The Missing Sector: Research Institutes in Sweden Lost and Found through Bibliometrics

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Abstract

This paper starts in the discussion on whether there are institutes at all in Sweden. We identify 79 research institutes and describe them with information from three databases. Through bibliometrics some aspects of research institute activities are analysed and a comparison between collaborative and non-collaborative articles, with academic partners only, is performed. The conclusion is that there is a great potential for improvement through increased academic collaboration.

Introduction

Science of science is often focused on the evolution of universities and to some extent on the organisation of industrial R&D. Much less attention is being devoted to the third group of players in knowledge production – public and private (non-profit) research institutes. In the following all performers of the third category will be named ”research institutes”. These organisations have been subject to fundamental changes during the last decade. Many governments have reappraised their innovation systems which have led to a discussion on the role of the institute sector.[1] In some countries governments have tried to intensify responsibilities from the private firm sector for the institutes.

The Swedish research system is a rare and special case. The country is greatly dependent upon a small number of large companies in various industry sectors (aerospace, electronics and telecommunications, pharmaceuticals, metal and mechanical, electrical, automobiles and paper and pulp). Very much in the core of these industrial activities are the metalworking and mechanical engineering technologies. As many other small countries Sweden has a high degree of specialisation, which consequently have lead to a high concentration of exports from these sectors of the economy.

In Sweden, a considerable proportion of funding for academic research is allocated through sectorial bodies reporting to ministries. The university sector is the main recipient of money for applied research and development, and the research institutes are held to be of little importance in Sweden. R&D in Sweden focuses heavily on certain key industries. Together, the five biggest R&D areas account for more than 80% of all research and development spending in industry. And these resources are concentrated to a few companies. Pharmaceuticals are the most R&D-intensive industry and it is closely followed by telecommunications.[2]

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[1] See e.g. many of the reports published by the consulting firm Technopolis in Brighton, U.K.

[2] According to Arnold the figure is relevant for companies: ”*Five companies - Ericsson, Astra-Zeneca, ABB, Volvo and Pharmacia-Upjohn account for 80% of the business spending on R&D. Four of these companies are partly or wholly foreignowned. Correspondingly, the rest of Swedish industry has a very low spend on R&D.*” Arnold (2000).

Most industry sectors in Sweden are in their turn highly concentrated so that a small number of multinational companies control most of the company based R&D-resources. In many other countries, small- and medium-sized firms are more important for production and employment. As small companies cannot create the preconditions for innovations by themselves they tend do organise external support, sometimes governmental organisations, and access to public research. In Sweden, a collective research organisation was organised during the 1940s. Government took active part in this process, but most of the organisations were formally external to the state. Support came from different agencies for sectoral research.

The collective research model has been under scrutiny for many years, at least since the 1980s. In numbers governmental white papers and bills are outnumbering the scientific articles on this subject. As mentioned by Hohn & Lautwein (2003, p.263) the general problem is that industries that "are subject to radical and discontinuous technical changes" will find the model less attractive. Also, heterogeneous or, which is often forgotten, oligopolistic or monopolistic situations will act in the same direction. If a large company is alone at the national market it has almost no incentives to collaborate with research institutes. The logic for this is, of course, that collaborations introduce risk of spreading information that should be kept secret.

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In areas of high concentration and few players there is no need for intermediary institutional arrangements. This is the first and often neglected explanation as to why Sweden has a relatively small institute sector in industrial areas. A review of articles and books in the tradition of "systems of innovation" shows a surprising disinterest for research institutes.[3] In the Swedish case there are no academic studies whatsoever focusing on the role of institutes.[4]

Research questions

The policy debate in Sweden has been intensive. Institutes, the collective industrial type, are said to be in need of more resources and improved academic links. First, we analyse the sector of research institutes in Sweden in general, secondly we describe the institutes in Sweden specifically, and thirdly we investigate whether institutes are having academic links or not and if so, does it pay? Methods are mainly standard bibliometric procedures[5] using the Thomson/ISI Web of Science full version 1982–2003.

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[3] See books by Freeman & Soete (1997), Nelson (1993), Lundvall (1992).

