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Abstract

This paper show that Swedish HEIs, in terms of structural characteristics - size, research orientation, density in research areas, and research productivity - group into two clearly separated categories. These are the 'Older research oriented' universities, being largest and highly research productive, and the 'Younger education oriented', being smaller, regional HEIS with low research productivity. The former are 'high-performing' in terms of external research funding related to education income, while the latter are 'low-performing' in this respect. In other words, these characteristics may explain the ability of HEIs to attract external research funding. Furthermore, we propose that there exist a Matthew effect regarding allocation of external research funding at the university level in Sweden.

1 Introduction

European universities are facing major transitions, where at the overall level, we can see a combination of increasing number of students, decreasing research funding per faculty and increasing types of commitments to society (Lawton Smith, 2006). This is leading to societal debate, especially about how universities obtain external research funding, as well as the relative success of individual universities as organizations in doing so. Universities here include higher education institutes, universities and colleges. Like much of Europe, Swedish universities are moving from a state-regulated institution providing a public good towards a more Anglo-Saxon model, where universities more explicitly compete for resources. When university researchers are in competition over resources, then the issue of which factors positively and negatively influence access to external financing becomes more interesting, from the perspectives of both public policy and university strategy. Sweden provides an interesting case, due to major changes in public policy in the past twenty years and due to exceptional micro-level data. This paper contributes to these debates, by firstly describing structural characteristics of the population of universities and secondly by focusing on whether structural characteristics such as size and 'R&D intensity' affect the success of universities' in obtaining external research grants. External research grants here include research money from research councils, foundations, and the like as well as from companies located in Sweden and abroad.

Existing literature about the ability of universities to obtain research grants in general, and to obtain industrial funding for research in particular, have focused on questions such as the quality of the research performed, the impact of informal networks in creating constructed communities, and the 'Matthew effect' for individual researchers. Merton (1968) described the Matthew effect as a cumulative advantage that operates in science, both when it comes to recognition and rewards as well as the 'visibility' of scientific contributions. These streams of literature raise interesting and relevant issues about the quality and orientation of research. This paper, however, takes a different angle, analysing the relative position and specialisation within the total population. We wish to explore whether university's relative success in obtaining external research funding is related to their density, research specialization and 'critical mass'. The large changes in Swedish research policy during the 1990s lead to

the starting-up of new colleges and universities, explicitly designed to stimulate regional economic growth and teaching, as well as to become new research centers (Sörlin & Törnqvist, 2000; Schilling, 2005). This in turn sparked debates about the importance of critical mass and quality as well as how to design the external research funding system to become more competitive. Many of these debates implicitly assume that the best researchers will receive external funding, wherever employed. Given the Swedish emphasis on equality, few have asked whether universities with specific characteristics tend to receive above average research funding from councils, foundations and firms. This paper therefore addresses external research funding of Swedish universities, in relation to the characteristics of density of research personnel, research productivity as well as size and research intensity. In other words, how do these characteristics affect the propensity of specific Swedish universities to obtain external research funding?

Section 2 provides an overview of relevant literature on university-industry relations and on the relationship between structural characteristics and R&D. Section 3 presents the research design and methodology. Sections 4 and 5 present the data and analysis, in terms of descriptive results and in terms of an analysis. Section 6 presents the conclusions, discussion and implications.

2 Theoretical Overview

In this section, the theoretical overview is presented, leading up to the formulation of the research questions.

2.1 European Context and University-Industry Relations

European universities are in many ways a regulated sector, tightly coupled to policy objectives and government financing, and therefore often dependent upon national governments. Within Europe, government funding is still the largest overall source of income for university research in Europe. However, Genua (2001) shows a decrease in the relative share of [1]government funding during the last few decades in the

[1] According to OECD classification, there are two categories of government funding: general university funds (GUF), i.e. 'block funding'/general grants, and direct government funds (DGF), e.g. contract research and earmarked funds (see e.g. Geuna, 2001).

European countries, accompanied by an increase in the share of external funding. Hence, within European countries, we can identify the share of external research funding won on a competitive basis, as opposed to flows of financing which (traditionally) 'automatically flow' into European universities.

The rationale for government financing of universities, science and basic research are usually based on an economic view of the contributions of research institutes to society (Bush, 1945; Arrow, 1962). In other words, universities have a particular role, because science and education have been seen as public goods. As such, the university is seen to play a particularly important role in education, teaching and commercialization to deliver what are now called externalities, general-purpose technologies and knowledge spill-overs. These benefits are seen to promote societal development, solve societal problems, and stimulate economic growth.

Public policy has also been modified, to stress innovation and the societal usefulness of science. In the end of the 20th century, Europe began to move away from the post-World War II dominant paradigm, with its linear model of innovation, which stressed basic science as the main driver. This move has in some aspects been towards a model of applied research as a mechanism to create national wealth (e.g. Geuna, 2001; Lawton Smith, 2006). Recent debates have swung to stress that universities should more directly contribute to economic growth (Salter & Martin, 2001). The literature has exploded on topics such as academic entrepreneurship, commercialization of research results, and university-industry interaction. For example, *Research Policy* published 43 articles using the words 'academic entrepreneurship', 'commercialization' and 'university-industry' in abstract, title or/and keywords in 2000-2005. The majority of these studies use patents, licenses and start-up companies as the empirical data.

However, studies regarding the impact on economic growth by university research (e.g. Salter & Martin, 2001), and on the different mechanisms for knowledge transfer and for appropriability, across different industries (e.g. Cohen et al., 2002) provide a broader picture. Salter and Martin (2001) identify six major mechanisms for diffusion of university research to industry: increasing the stock of useful knowledge; educating skilled graduates; developing new scientific instrumentation/methodologies; shaping

networks and stimulating social interaction; enhancing the capacity for scientific and technological problem-solving; and creating new firms. Similar lists can be found in many other references. Cohen et al. (2002) show that the key channels for university research to impact industry are publications, public conferences and meetings, consulting and informal information exchange. This suggests that the focus of current public policy and academic literature on patents and start-up companies is highly misleading. Patents and start-up companies demonstrate only a small part of the impact of universities on growth.

Another important topic of debate has been the quality of research required to stimulate university-industry interactions. The results about the relative importance of the quality of research partly depend upon the research area and partly on the perspective taken. Within biotechnology in the USA, Zucker and Darby (1996) early put forth the 'star scientist' hypothesis. Based on data of scientists, they could show that prominent scientists were also prominent commercializers of science and thereby able to individually benefit from their human capital.

Quality is almost always taken to mean quality of the science-base at universities, whereas the 'quality' of firm knowledge has been less prevalent in the debate, with the exception of 'absorpative capacities' of firms (Cohen et al 2002). However, some have examined the importance of having high quality of science, from the perspective of firms and different industries. Mansfield (1995) surveyed industrial technology managers in the USA, finding that the university research perceived as most important was often directly related to the quality of the faculty in relevant departments and to the size of R&D expenditures in relevant fields. High-quality science thus seems to attract more industrial interaction with universities. However, this does not mean that lower quality or lower prestige universities do not interact with firms. Mansfield (1995) also found that in several industries, the relationship between faculty rating and their contribution to industrial innovation was very weak. Hence, in some industries and research fields, many modestly ranked departments play as large a role as some of the most highly ranked departments.

In the UK, it was found that the research quality of the departments did not impact the probability to engage in various mechanisms to interact with firms. Moreover,

departments in applied fields rated as low quality appeared to have a higher likelihood of engaging in a variety of mechanisms for transfer (D'Este & Patel, 2005), One explanation put forth is that less prestigious departments may be more willing to focus on firms' immediate problems, rather than long term research (Mansfield & Lee, 1996).

Other literature suggests that variations in the level of business financing of research may relate to differences between scientific fields as such. By having professors from five different technical fields assess the share of basic research, applied research and development they pursued, Meyer-Krahmer & Schmoch (1998) found that in the German case, researchers in the more application-oriented fields seemed to have higher degrees of industrial funds within their total research budgets. On the other hand, variations might be explained by the history of university-industry relations in a specific context. Overall, they found that professors in general ranked collaborative research as the most relevant type of interaction and that additional funds were considered the biggest advantage of industry interaction.

Industry does not seem particularly keen on directly finance research activities at the universities. As Geuna (2001) points out, the proportion of university research that is financed by industry is very low everywhere, usually less than 10 percent. OECD figures show that the average of industry funded higher education expenditure on R&D (HERD) in the EU-25 in 2001 was 6,7 percent. This is slightly higher than in the USA the same year, and substantially higher than in Japan (Dosi et al., 2006).

2.2 The Swedish Context

In this section, a brief depiction of the development of research policy in Sweden is presented, with a special emphasis on the important changes occurring in the 1990s. Where not otherwise stated, this presentation draws upon the book "Knowledge for prosperity" by Sverker Sörlin and Gunnar Törnqvist (2000).[2] A short review of literature regarding the Swedish case follows.

