanities, edited books have strengthened their already strong position. Journal article publishing has not increased in the humanities. According to the publication data, publishing is shifting more to edited books, and the proportion of singly authored monographs has decreased. Finding the time for writing a singly authored may become more difficult and edited books may act as substitutes for monographs: they uphold the tradition of book publishing but are not as time demanding for a single author as monographs. Articles in the humanities are still mostly single-authored (Puuska et al. forthcoming 2014) but edited books including contributions from several authors also manifest increased collaboration.

There are some trends that are common to both two disciplines under scrutiny. The shares of international publications have increased in relation to domestic publication. Publishing engineering was strongly international already earlier. In the questionnaire responses representatives from both disciplines stressed the increase in international publishing. Although domestic

publication still formed 66% of the actual publications, there is a trend toward increasing internationality of publishing also in the humanities.

Another trend common to both disciplines is the lowered prestige of publishing in non-scholarly publication channels. In the humanities, the lowered prestige was reflected in the questionnaire answers, but the publication data does not entirely support this. Non-scholarly publications still form about a half of all publications in the humanities although they are rarely considered in funding decisions or taken into consideration in measures of publishing performance, and do not necessarily promote the researcher's career (see Puuska & Miettinen 2008). This may be partly due to a low share of external funding in humanities, allowing more academic freedom in publishing efforts and decisions.

In engineering, the decreased share of non-scholarly publications in the publication data confirm the lowered esteem of non-scholarly publications. It may also be that non-scholarly publications are not actively reported in publication registers more. The limitation of the data is that it did not allow studying typicality of producing reports of results from non public research, which is characteristic for technology fields that have close collaboration with companies and produce results with high commercial potential (see e.g. Ylijoki et. al. 2010).

The answers of the department heads showed slightly less diverse patterns of publishing which indicates differences between the research profiles of Finnish universities. The questionnaire answers reflect the situation at 2008, and may also be indicative of the kinds of aims, attitudes and values that may manifest in the actual publishing output later. Department heads are particularly familiar with discussions regarding potential future changes in research resources, funding patterns, and reputation and reward systems. As stated earlier, the questionnaire responses also express the prestige of publication types and not the exact degrees of shares of publications in different publication categories. In both disciplinary groups, the typicality of journal articles in relation to other publication types was estimated somewhat higher than they were in the publication data of the two universities. Nearly half of the humanities respondents were of the opinion that monograph publishing has increased whereas the publication data

showed that the role of monographs in the humanities is decreasing even though the traditional monograph publishing continues in the form of edited books.

This study's limitation is that it covered a time period before bigger changes in the Finnish science policy. The implementation of innovation system and performance-based steering model and the new structural developments were underway, but the structural change guaranteeing the autonomy of universities and the new funding model where the funding is dependent on numbers of publications and quality of publication channels were not yet implemented. The effects of these fundamental turns on publishing practices remain to be explored later. In addition to science policy and funding systems, also other factors are influencing publishing patterns, for instance, the development of technologies providing better opportunities for international collaboration and better access to scholarly publications via electronic and open access publishing.

Winning resources for research is of course a primary concern to scholars. The results from this study indicate that the cultures of various disciplines are fairly unchangeable and publishing patterns remain distinct due to epistemic considerations. However, the publishing patterns are also influenced by the national science policies, recruitment policies of academic institutions and criteria of funding allocation applied by various funding bodies. Disciplines do not adjust to these factors in a uniform manner but in ways that are in line with their nature. Also, there are discrepancies in the kinds of pressures academic institutions are facing from outside of the academia. The increasing evaluations of research performance in both international and national levels direct the research practices to produce measurable outcome often considered as contributions in prestige journals. On the other hand, the innovation policy does not entail international excellence nor writing to academic colleagues as its primary goal but instead emphasizes the significance of practical applications and utility of results. Thus, there often seems to be a systematic tension between scientific productivity and societal relevance (Hessels et al. 2011). Although not necessarily in conflict, these goals tend to involve divergent incentives and demands. This makes policy steering blurred and diffused, leaving room for a variety of responses in actual research and publishing practices. It can be argued that disciplinary cultures act as a

buffer that filters these divergent policy pressures (e.g. Ylijoki 2000). With a long-standing tradition in university-industry collaboration, technology fields have better potential to fulfil the aims of innovation policy, namely the economic value and commercialization of research (Ylijoki et. al. 2011, 2012), but these are quite far for humanities. In this way policy pressures are more readily adopted and enacted if they resonate with prevailing values, ideals and practices of one's disciplinary culture (Kyvik 2007).

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International and domestic co-publishing and their citation impact in different disciplines

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Abstract This paper studies disciplinary differences in citation impacts of different types of co-publishing. The citation impacts of international, domestic inter-organizational and domestic intra-organizational co-publications, and single-authored publications, are compared. In particular, we examine the extent to which the number of authors explains the potential differences in citation impacts when compared to the influence of different types of international and domestic collaborations. The analysis is based on Finland's publications in Thomson Reuters Web of Science database in 1990–2008. Finland is a small country, thus, it has fewer opportunities to find collaborators inside own country when compared to larger countries. Finland's science policy has underlined internationalization and research collaboration as key means to increase the quality and impact of Finnish research. This study indicates that both international and domestic co-publishing have steadily increased during the past two decades in all disciplinary groups. International co-publications gain on average more citations than domestic co-publications. In natural sciences and engineering, co-authorship explains only a small proportion of variability in publications' citation rates. When the effect of the number of authors is taken into account there are no big differences in citation impacts between international and domestic co-publications. However, international co-publications by ten authors or more gather significantly more citations than other publications. In humanities, the difference in citation impacts between co-authored publications in relation to single-authored publications is significant. However, international co-publications are not on average more highly cited in relation to domestic co-publications in humanities.

