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Effects of Research Funding, Gender and Type of Position on Research Collaboration Networks: A Micro-level Study of Cancer Research at Lund University

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Abstract

The aim of this study was to analyse how research funding, gender and research area relate to the size and density of collaborative networks within cancer research. The material consisted of 3,306 publications from scientists in cancer research associated with Lund University, indexed in the Web of Science databases. The author and address fields were analysed, by studying frequencies and distribution of authors and organizations, and by conducting co-authorship analyses on the organizational level. The results showed substantial differences between scientists with and without national funding, defined as research grants from the Swedish Cancer Society (SCS). Collaborative research networks were larger and denser among scientists with national grants and these differences were more pronounced than differences related to sex and research area, i.e. preclinical versus clinical research. The results suggest that the relation between research funding and the size and nature of collaborative research networks is stronger than the relations between gender or research orientation.

Conference Topic

Collaboration Studies and Network Analysis (Topic 6).

Introduction

Research collaboration has been analysed from a wide range of perspectives, most commonly using bibliometrics and in particular through co-authorship analyses (e.g. Katz & Martin, 1997; Melin & Persson, 1996; Newman, 2004). Important areas of investigation include analyses of factors behind research collaboration (e.g. Abbasi et.al., 2011; Birnholtz, J.P., 2007; Hara et.al., 2003; Jeong et.al., 2011; Lewis et.al., 2012), issues related to international research networks, measures of scientific productivity and impact in relation to co-authored research papers (e.g. Lee & Bozeman, 2005; Lukkonen et.al., 1992; Lukkonen et.al., 1993; Narin et.al., 1991; Persson, 2010). Another important issue, in social studies of science, and increasingly also in bibliometrics, is analyses of the impact of gender: on the access to research collaboration networks, but also on the access to research funding, the peer review process and opportunities for building scholarly careers in general, as well as in terms of scientific impact and productivity (e.g. Alcaide et.al, 2009; Kretschmer et.al., 2012; Larivière et.al, 2011; Mählck, 2001; Wennerås & Wold, 1997).

The effects of research funding and research orientation on the construction of, and access to, research networks have been analysed to a lesser extent. The relation between funding and productivity, impact and collaboration has been analysed by e.g. Clark and Llorens (2012), Haiqi (1997) and Heffner (1981), all of whom identified a positive relation between financial support and the size of networks of collaborating scholars; and Zhao (2010), who found that research with grant-funding had a larger impact in library and information science. In relation to type of positions: Bordons et.al. (2003) analysed scientific productivity in relation to gender and professional category; and while there are overall differences between genders, the differences between genders within the professional categories are not significant. When analysing pre-clinical and clinical sciences, Satyanarayana & Ratnakar (1989) found that clinical sciences have a higher average of authors per paper than preclinical basic research areas such as biochemistry and molecular biology.

However, the question remains: can we identify relations between on one hand: type of funding and type of position or orientation, together with gender; and on the other: the character of research networks? The aim of this study is to analyse the extent of which different types of research funding, gender and type of position can be related to the size and density of research collaboration networks. To analyse this issues, micro-level analyses were performed on a group of cancer research scientists associated with Lund University (LU), including researchers at the Skåne University Hospital, and with a particular focus on scientists with or without national funding, defined as research grants from the Swedish Cancer Society (SCS). The reason for focusing on scientists with funding from the SCS is that, in the context of Swedish cancer research, SCS funding/grants can be seen as a proxy indicator on being an established cancer scientist.

Methodology

The first stage of the data selection process was to identify scientists at LU involved in cancer research through identification of scientists responsible for PhD research supervision with projects categorized as cancer research. In total, 93 scientists were identified; 47 with research funds from the SCS and 46 without SCS funding. Using Lund University Publications (LUP), the Web of Science (WoS) 'accession number' for these scientists' publications between the years 2002-2011, were used for retrieving 3,306 publications in WoS. Based on the full dataset, 14 subsets were created in order to perform analyses of cooperation networks among cancer scientists according to the analytical categories selected for this study; a division based on differences in research funding – i.e. with or without research funds from the SCS, gender and work orientation – i.e. those solely having pre-clinical positions and those with clinical or combined positions. To control for effects by the different analytical categories, a further division of sub-sets was done analysing differences between men and women, as well as pre-clinical and clinical/combined scientists, within the SCS and non-SCS document sets.

