

# **Academic publishing activities among Danish research-based companies: a preliminary assessment**

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## Introduction

Several observers have stated that scientific knowledge is increasingly created and utilized in networks (Nowotny et al 2001). Additionally, the roles of the three institutional spheres in the triple helix – industry, universities and government - are changing and increasingly interwoven and the roles are no longer clearly defined and divided (Etzkowitz & Leydesdorff, 2000; Nowotny et al 2001; Hellström and Jacob, 1999). Powell et al (1996) have pointed out that the locus of innovation has to be found in networks and not within the boundaries of an organisation. When knowledge is created and utilized in networks, the necessity of participating in the right networks becomes crucial to knowledge-based organizations. The interaction is not merely a matter of knowledge transfer, it also includes mutual agenda setting, negotiated criteria of validity, joint knowledge production etc. This kind of mutually committed interaction unfolds in meeting places like the agora (Nowotny et al 2001) or the trading zone (Gallison, 1997).

Given the above, the ability of research-based firms of creating value by investing resources in research is closely related to the networking capacity of the firms. Firms need to be involved in relevant knowledge producing networks. As argued by Jones et al (1997), exchanges among the participants in networks will often be safeguarded by restricting access to participating in the exchanges. The restricted access occurs through status maximization, in which persons seek to avoid co-operating with persons with significantly lower status. As others do the same, status maximization results in co-operation among persons with the same status. Status is based on the person's track record in delivering quality output or co-operation with other high status persons (Podolny, 1994). Publishing research results would be one obvious way for research-based firms to demonstrate quality in their research and thereby obtaining access to knowledge creating networks with the desired level of status.<sup>1</sup>

Disseminating research results in academic journals may seem a paradoxical behaviour for organizations devoted to the creation, appropriation and strategic management of private knowledge. However, the benefits of sharing the results through publishing in academic journals could in some situations outweigh the disadvantages of inviting for spillovers.

The purpose of this paper is to provide a snapshot of the publication activities in academic journals by researchers employed by Danish companies. More specifically, the paper presents data on the extent of publication activity, the collaborative patterns and the cross industrial differences.

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<sup>1</sup> It has already been noticed from studies in UK and Canada that industrial researchers publish their results in academic journals (Godin 1996; Hicks 1995). Some of the incentives for publishing suggested in the literature are to satisfy employees, quality control of internal research results, access to networks, reputation building etc (Godin, 1996; Hicks, 1995, Rosenberg, 1989).

This section will be followed by a discussion of the methodological aspect of studying industrial publication activities. The third section presents data on the overall publication activity in Danish industry in 1998 and data on patterns on collaboration with other firms and universities. The last section sums up the main conclusions regarding industrial participation in academic publishing activities and outlines the implication for further conceptual and empirical research in the area.

### **Methodological constrains and clarification**

The research reported in this paper covers the first stage of an in depth, long-term study on how research-based companies obtain benefits from the research they sponsor by disseminating their results in academic journals. The empirical basis of the first stage of the study is publications by at least one author employed in a Danish company and registered in ISI's Science Citation Index (SCI) in 1998. An important output of this stage is knowledge about limitations and reliability of ISI's Science Citation Index for a study with this purpose. In other words, the first stage has also had an explorative function laying the methodological ground for further more detailed and long-term studies of the role played by research-based companies in dynamic knowledge networks.

SCI is, for several reasons, the most used database in studies of publications. First, it has the most extensive coverage including more than 5,900 full indexed journals<sup>2</sup>. Despite this extensive coverage, SCI is far from including all international or even all English-language academic journals. Of course, there is an ongoing discussion on whether SCI includes all the significant journals. For the purpose of our study, it will not serve any reason to enter this dispute. However, we have to keep in mind that our study – as well as others – is based on a selection of journals, which implies that the number and hence the publication activity by researchers employed in industry can be expected to be higher than revealed through this study. Secondly, the SCI database has an attractive coverage in terms of disciplinary scope and covers almost every scientific discipline in science, technology and medical areas. Finally, SCI also offers a more rich variety of information about the registered publications than the competing databases. Most importantly for the present study, SCI includes information on the affiliation of the authors of a publication, which facilitates analysing patterns of collaboration between institutions. Based on these advantages, we decided to use SCI for our study of academic publishing activities among Danish research-based companies. Since most studies of scientific publication patterns use SCI, our choice also prepares the study for later comparative studies across sectors and nationalities. The SCI database is available in various versions – online, on CD-

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<sup>2</sup> In October 2001, the total number of full indexed journals was 5,900. This means that the journals are indexed "cover-to-cover" including all contributions in the journals.