Keywords Co-publishing · Research collaboration · Research policy · Citation impact

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Introduction

Several studies have shown that international co-publishing has increased rapidly and that international co-publications are cited more often than publications authored by scientists coming from one country only (Glänzel 2001; Glänzel and Schubert 2001; Katz and Hicks 1997; Muhonen et al. 2012; Narin et al. 1991; NordForsk 2010; van Raan 1998; Schmoch and Schubert 2008; Sooryamoorthy 2009). Furthermore, it has been demonstrated that also domestic inter-organizational collaboration increases citation rates compared to articles published by authors from one organization. Domestic co-publications are, on average, less cited than international co-publications however (Katz and Hicks 1997; Must 2012; Persson et al. 2004; van Raan 1998; Sooryamoorthy 2009).

The number of authors has a positive influence on the number of citations received by a publication (Baldi 1998; Goldfinch et al. 2003; Hsu and Huang 2011). The higher citation rates of international co-publications are in part explained by the fact that on average they have a higher number of authors than publications by authors from one country only. Goldfinch et al. (2003) argued that a co-publication allows access to a larger social network that consequently leads to increased visibility which in turn is reflected in higher citation rates. The causal relationship can also work the other way round: highly cited researchers and research groups are more attractive as collaborative partners (see also Schmoch and Schubert 2008).

The increase in co-publishing varies between scientific fields. Larivière and colleagues (2006) found that natural sciences and social sciences have witnessed a steady growth in the share of co-authored publications, both international and domestic, whereas the share of co-publication has stayed fairly low in the humanities between 1980 and 2002. Previous studies comparing different fields and countries show that co-authorship is not always positively associated with citation impact. Sooryamoorthy (2009) found that while in general co-authored papers receive more citations, in some natural sciences fields (psychiatry, biochemistry, agriculture and material sciences) single-authored papers are on average more highly cited. Goldfinch et al. (2003) found that the citation rates of New Zealander articles in 1998–2005 were negatively associated with the number of domestic institutions involved. Similarly, in forestry research, international collaboration did not lead to higher citation impact (Goldfinch et al. 2003). Leimu and Koricheva (2005) also found that international collaboration did not have a significant effect on the citation rates of papers in ecology. International co-publications of European ecology researchers received fewer citations on average than papers resulting from domestic collaborations.

There is lack of research exploring whether citation rates are influenced in the same way by international versus domestic collaborations across disciplines. Furthermore, there exists little research on whether the higher citation rates of international co-publications can be explained by the higher average numbers of authors in these publications.

This study looks at patterns in how international and domestic collaboration have influenced citation rates in six disciplinary groups (natural sciences, engineering, medicine and health sciences, agriculture and forestry, social sciences and humanities) between 1990 and 2008. The study focuses on Finnish publications in Thomson Reuters Web of Science (WoS) database. Disciplinary differences are examined in terms of the following subquestions:

- (1) How has the international and domestic co-publishing developed in various disciplinary groups during the past two decades?

- (2) Are the citation impacts between different types of collaboration (single-authored publications, domestic intra-organizational and inter-organizational co-publications and international co-publications) similar across various disciplines?
- (3) To what extent can the variation in citation rates be explained by type of collaboration, and to what extent by the number of authors?

Disciplinary cultures and variations in co-publishing

In natural and life sciences, international collaboration has been historically seen as a self-evident part of research. In these fields, research often requires access to expensive equipment or gathering a critical mass of colleagues working around the same problem and line of research. In social sciences and humanities, internationalization has rather been seen as a possibility for cross-cultural dissemination of research ideas (Hakala 1998). Therefore, co-publishing has been much more common in natural and life sciences. In social sciences and humanities, publications are often single-authored (Kyvik 1991; Larivière et al. 2006). As explained by Frame and Carpenter (1979), fields that deal with shared generally agreed-upon research interests and problems are more oriented towards the international scientific community. Researchers in fields working on creating solutions to national and local problems aim their publications to domestic forums and publications are more frequently authored by researchers from one country only.

Kaukonen et al. (2009) found that heads of Finnish university departments in all disciplines agreed that international collaboration is conducted to enhance the competitiveness of the unit in the own research field and to be able to seek for international funding. In the social sciences, however, international collaborative research was more often motivated by the wish to conduct international comparative research. In natural sciences, the international research collaborations were also seen as a means of gaining access to better research equipment and cutting edge technology. In engineering, international collaboration was seen as helpful for establishing contacts with international companies.

The need for research collaboration hence depends on the nature of the research in a field and the way the research work is organized. In certain types of experimental research, data collection requires a lot of human resources and the complexity of research methods or instruments requires several types of expertise (Kyvik 1991). In these areas, research cooperation also involves mutually exploiting well-equipped laboratories or the sharing of research data and materials between research groups. In areas such as high energy physics and astrophysics, dependence on large laboratories and expensive special and rare research equipment creates a prerequisite for international research collaboration (Glänzel 2001; Laudel 2001.)

Whitley (2000) describes such fields in natural and life sciences as fields in which the degree of mutual dependence between researchers is high. The development of science relies heavily on an accumulated knowledge base, and therefore the utilization of earlier and others' research results is mandatory. Collaboration is necessary for making progress and ensuring the novelty of results. Kyvik (1991) argued that in the fields sharing a common paradigm, that is, having a generally accepted theory linked to a common technology and methodology (see Kuhn 1970), researchers share a consensus on how research results must be presented. Collaboration and co-publishing is therefore easier than in the social sciences and humanities, where there are often multiple competing paradigms, where research is not based on shared and mutually agreed-upon theories and

methodologies, and where researchers often do not agree on what constitutes quality or relevance in research (Kyvik 1991).