The analyses were based on the 'author' (AU) and 'address' (CS) field from WoS. Before the analyses were done, author and author address data was cleaned and standardized. The main organization was identified as the name before the first comma in the CS-field, thus: in cases where e.g. both a university and a hospital are part of the same address, only the first mentioned named will occur in the analyses. Also, variant names of organizations were standardized, where e.g. 'Malmo Univ Hosp' was changed into 'Skane Univ Hosp' (Figure 1).

Doc.nr.	Address
1	Lund Univ, Div Clin Chem, Dept Lab Med, Skane Univ Hosp, Malmo, Sweden
1	Malmo Univ Hosp, Wallenberg Lab, Entrance 46, SE-20502 Malmo, Sweden

Figure 1. Example: WoS CS-field, author addresses.

The analyses were performed using the Bibexcel software (Persson, Danell & Schneider, 2009), on both author and organization level. On author level, author frequencies and the distribution of authors per document were investigated; the latter both by looking at the average number of authors per document, and by analysing the distribution of documents according to numbers of authors. The organisation level analyses were performed both by looking at frequencies as well as the distribution of organizations per article; and by co-occurrence analyses (Melin & Persson, 1996) of author addresses, which were visualized using Pajek (de Nooy, Mrvar & Batagelj, 2005).
The analyses were conducted using full counting on both author and organization level. Thus, in cases where there are articles involving e.g. both SCS and non-SCS funded LU scientists, where both are also among the 93 selected, there will be an overlap of articles distributed between SCS and non-SCS scientists. In cases where there are scientists with more than one affiliation, all organizations were counted if stated in the CS-field.

Results

The results section reports the results in three sub-sections: the first accounts for basic information on the dataset in terms of LU authors laying the foundation for the documents, the second sub-section presents the results of the author level analyses and the third sub-section reports on the number of organizations – as represented by article author addresses – involved in collaboration with LU cancer scientists.

LU Authors and Documents per Analytical Category

The most basic set of results from the analyses was LU author – i.e. the scientists selected as basis for the data collection, the actual number of authors contributing to each article will be reported in the second section of 'Results' – and document frequencies as well as the distribution of documents per author within each analytical category (Table 1). Apart from the number of authors, articles and documents per author, the aforementioned overlap due to the full counting is also reported.

Table 1. Distribution of LU authors and documents per analytical category.

	LU Authors	*No. of Documents*	*Documents/ Author*	*p-value*	*Overlaps*
Full set	93	3,306	35.55		
SCS	47	2,029	43.17	p=0.0033	222
Non-SCS	46	1,499	32.59		
Women	31	993	32.03	p=0.036	350
Men	62	2,663	42.95		
Pre-clinical	43	1,448	33.67	p=0.10	403
Clinical/Combination	50	2,261	45.22		
SCS: Women	12	465	38.75	p=0.16	245
SCS: Men	35	1,809	51.69		
Non-SCS: Women	19	547	28.79	p=0.32	26
Non-SCS: Men	27	978	36.22		
SCS: Pre-clin.	27	1,012	37.48	p=0.011	329
SCS: Clin./Comb.	20	1,346	67.3		
Non-SCS: Pre-clin	16	479	29.94	p=0.56	21
Non-SCS: Clin./Comb.	30	1,041	34.7		

The data contain considerable variations within and between the different analytical categories. Since the main focus of the study was to investigate differences between scientists with and without SCS funding, we designed the study to have an even distribution of authors between those groups. There were, however, more men than women; and more scientists with a clinical or combined position than with an exclusively pre-clinical position. In terms of documents per LU author, the average number of papers per author was higher among those with SCS funding, men and clinical/combined scientists. It should however be noted that there were also more authors among men and clinical/combined scientists, whereas the distribution of LU authors among SCS and non-SCS funded scientists was relatively even.
As previously mentioned, a further division between sub-categories was made and gender and type of position were analysed in relation to funding from the SCS. Using average values, we found differences between women and men with SCS funding, as well as between pre-clinical and clinical scientists without SCS funding. However, there were some tendencies towards larger differences between e.g. men with or without SCS funding than between men and women without SCS funding. Thus, the rest of the analyses focused on investigating gender and type of position differences in relation to access to funding, rather than as separate entities. At the same time, when looking at p-values, we found significant differences between men and women, as well as between pre-clinical and clinical/combined scientists, together with those with or without SCS funding. However, when looking at the differences in the distribution of papers between men and women, it should be taken into account that the age distribution was also varied, among the LU researchers analysed here: men were typically older than the women; and thus likely to have come further in their careers, as well as having produced more papers (Figure 2).