[2] Authors' translation (original title: "Kunskap för välstånd")

In the 1990s, large changes in research polices took place. The major underlying mechanisms were a recession, accompanied by a new belief in universities as driving economic growth. The consequences were that Sweden got several more institutions conducting research and educating PhDs, alongside of a focus on competitive funding. This more competitive environment regarding research funding was created on the one hand by the introduction of new public foundations based on the so-called wager earners' funds meant to stimulate strategic research, and on the other hand by enhancing co-operation and interaction with industry (Schilling, 2005). However, the general research funding was not enlarged, but rather spread out more thinly amongst more actors. Similar to the general trend in Europe, there has occurred a decrease in the relative share of government funding during the last few decades in Sweden (Heyman & Lundberg, 2002; Hällsten & Sandström, 2002). All this indicates an increasing importance of external research funding and a more competitive environment regarding research funding. The relative importance of external research funding is likely unevenly distributed amongst universities and amongst areas. This has given rise to some debate, not the least lately, in the Swedish press, where concerns regarding the difficulties of conducting high-quality research in this 'boot-strapped' environment have been lifted forward. Other concerns, adhering to the increased regional focus and the introduction of research in all higher education institutions (HEIs), have been about critical mass, i.e. a debate about the necessary size of research groups in order to be able to conduct "good research".

Studies regarding the topics discussed earlier in the literature review have to certain degrees also been conducted for the Swedish case. Henrekson & Rosenberg (2001) show that despite large efforts to tie university research closer to industry, 'academic entrepreneurship' so far play a small role in Sweden. In contrast, Granberg and Jacobsson (2006) argue that this belief in a large gap between industry and academia in Sweden does not hold true. By examining, and rejecting, this and three other dominant beliefs in the Swedish science policy debates, they point to the risk that policy makers focus too narrowly on commercialization issues.

In a forthcoming paper, Magnusson et al. (2007) presents data, suggesting a close association between highly productive scientists and their ability to commercialize through patents and start-up companies. This study focused on engineering fields.

When it comes to the HERD financed by industry, Sweden seems to follow the rest of Europe. Data from Statistics Sweden[3] show that Swedish and foreign firms in 2006 provided approximately six percent of the university research funding (Swedish National Agency for Higher Education's annual report 2007).

2.3 Structural Characteristics of Firms and Universities

When university researchers are in competition over resources, then the issue of which factors influence access to external financing becomes more interesting, from the perspectives of both public policy and university strategy. This section considers literature that helps explain why firms expend resources on universities in terms of the size, age, and R&D intensity of those firms, then turns the question around to address the structural characteristics of universities.

One type of explanation has to do with the firms and industries that tend to provide funding to university researchers. Literature on university-industry has primarily focused on structural characteristics, especially firm size, R&D intensity, industry, and age, in relation to the firm. It appears that firm size is positively related to interactions (e.g. Beise & Stahl, 1999; Laursen & Salter, 2004), but perhaps not to contract or collaborative research (e.g. Cohen et al., 2002; Santoro & Chakrabarti, 2002; Schartinger et al., 2002). R&D intensity has been found to generally be positively related to interaction, in studies using different proxies such as R&D expenditures over sales and number of scientist in a firm, (e.g. Laursen & Salter 2003), but not be related to contract or joint research specifically (e.g. Mohnen & Hoareau, 2003). Several studies have found that intensity and types of interactions differ between industries, where industries ranked as most prone to interact with universities include pharmaceuticals, semiconductors, and other manufacturing industries (e.g. Cohen et al. 2002; Klevorick et al., 1995). The age of firms is found in some studies to be related to interaction. This is not as well researched, and the results are somewhat inconclusive (Meyer-Krahmer & Schmoch, 1998; Schartinger et al., 2001; Laursen & Salter, 2004).

[3] www.scb.se

The literature examining universities in interactions rarely deal with structural characteristics of the individual universities and of populations of universities. To the extent they are studied, these refer more to the organizational set up for handling patenting and spin-off activities, than to the universities as such. Instead, literature has often focused on the role of national policies and university quality for explaining why universities engage in industry interaction, as discussed earlier.

There are nonetheless a few studies that are specifically concerned with structural characteristics of universities. Looking at department levels rather than disciplines in Austria, Schartinger et al. (2001) found that university department size had a significantly positive impact on industry interaction. They also attempted to capture the effects of departments' R&D intensity on interaction, but they found no significant impact on interaction in general. Similarly to industry differences for firms, intensity and type of interaction seems to vary among research orientations and scientific fields (see e.g. Meyer-Krahmer & Schmoch, 1998; Schartinger et al., 2002).

Our issue about whether structural characteristics of universities tend to influence the ability to obtain external financing from research councils, foundations and business becomes interesting when the individual organizations face a new, competitive regime. In contrast to the USA, where such tendencies have been visible for many years, European countries have only during the last decades begun to introduce more competitive mechanisms for resource allocation, within the university sector (Genua 2001).

One preceding study on this subject is by Geuna (1999) on the EU universities' behavior related to the changes in their research funding environment. As part of his study, Geuna (1999) relates specific characteristics of universities, such as size, age, R&D orientation, and scientific productivity to the changes in the university research funding system in Europe during the last decades. The results show, among other things, a polarization of the European university system based on these characteristics. On the one hand, there are the pre-WW II research universities, sitting on most of the research resources, and on the other there is the lion part, being post-WW II education universities.

Following on the literature on university-industry interaction, we propose to examine whether structural characteristics of universities, such as age, size, R&D intensity and research orientation are explanatory factors of the level of external research funding. Although there are some attempts to study the structural characteristics of universities, they are few and generally not related to what we are looking at here. Hence, this study is exploratory, even if comprehensive in examining the total population of universities and colleges in Sweden.

2.4 Research Questions

The first research question is a descriptive one, intended to improve classifications.

1) *What categories can be generated based on specific characteristics, which are useful to classify different universities? Where do specific universities as organizations position themselves, within the Swedish national innovation system?*

Hence, the first descriptive research question is to categorize based on the identified characteristics of universities.

The second research question is an analytical one, dealing with positive and negative effects of characteristics. It entails a series of sub-questions about the impact of these characteristics, on the different categories of universities. They thus explore different ways in which the density, research productivity, size and R&D intensity of the universities affect their ability to attract external research funding.

2) What are the positive and negative impacts of the characteristics as found in the categories, in relation to external research funding, in terms of

a) size of research efforts? Does the size of research at the university affect their ability to obtain external research funding? In other words, does greater size mean a greater inflow of external research funding, and vice versa?

b) research orientation? Does a greater research orientation of the university positively affect the level of external research funding? On the opposite, does a greater education orientation (i.e. a lower research orientation) negatively effect?

c) density? Does higher density of research personnel across research areas increase the level of external research funding?

d) research productivity? Does higher research productivity increase the ability to obtain external research funding?

3 Methodology and Data

In this section, methodology and data to analyze the characteristics of the Swedish university sector are presented.

3.1 Data and Methods

The data for the analysis is to a large extent drawn from a Swedish national database on universities (the NU-database: http://nu.hsv.se/nu/index1.html). The database is run by the Swedish National Agency for Higher Education and uses data that the agency collects directly from all Swedish HEIs as well as from other sources on a yearly basis.

The database contains data on students, personnel, and finances. Information on personnel is retrieved from Statistics Sweden. They in turn collect the information from respective higher education institution for the short-term salary statistics. Financial data is collected by the Swedish National Agency for Higher Education (SNAHE) from respective HEI on a yearly basis. This can include figures from annual reports, and more detailed data on specific issues like different sources of funding. This data is obtained at the university level and cannot be broken down on different research areas at the respective HEI.

This paper uses the averages over the period 2001-2005, for all the variables analyzed here, except for publications that use the average for 2001-2004. There are several reasons for this. Firstly, 2001 represents a break in the reporting of some of the data-series. While the database goes back to the fiscal year 1993/1994, for some data of interest, such as the number of employees, the statistical sources were changed in 2001, making it hard to combine data from the recent years with data from before. Secondly, some variables fluctuate, for reasons that may have to do with reporting routines rather than representing changes. In particular, the average over the period is used as in particular the amount of grants and funding can vary considerably from year to year.

The NU-database has been criticized in earlier studies using it (Hällsten & Sandström, 2002). However, these criticisms mainly relate to reported figures during some years in the 1990s. Of greater relevance to this study is that, according to Hällsten and Sandström, it is difficult to differentiate between the grants and contract research obtained from Swedish and foreign firms. In response to this problem the two categories were merged into one category, representing industry-funded research.

To complement and check data in the NU-database we have also used other sources of data, such as the web-sites and annual reports of respective HEI, to obtain data on e.g. the age of the institutions. Publications were gathered from the Science Citation Index (SCI). This data covers all research areas and are gathered at the aggregated level of the HEIs.

In terms of analysis, we have chosen a descriptive analysis. In light of the fact that we are here concerned with categorization of the university sector, the use of factor- or cluster-analysis would be appropriate. However, seeing that the range of data are rather limited, mainly due to the small number of HEIs located in Sweden, we have in this first attempt decided to do a purely descriptive analysis.

3.2 Variables and metrics

Based on the literature review, we identified a series of variables as relevant to the analysis, namely external research funding (of different types), size, research intensity, age, density and quality (of science). For each, we have identified a metric where data can be gathered. Table 1 summarizes the variables and metrics, and includes details of the specific information gathered and the sources.