[4] See Gregersen (1992), Lundvall & Edquist (1992), Jacobsson (1997), Carlsson et al (2002), Edquist (1997), Stankiewicz (2000).

[5] Certain data included herein are derived from the Web of Science prepared by Thomson Scientific Inc. (ISI), Philadelphia, Pennsylvania, USA.

Financing of R&D in an international context

Governments in the EU spend a larger amount than either the US or Japan on institutes though Japan is the only region to show an increasing trend as its laboratories have benefited from science policy initiatives. The spend for the EU-15 has been remarkably stable in real terms over the whole period.[6]

There is a wide national variation in proportion of GERD spent in the government sector. Countries like Belgium, Sweden, Ireland and Austria spend low proportions of GERD.[7] Low expenditure is normally associated with a prominent role for higher education R&D (Sweden and also the UK) or an absence of defence R&D (Belgium and Ireland). High expenditures are found in systems where national organisations of laboratories are dominant research players, and are engaged in basic as well as applied research (France, Italy and Spain).

At the same time there are considerable problems connected to the R&D statistics used. Many of the Swedish institutes are privately owned in the form of joint stock companies. Behind these share-holder organisations there are “private” associations of companies and other organisations (often public ones, formally belonging to the governmental sector). The association constitutes an organisation for buying and holding stock in the company. Shareholders might go in and out of the association without taking away any capital form the company. Also, the government act as single owner of institutes that legally are joint stock companies. In the statistics these “private” organisations are considered as private firms and are reported as such. Therefore, institutes in Sweden are constantly underreported by the Statistics Sweden.

Table 1. Government intramural expenditure on R&D – change in the share of GERD (%) 1990-1999

	1990	1995	1999	%CHANGE 1990-99
EL	41.2	25.5	21.3	-19.9
IRL	14.8	8.5	5.2	-9.6
FIN	18.8	16.6	11.4	-7.4
F	24.2	21	17.9	-6.3
E	21.3	18.6	16.9	-4.4
BE	6.1	3.4	2.7	-3.4
US	10.5	9.6	7.2	-3.3
DK	18.3	17	15.6	-2.7
UK	13.1	14.4	10.7	-2.4
EU-15	16.4	16.3	14.2	-2.2
S	4	3.7	3.4	-0.6
NL	17.1	18.1	17	-0.1
I	20.9	21.1	21.2	0.3
A	10	9.8	11	1
D	12.9	15.4	14.0	1.1
JP	8	10.4	9.1	1.1
P	25.4	27	28.1	2.7

Source: EUROSTAT data

Institutional Arrangements

Most of the institutes within the governmental sector are public authorities and accountable to the Ministry of Industry (or other Ministries). Ownership may also be mixed or “semi-public”. The emergence of this model is seen in the case of industrial research institutes in Sweden. Originally established as R&D resources for specific industry sectors, but now organised around technological competencies, they receive around one third of their

[6] EUROLABS 2002 Summary p. 2

[7] DG-Research: *Third European Report on S&T Indicators*, 2002.

income from government and obtain the rest from contracts for applied research and knowledge transfer. These had previously operated as independent foundations but are now being reorganised to become limited liability companies. A minority shareholding will be taken by a governmental holding company, IRECO (Institute for Research and Competence Holding) while the majority shareholding will belong to an association of member companies. The Members Associations are intended create closer links between the institutes and industry and also to provide a platform for co-operation and joint action between the firms.

Thus, mainly there are three different forms of legal status for research institutes in Sweden (government, shareholder association, private firm). During the latest five-year period there has been going on a re-shuffling between the government and private firms about the cost, which have taken the form of battle on shareholding and joint ventures, integration and so on. Changes in ownership or governance have not necessarily signified a withdrawal of government from the mission in question. Privatisation has usually been accompanied by continuation of government sponsorship on a contractual basis.

The convergence in mission with university and corporate laboratories during the beginning of the 1990s has been noted elsewhere and is typical for Swedish institutes. [8] The norm of international publications practises were introduced around 1993-1995 and has since then been the actual policy, but without any formal incentives.[9]Other challenges are facing the sector: e.g. the construction of valid research careers and the commercialization of research.

