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Medical Research at Universities – An International Comparison

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Studien zum deutschen Innovationssystem
Nr. 8-2014

Fraunhofer Institute for Systems and Innovation Research ISI

February 2014

This study was conducted on behalf of the Expertenkommission Forschung und Innovation (EFI). The results and interpretations are the sole responsibility of the institute conducting the study. The EFI exercised no influence on the writing of this report.

Studien zum deutschen Innovationssystem

Nr. 8-2014

ISSN 1613-4338

Publisher:
Expertenkommission Forschung und Innovation (EFI)
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0 Summary

This study compares the publication and patent performance of selected medical research locations in five countries. The bibliometric indicators reveal that mostly the U.S. locations, above all Harvard University, have the highest score in the rankings in terms of quantity and quality of their research output. On average, the German research locations score in the medium ranks when it comes to the number of publications and publication intensities. Medical research in Munich and Hanover, however, achieves top scores in publications per capita, and thus can be seen as highly productive. Yet, the citation indicators show that the scientific profiles of German universities in medical research differ. While on average the locations Hanover, Berlin and Munich target internationally less visible journals, and reach high citation rates there. Heidelberg and Tubingen are more internationally oriented, where it is harder to achieve high scientific regard values. The differences can mainly be explained by differences in the subdisciplines of medical research, which are more or less internationally oriented and therefore also reach higher or lower citation numbers.

Multivariate analyses also support these findings. Even after controlling for field and country-specifics as well as differences over time, publications of Harvard University still receive the largest number of citations and also have the highest probability to belong to the 10% most cited papers in medical research in the world. Heidelberg, however, is able to catch up with the international elite after controlling for these field and country-specific characteristics, so partially the lagging-behind of German medical research locations can be explained by field characteristics and also by general differences between the public research systems in the countries under analysis here.

The patent indicators largely resemble the trends found in the publication analyses. Yet, in terms of patenting, the German research locations, especially Munich and Berlin, seem to be major players besides the U.S. locations, at least when looking at the absolute numbers. Yet still, Harvard University, followed by Johns Hopkins University, files the largest number of transnational patents compared to all other locations. As for the cooperation structures in patenting, most German universities cooperate heavily with public research institutes, yet also industry partners are important. When looking at the patent and publication profiles in an integrated view, it becomes obvious that, although some of these locations are more oriented towards either patenting or publishing, none of the universities is exclusively limited to one or the other. The locations of medical research mostly maintain rather differentiated patent/publication profiles.

Funding of medical research in Germany mostly comes from the German Research Foundation (DFG) and the Federal Ministry for Education and Research (BMBF) but also industry und foundation-based funding is important.

In sum, there are performance differences between the research locations under analysis here. Some can simply be explained by country- and therefore system-specific differences, which are mainly a language issue. Some can be explained by differences in the disciplinary profiles of the locations, resulting from different publication and citation behavior within the sub-fields of medical research. However, a large part cannot be explained by these factors and therefore seems to stem from qualitative differences. Here, Harvard still clearly stands out among the locations examined in this study. Heidelberg is – in relative terms – the most prolific one within Germany, at least in terms of scientific publications. In terms of patents – reflecting a certain level of application orientation – Munich and Berlin stand out among the German locations.

1 Introduction

This study identifies the most research-intensive locations of medical research in Germany, Canada, the Netherlands, Switzerland and the United States via bibliometric indicators. The top locations in these countries are then compared to each other over time by various bibliometric and patent statistical indicators. In addition to a detailed presentation of the publication output, in absolute numbers and as a share of total publications, further quality-oriented indicators, such as the citations of individual publications or the proportion of publications among the world's most highly cited publications in the medical field will be analyzed. Besides publications, also patent statistical indicators will be calculated, so not only scientific but also the technological output of the medical research locations is in the focus.

The study aims to identify the most research-intensive locations of medical research in five countries and compare them with each other alongside several bibliometric as well as patent statistical indicators. The analysis aims for an international comparison of medical research facilities in terms of quantity and quality of their research output and includes medical research locations in Germany, Canada, the Netherlands, Switzerland and the United States.

In a first step of our analyses the identification of the most research-intensive medical research facilities is pursued. Alongside the dimensions of a) publication output as well as b) quality of the publication output, as indicated by the average citation rate of the publications, the top-institutions within the respective country were selected. These are then analyzed more deeply by calculating further bibliometric indicators, which provide us with more in-depth information about research excellence, international orientation as well as the funding of these institutions. In addition to bibliometric indicators, also academic patents will be used as an indicator for the (technology-oriented) research output. By a newly developed concept of academic patents, not only patents filed by the university themselves but also inventions that were made within the university (and for which a patent was filed) are analyzed. The approach for the identification of patents with university involvement, i.e. academic patents, is based on the examination of name matches between of authors of scientific publications and inventors named on a patent filing.

The creation, diffusion and application of scientific and technological knowledge are crucial foundations in the technological activities and key elements for the performance of national innovation systems. Basic scientific research thereby plays a significant role in technological development. In order to quantify the output of basic research and thus the performance and impact of national science systems or parts of these, scientific publications and their citations are the most commonly employed indicators, also used in this study. The basic underlying assumption hereby is that scientific achievements are mostly published in journals, so that other scientists can access them and consequently cite them if they deem them appropriate (Michels et al. 2013). Publications as well as their citations can therefore be used to assess the scientific output of research systems.