Rom and on WWW – and the versions are not always identical. We have used the latter, the Web of Science edition.

SCI offers a wide range of information on each publication. For our purpose, the author affiliation is a crucial information. However, analysis based on the author affiliation is far from unproblematic. The most serious challenge is that the affiliated organisations are registered under not only one but several names and abbreviations in the database. This is due to a variety of reasons ranging from simple spelling mistakes to various variants of short names for the company to the fact that many contributions are not directly assigned to an institution or company but only to a department or unit within the institution or company. We have decided to address this issue by going through a very thorough verification procedure for all the Danish institutions and companies<sup>3</sup>. In this procedure, we have double-checked all information on each publication in case of any doubt about the author's institutional affiliation<sup>4</sup>. However, this procedure is extremely resource demanding and we have therefore chosen not to include information on institutional affiliation for foreign co-authors. They are only registered by nationality in the present study.

Another strength of SCI is that it indexes the journals cover-to-cover including all kinds of contributions. As a consequence of the cover-to-cover indexing, the publications in SCI are classified in various "document types", i.e. "article", "editorial material", "letters", "meeting abstracts", "reviews", etc. Several studies have their focus on "substantial research contributions", but what is to be included in the studies is not obvious, and it varies in the various analyses and articles. It can, for instance, be articles and notes (e.g. Hicks et al., 96) or just articles (e.g. Godin, 96). The content of the document types is not always the same in the various journals. It differs from journal to journal and from one scientific field to another. A letter published in an academic journal can reveal research results at the forefront, and meeting abstracts can be a very important channel of communication in some disciplines. As a consequence, we have chosen to include all document types. As an illustration of the distribution of the various document types, we can mention that of all research publications with Danish contributions in 1998 (more than 8,500), 83% of the contributions were articles, meeting abstracts consists of 9%, reviews and letters 3%

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<sup>3</sup> Concerning the companies, the "unit" of a company is the company name. We are not searching for collaboration between various departments in the same company, and we are not looking for the research activities of multinational companies in other countries. As in similar studies, we have had problems with changes in names, ownership, bankrupts, etc

<sup>4</sup> A special problem with the use of the 'Author affiliation' field in SCI is the many variations and the insufficient information about the relevant unity, as mentioned above. The consequence was that the correspondence between SCI and the company database – CD Direct – was problematic and many potential companies were impossible to verify. Sometimes the only information was a postal address. See Seglen (1997) for a broader discussion of the general methodological problems and disadvantages of SCI.

each while other types of published documents covered the remaining 2%<sup>5</sup>. In this paper, we refer to all kinds of contributions in academic journals as articles.

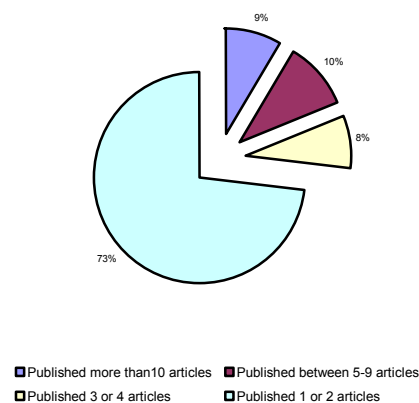
### **An overview of industrial publication activities**

Searching SCI reveals that 8,675 articles in academic journals in 1998 had contributions from Danish employed researchers of which 808 articles included contributions from researchers directly employed by Danish companies. In other words, Danish industrial researchers contributed to approximately 10% of the overall scientific output measured as published material in academic journals in 1998. This share is slightly higher than the ones identified in the UK, the Netherlands and the USA in the 1980'ies and the beginning of the 1990'ies. According to Hicks and Katz (1994), company researchers participated in 8% of all UK papers, whereas Dutch companies produced on average 6% of the Dutch scientific output in the period 1980 to 1989 (De Bruin et al., 1992), and whereas in 1991, companies located in the USA produced 9 % of all scientific and engineering publications (Hicks 1995).