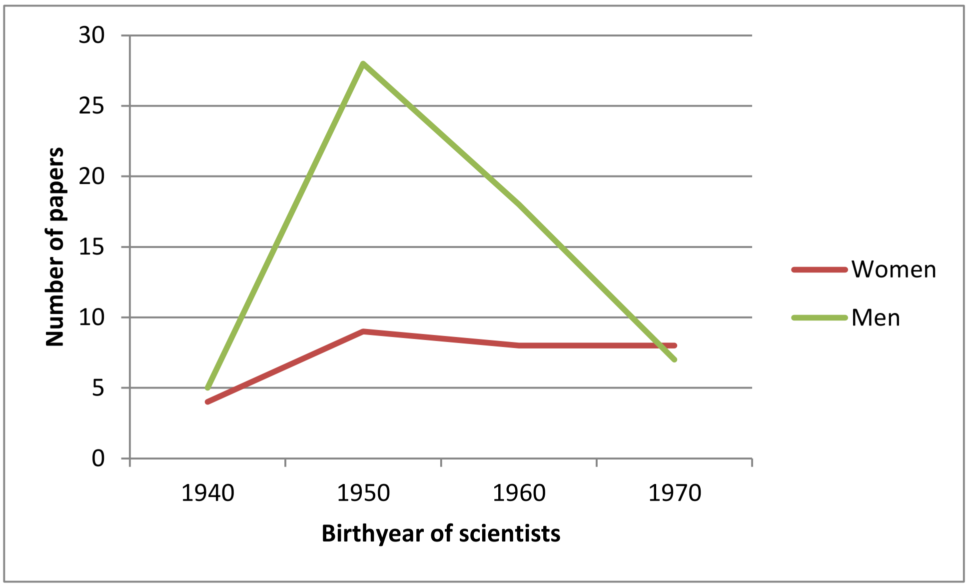

Figure 2. Distribution of papers in relation to age and gender.

Author level collaboration

On author level, investigations were made into the number of authors contributing to LU cancer papers, as well as the average number of authors per article (Table 2). Taken together, the average number of authors per article was almost nine. However, when looking at the different analytical categories, articles by SCS funded LU authors had substantially more authors per article than the ones without SCS funding: whereas the set based on SCS funded authors showed an average around 10, the average for non-SCS funded articles was around six authors per article. In this analysis, the tendency towards differences based more on funding rather than gender or orientation appeared stronger. Average number of authors for papers by male or female LU scientists varied little among e.g. SCS funded papers, while the difference for SCS and non-SCS men or women was larger. The one notable exception was between pre-clinical and clinical/combined scientists without SCS funding.

Table 2. Number of authors and average number of authors per article.

Category (N=no. docs)	*Authors*	*Author/Article*
Full set (N=3,306)	8,930	8.69
SCS (N=2,029)	5,843	10.3
Non-SCS (N=1,499)	3,644	6.38
SCS: Women (N=465)	1,398	10.7
SCS: Men (N=1,809)	5,728	10.25
Non-SCS: Women (N=547)	1163	5.95
Non-SCS: Men (N=978)	2895	6.64
SCS: Pre-clin. (N=1,012)	3,336	9.7
SCS: Clin./Comb. (N=1,346)	3,976	10.86
Non-SCS: Pre-clin (N=479)	1,316	2.23
Non-SCS: Clin./Comb. (N=1,041)	2,556	6.47

Apart from the average number of authors per article, analyses were performed on the distribution of articles over papers with different number of authors (Table 3). In total, the grand majority of the papers had 1-10 authors, regardless of analytical category, and a very small amount of papers with more than 50 authors. However, the largest shares of papers with 1-5 authors were found in the non-SCS set, while the majority of articles with more than 20 authors were primarily found in the set of documents by authors with SCS funding. In addition to the results presented in the table, it is also noteworthy that all papers – albeit being very few – with more than a 100 authors were found among the articles by scientists funded by the SCS.

Table 3. Distribution of articles over authors per article.