Table 1 here

External research funding: We take a broad definition of external research funding, including funding for which universities and research groups have to compete. This excludes general university funds (i.e. block funding and similar) and internal funds. In the analysis, we compare different types of external funding to income generated from undergraduate (including Masters) education. Thereby, we can differentiate universities that compete with research from those that compete with education.
To make a more detailed analysis, external research funding is broken down into

seven categories. We base these categories on a model, constructed to reflect that research financers differ in their funding processes and in demands for counter funding. This model was constructed for the Swedish situation and the categories are thereby possible to extract from the database (Sandström, 1997; Hällsten & Sandström, 2002).

In addition, we create a separate category for business funding, by including both contract research and grants from firms. One reason has to do with problems of reporting (as discussed in Section 3.1). Another reason is that there is a perceived increasing importance of industry for university research, especially for certain types of HEIs. By doing so, we should be able to identify which universities that are dependent on their relations with firms.

The categories used here are:

- *Research councils*: the Swedish Research Council (Vetenskapsrådet)
- *New foundations*. Comprising all public foundations, such as the Knowledge foundation (KK-stiftelsen) and the Foundation for Strategic Research (SSF).
- *Foundations:* Private or semi-public foundations, such as the Wallenberg foundation, The Bank of Sweden Tercentenary Foundation (Riksbankens Jubileumsfond) and the Swedish Cancer Society. University foundations are not included, since it is considered to be internal funds.
- *Government institutions & EU*: Funding from the government through institutions such as VINNOVA, local authorities, county councils and EU.
- *Industry*; contract research and grants from Swedish and foreign firms.
- *Contract research*: Contract research from all different financers, except from industry.
- *Other external funding*: grants from Swedish and foreign non-profit organizations, as well as "other" incomes.

University size may affect the resources available for R&D projects aside from day-to-day tasks and has been shown as important to explain R&D in firms. As an indicator for university size, we use number of research personnel, since employees is commonly used to denote firm size (e.g. Laursen & Salter, 2004; Cohen et al., 2002) as well as occasionally university size (Schartinger et al., 2001). In the Swedish

database, personnel categories do not easily distinguish those employees who are researching from those who are only teaching. Moreover, in Sweden, PhD students are usually university employees, considered to do much of the research. Out of the personnel categories available in the NU database, this paper includes Professors (Chair, Full), Senior Lecturers (e.g. Associate Professors), Research Assistants (e.g. post-docs, Junior Lecturers), other researching and teaching personnel and PhD students.

In studies of firms, *R&D intensity* is usually measured in terms of R&D expenditure over sales (e.g. Mohnen & Hoareau, 2003). However, due to the nature of the university 'business' and the shakiness of this data in the NU-database, due to changed reporting during the studied period, a corresponding metric cannot be used directly. Instead, we propose that R&D intensity can be seen as research intensity.

Our argument is based on the main businesses of the universities. Universities can be seen as having two main tasks, namely education and research. Therefore it seems feasible to construct indicators that measure the relation between these two tasks, in order to capture research intensity. Geuna (1999) uses researchers per student as an indicator, the rationale being that the higher the indicator is the higher "the propensity of the institution to carry out research". Hence, the detailed level of data on personnel per research field may be used to classify the universities and the university colleges in terms of being more or less science-based. Rather than research personnel (which is a broad category), we focus on chair professors, as they can be claimed to play a central role in research activities. Since our analysis is descriptive in nature, we use students per professor, in order to get a more easily comparable indicator of research intensity.

Age is used as mainly a complementary variable. It is not included in the NU-database but founding year was obtained from sources such as the universities' web sites and annual reports. The age in the Swedish university sector is rather skewed, ranging from a couple of very old institutions to the bulk being fairly young. Here, the variable is mostly useful in developing categories.

Density refers to high number of researchers within specific areas, and can also be

seen as an indicator of specialization. The density of research personnel in the different research areas reveals to some extent the intensity of the research conducted at a particular university. Here we study the share of research areas with more than a certain number of researchers active in them, The rationale is that if this share is low, then the university is not reaching a "critical mass" in a large part of its research areas, meaning that the overall research intensity is low.

A common indicator of *quality* has been publications. A more cautious way to handle this indicator is to call it *scientific productivity* instead of quality, as has been done by Geuna (1999). Rather than analyzing total publications (which would demonstrate overall research output), we want to analyze publications per researcher. We therefore normalize publications per author, so that a paper with e.g. three authors from the same HEI would be counted as one paper for that institution. If you do not normalize, you end up with skewed results, due to separate counts, one per author. Hence, we normalize the number of publications by assigning each author his share of the publication, aggregate the numbers on the university level and then relate it to the number of researchers to get an average.

4 Characteristics of the Swedish Universities

In order to address whether and how characteristics of the Swedish HEIs may influence the relative success of obtaining external grants, we must first consider the total population of organizations, within this sector. The main goal of the section is to categorize the population of organizations within the Swedish university sector, thereby answering our first research question.

4.1 Classification of Organizations

In Sweden, university status relates to the so-called 'right' to examine research students in all scientific areas; i.e. within Medicine, Natural sciences, Humanistic and Social sciences and Technical sciences. University colleges on the other hand can only examine research student within scientific areas that they are specifically granted. As of 2007, the Swedish higher education sector consists in total of 14 universities and 22 state controlled university colleges. In addition, there are three private HEIs with the right to examine research students. We are here interested in the HEIs performing research, and therefore we focus on research in all scientific areas at

the universities and the colleges active in several research areas.

Our first research question is related to which characteristics are useful to define categories, as well as where specific HEIs land in these classifications. First we analyze the population according to general data about age (Year of establishment), number of undergraduate and Masters students (Students), number of chair or full professors (Prof.), number of PhD students (PhD), income from undergraduate education (Income education), total income and cost from research and research education (Income research and Research expenditure). The variables for education and research include all scientific, engineering, humanities and social science disciplines. Table 2 presents the 30 chosen Swedish HEIs, ranked according to their aggregated absolute size in these variables in 2005.

Table 2 here

Table 2 reflects Swedish science and educational policy in the 19th and 20th centuries, especially the waves of HEI establishment in the 1970s and the 1990s. About one hundred years ago, Sweden had four diversified universities including Lund, Uppsala, Gothenburg, Stockholm; one specialized in medical subject (Karolinska Institute), two specialized in engineering and technical subjects, namely the Royal Institute of Technology and Chalmers University of Technology, and a private university specialized in business and economics (Stockholm School of Economics). The first so-called regional colleges were founded as university filials during the 1960s and 1970s. They were placed in the next tier of Swedish students such as Linköping, mainly for reasons of regional politics. The main task of these HEIs was first considered to be to attract more of the 'reserve of talent' to provide the regional industry with workers (as can be seen in the 1977 law). Later on, many of these expanded and also became independent universities.

Table 2 also shows a clear size and age distribution, running the range from Lund University to Gotland college. Generally speaking, the oldest organizations are also the largest, as indicated in terms of incomes from research, research expenditures as well as number of professors, PhD students, and undergraduate students. Some of the HEIs started in the 1990s have grown larger than ones started in the 1970s, particularly MittUniversity and Malmö. They lie close to two of the three top cities

and population centers in Sweden, located close to Stockholm-Uppsala respectively Malmö-Lund.

Two noticeable exceptions are Karolinska Institutet (KI) and the Swedish University of Agricultural Sciences (SLU), which have considerably fewer students than other organizations of their size. The third exception is Malmö H, which has a rather high share of students relative to its research effort, as compared to other organizations.

Hence, our first classification suggests that most Swedish universities, colleges and HEIs can be divided into large-old and younger-smaller categories. The variables for size cover a range from students to professors and income streams, and most of the organizations appear to fall within similar size categories for all such variables.

4.2 Specializations in Education and Research

To go further with our classification, we wish to find a way of identifying relative specializations in education and research. These reflect the structural characteristics mentioned earlier, especially relating the overall size in terms of research to the research intensity in terms of relative efforts put into education or research. To some extent, age may explain the relative specializations and hence will be discussed below.

Figure 1 relates the overall size in terms of number of researchers, on the x-axis to the research intensity related to education, in form of students per professor, on the Y-axis.[4] The different HEIs are in the figure labeled with the national so-called university code (see Table 9 in Appendix A).

Figure 1 here

This figure reveals two rather distinct groups of Swedish HEIs. The first group has a large number of researchers as well as a high specialization in research. The second group has the inverse characteristics, with low overall number of researchers as well as high relative specialization in education. Note that specialization simply refers to

[4] For actual numbers, see Table 6 in Appendix A.

relative emphasis on the activity at the organisation, and not the relative size in Sweden.

The first group is the 'Older research oriented' HEIs. They have a large number of researchers as well as a high specialization in research, relative to teaching. They are grouped along the x axis, and they are (from right to left on this axis): Lund University (LU), Uppsala University (UU), Gothenburg University (GU), Stockholm University (SU), Karolinska Institute (KI), Royal Institute of Technology (KTH), Umeå University (UmU), Linköping University (LiU), the Swedish University of Agricultural Sciences (SLU), and Chalmers University of Technology (CTH).