Variation in international research collaboration between countries

The typicality of international collaboration as well as impact on citation rates varies significantly by country (Glänzel 2001; Gossart and Özman 2009; Larivière et al. 2006; Must 2012). Geographical, linguistic, cultural, political, and geopolitical factors as well as bilateral or multilateral agreements between countries or institutions have an effect on the degree and direction of international research cooperation (Frame and Carpenter 1979; Glänzel 2001; Schubert and Braun 1990). Frame and Carpenter (1979) argued that the scientific size of a nation determines the need for international collaboration. Countries with lower degrees of material and intellectual resources are more likely to look for research partners outside national borders than resource-rich countries (see also Schubert and Braun 1990, Luukkonen et al. 1992). Small countries have fewer opportunities to find collaborators inside their own country when compared to larger countries and they have a greater need for research partners from other countries (Narin et al. 1991). Differences in international collaboration patterns across countries can also be explained by their location either in the scientific centre or the periphery. Goldfinch et al. (2003) found that countries in scientific periphery benefit from international collaboration while domestic collaborations between institutions in these countries have a negative relationship with citation rates (see also Schubert and Sooryamoorthy 2010).

It has been shown that small countries are more active in international collaboration and the share of international co-publications is bigger in their overall scientific production than in big countries (Glänzel 2001; van Raan 1997). Finland is a relatively small country of 5 million inhabitants. The next subsection briefly describes Finland's science policy in relation to internationalization of research and research collaboration in the past decades.

The Finnish science policy and patterns of international research collaboration

The Finnish science policy turned towards favouring and supporting internationalization in the late 1980s. Internationalization was seen as a necessity for developing a competitive “national innovation system” (Hakala 1998). At that time Finland became a member of European cooperation networks, such as Eureka in 1985, CERN (the European Laboratory for Particle Physics; 1991) and ESA (the European Space Agency; associate membership in 1987, full membership in 1995). Finland joined the European Union in 1995. The full participation in EU research programs since the mid-1990s has reinforced European research collaborations. Since the beginning of the 2000s, research policy, for example, the policy statements of the Finnish Ministry of Education (2004) have underlined the support of internationally competitive units of excellence in research. Supporting collaboration networks at all levels (international, national and regional) is seen as an important means to achieve excellence.

Despite its small size, Finland is highly research intensive. It has heavily invested in research and the higher education R&D expenditure has grown remarkably since the mid-1990s (Hakala 1998; Himanen et al. 2009). In 2010, Finland's R&D expenditure measured as percentages of GDP was the second highest of all OECD countries: 3.9 %. The number of researchers per total workforce in Finland is the highest in all OECD countries: 17 researchers per thousand total employments in 2010 (OECD 2012). Moreover, Finland's

per capita ratio of publications in the WoS was higher than in any other OECD country: 1,259 publications (as a fractionalized count) per million inhabitants a year were produced in Finland in 2006–2009. In citation rates, Finland is of average level among OECD countries. Normalized to scientific fields, Finnish publications gained on the average 7 % more citations compared to all WoS publications in 1990–2008 (Finnish Ministry of Education and Culture 2012).

The share of Finland's international co-publications of all the Finnish publications in WoS increased from 25 to 49 % between 1990 and 2009 (Muhonen et al. 2012). Despite the steady growth in international co-publishing, Finland has a lower integration to international collaboration networks compared to other Nordic countries. The share of international co-publications has remained lower than in Sweden, Denmark, Norway, and Iceland each year during 1984–2008 (NordForsk 2010). Based on research collaborations funded by the EU framework programs, European research networks are concentrated within a triangle formed by England, Sweden and Switzerland and including Germany, Denmark and the Netherlands. Finland is located in between the centre and the periphery (European Commission 2008).

The development and citation impact of Finland's international co-publishing has been studied in a few studies (e. g. Muhonen et al. 2012; NordForsk 2010; Persson et al. 2000). These earlier studies show that international collaboration has a positive effect on the citation impact of publications by Finnish scholars. This study extends the understanding of the phenomenon by concentrating on disciplinary differences in co-publishing patterns and the citation impact of not just international but also domestic co-publications. Particularly, it provides new insight on to what extent the number of authors explains the potential differences in citation impacts between international and domestic co-publications.

Data and methods

The study analyses Finland's co-publishing patterns and citation rates between 1990 and 2008 based on publication and citation data provided by the Thomson Reuters WoS database. Finnish publications were identified on the basis of country codes given in connection with addresses. A publication was counted as Finnish when at least one author or research group had recorded a Finnish address for him/herself in the publication. *International co-publications* were defined as publications where, in addition to one or several Finnish organisations, at least one foreign organisation was recorded. In this study, a *domestic inter-organizational co-publication* refers to publications that include authors from several organizations with Finnish addresses. *Domestic intra-organizational co-publications* are authored by several authors from only one Finnish organization. A publication by only one author was counted as a *single-authored publication* even if the author had affiliations to several international or domestic organizations.

Three types of publications in WoS have been taken into account in this study: *Article*, *Letter* and *Review*. In all statistical analyses of this study, whole counting of publications was applied, that is, each publication is counted as a whole independent of its number of Finnish authors or organizations. The alternative calculation counting method, fractionalization, is not used since we are not interested in Finland's publishing performance in relation to other countries but differences in publishing patterns and citation impacts between various types of collaboration within Finland.