Patents, on the other hand, are filed to achieve temporary protection of technologically new products or processes on the market place (Schmoch 1997). Therefore, patents indicate an interest in the commercial exploitation of a new finding or a new technology and thus are more strongly focussed on measuring an orientation towards the technological application of a given invention.

By applying bibliometric and patent statistical indicators to measure the performance of medical research locations, we can assess the scientific and technology-oriented output of these institutions at the same time. Therefore, we are able to gain a complete picture of the research output of these institutions.

The first step towards this assessment, however, is the identification of the most research-intensive research locations in medical research. This is achieved via ranking the research output of the respective facilities, i.e. universities as well as university medical centers, in terms of scientific publications.

For each of the above-mentioned countries, based on the rankings, the largest research universities are selected, which will then be analyzed in more detail with the help of several bibliometric and patent statistical indicators. In addition to a detailed presentation of the publication output in absolute numbers and as a share of total publications, further quality-oriented indicators, such as the citations of individual publications or the proportion of publications among the world's most highly cited publications in the medical field, will be presented.

In section 2 of this report, we will give a more detailed overview of the databases and methods used for the identification of the top-locations of medical research and the further analyses. In section 3, the results of our study will be presented. While we will focus on the scientific output in medical research by analyzing publication trends in section 3.1 and 3.2, section 3.3 sketches the technology-oriented research output in terms of academic patents. In section 3.4, publication and patent analyses will be compared in order to give a more complete view on medical research institutions. Section 4 concludes.

2 Data and Methods

The data and methods used for the study are presented in this section. Besides taking a look at the relevant data sources, the concept of identifying most research-intensive locations of medical research in the given countries as well as the concept and identification of "academic patents" are presented.

2.1 Data Sources, Classifications and Indicators

Bibliometric as well as patent data will be employed. For both kinds of data, the databases as well as the classifications will briefly be summarized in the following sections. In addition, all indicators used throughout the study will be depicted in the final paragraph.

2.1.1 Publication Data

The database *Web of Science* (WoS) by Thomson Reuters is used to identify the publications of the universities within medical research as well as the affiliated medical research centers and for the further analysis of bibliometric indicators. We limit our analyses to the journal publications from the Science Citation Index Expanded (SCIE) and the Social Science Citation Index (SSCI). It covers “articles”, “letters”, “notes” and “reviews” for journal papers. The external citations are the most relevant for evaluative purposes and therefore this study follows the recommendation of CWTC to exclude self-citation (Nederhof et al. 1993).

For the definition of medical publications as such, the field classification of WoS will be used. To distinguish the publications of universities and medical research centers, the author affiliations captured in the respective publications are employed. The publications of the associated medical research centers were identified, in case the university itself was mentioned as the author’s affiliation or the name of the respective city in combination with the term "clinic" was named. In the following analyses, only medical publications and not the total number of publications per research location are taken into account.

For some specific analyses, as well as for the identification of academic patents (see below), the publication database Scopus by Elsevier is employed in addition to WoS.

2.1.2 Patent Data

The patent data for the study were extracted from the "EPO Worldwide Patent Statistical Database" (PATSTAT), which provides information about published patents collected from 83 patent authorities worldwide. The new list of research-intensive industries and goods (NIW/ISI/ZEW-Lists 2012) differentiates 38 high-technology fields (Gehrke et al. 2013). A corresponding definition of these 38 fields in terms of IPC classes was used to identify medical patents. Pharmaceuticals, medical instruments and electronic medical instruments were defined as the field of medical research from this list of 38 fields. In all of the following analyses, only medical patents and not the total number of patents per research location are depicted.

The patents in our analyses are counted according to their year of worldwide first filing, which is commonly known as the priority year. This is the earliest registered date in the patent process and is therefore closest to the date of invention. At the core of the analysis, the data applied here follows the concept of transnational patents suggested by Frietsch and Schmoch (2010), which is able to overcome the home advantage of domestic applicants. Thus, a comparison of technological strengths and weaknesses becomes possible – beyond home advantages and biasing market orientations. In detail, all PCT applications are counted, whether transferred to the EPO or not, and all direct EPO applications without precursor PCT application. Double counting of transferred Euro-PCT applications is thereby excluded. To put it simply, all patent families with at least one PCT application or an EPO application are taken into account.

2.1.3 Indicators

The analysis of scientific publications gives an insight into the academic performance of economies. More specifically, it particularly reflects scientific results of universities and research institutes. The vast majority of publications stems from public research, i.e. universities, colleges and other research institutions. Companies are significantly less involved in the preparation of scientific publications. Publications are not only a key means of scientific discourse, but also a key output of universities and public research institutions, whose main mission is to generate knowledge. This knowledge is documented in the literature. Not only research groups and research institutes, but also entire research systems can be analyzed and evaluated with the help of bibliometric analyses, (Schmoch et al. 2012).

Patents, on the other hand, are among the most important indicators for the output of R&D processes and are frequently used to assess the technological performance of firms, technology fields and economies as a whole (Freeman 1982; Griliches 1991; Grupp 1998). A large amount of patents thus indicates strong efforts in R&D activities and therefore a higher innovative output. However, large patent portfolios are also strategically useful, for example, to block competitors in the same or adjacent technological areas or prevent especially smaller potential competitors from entering relevant markets (Blind et al. 2006; Blind et al. 2009; Neuhäusler 2012).