These ten institutions have more than 1000 researchers. As can be seen in Table 6 in Appendix A, they also have more than 100 professors. These are clearly the largest in size, in terms of employed researchers. Moreover, this group clearly has the highest specialization in research, as compared to teaching, by having by far the lowest number of students per professor in the population. This indicates an orientation less direct dependent on education, and with more room for research. These HEIs all have university status, and seven of them are the oldest in Sweden.[5] The remaining three of these ten universities were founded about 1970, and they represent the largest of the younger universities.

Within this first group, we can identify a few more detailed differences. One is that the age is generally, but not always, related to size. Chalmers is the exception here, in that it is relatively old compared to the population but also the smallest in the group. Otherwise, the older are larger, and the three younger universities of Linköping, Umeå and SLU are all somewhat smaller than the older HEIs in the group. Finally, of these three younger universities, one of them has almost the lowest student to professor ratio (SLU) whereas the other two have the highest student professor ratio in the group (Linköping and Umeå).

The second group is the 'Younger education oriented' HEIs. They differ on both dimensions from the first group. They have lower numbers of researchers, as well as

[5] Stockholm SE is the only institution being more than 100 years old that do not show up in this group

many more students per professor. They are grouped along the y-axis of Figure one, and they are (descending order on that axis): Kristianstad (HKr), Dalarna (Hda), Gotland (HG), Gävle (HiG), Skövde (HS), Borås (HB), Halmstad (HH), MittUniversity (MiU), Malmö (MaH), Kalmar (HK), Mälardalen (MdH), Jönköping (HJ), Växjö University (VxU), Karlstad University (KaU), Södertörn (SH), Örebro University (ÖU) and Blekinge (BTH).

This second group is composed of younger institutions, which are also smaller, as defined in terms of research. These are all regional HEIs, with the oldest founded in 1965 and the youngest being less than ten years old. As can be seen in both the figure and in the appendix table, most HEIs in this group have less than 300 researchers and less than 50 professors. Furthermore, only eleven of them have the right to exam PhD degrees. We would like to stress the relative specialization on education. Hence, important to note is that the HEIs in this group distinguish themselves not only by being smaller, but also by having significantly more students per professor than the universities in the first group. In fact, almost all of them have more than 200 students per professor, which is more than twice as much as in the other group. Hence, this group of organizations is clearly more specialized towards providing education, but also smaller in absolute numbers and younger.

Within this second group, one organization has been left out, because it is an outlier. West (HV) is the second smallest HEI, even more specialized in education than the others, having a student per professor ratio that is extremely high (1575 students per professor).

Furthermore, one organization, Luleå, lies closer to the second group but shares some characteristics of the first group. Luleå is considerably larger than the other HEIs in the second group but also much smaller than most organizations in the first group. Luleå also has a specialization towards research, closer to those found in the first group. One interpretation is therefore that Luleå may be moving between the two groups.

In summary, the first analysis shows that the total population can be divided in terms of specialization into, respectively, research and education. Size of research effort and

age are important characteristics, even if one younger university has, or is trying, to move from the second to first groups. Hence, one might rephrase the two groups as 'Older Research oriented and 'Younger Education oriented'.

One organization does not follow the general pattern. Stockholm School of Economic (HHS) has one of the lowest students per professor ratio, but it combines its specialization in research with a small size. Moreover, it is among the oldest universities in the country but also private. They have obviously evolved, or chosen, a specialization which differs significantly from the other organizations.

4.3 Density in Research Areas

The next step is to try to identify whether the organizations have different numbers of research areas in which they are active as well as whether they have different density of professors and researchers within a specific research area. Organizations must report their own activities within research activities to the Swedish government. In many ways, the idea of 'density' can be related to the issue of 'critical mass', e.g. do universities have many or few researchers and professors within each specific area?

Table 3 presents the Swedish HEIs according to the two groups, defined above, and by density within that group. This tables shows, for each declared research area, how many researchers and professors, respectively, are employed at that organization. For example, Lund has more than one researcher in 63 of their research areas, and more than 50 researchers in 22 of their research areas.

Table 3 here

The first column in Table 3 suggests the total number of research areas, per organization.[6] A first reflection is that the regional university and colleges are present in almost as many research areas as the larger and older HEIs. Hence, if one only looks at the declared research areas, it appears that all Swedish HEIs are quite similar.

However, looking across the other columns, a rather striking difference is shown, namely in the density of research staff and professors in these areas. This difference in

[6] The number of research areas represented by one, or more, researchers.

density across research areas grows the more researcher and professors you set as the minimum, as can be seen moving from left to right in Table 3.

The 'Older Research oriented' HEIs have a high density in all areas reported, such that they are represented in most research areas by at least 20 researchers, and in many areas also with at least 50 people. The 'Younger Education oriented' of the regional HEIs have few research areas represented by more than 20 people, and with few exception no areas with more than 50. In fact, in most cases a large share of the research areas in these HEIs are represented by less than five people.

Interesting is that while a substantial share of research areas in the universities in the first group have more than five professors, a surprisingly small share at the smaller regional institutions in the second group have even one. For example, Malmö has 41 declared research areas with at least one researcher, but only 8 areas with at least one professor. Similar results are shown for the other organizations in this group. Naturally, given the social structure of science where professors signal scientific competence, this raises questions about relative scientific specialization.

This issue of density of researchers and professors, per declared research area, is quite provocative, and so we decided to find more systematic differences to distinguish organizations and groups. Looking across the sector, we made a calculation of the absolute average of researcher per research area. From this, ten researchers per area was chosen as a reasonable benchmark to compare the density in research areas in the different HEIs.

From this, Figure 2 plots, for each organization, the share of research areas with more than ten researchers by the total number of researchers.

Figure 2 here

The figure confirms the usefulness of discussing 'Older Research oriented' and 'Younger Education oriented', and that this holds when we examine researchers as an indication of actual research performed within each area.

Figure 2 shows that the ten universities identified as the first group previously have a significantly higher share of research areas comprising more than ten researchers, than do those in the second group. More specifically, the organizations in the first group have ten or more researchers in more than half of their research areas. The HEIs in the second group, on the other hand, have less than half of the research areas comprising more than ten researchers, and in most cases substantially less. Table 8 in Appendix A provides more detailed information.

The outliers are interesting. Looking at Figure 2, Stockholm SE lies rather close to the second group, although having a higher density relative to size. However, when studying Table 3, one can see that the higher the number of researcher you set as the minimum, the more SSE aligns with the ones in the first group. This also holds true for the density of professors in general. In other words, they clearly seem to belong to 'Older Research oriented'. Also Luleå shares characteristics with this first group.

In summary, the results here indicate that both groups declare similar numbers of research areas, but by examining actual number of researchers and by examining density per area, major differences are visible. The 'Older Research oriented' tend to concentrate employees – and thereby assumedly research activities – within research areas. They have more people and a higher density across areas. In contrast, the 'Younger Education oriented' do the opposite. They declare many areas but do not have many researchers. In a surprisingly high proportion of cases, they only have one researcher and no professor active. It should be noted that we have only dealt with research areas comprising on average more than one full-time equivalent researcher. A quick review of the data, however, show that areas with less researchers are generally more in the HEIs in

4.4 Research Productivity

Here we study whether the Swedish universities differ when it comes to research productivity. Figure 3 therefore places the research productivity, in terms of normalized publications per researcher, against size, in terms of total number of researchers. For more detail, look at Table 8 in Appendix A.

Figure 3 here

Figure 3 also confirms that there are clear differences between the two groups previously identified. Even more interestingly, the data reveals a relationship between the size of research effort and total research productivity. Plotting this relationship shows a clear tendency to that researchers whom are active at organizations with large numbers of researchers also write more papers, or in other words, they have a higher research productivity as measured in output per researcher.

For the 'Older Research oriented, the normalized publication rate is higher. They have all, with the exception of Stockholm U, more than 0,3 publications per researcher and year. For the 'Younger Education oriented', the publication rate is lower. In fact, all the HEIs identified as belonging to the second group are all rather similar regarding publication rate, ranging between 0,15 for MittUniversity and 0,07 for four of the smallest institutions. Figure 3 demonstrates in other words a somewhat wide gap in publication rate between the first and the second group – that is, the larger universities have not only a higher research output but also higher research productivity.

Again, there are some nuances and outliers within the two groups and between the groups. Within the 'Older research oriented' group, Karolinska I has by far the largest publication rate in the first group, while Stockholm U has the lowest in the group. Within the 'Younger education oriented' group, the outlier is Örebro, with substantially higher publication rate. With 0,26 publications per researcher, they are by far the most research productive in the second group, being not far from Stockholm U in the first group. Finally, as before, Stockholm SE differentiates itself, by having a high number of publications relative its size, and Luleå end up in between the two groups.

In summary, examining publications per researcher (i.e. normalized per organization) confirms the two groups and the main outliers, with some differences within groups. The figures do suggest that the organizations that are older, larger, and have a higher density of researchers per area tend also to publish more, per researcher.