The disciplinary group of an individual publication is determined by the journal in which the publication appeared. For the purposes of this study, each of the 260 WoS subject fields was classified into one of six disciplinary groups: natural sciences, engineering, medicine and health sciences, agriculture and forestry, social sciences and humanities. In WoS, each journal is assigned between one to six subject fields. Thus, a publication may belong to several subject fields. In this study, if a publication was categorized into subject fields representing more than one disciplinary group, it was counted into each group. Therefore, a single publication can belong to several disciplinary groups and the sum of publications exceeds the total number of Finnish publications in WoS. Some journals in WoS are classified into the category “Multidisciplinary Sciences.” This category includes journals as “Nature” and “Science” and it formed 0.6 % of all Finnish publications in WoS between 1990 and 2009. In this study, these publications were omitted from the analysis since they could not be unambiguously classified into any of the six disciplinary groups.

The amount of references in reference lists and consequently average citation rates vary significantly by scientific field, publication type and year of publishing (see e.g. Moed et al. 1995; Lancho-Barrantes et al. 2010; Lundberg 2007). In our analysis, we follow the established practice in bibliometrical analyses where the number of citations received by a publication between the year of publication and 2011 is normalised by comparing it to the average citation count from the equal time period of all WoS publications in the world in the particular subject field (out of WoS’s 260 subject fields) which were published in the same year and which represent the same publication type (Article, Review or Letter). To describe the citation impact of Finnish publications in comparison to the average citation rates of all WoS publications, we use the *item-oriented field normalized citation score average* (FNCS) introduced by Lundberg (2007):

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

where c_i is the number of citations to publication i , P is the number of Finnish publications in the unit under scrutiny, $[\mu_f]_i$ is the average number of citations of all publications in the world of the same type, published in the same year and in the same subject area as publication i . If a publication belonged to several subject areas, the average of field normalized citation scores was applied.

FNCS was introduced by Lundberg (2007) as an alternative to the widely used “crown indicator” developed by Moed et al. (1995). While the crown indicator normalizes the average citation count of a group of publications in relation to all publications from the same year, in the same subject area and of the same document type, FNCS is calculated by dividing every single publication’s citation count by all publications in the respective subject field, year and publication type (Lundberg 2007). FNCS is more suitable for the purposes of this study, because it gives an equal weight to each publication, while the crown indicator gives a higher weight to publications with a higher number of citations received.

The distribution of the number of citations received by publications is highly skewed. In theory, the tail of distribution of number of citations can in some subsets be characterized by the power law distribution $p(x) = kx^{-\alpha}$ (e.g. Katz 2012). If such a power law distribution has a scaling exponent α less than 3, it has an infinite variance, the central limit theorem is no longer satisfied and the indicators based on average are not valid. This is especially the case when the group size is small (Katz 2012). In such cases, the possible

outliers, namely publications with an exceptionally high number of citations may have an increasing effect on the world average which consequently decreases the normalized citation scores of other publications. Therefore, the results from the smallest subfields should be interpreted with caution.

We use normal linear regression analysis to examine the effects of type of collaboration and number of authors on the citation impact. The distribution of the normalized citation scores of publications is highly skewed. For that reason, we used logarithmically transformed citation rates as the dependent variable in the regression model which induced to almost symmetric distribution. Lundberg introduced in his paper (2007) a normalized logarithmic-based field citation z-score which also takes into account the standard deviation in citation rates within subject fields. In order to achieve more interpretable statistics in the regression model we instead applied a simple logarithmic transformation of the field normalized citation score which was calculated by adding one to the citation score normalized to all publications of the same type, same year of publishing and same subject area:

$$\text{FNCS}_{[ln]i} = \ln\left(\frac{c_i}{[\mu_f]_i} + 1\right)$$

Through using $\text{FNCS}_{[ln]i}$ as the dependent variable in the regression model, the antilog transformation of regression coefficients, $\exp(B)$, gives the geometric mean ratio. In the regression model, the effects of (1) number of authors and (2) type of co-authorship were investigated both through a single-variable and a multiple regression model. For number of authors, the geometric mean ratio $\exp(B)$ describes the relative difference in the citation score in relation to addition of one author. As regards type of co-authorship, $\exp(B)$ gives the average citation score of the co-authorship type (international, domestic inter-organizational or domestic intra-organizational) in relation to single-authored publications.

The number of authors is also a highly skewed variable. Publications by 10 authors or more account for 5.4 % of the total publication count and only 1.6 % of publications have 20 authors or more. Some publications are co-authored by even thousands of scholars and these exceptions would have a remarkable effect on the results. If the number of authors exceeded 20 it was therefore recorded as 20 in our analyses.

The open citation window was applied; hence the accumulation period of the citations is not limited and all citations between the year of publication and 2011 from all WoS publications are included. This procedure gives a better coverage of citations cumulated by publications than the fixed citation window which takes into account citations only from a fixed period, for example, three or 6 years after publication year. The advantage of fixed citation window is that it is lesser subject to distributional effects. Nederhof and Visser (2004) found that, for example, a relatively large percentage of papers published in the later year of publication period leads to the field normalized citation scores below average because articles published in the early part of the period under scrutiny thus have had more time to gain citations. Nederhof and Visser (2004) argue, however, that the normalized indicators are free from such effects. In order to make citation scores of publications from different years more comparable, we applied normalization as regards publication year. That is, the citations received between the year of publication and 2011 by a Finnish publication are always compared to the citation count from the same period received by all WoS publications in the world published in the same year.

The development of publishing patterns is explored in four-year time blocks: 1990–1993, 1994–1997, 1998–2001, 2002–2005 and 2006–2008. Since publications that

came out from 2009 afterwards have had less than 3 years time to gain citations, all indicators were calculated only for publications published in or before 2008 and the last block is limited to the 3 years between 2006 and 2008.