Besides absolute numbers of publications and patent filings, intensities are calculated, which ensure better international comparability. The figures for the publication- and patent intensity are calculated as the total number of publications/patents per author within the respective medical research locations.

As for the publication statistics, the average number of citations a publication receives from subsequent publications - in a 3-year time window - are employed as an indicator of the quality of publications. Also further metrics based on citations allow for a more detailed assessment of the quality of scientific publications over time. One of these measures is the scientific regard (SR), which describes whether the publications of a university are cited above average or below average, compared to other publications in the same journals where the observed papers appear (Grupp et al. 2001). The publications are hereby normalized alongside the journal-specific citation rates in order to balance effects that are not necessarily linked to the quality of a publication but dependent on the reputation of the respective journal. Another indicator called "International Alignment" (IA) describes whether the authors of a country publish their achievements in internationally more or less visible journals, compared to the world average. Finally, the excellence rate for the respective locations is calculated. The excellence rate is defined as the number of publications that belong to the top 10% papers in medicine in terms of citations in relation to all medical publications of the respective location. This measure primarily aims at measuring research excellence, i.e. the tip of the iceberg, whereas the indicators scientific regard and international alignment try to grasp a broader definition of the quality of the publications.

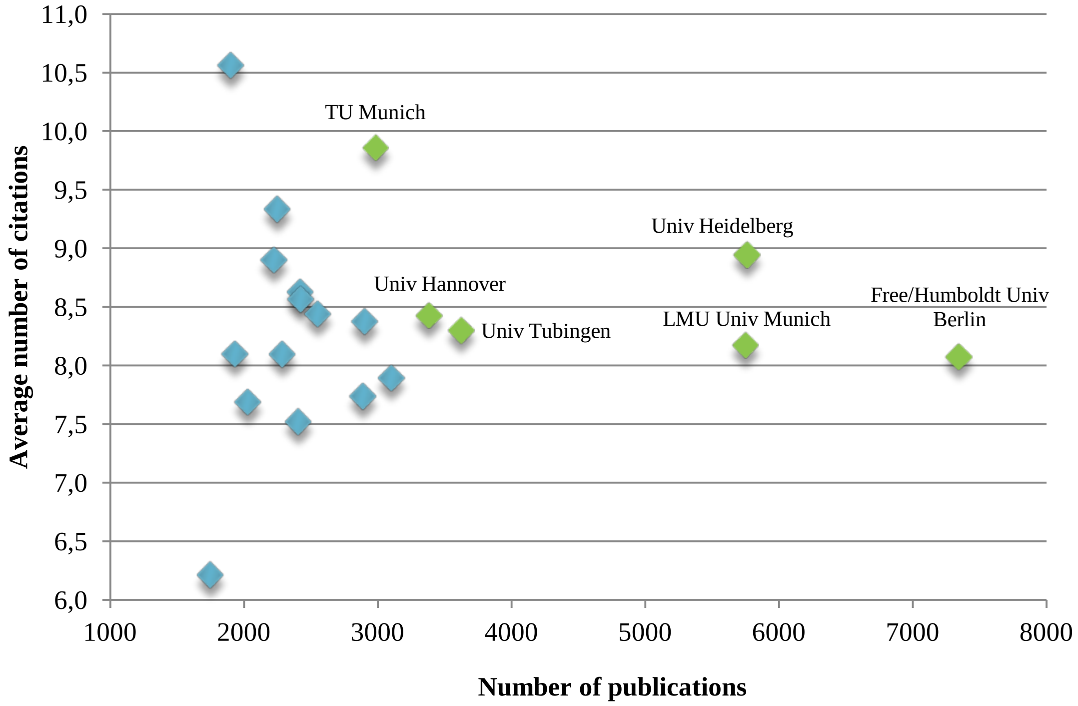
As for the patent statistics, the average number of citations a patent receives from subsequent patent applications (here in a 4-year time window) are used to indicate patent quality. Citations a patent receives are commonly called forward citations and are probably the most common and widely used patent quality indicator (Frietsch et al. 2010; Hall et al. 2001; Hall et al. 2005; Neuhäusler et al. 2011; Patel/Ward 2011; Webb et al. 2005). Many scholars argue that forward citations, besides indicating technological spillovers, are able to indicate the technological as well as economic value of a patent (Narin et al. 1987; Trajtenberg 1990). The basic assumption is that the number of forward citations measures the degree of a patent's contribution to further developing a certain technology, thus this can be seen as an indicator of technological significance (Albert et al. 1991; Blind et al. 2009; Carpenter et al. 1981). In order to additionally capture the breadth of a patent application in terms of its market coverage, the average family size of the patent filings in the field of medicine by the universities analyzed here is calculated. It is determined by the number of countries or patent offices at which a patent has been applied (Putnam 1996; Schmoch et al. 1988), including singletons (Martinez 2009; Martínez 2010). This means that for this indicator we step away from the concept of transnational patents and analyze all patent families, no matter at which offices their members had been filed. In sum, the family size indicator provides information about the number of markets the applicant seeks to secure to sell his inventions. Since the costs for applying and upholding patents in foreign countries are high, it can be assumed that an applicant is only willing to bear those costs if he expects a corresponding profit. Thus, the size of the patent family can additionally be interpreted as an indicator of (economic) patent value (Frietsch et al. 2010; Neuhäusler/Frietsch 2012; Neuhäusler et al. 2011).