5 External research funding

Here external research funding is analyzed in relation to the categories derived from the characteristics of the university gone through in the previous section. We will start by making an overview of the external research funding. In Table 4, the total external research funding is displayed alongside income from undergraduate education, for the Swedish HEIs. It also shows the external research funding per researcher, and the ratio between income from education and external research funding. The table is ordered according to the two groups, and the total amount of external research funding received. Firstly, there seems to be two distinct groups with regard to the ability to obtain external research funding. The ones that are attracting the largest amount of external research funding (>500 MSEK) are the ten universities in the first group. The seven HEIs that attract the most external funding in this group are also the oldest in the sector.

Table 4 here

Moreover, the smaller, regional, HEIs that previously were categorized as the second group attracted on average less than 200 million SEK. Rather naturally, all of the institutions lacking the right to graduate research students, with the exception of Södertörn, are the ones attracting the least external research funding. However, almost all of the money that Södertörn receive comes, as can be seen in Table 10, from the category New foundations. This is because of the Foundation of Baltic and East European Studies (Östersjöstiftelsen) – a foundation more or less entirely focused on funding Södertörn.[7] For the period studied, the university has received approximately 130 million SEK on average every year from this foundation. Contrasting this sum to the rest of the income for the university makes it clear that this skews the total relation for this university, and thus also the pattern showed in the table.

Studying external research funding relative to size, the pattern remains similar as before, with a couple of exceptions. Most of the HEIs in the second group have a substantially lower funding per researcher than those in the first group. However, due

[7] Plus small sums to Uppsala

to the reasons discussed before, Södertörn has one of the highest ratios. MittUniversity has also a noticeably high funding per researcher, being higher than for the younger HEIs, Stockholm and Uppsala in the first group.

Looking at the ratio between income from undergraduate education and external research funding reveals a large difference. The ten universities identified earlier as receiving the most external research funding, together with Stockholm SE and Luleå, all have a rather low ratio, generally receiving not more than double the sum from education than from research. Interesting is for instance that Karolinska receives much more funding for research than for education, and to some extent this is also true for the two older technical universities, Stockholm SE and SLU. In other words, the HEIs that attract more money for research than for education are all rather specialized institutions.

The regional HEIs, on the other hand, all have a much higher education research ratio, generally being between 5 and over 20. Noticeable exceptions here are Södertörn, due to the reason explained above, and MittUniversity, that in relation to its size attract quite much external research funding – mainly from Government institutions and New foundations.

5.1 RCA Analysis

Absolute numbers provide us with a picture of the general HEI-landscape, but do not say much about the relative effectiveness. In order to say something about this, from a descriptive point of view, we normalized the incomes with the size of the universities, in terms of number of researchers. Also, we use a relative number that reveals the importance of a particular funding source for a university relative to the importance for the whole population (so-called RCA). [8] In Table 5, the RCA for the HEIs of the seven categories of external funding and of the income from undergraduate education are displayed. The RCAs being more than one can be said to be income categories that are more important to the specific university than to the overall population of HEI here studied, i.e. a dependence above average. In order to make the patterns more clear, these RCAs are highlighted with gray. Furthermore, a lighter shade of gray is

[8] Revealed Comparative Advantage

used to code for the cases where the RCA is just above one, i.e. when it reveals a slightly high dependence. The table is ordered firstly according to the two groups identified, and secondly according to the absolute amount of external research funding received.

Table 5 here

Looking at the universities categorized as the 'Older research oriented' group reveals that these are also the HEIS with low relative dependence on education, in terms of income. Moreover, the HEIs categorized in the second group are on the other hand all those showing a high reliance on income from education, These were identified earlier as being more oriented toward education, which supports our interpretation of the RCA pattern. For some of these HEIs in the second group, one or two funding sources, limited mainly to New foundations and Contract research, in addition to education, seem to have some importance. However, these cases can to a large extent be attributed to policy efforts, such as regional politics, manifesting itself in for example funding from certain foundations.[9] It should be noted that MittUniversity show a somewhat high dependence on Government institutes & EU and not a very high reliance on income from education. Noticeable is also that it is only the HEIs in the 'Research oriented' group, together with Stockholm SE and Luleå, that show a high dependence on Industry funding.

Stockholm SE is close to the first category, showing low relative dependence on education and, for example, a very high dependence on industry funding. Luleå, previously seeming to be in the middle of the two categorizes, shows a low dependence on education. The only dependence Södertörn seems to have is on New foundations, which on the other hand is extremely high. This is due to their dependence on the Foundation of Baltic and East European Studies as a funding source, as explained before.[10]

[9] For example, the Knowledge Foundation has as main objective to support the smaller regional HEIs, in order to stimulate university-industry interaction.

[10] This means that the unusually high dependence on New Foundations keeps down the RCA for all other funding sources. In other words, if left out, Södertörn would show the same pattern when it comes to education as the rest of the HEIs in the group.

6 Conclusion and Discussion

We were able to identify specific characteristics of the HEIs in the Swedish university sector, which are useful in order to develop categories. By examining structure, density and research productivity of the 30 HEIs in the Swedish university sector, we identify two distinct categories of HEIs as well as two outliers. First, there are the ten largest and most research oriented universities in the country, including the seven oldest ones as well as three younger ones. These universities were labelled as the 'Older research oriented' group, and are also top when it comes to publication rate, per researcher. Note that they generally have large numbers of students, but also relatively many professors per student. Second, eighteen of the smaller institutions showed a tendency to group at the other end of the spectrum in terms of these characteristics, all being much younger and smaller, with substantially lower research orientation. They make up the 'Younger education oriented' group. Their publication rate is also lower, per researcher. If we take research productivity to be some sort of indicator of 'quality', as earlier discussed, we can in other words here distinguish a clear difference between the two groups in the ability to accumulate 'talent'. Two universities were on this basis hard to categorize. Stockholm School of Economics is an outlier because it has a small size in comparison to its somewhat 'high-performance' in the other characteristics. They thus seem to have a different strategy than other Swedish HEIs. Another outlier is Luleå, which is lying in between the two groups and could be moving between groups.

Hence, structural characteristics do differentiate the groups. This is especially so when we compare the research area specialization that the organizations themselves report to the Swedish government, as compared to faculty in those areas. The data shows that we can distinguish universities and university colleges on basis of how specialized they are. Generally, smaller universities and university colleges report quite a large number of research areas relative to their size. In fact, generally, the smaller universities comprising the second group report that they have an amount of research areas equal to those in the first group. In other words, a quick glance at the Swedish universities would reveal that most have a general diversity in research, in terms of number of research areas, not related to size. However, this diversity is not supported by the figures on actual numbers of researchers. Among the HEIs in the

second category, surprisingly many of the research areas are represented by less than five people and no professors. The figures suggest that most of the research areas in these HEIs are fairly ’empty’, lacking to some extent a ‘critical mass’. Not surprisingly, only the largest universities are able to simultaneously uphold diversity, density and size. However, the specialists in engineering, medicine or economics and management are able to combine smaller size with density, or what we may call specializations with critical mass. In our opinion, this shows that a debate regarding critical mass and research in regional HEIs is of importance.

The results in relation to obtaining competitive external research funding support the clear differences amongst the groups. The first group 'Older research oriented', comprising the larger universities, can be seen as being ‘high-performing’ in regards to obtaining competitive external research funding, both in absolute numbers and in relative importance as compared to income from education. One must also note that the 'older research oriented' educate, on average and in total, more students than the second group. The second group, consisting of the smaller HEIs, can be viewed as ‘low-performing’ in this regard. The first conclusion to draw from this is that the HEIs in the former group are able to compete for research funding, and they are therefore somewhat more specialized in research as compared to education. For the second group, those organizations rely more on education income. This seems to indicate that there can be such a thing as a division between ’research-education’ and ‘primarily education’ universities, in spite of recent Swedish public policies. Noticeable is that industry funding seems to be mostly important for “Older research oriented” universities. This goes a bit against the policy attempts to stimulate industry interaction for the regional HEIs. Also, it has been earlier suggested that financially weaker universities rely more on funding from industry (Geuna, 1999). Our study shows this not to be the case for the Swedish university system.

Already in the introduction, we mentioned Merton (1968) and his recognition of a cumulative advantage operating in science. Although he primarily keeps on the level of the individual scientist, he also deals briefly with the institutional side of this Matthew effect. Centres or universities of proven scientific excellence through this effect are allocated larger resources and attract more talented researchers, in a cumulative fashion. In other words, this cumulative effect would in the long run lead

to a stratification of research institutions – a self-reinforcing cycle that would be hard to break. Let us think about this, from the point of the present study. What has been shown is a polarization of the Swedish university system into two distinct groups, with (external) research resources highly concentrated in the group consisting of a handful of older, larger, and more research productive HEIs.[11] The research resources are thus concentrated to the group of 'traditional' research universities, both in absolute and in relative numbers, while the regional HEIS, most new in the research game, seems in this perspective to lack according external recognition in terms of funding. Hence, we would like to raise the proposition that there exist a Matthew effect regarding the allocation of external research funding at the university level in Sweden. Furthermore, as discussed earlier, this effect clearly holds for industry funding alone.