To some extent, the higher citation rates of co-publications can be explained by the higher number of authors who potentially cite themselves (Herbertz 1995; Leimu and Koricheva 2005; van Raan 1998). As self-citations do not reflect the true impact of a publication, the citations from publications whose authors included at least one of the same names as the cited publication were discarded from our analysis.

The coverage of WoS varies greatly by discipline. The data cover publications in natural and life sciences most comprehensively. As for social sciences and humanities, only a small fraction of publications are represented in WoS, because the research results of these disciplines are frequently published in books and national forums. In engineering, where articles in conference proceedings are a typical form of publishing, the coverage of WoS is moderate (see e.g. Moed 2005). The majority of the 143,221 Finnish publications between 1990 and 2008 were published in journals belonging either to natural sciences (47.4 %) or medical and health sciences (42.1 %). Engineering accounts for 14.1 %, social sciences for 6.4 %, agriculture and forestry for 5.2 % and humanities 1.2 % of the publications (Table 1). The sum of these percentages exceeds 100 % since a single publication can belong to several groups.

Finland's publishing output has increased steadily in all disciplinary groups (Table 1). The publication counts in engineering and social sciences have, however, grown faster than the output for other disciplinary groups in Finland: the number of publications per year has increased by more than three times between the years 1990–1993 and 2006–2008. This is due to the overall improved coverage of engineering and social sciences journals indexed by WoS.

Results

Trends in international and domestic co-publishing

International co-authorship had become more common in all disciplinary groups during the past two decades (Fig. 1). The relative increase in international co-publishing between 1990 and 2008 was highest in agriculture and forestry (from 10 to 40 %). The degree of international co-publications was lowest in the humanities. There was a strong growth of international publishing also in the humanities, however, where the share went from 4 % up to 11. Yet in the latest period 2006–2008, publications involving authors affiliated only with Finnish organisations formed the majority of the publications in all disciplinary groups except natural sciences.

Along with the growth of international co-publishing, there has been an increase in the relative share of domestic inter-organizational co-publications in all disciplinary groups but especially in medical and health sciences and agriculture and forestry (Fig. 1). Consequently, the share of publications produced in domestic intra-organisational cooperation as well as the share of single-authored publications have decreased in all disciplinary groups. The share of domestic inter-organisational publications is highest in medical and health sciences where universities often collaborate with university hospitals. As an exception to other disciplinary groups, the share of intra-organisational co-publishing

Table 1 Number of Finnish publications in WoS in 1990–2008 by disciplinary group

	1990–1993	1994–1997	1998–2001	2002–2005	2006–2008	Total 1990–2008
Natural sciences	7,355 41.9 %	10,722 44.7 %	14,319 47.3 %	16,535 50.1 %	14,015 50.1 %	62,946 47.4 %
Engineering	1,909 10.9 %	2,970 12.4 %	4,176 13.8 %	5,080 15.4 %	4,523 16.2 %	18,658 14.1 %
Medical and health sciences	8,562 48.8 %	11,059 46.1 %	12,988 42.9 %	12,811 38.9 %	10,399 37.2 %	55,819 42.1 %
Agriculture and forestry	865 4.9 %	1,082 4.5 %	1,604 5.3 %	1,788 5.4 %	1,534 5.5 %	6,873 5.2 %
Social sciences	823 4.7 %	1,335 5.6 %	1,881 6.2 %	2,235 6.8 %	2,273 8.1 %	8,547 6.4 %
Humanities	223 1.3 %	205 0.9 %	351 1.2 %	374 1.1 %	423 1.5 %	1,576 1.2 %
Total	17,533 100.0 %	23,964 100.0 %	30,244 100.0 %	32,973 100.0 %	27,975 100.0 %	13,2689 100.0 %

The sum of percentages of all disciplinary groups exceeds 100 % since a single publication can belong to several groups

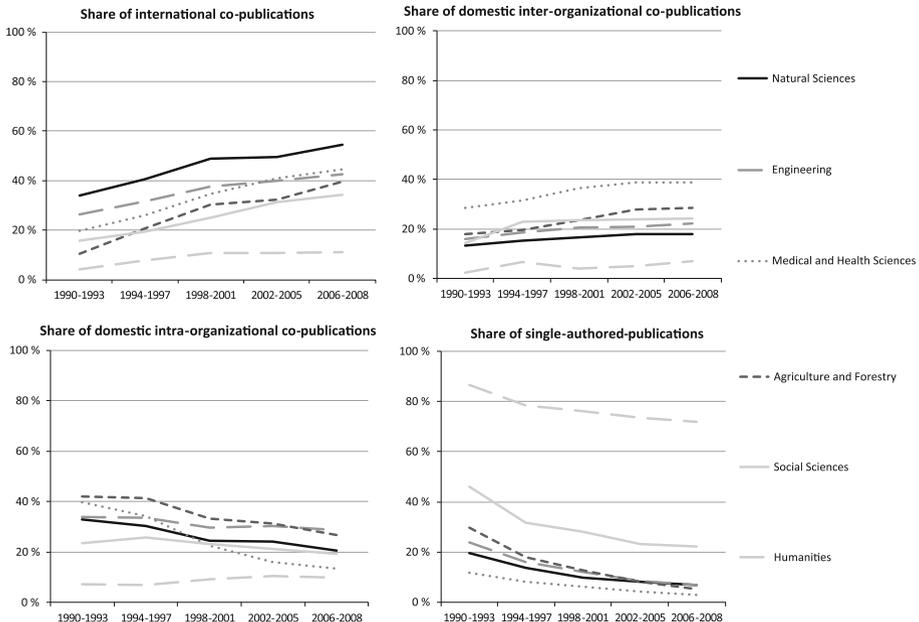


Fig. 1 Shares of different types of co-publishing of Finland's WoS publications in 1990–2008 by disciplinary groups

increased slightly in the humanities. Even though single-authorship has become less typical also in the humanities, it still clearly remained the most typical form of publishing. In 2006–2008, 72 % of Finnish humanities publications were single-authored.