2.2 Identifying research-intensive locations of medical research

As a first step of our analyses, the most research-intensive medical research facilities as well as the respective medical research centers were identified. We defined research intensity to be reflected by the publication output, relative to the total output of medical publications within each of the five countries Germany, USA, Canada, Switzerland and the Netherlands. In order to select the most research-intensive research facilities, a ranking of all universities (incl. medical research centers) that have published scientific articles within the field of medicine between the years 2008 and 2010 in two dimensions was created. The first dimension is the absolute number of publications between the years 2008 to 2010[1].

1 A three-year publication window instead of the last available publication year is used in order to balance annual oscillations.

Figure 1 Selection of the most research-intensive research facilities in Germany



Source: Web of Science, Fraunhofer ISI calculations.

Yet, the number of publications only indicates the quantity of the research output of the respective institution. Not only quantity but also quality determines the research strength of a given institution. Therefore, the average citation rate of these publications was used as a selection criterion as the second dimension. This is a simple measure of the quality of scientific publications, which has the advantage of being independent of the size of the respective research institution. From these two indicators those facilities were chosen that are among the top-institutions, both quantitatively and qualitatively, calculated as the arithmetic mean of the ranking of the number of publications and the ranking of the citation rate, within the respective country.

In case several research facilities from one city were identified as belonging to the top institutions, these institutions were aggregated to form a location of medical research (compare Figure 1). For Munich, for example, the Technical University of Munich as well as the Ludwig-Maximilian-University (LMU) in Munich (incl. the affiliated medical research centers) were identified as being among the top research facilities in medical research in Germany. Both were then aggregated to form the research location "Munich". All further bibliometric and patent indicators were then calculated for the location "Munich". Figure 1 shows the selection of the research locations for the example of

Germany. An overview of all analyzed locations as well as the respective facilities can be found in Table 1.

Table 1 Overview of the analyzed research locations and the respective facilities

Location	Facilities	Abbreviation
Berlin	Free University of Berlin, Humboldt University Berlin, Charité	B
Hanover	University of Hanover, Hanover University Medical Center	H
Heidelberg	University of Heidelberg, Heidelberg University Medical Center	HD
Munich	LMU Munich, TU Munich, Munich University Medical Center	M
Tubingen	University of Tubingen, Tubingen University Medical Center	TU
British Columbia	University of British Columbia, UBC Hospital	CA_BC
McMaster	McMaster University, Hamilton Health Sciences - Chedoke McMaster Hospital	CA_MM
Montreal	University of Montréal, McGill University, University of Montreal Hospital Centre, Montreal General Hospital	CA_Mo
Toronto	University of Toronto, University Health Network (Princess Margaret Cancer Centre, Toronto General Hospital, Toronto Western Hospital, Toronto Rehab)	CA_To
Basel	University of Basel, Basel University Medical Center	CH_Ba
Bern	University of Bern, Bern University Medical Center	CH_Be
Geneva	University of Geneva, Geneva University Medical Center	CH_Ge
Zurich	University of Zurich, ETH Zurich, Zurich University Medical Center	CH_Zu
Amsterdam	University of Amsterdam, VU University Amsterdam, Amsterdam University Medical Center	NL_Am
Leiden	University of Leiden, Leiden University Medical Center	NL_Le
Rotterdam	University of Rotterdam, Rotterdam University Medical Center	NL_Ro
Utrecht	University of Utrecht, Utrecht University Medical Center	NL_UT
Harvard	Harvard University, Massachusetts General Hospital - HMS (Harvard Medical School)	US_Ha
Johns Hopkins	Johns Hopkins University, Johns Hopkins Hospital	US_JH
San Francisco	University of California, San Francisco, UCSF Medical Center	US_SF
Texas	University of Texas, Houston, University of Texas Health Science Center at Houston	US_Tx
Washington	University of Washington, University of Washington Medical Center	US_Wa

Source: Compilation by Fraunhofer ISI.

2.3 Identification of academic patents

For the analysis of patent filings from medical research locations, the patents filed by universities have to be differentiated from patents that are based on an invention made within a university. As a result of cooperative projects between universities and companies or in the case of external R&D projects that are carried out by universities on behalf of and financed by companies, inventions arise for which a patent is filed by the company. Frequently, the university is not named on the filing as a patent applicant.[2] A count of the patents, for which the university is named as the applicant, thus provides only a limited picture of the patent output from universities. To draw a more complete picture of the patent output of universities, also inventions that were made within the university and for which a patent was filed by a company, also need to be taken into account to cover the full inventive output of the respective university. Both, university-invented as well as university-filed patents will be called "academic patents" or "patents with university involvement" throughout the remainder of the study.

In order to identify these academic patents, first of all the patents filed by universities were identified within PATSTAT with the help of a keyword search, including the names of the universities with different spelling variations and languages as well as a search for the names of the respective cities, also including spelling variations and languages. In the case of the Technical University of Munich, for example, patents are filed under the names "TECHNICAL UNIVERSITY OF MUNICH", "TECHNISCHE UNIVERSITAET MUENCHEN", or "TU MUENCHEN". For the corresponding medical research centers, the name of each city and the term "clinic" in the applicant name were employed.