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[11] In many ways, resembling the polarization shown by Geuna (1999) for universities in Europe as a whole

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8 Tables and figures

Table 1 Summarizing the variables, metrics and data collection

	Metric	Specific information	Source
Competitive (external) research funding	Research funding	All research funding except general university funds and internal funds (in absolute number or per researcher)	NU
Funding for undergraduate education	Income from undergraduate education	All income, including from Master	NU
Size	Research personnel	Number, in FTE, of research assistants, research students, lecturers, other researching personnel and professors	NU
R&D intensity	Research orientation	Students per professor	NU
Age	Foundation year		University web sites, annual reports
Density	Research personnel	Number, in FTE, of research personnel broken down per research area	NU
Quality (Research productivity)	Publications	Normalized # of publications per researcher in a HEI	SCI

Table 2 Overview of the Swedish HEIs, 2005 [1000 SEK]

HEI	Year of est.	Students	Prof.	PhDs	Income education	Income research	Research expenditures
Lund U	1666	27 525	572	1 196	1 713 812	3 282 072	3 295 967
Uppsala U	1477	21 657	472	1 117	1 350 335	2 761 855	2 758 065
Karolinska I	1810	5 813	308	568	813 718	3 021 736	2 990 967
Göteborg U	1891	25 752	433	582	1 781 269	2 441 777	2 439 510
Umeå U	1965	16 805	243	565	1 383 975	1 574 108	1 574 562
Stockholm U	1904	23 694	351	719	1 047 940	1 698 178	1 707 119
Royal TU	1826	12 343	242	772	978 333	1 703 328	1 710 099
Linköping U	1970	18 044	264	685	1 260 338	1 253 291	1 232 334
SLU	1977	3 338	190	388	475 486	1 607 385	1 559 843
Chalmers TU	1829	8 382	150	585	741 257	1 371 704	1 389 577
Luleå TU	1971	8 360	89	287	617 696	566 903	561 674
Malmö H	1998	10 348	40	77	805 768	130 274	141 400
Örebro U	1965	9 756	56	139	576 416	250 354	250 615
MittUniversity	1993	8 073	37	130	514 433	279 391	261 199
Karlstad U	1977	8 359	45	113	505 667	262 048	264 364
Växjö U	1977	7 658	42	130	479 971	207 686	206 275
Mälardalen H	1977	9 037	41	91	573 213	131 545	130 118
Kalmar H	1977	6 230	32	72	463 024	126 690	133 909
Södertörn H	1995	6 757	34	89	268 519	217 454	228 996
Jönköping U	1977	6 770	31	74	426 416	138 744	130 594
Gävle H	1977	6 317	23	15	357 934	97 182	99 869
Borås H	1977	4 913	19	43	374 544	56 316	62 610
Blekinge TH	1989	3 304	22	55	261 725	106 761	107 493
Dalarna H	1977	5 063	16	30	335 252	66 521	67 258
Stockholm SE	1909	1 372	32	35	88 450	152 820	222 255
Halmstad H	1983	5 404	21	28	280 325	72 962	71 906
Kristianstad H	1977	5 472	14	13	319 100	42 803	47 986
Skövde H	1977	4 221	12	55	266 662	45 314	52 815
Väst H	1990	4 199	5	20	268 672	38 652	43 592
Gotland H	1998	2 261	8	4	129 870	23 322	19 395

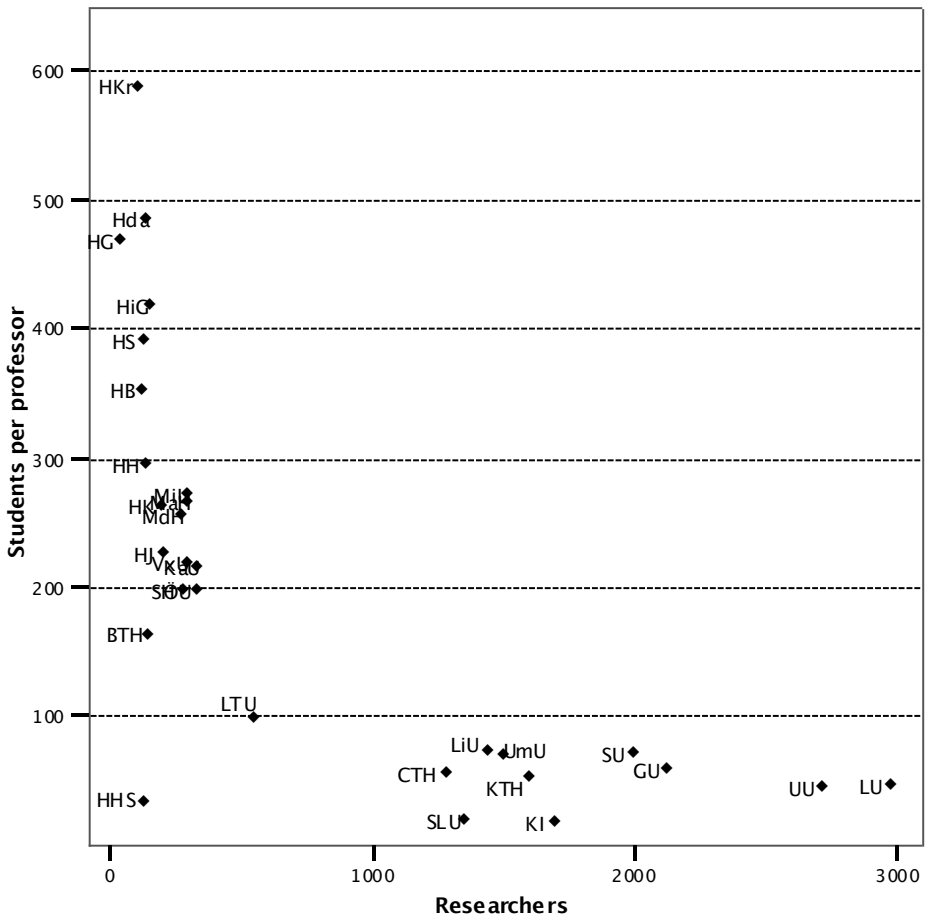

Figure 1 Research orientation: Students per professor vs. Researchers[12]

[12] One extreme case, Väst (HV), has been left out in order to make the figure more clear.

Table 3 Number of research areas comprising more than a specific number of researchers and professor

	Researchers					Professors	
HEI	**>1**	**>5**	**>10**	**>20**	**>50**	**>1**	**>5**
Lund U	63	53	49	40	22	56	32
Uppsala U	54	49	45	34	18	51	25
Göteborg U	54	50	41	31	15	49	23
Stockholm U	49	38	33	28	11	44	21
Karolinska I	12	11	11	10	10	12	10
Royal TU	23	17	15	13	12	17	13
Umeå U	60	46	37	25	6	40	17
Linköping U	59	45	33	25	7	43	17
SLU	14	12	12	10	10	11	10
Chalmers TU	20	16	14	13	10	14	11
Karlstad U	37	20	13	4	0	18	0
Örebro U	32	22	14	3	0	17	0
MittUniversity	36	21	10	2	0	13	0
Växjö U	30	15	13	4	0	14	1
Malmö H	41	17	6	3	1	8	2
Södertörn H	25	13	8	4	1	12	1
Mälardalen H	31	17	8	3	0	13	1
Jönköping H	27	10	7	1	0	10	0
Kalmar H	35	10	4	2	0	6	1
Gävle H	28	13	3	0	0	7	0
Blekinge TH	16	7	3	1	1	7	1
Dalarna H	38	8	2	0	0	3	0
Halmstad H	25	12	1	1	0	5	1
Skövde H	21	6	3	1	0	5	0
Borås H	26	9	2	0	0	5	0
Kristianstad H	22	7	2	1	0	4	0
Väst H	6	6	0	0	0	1	0
Gotland H	9	3	0	0	0	1	0
Luleå TU	24	13	10	7	4	15	6
Stockholm SE	6	4	2	2	1	5	2