The average number of authors in Finnish WoS publications has increased steadily in all disciplinary groups since the beginning of 1990s (Fig. 2). The increase in the number of authors concerns both international and domestic co-publications. There are no big differences in the growth rate of author numbers for the three types of co-publications with the exception of the humanities where the number of authors in international co-publications increased from 2.6 to 4.0 between early 1990s and late 2000s. At the same time, the average number of authors in humanities domestic co-publications did not increase significantly.

Co-authorship and citation impact

A positive relationship between international cooperation and citation scores can be found in all disciplinary groups (Table 2). The citations received by Finnish international co-publications exceeded the average level of all WoS publications throughout the studied period 1990–2008. However, Finnish single-authored publications were cited less often compared to the world average in all disciplinary groups. There was no systematic pattern in terms of growth or decrease of citation impact of Finnish publications during the studied period 1990–2008 in either international or domestic co-publications or single-authored publications (See also Muhonen et al. 2012).

Domestic inter-organizational collaboration has not led to a significantly higher citation impact compared to intra-organizational publishing collaboration (Tables 2, 3). Humanities make an exception since there are no remarkable differences between international and domestic inter-organizational co-publications in the average citation impact but publications with authors coming from several organizations gathered significantly more citations than publications authored by scholars from one organization.

Compared with single-authored publications both domestic inter- and intra-organizational cooperation is associated with higher citation impact in all disciplinary groups. The difference is biggest in the humanities where publications with authors from several organizations get as much as 73 % and intra-organizational co-publications 37 % more citations than single-authored publications. As stated earlier, single-authored publications are far more typical ($n = 1,200$) in the humanities than domestic ($n = 226$) or international co-publications ($n = 150$).

The number of authors has a positive effect on the citation impact of a publication in all disciplinary groups. Medical and health sciences and humanities express the most linear association between number of authors and citation scores in logarithmic scale (Fig. 3). The influence is strongest in the humanities where the augmentation of one author increases the publication's normalized citation score by 18 % on the average (Table 3). In other disciplinary groups, one additional author raises the citation score by only 3–6 % on the average. In the humanities, the number of authors explains almost 10 % of the variance in citation scores. In natural sciences and engineering, only a small portion (2.1 and 1.3 %) of the variation in citation scores is explained by the type of co-authorship.

When the effect of the number of authors is taken into account there are no longer big differences between international and domestic co-publications in other disciplinary groups except social sciences and humanities (see multivariate model in Table 3). Figure 4 shows that the number of authors is positively related to citation impact of both international and domestic co-publications. When comparing publications with the same number of authors in natural sciences, engineering, and agricultural sciences, the citation scores are almost equal regardless of whether all authors are from Finland or whether there are international co-authors. However, international co-publications with more than ten authors get far more citations than other types of publications in all disciplinary groups.

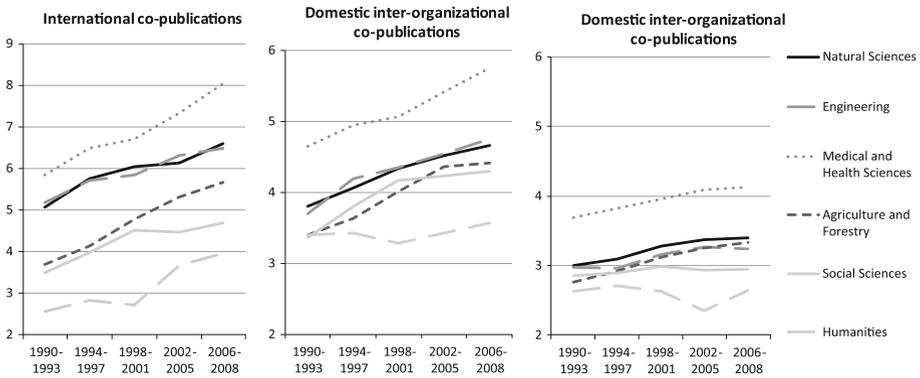


Fig. 2 Patterns in the number of authors in international and domestic co-publications of Finland’s WoS publications in 1990–2008 by disciplinary group

Table 2 Field normalized citation score (FNCS) of Finland’s WoS publications in 1990–2008 by type of co-authorship and disciplinary group

	Type of co-authorship			
	International	Domestic inter-organizational	Domestic intra-organizational	Single-authored
Natural sciences	1.19	0.98	0.98	0.83
Engineering	1.35	1.03	1.07	0.94
Medicine and health sciences	1.64	1.09	0.96	0.73
Agriculture and forestry	1.74	1.34	1.15	0.89
Social sciences	1.33	0.98	0.91	0.66
Humanities	2.26	2.28	1.73	0.74

The potential interaction effect between the number of authors and type of co-authorship was analyzed, but there were no significant effects. That is, the effect of the number of authors is by and large the same within both internationally and domestically co-authored publications.