The approach for the identification of the whole set of academic patents, including university-invented patents, is based on the examination of name matches of authors of scientific publications and inventors named on a patent filing. As a matter of fact this basically covers only research-active individuals who publish articles in scientific journals. A detailed description of the matching and its validation can be found in Dornbusch et al. (2013). The analyses were performed with the Scopus database (2013 version) as Scopus, in contrast to WoS, provides full first names of authors as well as an author-affiliation-linkage for all publication years, which are necessary for the matching. This data was matched with PATSTAT.

With a growing amount of data the matching of the names of the authors and inventors leads to an increasing number of homonyms and thus erroneous classifications of patent filings to universities. Therefore, the application of the selection criteria is required. Figure 2 shows these selection criteria.

2 As the legal systems and patent law differ, this phenomenon might be more or less pronounced in the selected countries.

Figure 2 Selection criteria for academic patents

2) Organization	3) Names	4) Time	5) Location	6) Subject

$$x_{\text{uni-inv}} = 1 \text{ if } (a_{\text{names match}} + b_{\text{time match}} + c_{\text{location match}} + d_{\text{subject match}})$$

	Organization matching	Name matching	Time window matching	Location matching	Classification matching
PATSTAT	?	Full strings of last- and first name	Priority year	NUTS3-Codes and distance matrix	IPC classification = WIPO 34
SCOPUS	Author affiliation = university	Full strings of last- and first name	Publication year: One year time-lag and time-window	NUTS3-Codes and distance matrix	Scopus classification: fine- / coarse-grained

Source: Adapted from Dornbusch et al. (2013).

Besides the information on the country of the inventor, the institution/organization, the full names and a time window between the priority year of the patent and the publication year of the scientific publication were used. Based on the "affiliation IDs" and a keyword search, the publishing medical facilities as well as their publications were identified within Scopus and stored in a separate table. On the patent side, all transnational patent filings of the five relevant countries within the field of medicine, i.e. pharmaceuticals, medical instruments, electronic medical instruments, were stored within a separate table. The author-/inventor names from these two tables were then used for the matching.

We applied a time window of two years with a one year delay of the patent filing to take account of the review process for journal articles. For example, the inventors named on a patent filing from the priority year 2006 were matched with the authors of the publication cohort from the years 2007/2008.

A further selection criterion is the match of the inventor address with the location of the university. Here, the NUTS3 code according to the NUTS classification (nomenclature des unités territoriales statistiques) of the OECD was applied. To address the problem of rigid regional definitions, we additionally worked with a distance matrix, which also allows adjacent regions to be taken into account by the matching. As a standard, a distance of 30km was used. Only for the state of Texas the distance had to be extended to 100km as an analysis of the distances between individual inventors revealed a significantly larger radius than in other states. Since there is no distance matrix available for Canada, only the exact location could be taken into account.

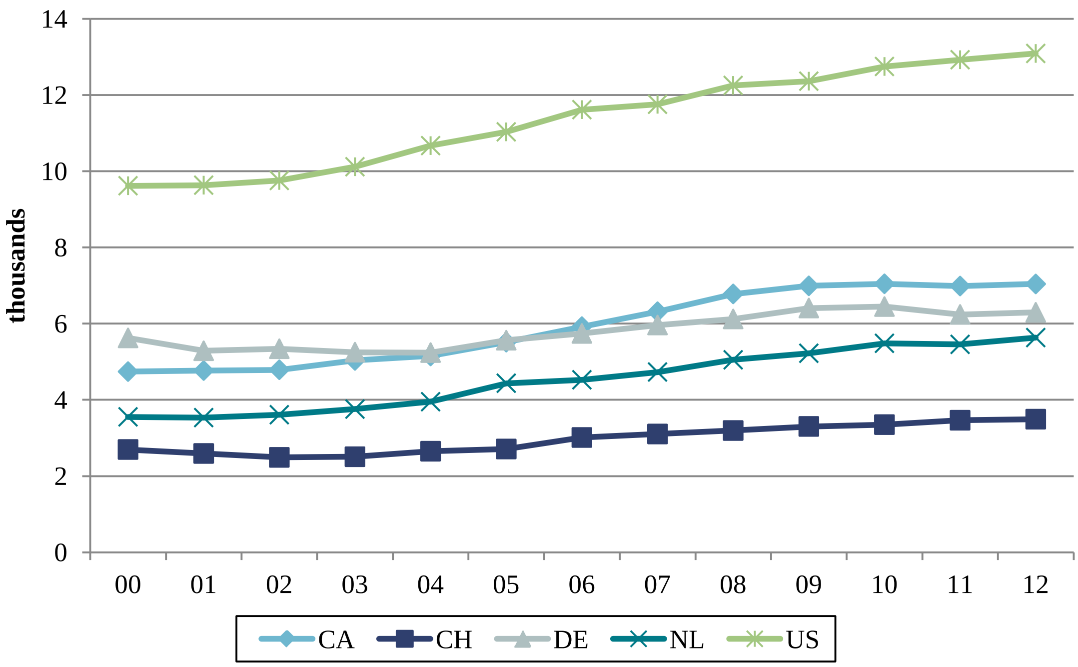
In order to ensure a content-related correspondence between the matched documents, a concordance between technology fields based on the existing WIPO34 classification (Schmoch 2008) and the science fields within Scopus, was additionally employed. For the verification of the selection criteria and the results of the matching, an estimate of the proportion of correctly identified documents in all documents (recall analysis) was performed. Finally, the precision of the algorithm was randomly checked.