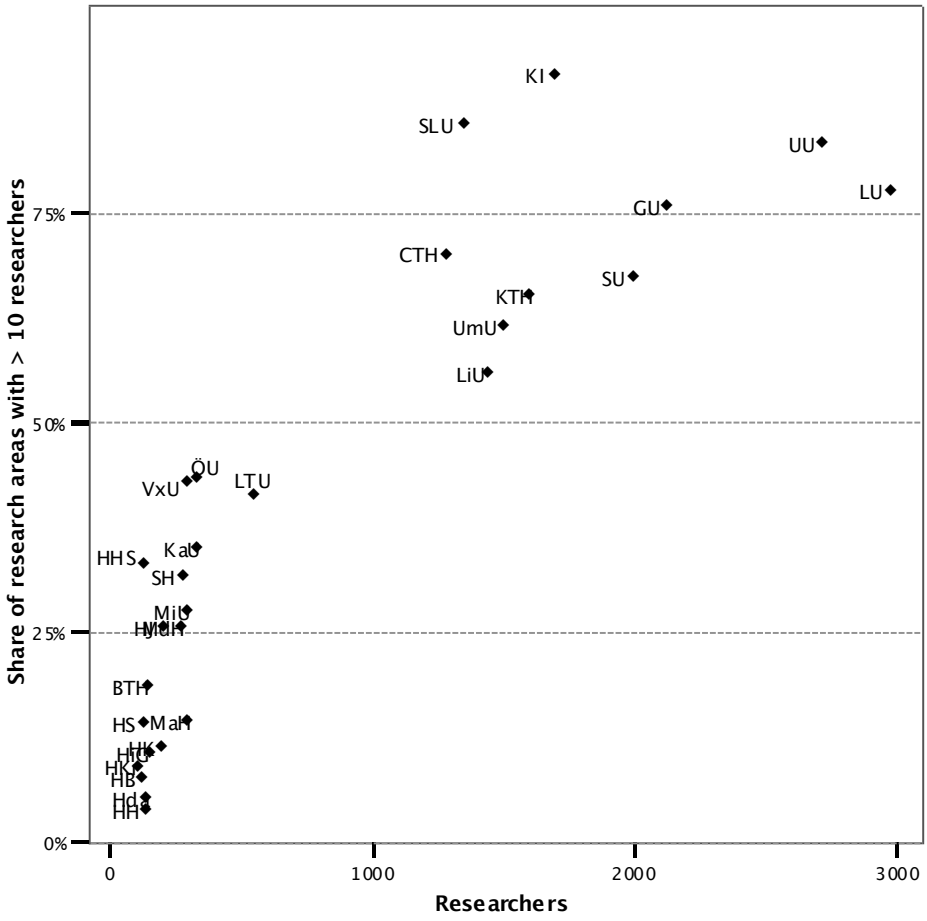

Figure 2 Density: Share of research areas comprising > 10 researcher vs. Researchers

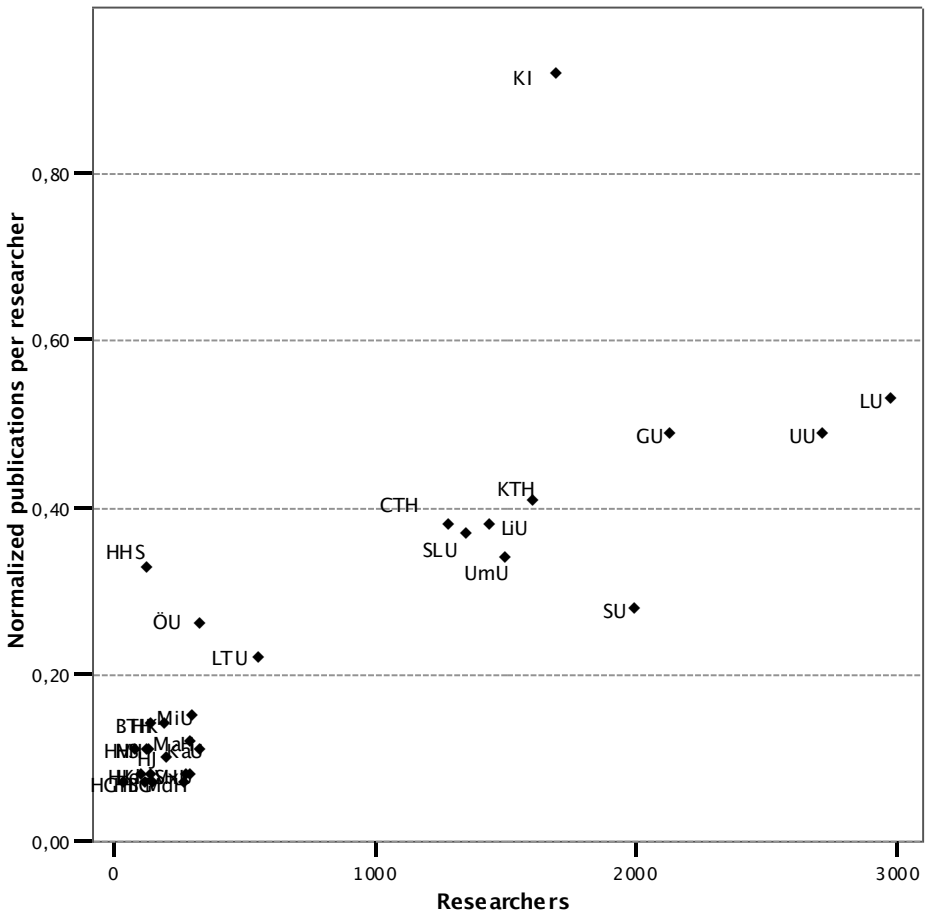

Figure 3 Research productivity: Normalized publications per researcher vs. Researchers

Table 4 External research funding and income from education [1000 SEK)

HEI	External research	Funding/ researcher	Education	Education/ Research
Karolinska I	1 514 115	921	754 475	0,50
Lund U	1 465 017	507	1 648 200	1,13
Uppsala U	1 151 363	447	1 249 355	1,09
Göteborg U	1 050 701	500	1 643 561	1,56
Royal TU	1 007 505	629	928 021	0,92
Chalmers TU	932 178	729	700 439	0,75
Stockholm U	620 613	316	1 010 096	1,63
SLU	616 715	462	507 850	0,82
Umeå U	561 873	384	1 219 809	2,17
Linköping U	554 584	389	1 205 926	2,17
Södertörn H	199 954	731	251 062	1,26
MittUniversity	132 612	452	511 988	3,86
Karlstad U	97 235	296	491 642	5,06
Örebro U	76 390	239	549 419	7,19
Mälardalen H	65 701	246	535 220	8,15
Växjö U	59 277	204	428 017	7,22
Malmö H	58 912	205	724 515	12,30
Jönköping H	55 160	283	383 865	6,96
Kalmar H	47 583	252	439 061	9,23
Blekinge TH	37 955	277	251 989	6,64
Gävle H	35 561	247	349 178	9,82
Halmstad H	32 727	253	272 259	8,32
Dalarna H	29 459	220	340 532	11,56
Väst H	22 039	276	255 622	11,60
Borås	19 423	165	349 679	18,00
Skövde	19 198	153	246 960	12,86
Kristianstad	13 379	128	305 012	22,80
Gotland	7 344	256	117 936	16,06
Luleå TU	290 511	530	595 780	2,05
Stockholm SE	97 269	769	70 163	0,72
Total	*10 872 352*		*18 337 632*	*1,69*

Table 5 RCA of the external research funding and income from undergraduate education

HEI	RC	NF	F	G & EU	O	CR	I	E
Karolinska I	1,43	0,82	2,21	0,92	2,72	1,42	2,78	0,54
Lund U	1,55	0,95	1,38	1,15	1,29	0,57	0,92	0,88
Uppsala U	1,78	1,03	2,02	0,84	0,76	1,13	1,37	0,88
Göteborg U	1,06	0,60	1,32	0,88	1,31	1,44	0,80	0,99
Royal TU	1,28	1,50	1,11	1,61	0,63	0,43	1,69	0,79
Chalmers TU	1,20	1,85	0,66	1,30	2,06	0,74	1,25	0,72
Stockholm U	1,57	0,32	1,25	1,15	0,46	0,94	0,39	1,05
SLU	0,32	1,40	0,23	2,15	1,44	1,86	0,62	0,75
Umeå U	0,98	0,30	1,11	0,95	0,64	2,06	0,47	1,09
Linköping U	0,94	1,00	0,67	0,97	0,47	1,18	0,65	1,12
Södertörn H	0,30	7,67	0,16	0,90	0,10	0,41	0,00	0,88
MittUniversity	0,09	1,37	0,06	1,35	0,47	0,15	0,65	1,19
Karlstad U	0,27	1,17	0,08	0,66	0,38	1,95	0,43	1,28
Örebro U	0,34	0,99	0,33	0,61	0,07	0,48	0,17	1,42
Mälardalens U	0,12	0,98	0,05	0,68	0,20	0,32	0,60	1,40
Växjö U	0,12	0,45	0,06	0,44	0,29	2,10	0,15	1,43
Malmö H	0,27	0,45	0,03	0,44	0,19	0,45	0,24	1,51
Jönköping U	0,10	0,38	0,10	0,48	0,48	1,42	0,69	1,40
Kalmar H	0,30	0,83	0,01	0,40	0,82	0,07	0,20	1,44
Blekinge TH	0,05	1,49	0,00	0,64	0,55	0,28	0,08	1,39
Gävle H	0,06	0,76	0,13	0,83	0,15	0,60	0,31	1,40
Halmstad H	0,05	1,42	0,02	0,49	0,21	0,36	0,45	1,43
Dalarna H	0,03	0,91	0,00	0,59	0,01	0,26	0,89	1,44
Väst H	0,02	1,59	0,01	0,64	0,55	0,13	0,23	1,38
Borås H	0,05	0,78	0,00	0,31	0,59	0,11	0,08	1,53
Skövde H	0,02	1,12	0,06	0,27	0,18	0,00	0,12	1,57
Kristianstad H	0,24	0,72	0,08	0,23	0,10	0,58	0,10	1,56
Gotland H	0,09	0,47	0,05	0,21	0,65	0,00	0,00	1,57
Luleå TU	0,32	0,51	0,01	1,38	0,74	1,43	1,89	1,01
Stockholm SE	0,36	0,07	1,76	0,59	2,50	1,97	3,96	0,72