The mimetical processes in relation to the university sector has drawn the institutes into the discussion on bibliometrics. Since the beginning of the 1990s the publication issue is one of the most debated. Will a focus on quantitative measures (citations) provide an objective and transparent measure of productivity; as a useful way of measuring one scientist’s performance against another? Or does it merely encourage an "audit" culture that stifles genuine scientific creativity? The fact that peer-review publication lies at the heart of the quality-control process in science means that, even though it may not be perfect, a system which judges scientists according to their publication record can still be a highly effective way of promoting good science. If appropriately applied, citation analyses can act as powerful drivers of scientific quality. Making promotion dependent on measurable scientific output is not such an outrageous concept, particularly in sectors where overall scientific productivity may not have been given the priority it deserves. This has, for example, often been the case in government-funded laboratories, whose income may depend as much on the political priorities of those in power as on the quality of results that researchers generate in these laboratories.

The debate over institutes in Sweden is spurred by consultancy firms: “*The real issue is deeper and more complex: there appear to be failures in the National Innovation System which include over-dependency on a small number of large (and potentially footloose) firms, under-investment in innovation in the SME sector, out-dated university structures and a failure to take a balanced view of the potential contributions to development which can be made by different actors within the research and higher education sector. We will go on to argue that reform of the Research Institute sector is one of the ingredients needed to rectify this situation.*”[10] In the

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[8] Georghiou (1998), see also Cox, Gummett & Barker (2001).

[9] See EUROLABS 3, the case study report.

[10] From Arnold (2000).

light of these dull prophesies it is surprising that almost nothing have been done to analyse publications from the institutes. From our point of view it is a starting point for the discussion.

Identifying the actors

Finding the actors in a scientific system is a key objective for the researcher. There are at least two issues involved in identifying them. First, how do we know that a specific actor belongs to the system and, second, how do we find all actors in the system? If we use the official Statistics used by the OECD, identifying the actors is a major problem as institutes are an anomaly in the statistics. Due to the statistical inconsistencies the EUROLABS project was launched in 1999.[11] The starting point for the project was to study major public or semi-public research centres in the European Union in order to analyse their specific features: status, organisation, research potential, performance and the resources at their disposal. The final aim was to develop a typology of research centres and indicators to describe them, their performance and their roles in the EU research and innovation system.[12]

An overall picture of European public research centres would fill a significant gap in the knowledge of European research performers. The project collected information about 786 institutes. Using the abbreviations for these institutes as match to the addresses in the Web of Science does not create a reliable set of data. Instead, in this paper we concentrate on the Swedish institutes in the EUROLABS database. The identification work is dependent on the unification of addresses in the database. Using the names from EUROLABS together with second round of interviews and data collection we ended up with 79 research institutes. In table 2 the different types of institutes are described.

Clearly, Sweden is a special case as a small country with a much diversified institute sector. In other small nations there is a tendency to form larger multi-technology research institutes, e.g. VTT in Finland and SINTEF in Norway. Larger countries often have a fragmented institute structure. The most frequent issue in the ongoing debate is how to increase the scale and capability of the industrial collective institutes. From the business sector the answer seem to be that this a task that has to be solved by the state.

Table 2. Number of research institutes in Sweden per category 2003.

Type	No	Type	No
Governmental	16	Collective Industrial	30
Part of Gov't Agency	24	Non-Profit	9

Source: Swedish Research Council Database.

During the last five-year period a few institutes have been established but simultaneously mergers have reduced the total number. Generally speaking, the institute sector has had a rather stable structure over a long period when it comes to number of institutes.

Budgets for institute research are higher than expected, see table 3.. If we consider that the university sector performed R & D in 2003 for approximately 2200 MEUROs we understand that the institute sector is a

[11] Information about the project and results are found at the PREST website [www.les1.man.ac.uk/prest].

[12] See EUROLABs reports 1 and 2.

rather important player in Swedish knowledge production. Calculating the sector importance will show that institutes are 25 percent of the non-firm based R&D in Sweden. As much as one third of this is related to defence research.

Table 3. Budgets (MEURO) per category of research institutes in Sweden.