In his study of publication activities in the Canadian industry, Godin (1996) found a remarkable growth in the production of scientific articles by the industry in the decade from 1979 to 1989. In this period, the annual number of articles produced by the industry rose with approximately 50%. Another indicator of an increased orientation towards scientific publication is patent citations to scientific journals. In Godin's study, patent citation to scientific journals increased by 300% in the period from 1979 to 1989. At the present stage, we do not have any data indicating the development of the publication activities among Danish industrial researchers.

According to our study, researchers from 138 Danish firms published in academic journals in 1998. It is remarkable that out of the 138 active companies 101 (73%) only published one or two articles in 1998. This low level of activity may indicate that these firms only sponsor a very limited in-house research or do not find it attractive systematically to

Figure 1: Publication activity



<sup>5</sup> Sample tests show that the distribution from the Danish companies has nearly the same share of the various document types. Some of the most publishing companies have a share of articles a little below average. They have published some 'meeting abstracts' in a specific journal 'Diabetologia', which is – just as a footnote – a high-reputation journal with a high impact factor.

disclose their result in academic journals. At the other end of the spectrum, we find that 9 % of the publishing firms published more than 10 articles each in 1998. Approximately 10% of the firms published between 5 and 9 articles in academic journals in 1998. This means that more than 70% of all the publications were authored or co-authored by researchers from the 10 most active companies (See table 1). This indicates that some companies are extremely active in terms of scientific publication. Taking a closer look at the group of companies with 10 or more publications, we find a very uneven distribution. One company, Novo Nordisk from the pharmaceutical industry, has contributed to 273 research articles. This is three times more than number two Carlsberg with 84 research publications.

Company	Number of articles	Company	Number of articles
Novo Nordisk AS	273	Danisco AS	20
Carlsberg	84	Scantox	17
Hagedorn Res Inst	56	Kruger AS	14
Leo Pharmaceut Prod	39	COWI	12
H Lundbeck AS	37	Danfoss A/S	10
Haldor Topsoe AS	29	ALK ABELLO	10

**Table 1: The twelve most publishing firms in 1998**

In comparison, researchers from the largest Danish university, University of Copenhagen, contributed to 1,153 international scientific publications in 1998. The third largest Danish university (Technical University of Denmark) had an output of 670 international publications, whereas one of the small Danish universities, Roskilde University, reached 70 publications.

The level of publication activity in academic journals by researchers employed by industry brings no support to the views that “commercialization of science” and having a practical aim of knowledge production should have negative consequences for the ability of science to generate new original knowledge, which is competitive in academic journals.

One possible explanation of the lack of conflict between creating useful results and - as indicated by the publication success – highly competitive scientific results at the same time could according to Hicks (1995) be that research results created in a corporate setting are not inherently public or private; Instead they are constructed for various purposes where one purpose does not exclude the other. Research quality is a more generic issue and not strictly related to the aspiration of the creator. Instead of re-acting to something inherent of the research results, they are shaped to fit various purposes and aims.

Among the six most publishing companies in Denmark in 1998, we find four companies from the pharmaceutical industry. This indicates that publication of research results in academic journals to some extent is an integrated part of the behavior of these firms.

Industry <sup>6</sup>	Number of articles
Pharmaceuticals & medicinal chemicals	458
Food, beverages and tobacco	116
Other business activities – consultancy etc.	76
Medical, precision and optical instruments	48
Television and communication equipment	37
Chemicals & chemical products	34
Agriculture etc	14
Computer and related activities	8
Metal-, plastic- and glass industry	7
Others	16
<b>Total</b>	<b>814</b>

**Table 2: Publications distributed on industries**

This impression is confirmed when we study how publications are distributed on industries. Researchers employed by companies in the pharmaceutical industry contributed to more than 458 publications in academic journals, while “Food, beverages and tobacco” as the second most publishing industry counted for only 116 publications. One possible explanation of the dominance of the pharmaceutical industry could be that within this industry it is a regulatory necessity to publish (Nelson, 1990) and in this way expose industrial results to academic scrutiny if the company wants to harvest the financial benefits by incorporating the research results in products and services sold on the market. In situations where both management and external stakeholders find it difficult to assess the quality and reliability of the research sponsored by the firm due to asymmetric distributed information, publishing results can be a way of controlling the quality of the research activity and the reliability of the results

When we take a closer look at the distribution of publications by researchers employed in the Danish industry, it is very clear that life sciences are dominating the landscape of publications with industrial participation<sup>7</sup>.