3 Results

3.1 The five medical locations in an integrated overview

Before digging deeper into the specific analysis for the single research locations, we take a closer look at the country-specific trends within medical research by analyzing all of the selected research locations in combination and relating their publication output to the national as well as the worldwide publication output in medical research.

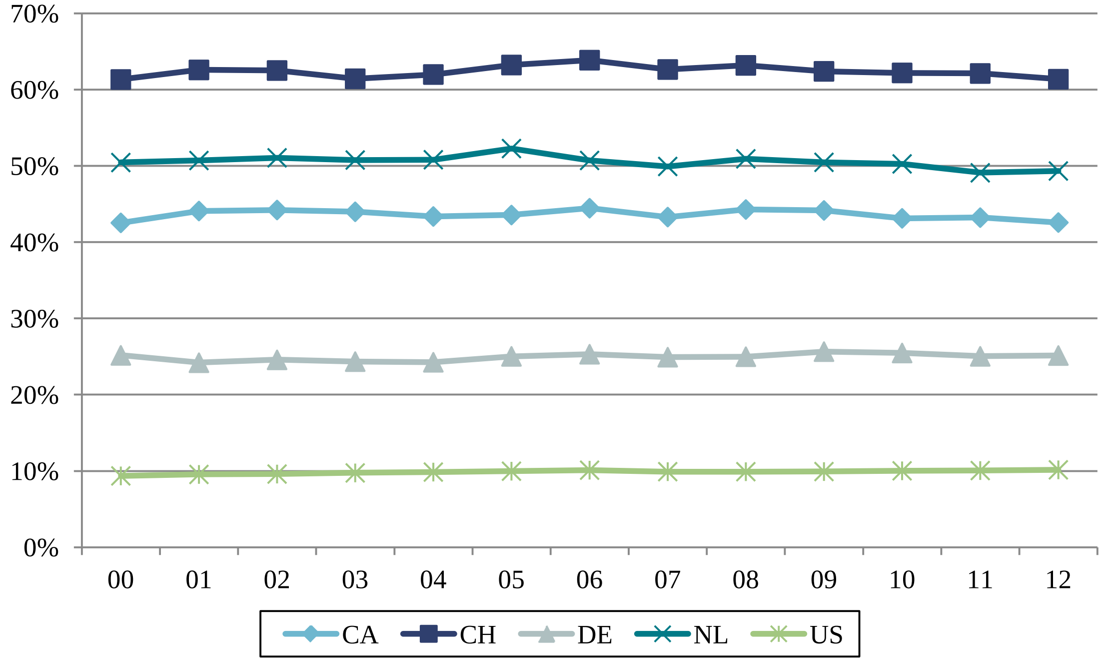
Figure 3 The absolute number of publications by the analyzed research locations in each country, 2000-2012



Source: Web of Science, Fraunhofer ISI calculations.

Figure 3 first of all shows the absolute number of publications by the analyzed research locations in each country from the year 2000 to 2012. The U.S. locations clearly are responsible for the largest number of publications in medical research, and the number of publications is constantly increasing over the years, at least from 2003 onwards. This increase in the number of publications can be observed for all the countries under analysis, yet they operate at a lower level than the U.S. in absolute terms. The Canadian medical research locations are responsible for the second largest number of medical publications, closely followed by Germany and the Netherlands. The locations from Switzerland have the smallest publication output in the international comparison.

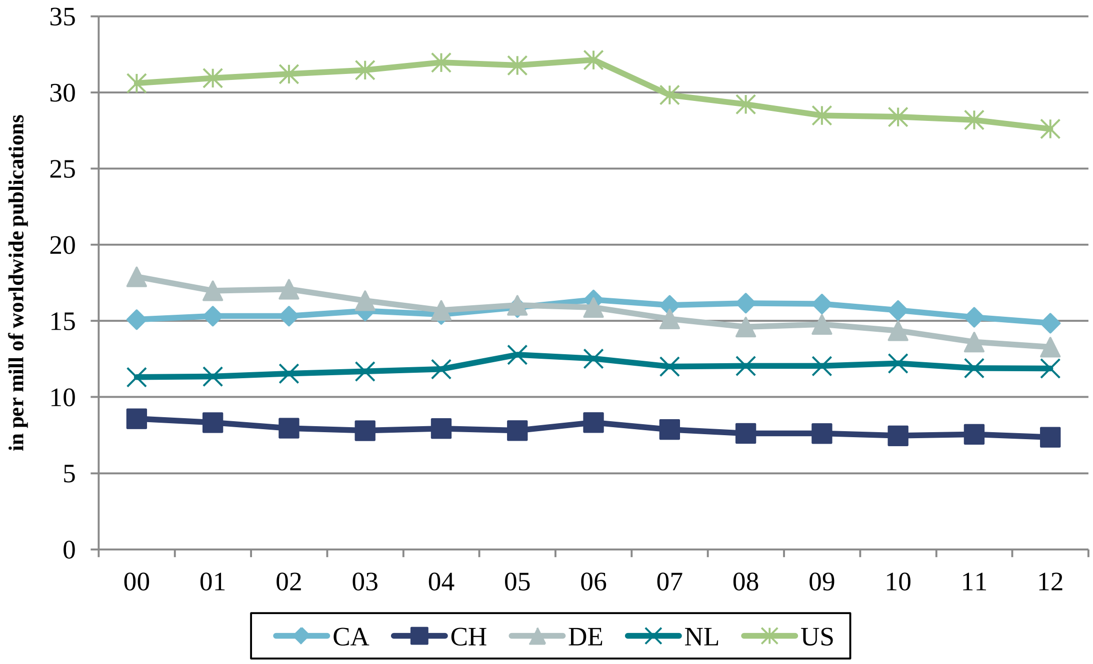
Figure 4 Share of publications in total national publications of the analyzed research locations per country, 2000-2012