Category (N=no. docs)	*1-5*	*6-10*	*11-20*	*21-50*	*51-*
Full set (N=3,306)	44 %	38 %	12 %	5 %	0,8 %
SCS (N=2,029)	36 %	41 %	15 %	8 %	1 %
Non-SCS (N=1,499)	52 %	38 %	9 %	1 %	0,3 %
SCS: Women (N=465)	32 %	47 %	10 %	11 %	-
SCS: Men (N=1,809)	36 %	41 %	15 %	8 %	1 %
Non-SCS: Women (N=547)	56 %	32 %	11 %	0,3 %	-
Non-SCS: Men (N=978)	49 %	41 %	7 %	1 %	0,5 %
SCS: Pre-clin. (N=1,012)	37 %	43 %	14 %	5 %	1 %
SCS: Clin./Comb. (N=1,346)	32 %	41 %	15 %	10 %	1 %
Non-SCS: Pre-clin (N=479)	60 %	32 %	8 %	0,6 %	0,4 %
Non-SCS: Clin./Comb. (N=1,041)	49 %	41 %	9 %	1 %	0,3 %

Both the analyses of average authors per article and the distribution of articles over number of authors showed substantial differences between documents involving LU scientists with or without SCS funding. In terms men and women, and clinically/combined or pre-clinical scientists, however, there were differences, but to a lesser extent than in relation to funding.

Organization level collaboration

The collaboration networks of LU cancer scientists were also studied on organization level, using the CS-field in WoS. As with the author level analyses, the frequency of organizations were analysed for the different analytical categories, as well as the distribution of organizations per article. In addition to these analyses, collaboration networks were also analysed doing an organization level co-authorship analysis.

In total, 1,385 organizations were identified among the author addresses, with an average of 3.86 organizations per article. And as in the case of collaborating authors, the number of institutions contributing together with LU and Skåne University Hospital was higher among the articles by scientists with SCS funding, while the differences between men and women or clinical and pre-clinical scientists were smaller (Table 4).

Table 4. Number of organizations and average number of organizations per article.

	Number of organizations	*Average: Organizations/article*
Full set (N=3,306)	1,385	3.86
SCS (N=2,029)	1,070	4.81
Non-SCS (N=1,499)	733	2.69
SCS: Women (N=465)	260	4.86
SCS: Men (N=1,809)	999	4.76
Non-SCS: Women (N=547)	269	2.59
Non-SCS: Men (N=978)	572	2.72
SCS: Pre-clin. (N=1,012)	665	4.11
SCS: Clin./Comb. (N=1,346)	819	5.22
Non-SCS: Pre-clin (N=479)	313	2.58
Non-SCS: Clin./Comb. (N=1,041)	558	2.72

Apart from differences in the number of organizations, the types of organizations also differed between scientists with or without SCS funding. In both cases, the majority of the organizations were universities and hospitals, while in the set of articles by SCS funded scientists, there was a greater representation of other kinds of institutions, such as local and national government institutions, corporations and free-standing research institutes.

To investigate the collaboration networks, a co-authorship analysis was conducted (Melin & Persson, 1996). For each analytical category, the numbers of unique pairs of organizations formed in the co-authorships were identified, together with the number of links between them and the average number of links per pair (Table 5). The latter was in part to adjust for the sheer number of organizations in the different analytical categories, but also as an indicator on the density of the networks.

Table 5. Organization level co-authorship pairs and co-occurrence links.

	Unique pairs	*Link frequency*	*Average links/pair*
Full set	37,293	90,244	2.42
SCS	33,192	81,981	2.47
Non-SCS	8,118	11,372	1.4
SCS: Women	2,844	14,889	5.24
SCS: Men	32,193	74,440	2.31
Non-SCS: Women	1,165	2,373	2.04
Non-SCS: Men	7,027	8,885	1.26
SCS: Pre-clin.	23,770	42,826	1.8
SCS: Clin./Comb.	18,448	51,687	2.8
Non-SCS: Pre-clin.	3,548	4,252	1.2
Non-SCS: Clin./Comb.	4,935	7,264	1.47

In general, the organizational networks for scientists with SCS funding were larger than for those without SCS funding, both in terms of the number of pairs formed as well as links between the individual pairs; and this tendency also remained when comparing men and women as well as pre-clinical and clinical/combined types of positions within the SCS and non-SCS categories. One interesting thing to note, is that women in both the SCS and non-SCS sets had networks with a higher average of links per pairs than men; and in the SCS set, the average for women was more than twice that of the men, thus appearing to have denser collaboration networks.

The co-authorship networks were also visualized using Pajek (de Nooy, Mrvar & Batagelj, 2005) and the Kamada-Kawai (1989) algorithm. The visualization analyses were conducted for LU cancer scientists with and without SCS funding, as well as further breaking down the analyses into men and women with and without SCS funding, and pre-clinical and clinically/combined scientists with or without SCS funding. In terms of structures discovered in the visualizations of the different analytical categories, there were substantial differences between scientists with or without SCS funding, whereas the differences between e.g. men and women with SCS funding were small. Thus, in this paper, only the visualizations for researchers with and without SCS funding are included (Figure 3a&b).