<sup>6</sup> The trade codes for each of the companies included in our population are found in the largest Danish company database CD Direct (Købmandstandens Oplysningsbureau). The companies are classified with NACE trade codes, which are the official EU standard. For the purpose of limiting the number of industry groups, we have used an approximation of NACE trade codes, which means that all companies only have one specific code.

<sup>7</sup> Journal subject categories is not standard information in Web of Science, instead we have used the NSI deluxe 105 subject categories. NSI – National Science Indicators – is a database derived from SCI and produced by ISI. These 105 categories are reduced to 24 categories in the NSI standard version.

Subject Category	Number of articles	Subject Category	Number of articles
Clinical Medicine	239	Materials Science	19
Biology & Biochemistry	216	Immunology	18
Chemistry	109	Pharmacology	10
Plant & Animal Sciences	58	Computer Sciences	9
Engineering	52	Multidisciplinary	8
Physics	44	Geosciences	6
Neurosciences	37	Psychology/Psychiatry	2
Agricultural Sciences	33	Space Science	1
Molecular Biology & Genetics	24	Mathematics	1
Ecology / Environment	23	Library & Information Sci	1
Total			910

**Table 3: Distribution of articles according to subject categories.**

The distribution of articles on subject categories also indicates that research results related to the historically strong Danish agriculture industry are published in academic journals whereas emerging industries based on computer sciences do not publish result in academic journals<sup>8</sup>.

#### *Appropriation and co-operation*

The maybe strongest incentive for research-based companies to publish their results is the access to relevant research networks. Firms want to participate in these networks to reach their aims of accessing technical opportunities produced in the science base (Hick 1995). As observed by Powell et al (1996), the locus of innovation is in the inter-organizational collaboration and not within the boundaries of individual firms. It has long been recognized that access to external knowledge production depends on the firm's absorptive capacity (Cohen and Levinthal, 1990). The access is also highly based on the principles of barter exchange.

Knowledge transfer through person-embodied knowledge is a crucial means of university research to have an impact on technology and industrial activities. However, individual researchers may only find it attractive to engage in person-

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We have used the latter version. There are several problems and limitations in the use of subject categories (Aksnes et al., 2000). One of the problems is that not all journals have one unique subject category and some journals are grouped in two different categories. 102 of the articles in our study are published in journals with two subject categories. The total of 910 – and not 808 articles – can be explained by the fact that some of the journals are classified within two subject categories.

<sup>8</sup> Differences in publication output can be a matter of efficiency (or quality), but it can also be a matter of differences between industries or research areas with respect to desired research output i.e. new products or processes, patents, publications, general growth in the companies' knowledge bases etc. It is, however, beyond the scope and the empirical foundation of the present article to discuss the reasons why differences in publication patterns may emerge between specific industries and scientific fields.