Source: Web of Science, Fraunhofer ISI calculations.

In Figure 4, the share of publications in total national publications of the analyzed research locations per country is depicted. Here it becomes obvious that although the U.S. medical research locations have the highest absolute number of publications in comparison, their share of publications in total national publications in the field of medicine is relatively low. Only about 10% of total national publications stem from the five analyzed locations. In Switzerland, on the other hand, the analyzed locations are responsible for a share of more than 60% of total national publications within the field. This implies that scientific research is highly concentrated on the analyzed locations in Switzerland, whereas it is rather diversified in the USA. In the Netherlands and in Canada, medical research also seems to be mostly centered within the selected research locations with shares of nearly 50% and about 45%, respectively. Germany is closer to the U.S. on this indicator and the shares are about 25%. Only one fourth of medical research in Germany is thus performed by the analyzed locations.

Figure 5 Share of publications in worldwide medical publications of the analyzed locations per country, 2000-2012



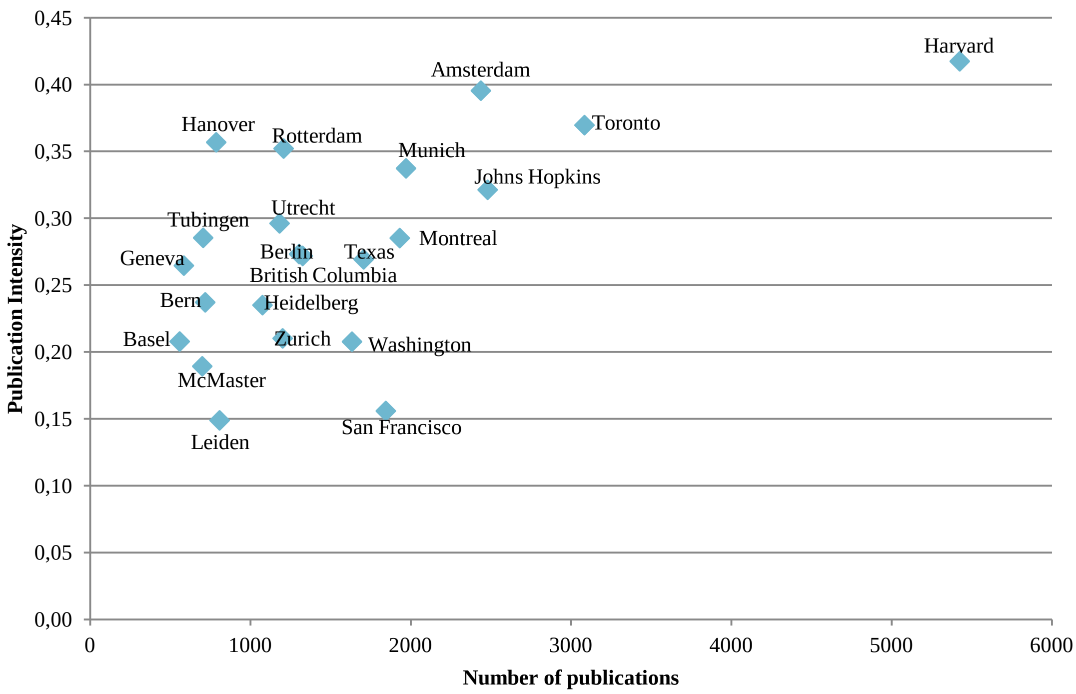
Source: Web of Science, Fraunhofer ISI calculations.

Finally, Figure 5 presents the share of publications in worldwide medical publications of the analyzed locations per country. The picture is very similar to what we have learned from the absolute numbers in Figure 3, at least when looking at the differences between the countries, i.e. the U.S. locations have the largest worldwide shares in medical publications, followed by Canada, Germany, the Netherlands and Switzerland. However, the striking difference to the absolute numbers is, that the shares are declining – to some extent - for all analyzed countries except for the Netherlands and to a certain extent also Switzerland. Especially the shares of the U.S. locations are declining from the year 2006 onwards. However, this mostly has to do with rising shares of medical publications from institutions from other countries, for example China. This means that, although the absolute number of publications is steadily increasing for the U.S. universities, new players enter the scene, which leads to the decreasing shares of the analyzed countries.