	1999	2003
Governmental	530	620
Industrial	182	182
Others	16	17
Total	728	819

Source: EUROLABS and Swedish Research Council Database.

Metrics for Institutes

In this section of the paper we will give a short description of the overall picture for publication activities from Swedish research institutes and universities. A mere count of papers has show that the figures have been stable during a long period of time. Consequently, growth rates are generally at the same level for both sectors, see figure 1, with approx 15-16 % growth between five periods since 1984 (geometrical mean). It can be noted that institutes account for 25 per cent of resources, and five per cent of the papers.[13]

Regarding the distribution over areas of research (SPRU-classes) there is a marked difference between the sectors. While universities have a strong concentration in medicine (clinical and biomed) the distribution is much more even for institutes. Both sectors can be said to level out the differences between areas, but this is truer for the institutes. In the latest period of 2000-2003 they had a relative activity profile emphasising the areas of Geoscience, Materials Science, Agriculture and Engineering (see figure 2).

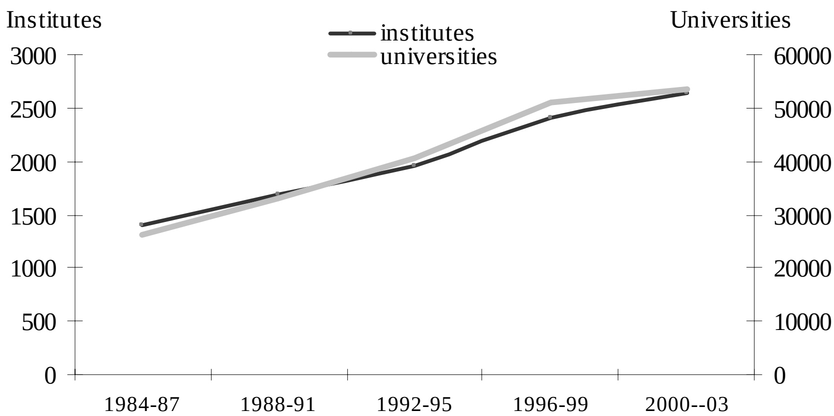


Figure 1. Growth of publications (fractions) from Research Institutes and Universities.

[13] Other sectors have no effect on this as their contribution is marginal.

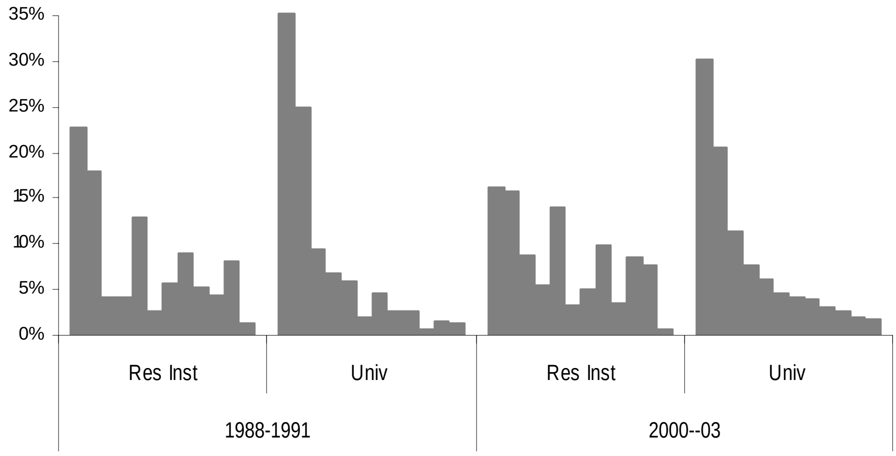


Figure 2. Distribution over SPRU macro-classes for Swedish Research Institutes and Universities during two periods.

Note: Areas are displayed according distribution for universities 2000-03: CLINICAL MEDICINE, BIOMEDICINE, PHYSICS, CHEMISTRY, AGRICULTURE, ICT, BIOLOGY, ENGINEERING, SOCIAL SCIENCE, MATERIALS SCIENCE, GEOSCIENCES, MATHEMATICS.