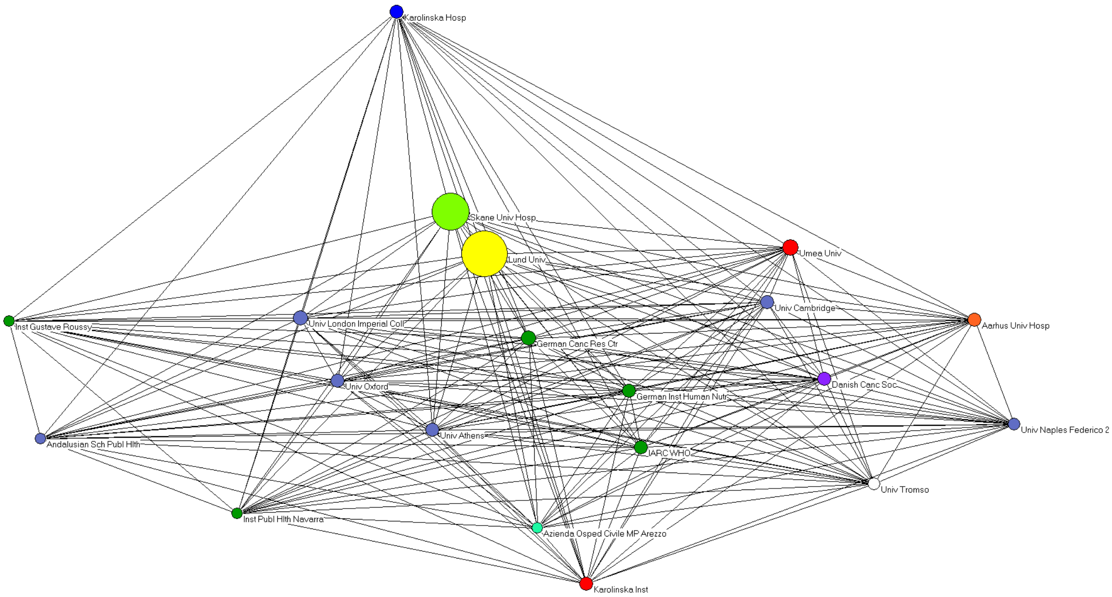

Figure 3a. Organization level co-authorship for LU authors with SCS funding. The 20 most frequently occurring organizations: 80 papers or more. (Unique pairs: 189, Number of links: 12,954, Links/pair: 68.54)

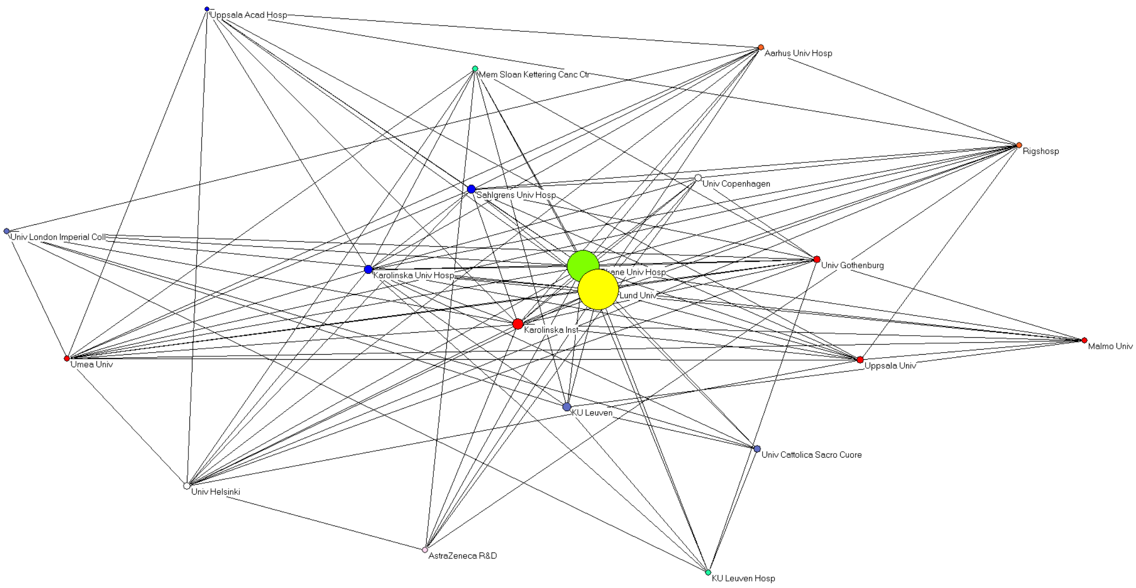

Figure 3b. Organization level co-authorship for LU authors without SCS funding. The 20 most frequently occurring organizations: 20 papers or more. (Unique pairs: 112; Number of links: 1,346; Links/pair: 12.02)