Conclusions

This study supports results from earlier research indicating that both international and domestic co-publishing has increased in the studied period 1990–2008 in all disciplinary groups. The amount of Finnish scientific publications conducted in international or domestic inter-organisational collaboration has increased more than the intra-organisational publications. The average number of authors involved in a publication has similarly increased in all disciplinary groups. Similar to earlier results on the positive effect of international co-authors on publication’s citation impact (e. g. Glänzel 2001; Katz and Hicks 1997; Muhonen et al. 2012; Narin et al. 1991; NordForsk 2010; Schmoch and

Table 3 Normal linear regression analysis on the effects of type of co-authorship and number of authors on logarithmically transformed field normalized citation score of a publication (FNCS_{[m]*i*})

	Simple model ^a				Multivariate model ^a			
	B	exp(B)	(95 % CI) ^a	R ² ^b	B	exp(B)	(95 % CI) ^a	R ² ^c
Natural Sciences								
Number of authors	0.028	1.028	(1.027–1.029)	3.2 %	0.022	1.022	(1.021–1.023)	3.7 %
Type of co-authorship				2.1 %				
International	0.242	1.274	(1.263–1.285)		0.126	1.134	(1.123–1.145)	
Domestic inter-org.	0.166	1.181	(1.170–1.192)		0.083	1.087	(1.076–1.097)	
Domestic intra-org.	0.120	1.128	(1.117–1.138)		0.067	1.069	(1.059–1.080)	
Single-authored ^d	0	1			0	1		
Engineering								
Number of authors	0.029	1.029	(1.027–1.031)	2.8 %	0.026	1.026	(1.023–1.029)	3.0 %
Type of co-authorship				1.3 %				
International	0.196	1.216	(1.184–1.249)		0.065	1.068	(1.036–1.100)	
Domestic inter-org.	0.104	1.110	(1.078–1.143)		0.016	1.016	(0.986–1.048)	
Domestic intra-org.	0.094	1.098	(1.069–1.129)		0.039	1.040	(1.011–1.069)	
Single-authored ^d	0	1			0	1		
Medical and health sciences								
Number of authors	0.039	1.040	(1.038–1.041)	6.1 %	0.032	1.033	(1.031–1.034)	6.7 %
Type of co-authorship				3.6 %				
International	0.327	1.387	(1.362–1.412)		0.130	1.139	(1.116–1.162)	
Domestic inter-org.	0.181	1.198	(1.177–1.220)		0.044	1.045	(1.026–1.065)	
Domestic intra-org.	0.121	1.129	(1.108–1.150)		0.027	1.028	(1.009–1.047)	
Single-authored ^d	0	1			0	1		
Agriculture and forestry								
Number of authors	0.058	1.060	(1.055–1.066)	6.5 %	0.054	1.055	(1.049–1.062)	6.7 %
Type of co-authorship				2.9 %				
International	0.278	1.320	(1.265–1.377)		0.059	1.060	(1.010–1.113)	
Domestic inter-org.	0.174	1.190	(1.139–1.243)		0.007	1.007	(0.961–1.055)	
Domestic intra-org.	0.102	1.108	(1.063–1.155)		-0.010	0.990	(0.949–1.033)	
Single-authored ^d	0	1			0	1		

Table 3 continued

	Simple model*				Multivariate model*			
	B	exp(B)	(95 % CI) ^a	R ² ^b	B	exp(B)	(95 % CI) ^a	R ² ^c
Social sciences								6.5 %
Number of authors	0.045	1.046	(1.042–1.050)	5.0 %	0.030	1.030	(1.025–1.036)	
Type of co-authorship				4.8 %				
International	0.303	1.354	(1.317–1.393)		0.201	1.223	(1.183–1.264)	
Domestic inter-org.	0.178	1.194	(1.160–1.230)		0.085	1.089	(1.053–1.126)	
Domestic intra-org.	0.141	1.151	(1.118–1.186)		0.083	1.087	(1.054–1.121)	
Single-authored ^d	0	1			0	1		
Humanities								11.0 %
Number of authors	0.168	1.182	(1.153–1.212)	9.8 %	0.101	1.106	(1.065–1.149)	
Type of co-authorship				9.5 %				
International	0.519	1.680	(1.514–1.864)		0.281	1.324	(1.155–1.518)	
Domestic inter-org.	0.551	1.734	(1.512–1.989)		0.304	1.355	(1.149–1.598)	
Domestic intra-org.	0.318	1.375	(1.237–1.528)		0.161	1.175	(1.041–1.325)	
Single-authored ^d	0	1			0	1		

* In the simple model, only one variable, either type of co-authorship or number of authors is included as independent variable whereas in multivariate model both effects are included

^a Exp(B) gives the geometric mean ratio. For number of authors, exp(B) describes the relative growth in the citation score in relation to addition of one author. In case of type of co-authorship, exp(B) describes the average citation score of the co-authorship type under scrutiny in relation to the reference group, namely single-authored publications. 95 % CI is the 95 % confidence interval for exp(B)

^b R² of the simple model describes the proportion of the variation in FNCS explained by a single predicting variable (either number of authors or type of co-authorship)

^c R² of the multivariate model describes the proportion of the variation in FNCS explained by both predicting variables simultaneously (number of authors and type of co-authorship)

^d Reference group

Schubert 2008; Sooryamoorthy 2009) we found that in almost all disciplinary groups international co-publications are on average more highly cited than publications by only Finnish authors. Especially in medical and health sciences as well as humanities the straightforward positive association between number of authors and average citation score supports the view presented by, for example, Goldfinch et al. (2003) that co-publishing enables access to larger scholarly networks and consequently leads to higher impact of co-publications.