Citation metrics for institutes

Measuring the relative citation impact (see methodological appendix) will be done in relation to figures for Swedish universities (relative citation index). Looking over periods of time it is obvious that institutes got stronger during the 1980s, but some into the next decade the trend became negative. To a large extent research institutes are following the overall negative citation trend for Sweden. Figure 3 illustrates that Swedish institutes are highly active in areas like Geoscience and Agriculture. In both of these areas the relative citation impact is matching the universities. The university sector is found in origo in all the figures. Except for ICT (Information and Communication Technologies), Mathematics, Physics and Social Science research institutes seem to produce at the same quality level as Swedish universities. That's a result which we wouldn't have expected.

Going further into details it can be noted that the trends for ICT and Mathematics are negative. In Physics institutes are increasingly becoming better and more active. Typically, Social Science is a problematic area with strong activity, but increasingly lower impact.

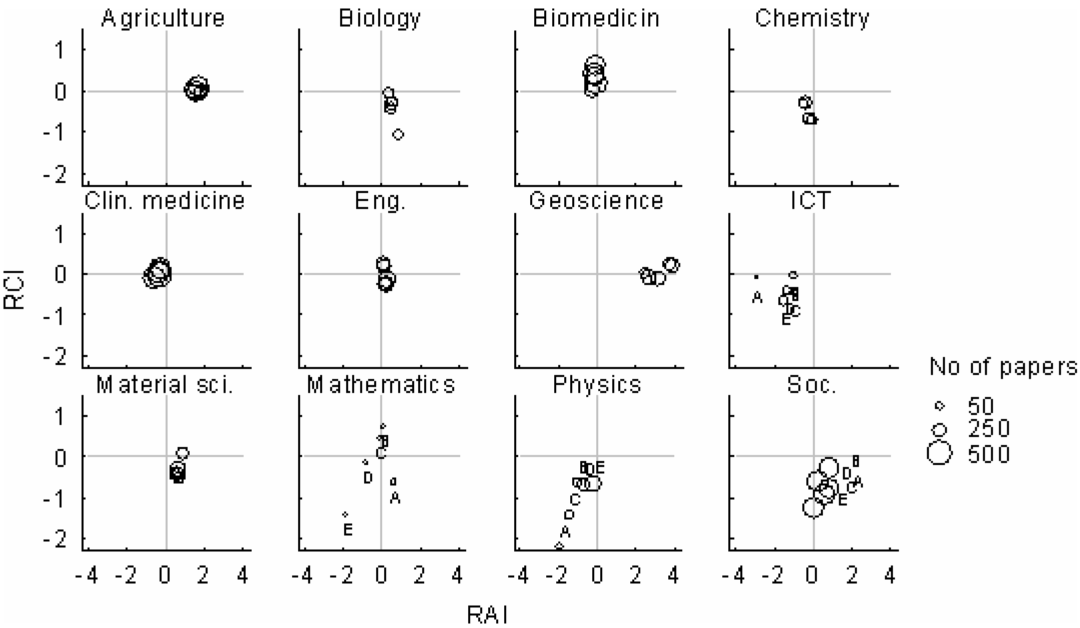


Figure 3. Relative Activity Index and Relative Citation Index for SPRU macro-classes during five time periods. Origo is the position of university sector research in each area.
Note: Periodisation:A=1984-87, B=1988-91, C=1992-95, D=1996-99, E=2000-03. When differences between periods are small legends are not displayed.

Does Collaboration Pay?

Taking for granted that research institutes will continue to compete at the international publishing markets it is interesting to analyse different possible strategies. The first and probably most obvious would be to intensify the collaboration with university researchers. As already have been notified this is one of the recommendations from consultancy firms that have been evaluating the proposed strategies. Many of the institutes do have strong links today with the universities. This applies not only to institutes in the medical areas of research, but also to the institutes in materials and engineering sciences. It should be underlined that the institutes historically have grown form the technical universities (Royal Institute of Technology, KTH and Chalmers Institute of Technology, CTH) and are located at the university campuses. Different categories of university employees split their time between the university and the institute. This is the case not only for professors, but also for doctoral students.