The maps show substantial differences in the structure of the networks. While the number of pairs formed by the 20 organizations included in the analyses was almost twice as high for SCS funded papers, the number of links between these pairs was almost 10 times higher for the SCS papers than for the ones without SCS funding. Both the number of links per se; and the distribution of links per pairs in the analysis, was substantially higher for scientists with SCS funding than for those without. Another difference was the higher frequencies for both non-Nordic organizations as well as organizational types that are not universities or hospitals for scientists with SCS funding; while the share of hospitals and Swedish collaboration partners was higher for the non-SCS papers (Table 6).

Table 6. Types of organizations in co-authorship maps (Figure 2a&b).

	With SCS funding	*Without SCS funding*
Swedish University	3	6
Swedish Hospital	2	4
Swedish Other Org.	0	1
Nordic University	1	2
Nordic Hospital	1	2
Nordic Other Org.	1	0
Non-Nordic University	6	3
Non-Nordic Hospital	1	2
Non-Nordic Other Org.	5	0

When analysing research collaboration on the organizational level, the differences between men and women, as well as between scientists with pre-clinical or clinical/combined positions, seemed to be even smaller than in the analyses on author level, whereas the differences between cancer researchers with or without SCS funding became even clearer. The collaboration networks for scientists with SCS funding were larger, more international and with higher frequencies of organizations outside academia and the hospital sector; and the density of the networks also seemed higher, with stronger links between the different organizations taking part of the research.

Conclusions

We aimed to study relations between on one hand: gender, research funding and research orientation; and on the other: the formation of research collaboration networks through a micro-level analysis of cancer research scientists at Lund University (LU). The frequency and distribution of contributing authors were investigated both on individual and organizational level and included analyses of co-authorship structures were also analysed.

An initial analysis of the number of LU authors per analytical category and the distribution of papers per LU authors, showed a significant difference between authors with or without funding from the Swedish Cancer Society (SCS), as well as between men and women and SCS funded authors with either a pre-clinical or a clinical/combined type of position. However, when analysing the research collaboration networks, the differences between men and women, as well as between clinical/combined and pre-clinical researchers, became less substantial, while the differences between scientists with or without SCS funding remained or became even more substantial.

That research collaboration networks are larger and more densely populated for scientists with SCS funding was expected and supports previous findings by e.g. Clark & Llorens (2012), Haiqi (1997) and Heffner (1981). In the light of e.g. Alcaide et.al. (2009) and Wennerås & Wold (1997), however, we would expect to see larger differences between men and women. When looking at the distribution of papers per LU author, we found differences between men and women, but as we turned our attention to the collaboration networks and looking at men and women with or without SCS funding respectively, the differences between genders were relatively small. This supports the findings of Bordons et.al. (2003), who did not identify differences in productivity in relation to gender within different professional categories. In our

study, women were younger than the men, which imply a shorter research career. Still, even though the results in this study suggests that funding has a stronger relation to collaboration networks than gender, there is obviously the matter of women getting access to e.g. higher academic positions and research funding, as discussed by Wennerås and Wold (1997).
In terms of clinically/combined and pre-clinically oriented scientists, differences seem – as previously mentioned – more related to funding from the SCS than orientation. However, there were a significantly larger amount of papers from clinically/combined scientists among the SCS funded ones; and the networks for clinically/combined authors also seemed larger than for pre-clinical researchers within both the SCS funded and non-SCS-funded papers, which is in line with findings by Satyanarayana and Ratnakar (1989).
In summary, we found differences between men and women as well as between pre-clinical and clinical scientists, with more pronounced results related to number of publications than size and type of research networks. We identified a tendency towards women having fewer publications, although this probably reflects women being at an earlier stage of their careers. Despite smaller networks among women, they had denser networks with a higher average of links per pair. The most substantial differences, both when analysing number of publications and size and form of networks, however, are related to funding.

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