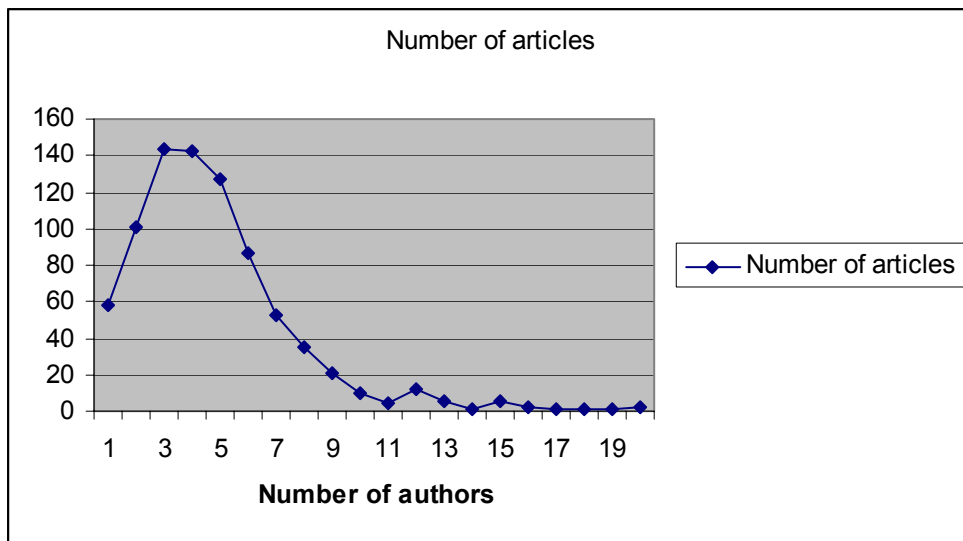


embodied knowledge transfer activities if they benefit from it one way or another. Consequently, knowledge transfer can be seen as an exchange in which each part has to bring interesting insights into the barter. Additionally, credibility is an important asset to be able to participate in the barter-governed exchange of scientific knowledge. It is therefore crucial for research-based companies to publish research results in order to create access for their staff researchers to the knowledge flow in the research community. However, in the network society the need for accessing external knowledge may have been supplemented or even replaced by a still stronger need for participating in relevant knowledge creating networks to get influence on the agenda and an early warning of potential results and access to underlying knowledge. “Participation offers a form of appropriating knowledge that otherwise appear remote and arcane” (Nowotny et al., 2001:210). Spillovers are a necessity for acting in a network economy, since access is conditioned by giving valuable contributions to intellectual development of the networks.

It has been emphasized that networks for creation, application and diffusion of knowledge are much more efficient and productive than research which does not take place in networks. The bulk of research into this phenomenon has been focused on either the process of transferring knowledge among the participants in the networks and the performance evaluation of the network (Hellström and Jacob, 1999). The emergence of the networks and especially how potential partners identify and qualify for participation in the networks that they find especially relevant for their own research have achieved less attention. As pointed out above, publications are a necessity for entering the research networks and especially entering the most attractive ones.

The pattern of co-authorship is an indicator of network activities. By studying patterns of co-authorships, we will gain insight of the extent and the configuration of the underlying researcher network. A co-authored publication is not just an end by itself it indicates a process of creating the results. The Danish data shows that only 7% of the published papers is written by one author, while the remaining 93% of the publications is co-authored by two or more researchers. Out of the total number of co-authored articles, 24% is written by one or more researchers from the same company. A significant share, 76%, is co-authored with researchers from other institutions and companies indicating a high level of cross-institutional research co-operation.

A closer look at the numbers of co-authors on each publication supports the existence of a high level of cross-institutional co-operation. A bulk part (67%) of the publications has between 3 and 7 authors. It is also worth noticing that approximately 6% of the publications is written by 10 authors or more and two of the publications involve 23 authors.



**Figure 2: Numbers of co-authors for each article**

An interesting implication of the extensive use of cross-institutional co-authorship is related to decision of balancing appropriation with dissemination of results. Not all results can be published and not all results, which can be published, can be published immediately. Companies are able to publish because they can choose which results to make public and when (Hicks 1995). The challenge of appropriating the findings of research through publication must necessarily be grounded in strategic consideration about which results to publish and when. Even though, research active companies can harvest a wide range of benefits from disseminating their knowledge, it is crucial to keep the attention on the fact that the revenue generated from utilizing research results for developing new products and services is the most significant benefit from sponsoring research. A dissemination strategy should consequently align the interests between capturing value through introducing research-based innovation to the market and the ability to protect these competitive advantages as long as possible on the one side and the ability to capture dissemination related benefits on the other side. Research results can only be published if the articles do not reveal information, which the company believes contain any significant potential for present or future value creation. The extensive use of co-authoring among researchers employed in Danish firms indicates that many of the published results are not created within the domain of a single institution or company, but are the result of a cross-institutional research effort. In this perspective, the strategic decision of publishing results changes character from a decision about sharing private knowledge to a decision about sharing semi-public knowledge that is already shared among a number of companies and institutions.