If academic collaboration should be the first and foremost strategy then there has to be a situation where it is possible to identify areas that have an underutilized potential for such collaboration. For analytical purposes we have split the Swedish institute database in two: 1) articles produced by institutes in collaboration with universities and 2) articles produced internally in the institute sector. Other collaborations are rare and will not be included in the investigation. In numbers the both groups of articles are of the same size, approximately 8,500 each. While the collaborative articles are in the medical areas most of the non-collaborative are evenly distributed over the areas, see figure 4.

Therefore, this could point in the direction that there are potentials for academic partnership in not so few areas of research. An analysis of this question can be made from figure 5, which shows the relative activity and relative citations for the relevant areas of research (SPRU classes). While articles from the institutes have a low impact, there is a tendency that academic partnerships have made the articles more cited than the EU-average.

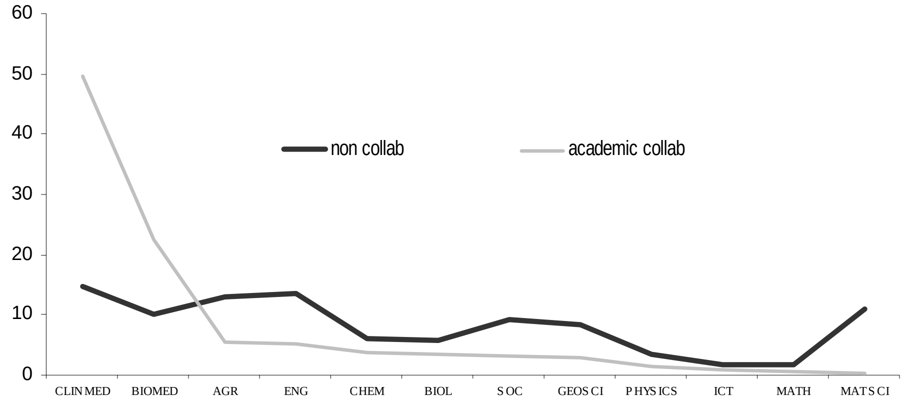
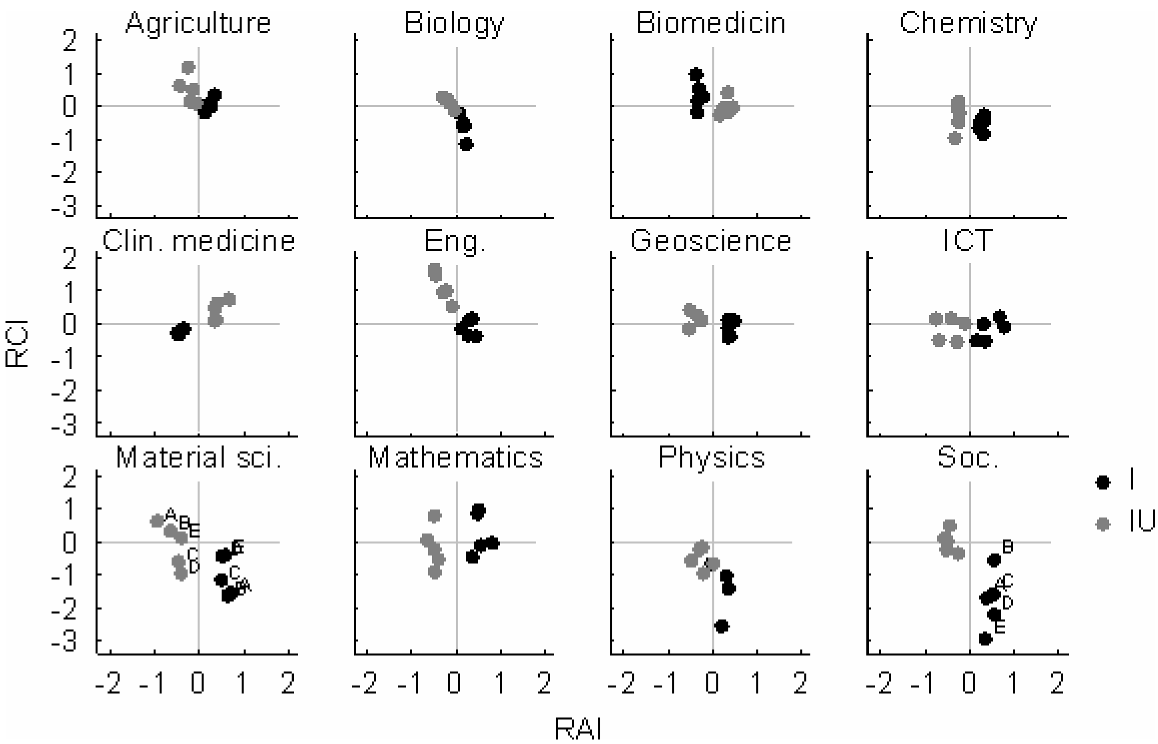