Despite the fact that citation impact varies between types of collaboration, in natural sciences and engineering only a small portion of the variation in citation rates is explained solely by international or domestic collaboration. The higher average number of authors in international co-publications when compared to domestic co-publications explains most of the differences in citation rates between these two types of collaboration. In the social sciences, however, international co-authorship has a strong positive impact on citations

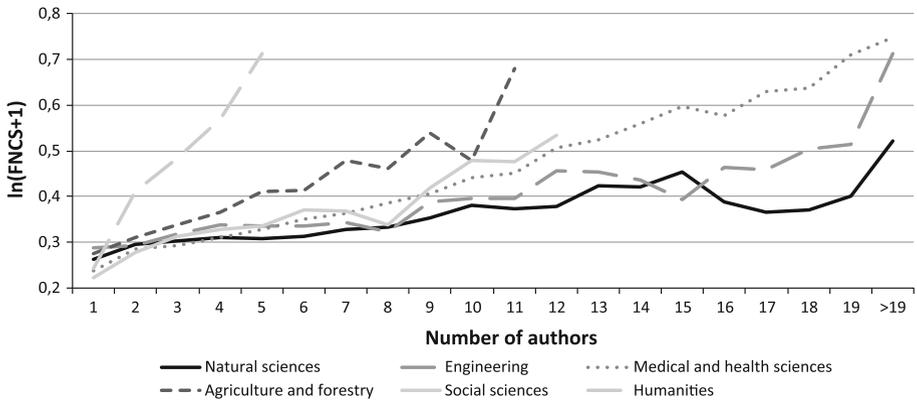


Fig. 3 Logarithmically transformed field normalized citation score, $\ln(\text{FNCS}+1)$, of Finland's WoS publications in 1990–2008 by number of authors and disciplinary group. *Note* Citation score is not displayed when publication count is less than 25

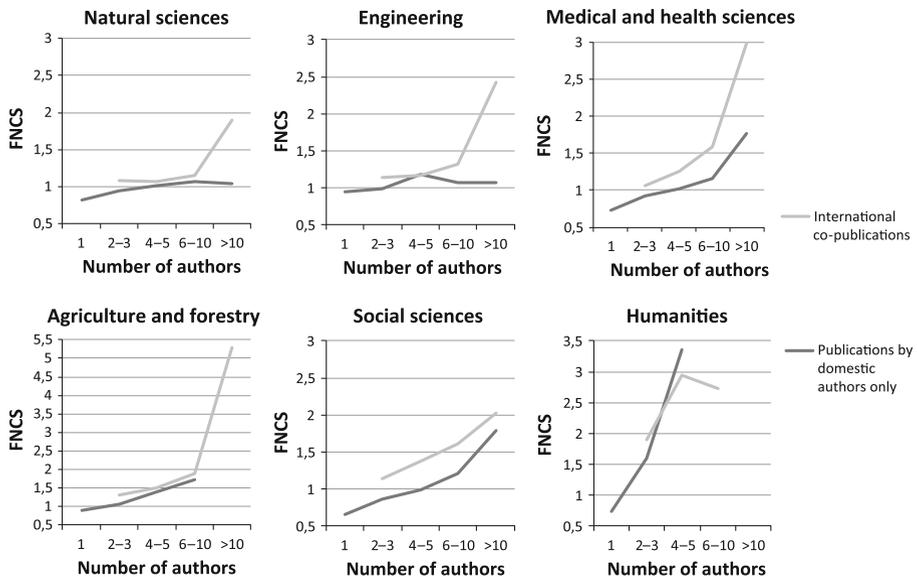


Fig. 4 Field normalized citation score (FNCS) of Finland's WoS publications in 1990–2008 by number of authors and by disciplinary group. *Note* Citation score is not displayed when publication count is less than 25

even when the higher average number of authors is taken into account. This is possibly due to the nature of research in social sciences where research topics are often nationally or locally oriented. Publications which have a national aspect receive fewer citations than publications in WoS on average. International co-publications are likely to deal with more universal topics or contain international comparisons and are thus of interest to a wider international audience. In natural sciences, research topics are universal by nature also in domestic co-publications. International co-publications by more than 10 authors, however, gather significantly more citations than similar publications by Finnish authors only in

almost all disciplinary groups. The higher impact of these publications can result from the fact that scholars and research groups participating in large international research projects already have an established and recognized status in their scientific community.

The number of authors has the strongest effect on citation scores in the humanities. The humanities differ from other disciplinary groups in that there is no difference between the average citation scores between domestic inter-organizational publications and international co-publications. There is a big difference between single-authored and multi-authored publications in the amounts of citations received. As most humanities publications are single-authored, co-authorship thus has an important role in increasing the visibility and citation impact of humanities research. Since humanities and social sciences fields are often multi-paradigmatic and produce arguments and interpretations, it may be that a publication's perceived credibility increases when there are several authors. It must be noted that the number of publications in social sciences and humanities is low and the possible outliers may affect the results. A more in-depth analysis considering the citation distribution of publications would be needed in order to validate the results.

The increase of international collaboration is a global trend in science. It is also a result of strong promotion of collaboration networks and internationalization of research within the EU and in national science policies. Finnish science policy has emphasized international research collaboration as the key means to increase the quality and impact of Finnish research. The results reached in this study show, however, that international collaboration is not the only factor that would in itself necessarily produce more impactful research. Hakala (1998) argues that from researchers' point of view, externally imposed internationalization directs towards particular types of research and particular geographic directions in collaboration and contacts. Without a basis on existing genuine international collaboration networks imposed collaborations may have unwanted implications, for example, increased homogenization of science. There are also contradictions in the aims of science policy which underlines internationalization, and national innovation policy emphasizing societal impact. Research conducted in international context may not always meet the national needs and interests.

The findings of this study indicate that citation impact of a publication may be related to other influencing factors not scrutinized in this article. These include the interdisciplinarity, universality or locality of the research topic, the scholarly positions of co-publishing authors, and the level of application. Further studies should take into consideration the influence of also these factors on the impact of international and domestic co-publications.

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