9 Appendix A: Tables

Table 6 Structural characteristics of the Swedish HEIs

	Age	*Size*		*R&D intensity*
HEI	**Found. Year**	**Researchers**	**Professors**	**Students/ Professor**
Lund U	1666	2 979	549	47
Uppsala U	1477	2 712	447	45
Karolinska I	1810	1 694	286	18
Göteborg U	1891	2 127	412	60
Umeå U	1965	1 495	231	70
Stockholm U	1904	1 996	326	72
Royal TU	1826	1 603	221	52
Linköping U	1970	1 432	238	74
SLU	1977	1 344	180	19
Chalmers TU	1829	1 279	149	56
Luleå TU	1971	548	81	100
Malmö H	1998	289	37	267
Örebro U	1965	327	45	198
MittUniversity	1993	293	30	274
Karlstad U	1977	328	38	217
Växjö U	1977	290	35	219
Mälardalen H	1977	265	33	256
Kalmar H	1977	189	23	265
Södertörn H	1995	274	31	199
Jönköping H	1977	199	28	228
Gävle H	1977	149	15	418
Borås H	1977	120	15	353
Blekinge TH	1989	141	19	163
Dalarna H	1977	136	11	486
Stockholm SE	1909	128	40	33
Halmstad H	1983	130	17	296
Kristianstad H	1977	104	9	588
Skövde H	1977	126	10	390
Väst H	1990	82	3	1 575
Gotland H	1998	33	3	469

Table 7 Number of publications per HEI and year

HEI	Total publications	Normalized publications	Tot pub/RP	Norm pub/RP
Karolinska I	4 987	1 565	2,94	0,92
Lund U	4 317	1 590	1,45	0,53
Göteborg U	2 929	1 044	1,38	0,49
Uppsala U	3 688	1 318	1,36	0,49
Royal TU	1 336	652	0,83	0,41
Chalmers TU	1 048	485	0,82	0,38
Linköping U	1 234	543	0,86	0,38
SLU	1 312	496	0,98	0,37
Umeå U	1 258	508	0,84	0,34
Stockholm SE	101	42	0,79	0,33
Stockholm U	1 168	550	0,59	0,28
Örebro U	254	87	0,78	0,26
Luleå TU	229	122	0,42	0,22
MittUniversity	86	43	0,29	0,15
Blekinge TH	38	20	0,27	0,14
Kalmar H	61	27	0,32	0,14
Malmö H	91	36	0,31	0,12
Karlstad U	74	37	0,22	0,11
Halmstad H	39	15	0,3	0,11
Skövde H	35	14	0,27	0,11
Väst H	24	9	0,29	0,11
Jönköping H	55	19	0,27	0,1
Dalarna H	24	11	0,17	0,08
Växjö U	45	24	0,16	0,08
Kristianstad H	18	8	0,17	0,08
Södertörn H	59	21	0,22	0,08
Gävle H	25	11	0,17	0,07
Borås H	19	9	0,16	0,07
Mälardalen H	48	19	0,18	0,07
Gotland H	5	2	0,15	0,07

Table 8 Share of research areas in the HEIs comprising more than a specific number of researchers and professors

	Share of RAs with # of researchers				Share of RAs with # of professors	
HEI	**>5**	**>10**	**>20**	**>50**	**>1**	**>5**
Uppsala U	0,91	0,83	0,63	0,33	0,94	0,46
Lund U	0,84	0,78	0,63	0,35	0,89	0,51
Karolinska I	0,92	0,92	0,83	0,83	1,00	0,83
Royal TU	0,74	0,65	0,57	0,52	0,74	0,57
Chalmers TU	0,80	0,70	0,65	0,50	0,70	0,55
Göteborg U	0,93	0,76	0,57	0,28	0,91	0,43
Stockholm U	0,78	0,67	0,57	0,22	0,90	0,43
Stockholm SE	0,67	0,33	0,33	0,17	0,83	0,33
Umeå U	0,77	0,62	0,42	0,10	0,67	0,28
Örebro U	0,69	0,44	0,09	0,00	0,53	0,00
Linköping U	0,76	0,56	0,42	0,12	0,73	0,29
Luleå TU	0,54	0,42	0,29	0,17	0,63	0,25
Borås H	0,35	0,08	0	0	0,19	0
Dalarna H	0,21	0,05	0	0	0,08	0
Gävle H	0,46	0,11	0	0	0,25	0
Jönköping U	0,37	0,26	0,04	0	0,37	0
Kalmar H	0,29	0,11	0,06	0	0,17	0,03
Karlstad U	0,54	0,35	0,11	0	0,49	0
Kristianstad H	0,32	0,09	0,05	0	0,18	0
Mälardalens U	0,55	0,26	0,10	0	0,42	0,03
Skövde H	0,29	0,14	0,05	0	0,24	0
SLU	0,86	0,86	0,71	0,71	0,79	0,71
Växjö U	0,50	0,43	0,13	0	0,47	0,03
Halmstad H	0,48	0,04	0,04	0	0,20	0,04
Blekinge TH	0,44	0,19	0,06	0,06	0,44	0,06
Väst H	1,00	0	0	0	0,17	0
MittUniversity	0,58	0,28	0,06	0	0,36	0
Södertörn H	0,52	0,32	0,16	0,04	0,48	0,04
Gotland H	0,33	0	0	0	0,11	0
Malmö H	0,41	0,15	0,07	0,02	0,20	0,05

Table 9 University code

University name	University code
Blekinge TH	BTH
Borås H	HB
Chalmers TU	CTH
Dalarna H	Hda
Gotland H	HG
Gävle H	HiG
Göteborg U	GU
Halmstad H	HH
Jönköping H	HJ
Kalmar H	HK
Karlstad U	KaU
Karolinska I	KI
Kristianstad H	HKr
Linköping U	LiU
Luleå TU	LTU
Lund U	LU
Malmö H	MaH
MittUniversity	MiU
Mälardalen H	MdH
Royal TU	KTH
Skövde H	HS
SLU	SLU
Stockholm SE	HHS
Stockholm U	SU
Södertörn H	SH
Umeå U	UmU
Uppsala U	UU
Väst H	HV
Växjö U	VxU
Örebro U	ÖU

Table 10 External research funding in the 7 categories [1000 SEK]

HEI	Research councils	New Foundations	Foundations	Gov & EU	Other	Contract	Industry
Karolinska I	220 523	76 654	140 462	277 529	399 143	98 394	301 410
Lund U	321 508	119 754	117 389	465 005	254 707	52 770	133 884
Uppsala U	289 815	101 708	134 850	267 911	117 427	82 845	156 805
Göteborg U	180 624	62 130	92 766	295 226	213 111	110 283	96 560
Royal TU	165 615	117 764	58 886	409 181	77 373	25 163	153 523
Chalmers TU	134 752	125 818	30 518	285 239	219 831	37 366	98 654
Stockholm U	171 926	21 522	56 168	246 454	47 963	46 371	30 209
SLU	24 565	64 366	7 209	319 786	104 320	63 451	33 017
Umeå U	102 953	18 987	48 072	195 773	63 889	97 642	34 557
Linköping U	101 027	65 428	29 560	204 124	47 700	57 238	49 506
Södertörn H	8 370	131 427	1 879	50 159	2 813	5 268	38
MittUniversity	2 755	24 058	729	76 783	13 038	1 938	13 311
Karlstad U	6 785	17 890	859	32 741	9 223	22 155	7 583
Örebro U	9 824	17 028	3 812	34 138	2 025	6 174	3 389
Mälardalen H	2 882	13 790	470	30 913	4 404	3 382	9 859
Växjö U	2 661	6 179	589	19 710	6 344	21 362	2 431
Malmö H	8 082	8 162	365	25 848	5 333	6 091	5 031
Jönköping H	1 867	4 436	809	17 859	8 732	12 210	9 247
Kalmar H	5 609	9 430	48	14 693	14 530	604	2 669
Blekinge TH	713	11 777	0	16 336	6 775	1 638	716
Gävle H	766	5 753	684	20 482	1 766	3 362	2 747
Halmstad H	698	10 960	111	12 332	2 501	2 065	4 060
Dalarna H	374	6 493	0	13 672	136	1 405	7 381
Väst H	151	7 104	27	9 292	3 865	419	1 182
Borås	524	5 132	0	6 514	6 074	542	637
Skövde	241	8 682	297	6 734	2 141	0	1 103
Kristianstad	2 031	3 683	264	3 778	831	2 213	579
Gotland	482	1 444	101	2 151	3 166	0	0
Luleå TU	15 322	14 977	148	130 558	33 954	31 256	64 296
Stockholm SE	4 249	516	8 442	13 402	27 790	10 361	32 510
Total	*1 787 694*	*1 083 051*	*735 516*	*3 504 324*	*1 700 907*	*803 967*	*1 256 893*