Figure 4. Distribution of collaborative and non-collaborative articles from Swedish research institutes 1982–2003.



Figur 5. What a difference a partner makes. Relative Activity Index and Relative Citation Index for SPRU macro-classes during five time periods for collaborative and non-collaborative articles from Swedish institutes. RAI is normalised within the institute category.

Appendix A. Calculations of relative activity (RAI) and relative citation (RCI) indices

To calculate the publication activity, the number of publications produced in different subject areas in each country was counted. To estimate impact the number citations per paper during a 2-year period following publication was also counted. The publications and citations per paper were divided by the number of countries among the contributing authors. Thus, if all authors of a paper come from one country the paper-score is 1 while if e.g. four countries were involved each country get the score of 0.25.

For each country and subject group a country-subject index (CSI) were computed as the proportion of papers or citations (PAP or CIT) in that subject relative to the sum of papers or citations in all subject groups of that country:

CSI_{PAP} = Sum of paper-scores in the subject / Sum of paper-scores for all subjects

CSI_{CIT} = Sum of citation-scores in the subject / Sum of citation-scores for all subjects

Similar ratios were computed for Europe (ESA):

$ESA_{PAP} = PAP_{EUROPE\text{-}SUBJ} / PAP_{EUROPE}$

$ESA_{CIT} = CIT_{EUROPE\text{-}SUBJ} / CIT_{EUROPE}$

The relative activity (RAI) and relative citation (RCI) indices were then computed for each country and subject as the ratio between CSI and ESA indices:

$RAI = (CSI_{PAP} / ESA_{PAP}) - 1$

$RCI = (CSI_{CIT} / ESA_{CIT}) - 1$

By the subtraction of 1 in the calculation of RAI and RCI we obtain values that are zero when a country's publication rate or citation rate is similar to that of Europe.

RAI and RCI indices were calculated for four different four-year periods:
A: 1984-1987, B: 1988-1991, C: 1992-1995, D: 1996-1999 and E: 2000-2003.

Appendix B: The EUROLABS project

The project was organised as a consortium of project groups led by the PREST group at Manchester University, under the project leader Luke Georghiou.

The **database** was designed to capture information available from documentary sources (which is subsequently validated). Key items covered include contact information, ownership, financial income, relationship with other organisations, location and structure, functions, sectors addressed, scientific and technological capability and personnel data. 769 centres were included in the database.

Data collection comprised three stages. The first stage made use of existing data sources. Published sources of data were gathered directly from the research centres. Secondly an Internet based 'pre-survey' was used to confirm and collect further information on the identified research centres. In the final stage the data was printed and mailed to the research centre for validation. A response rate of 66% was obtained. Data were entered in an Access database.

The following **definition** was used for extended Nordic version of the database that now is developed at the Swedish Research Council: "Research institutes are organizations outside of 1) the university sector, and 2) outside of firms producing other goods and services. The organizations should mainly perform R&D (>50 % of total budget) and have more than 4 active researchers."

The 769 centres in the EUROLABS database account for over 25 billion EURO per annum (599 cases) in their budgets and employ over 100,000 scientists (557 cases). The greatest number of centres (237) employ between 10 and 49 scientists comprising 6% of the total number of scientists. The greatest number of scientists work either in large organisations (45,241 in 18 organisations comprising 43% of the total) or in centres with 100 to 499 scientists (33,785 in 151 centres).

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