The Danish data shows that 221 publications out of the 612 publications written by authors from more than one organization are written in co-operation with researchers employed at Danish institutions. 279 publications are written together with

Written by:	Publications
One or more researchers from the same one company	196
Researchers from two companies	15
Researchers from one company and only Danish partners	221
Researchers from two companies and only Danish partners	17
Researchers from one company and only foreign partners	279
Researchers from two companies and only foreign partners	8
Researchers from one company and both Danish and foreign partners	68
Researchers from two companies and both Danish and foreign partners	4
<b>Total number of articles</b>	<b>808</b>

**Table 4: Co-author patterns**

researchers from foreign research institutions only. The figure indicates that researchers from Danish companies have a track record of doing research at a level, which makes them attractive partners for both domestic and foreign university researchers.

The study also includes information on the institutional affiliation of Danish co-authors. A closer look at these data reveals that industrial researchers co-author publications with researchers from 84 Danish institutions and companies. However, despite this highly dispersed pattern of co-authorship there is a high concentration of co-operation with traditional universities. Researchers from University of Copenhagen are co-authoring 83 of the publications and the Technical University 50.

Danish Institution	Number of articles
University of Copenhagen	83
Danish Technical University	50
Royal Vet & Agr Univ	34
Steno Diabet Ctr	28
Riso National Laboratory	21
Rigshosp	18
Royal Danish Sch Pharm	18
Aarhus Univ	17
Odense Univ	17
Herlev Univ Hosp	11

**Table 5: Distribution on Danish universities, hospitals and research institutions**

Another indication of scientific quality is the degree of internationalization in the research activity and output. When papers are co-authored by scientists from various geographical regions, it indicates that the researchers prior to the co-authoring process have established a scientific reputation, which enables them to attract international partners. Therefore by analyzing the geographical dispersion and intensity of co-authoring patterns, we get an indication of the past achievements of the involved organizations.

Country	Number of articles
USA	113
Germany	53
England	48
Sweden	43
France	36
Netherlands	28

**Table 6: The six most frequent nationalities of co-authors**

The international co-operation is also very dispersed with co-authoring activities with researchers from 40 countries. But in terms of intensity, the co-operation is very much oriented towards the USA. As table 6 shows, more than twice as many articles (113 articles) are co-authored with researchers from the USA than from the second most popular nationality, the Germans with 53 articles.

### Collaboration patterns within subject categories and industries

Do different industries or scientific disciplines have different preferences of whom to collaborate with? By dividing the publications by researchers employed in the Danish industry into scientific disciplines and industries we potentially gain insight into various configurations and the extent of the networks. In the following section, we will take a look at the collaboration patterns in the six subject categories and industries, in which most articles have been published. We study whether they have published together with Danish, foreign or both kinds of researchers. For each field, we will show a more detailed specification of the collaboration partners.

A closer look at the pattern of co-authorships at the level of subject categories reveals that many minor differences exist from one subject field to another.

	Clinical Medicine		Biology & Biochemistry		Chemistry		Plant & Animal Sciences		Engineering		Physics	
Co-authorship	%		%		%		%		%		%	
Only with Danish	71	30	53	25	27	25	24	41	15	29	15	34
Only with foreign	87	37	87	40	38	35	13	22	15	29	17	39
With both	23	10	24	11	4	4	6	10	5	10	7	16
Inside the firm	58	24	52	24	40	37	15	26	17	32	5	11
<b>Total</b>	<b>239</b>	<b>100</b>	<b>216</b>	<b>100</b>	<b>109</b>	<b>100</b>	<b>58</b>	<b>100</b>	<b>52</b>	<b>100</b>	<b>44</b>	<b>100</b>

**Table 8: Co-authorship according to subject categories**

It is remarkable that among the six most active subject categories, we find that with the exception of “Plant an animal sciences” industry researchers either find co-operation with foreign partners most attractive or second most attractive. In the largest subject category “Clinical medicine”, 37 % of the co-authored publications is co-authored with foreign authors while only 30% is co-authored with Danish partners. This tendency is even stronger in the second largest subject category “Biology & Biochemistry”. Within this category, 40% of the publications is co-authored with one or more foreign partners and only 25% of the publications is co-authored with Danish partners only.

Within the subject category “Chemistry” and “Engineering”, we see a strong preference for co-operation with other authors from the same organisation. In the case

of “chemistry”, 37% of the publications is co-authored with researchers from the same company. This could indicate that firms from the chemical industry see an advantage in keeping the cards close to the body until they are able to assess the potential value of the results that emerge from the research process.

A similar tendency is appearing when analysing the patterns of co-authorship according to industries.

	Pharmaceuticals & medicinal chemicals	Food, beverages and tobacco	Other business activities – consultancy etc	Medical, precision and optical instruments	Television and communication equipment					
<b>Co-authorship</b>		%	%	%	%					
<b>only with Danish</b>	113	25	30	26,3	28	38	15	33	14	38
<b>only with foreign</b>	172	39	40	35,1	15	21	16	35	15	41
<b>with both</b>	33	7	13	11,4	3	4	7	15	6	16
<b>In house co-author</b>	126	28	31	27,2	27	37	8	17	2	5
<b>Total</b>	444	100	114	100,0	73	100	46	100	37	100

**Table 9: Co-authorship according to industries**

The most publishing industries all have a small preference to co-operate with researchers abroad compared to co-operation with Danish researchers. The only exception is the industry “Other business activities – consultancy etc.’ which is characterized by having a limited collaboration abroad. They have the highest share of in-house publications and Danish collaboration

It also attracts attention that only a minor share of the publications is written in co-operation with both a Danish and a foreign partner. It could indicate that Danish companies prefer to co-operate with various research institutions for various purposes and that Danish research institutes only to limited extent serve as mediators between the Danish companies and foreign research institutions. The relative low level of co-authorships with both Danish and foreign researchers could indicate that the industrial researcher’s scientific reputation give them directly access to interact with researchers in the international academic society. In other words, it could imply publishing research results in academic journals has contributed to the development of the needed status for entering the right networks.

## **Conclusion**

By identifying the research publications in 1998 by researchers employed in Danish industry, we first get an impression of the extent of the contribution from the private knowledge production in industry to the public pool of knowledge. We also get an indication of the competitiveness of research result from industry in academic journals. Finally, the data can also be used for analysing the networks, which

industrial research-based firms take part in. The most exciting conclusions derived from the empirical study of publication activity by researchers in Danish industry are:

Danish research-based companies contributed with approximately 10% of the overall Danish scientific output in 1998 measured as publications in academic journals. The publication activity was spread over 138 firms. Despite of this significant number of firms, the main part of the publications (70%) was authored by researchers from the 10 most publishing companies. The data also shows that heavy concentration on publications from the pharmaceutical industry.

The pattern of co-authorship has been used as an indicator of network activities. An extremely high share (93%) of the publications has more than one author and out of these 76% is co-authored with researchers from other institutions and companies indicating a high level of cross-institutional research co-operation.

An interesting implication of the extensive use of cross-institutional co-authorship is related to decision of balancing appropriation with dissemination of results. The extensive use of co-authoring indicates that many of the published results are not created within the domain of a single institution or company, but are the result of a cross-institutional research effort. In this perspective, the strategic decision of publishing results changes character from a decision about sharing private knowledge to a decision about sharing semi-public knowledge that is already shared among a number of companies and institutions.

The geographically very dispersed pattern of co-operation based on direct contact between the Danish firm and the research institutions implies that publishing research results in academic journals has contributed to the development of the needed status for the research-based firms to entering the right networks.

What we have shown in this article is just a snapshot. One year does not necessarily show the correct picture. Including more years, it would be possible to see the steadiness of the patterns or to claim a probable development. For further studies, and especially if they cover a longer period, it would be important to ensure and further develop the validity of the available data, so that we – to the largest extent possible – can be sure to what extent the possible differences would be due to ‘real’ differences, and not due to differences in artefacts, i.e. the content of the databases.

The insights in this study raise some interesting questions regarding the relationships between industrial research and its surroundings, which can be subject for further studies. What factors determine the collaboration patterns? Or in other words: Where do the pressure or the incentives to common research projects come from? Is it due to

the quality of research in specific scientific areas on specific universities and other research institutions, or is it due to the specific industrial structure in Denmark?

It is probably a combination of both factors, but such questions are relevant in the light of the research policy in many Western countries, where there is a great emphasis on societal and commercial utility of public research. Many public research and development programs have their focus on participation from both public and private research institutions. A research landscape labelled the Triple Helix. But in this discussion, it is important to clarify the conditions for collaborations and to examine where the possibilities for a successful unifying of the research efforts are highest.

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