3.2 Scientific Publications in Medical Research

In this section we take a closer look at the publication trends within the top-location in medical research, in order to give an overview of the scientific performance of the institutions under analysis. We start with the absolute number of publications as well as the publication intensity per research location for the year 2012, which is shown in Figure 6. The publication intensity was calculated as the number of medical publications divided by the number of residential authors within medical research. The number of authors of the respective research locations was calculated with the help of the database Scopus[3].

Figure 6 Number of publications and publication intensity by research location, 2012



Source: Web of Science, Scopus, Fraunhofer ISI calculations.

The world's most publication-intensive location of medical research is Harvard University, including its affiliated medical research center. This is not only true in absolute terms, which in part also reflects a size effect, but also in terms of the publication inten-

3 In WoS, authors cannot be identified unambiguously. This is online possible within the Scopus database, where each author is assigned a unique author identifier.

sity. Followed by the locations Amsterdam and Toronto, the number of publications per author in Harvard is highest.

When taking a closer look at the publication intensity, it can be found that Leiden is the least publication-intensive medical research location within the group of the most research-intensive locations in medical research, which also applies to the absolute number of publications. However, also the universities of San Francisco, McMaster, Basel, Zurich and Washington reach similar publication intensities.

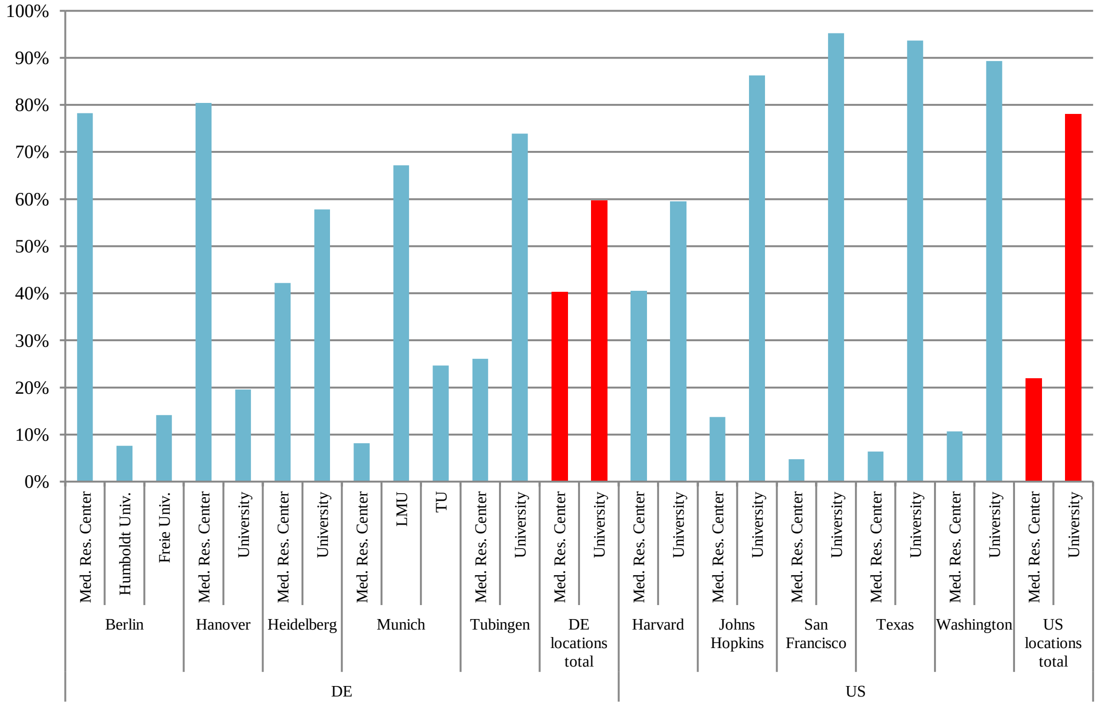
Measured in absolute as well as relative terms, the German universities generally score within the middle ranks compared to the rest of the universities under analysis. This is especially true for Heidelberg, Berlin and Tubingen. Munich and Hanover, however, score among the top ranks, especially when looking at the publication intensities. Although, in absolute terms, Munich publishes more than Hanover, the publication intensity of Hanover is highest in the national comparison.

To illustrate how many publications are published by the universities themselves and by the respective medical research centers, Figure 7 depicts the shares of the universities and medical research centers in the entire medical publications of the respective location of the U.S. and Germany within the period 2010 to 2012.

Comparing the total shares of universities and medical research centers, it can be found that medical research centers in Germany are responsible for higher publication shares than the centers in the United States. The German university hospitals are responsible for about 40% of the medical publications of the analyzed institutions, 60% stem from the universities themselves. In the U.S., the share of medical research centers is only about 22%, while the universities themselves account for 78% of medical publications. Harvard slightly deviates from this general U.S. pattern, as a share of 40% can also be found here.

In the case of Germany, this overall effect is mediated strongly by the location of Berlin (Charité) and Hanover. At these locations, the proportion of publications from the clinics reaches about 80%. In Heidelberg, Tubingen and Munich, the University shares are higher than those of the hospitals. In Munich most medical publications stem from the LMU. In the U.S., the shares of the respective clinics are consistently lower than those of the universities. This effect is particularly strong in San Francisco. Yet, also in Texas, Washington and at Johns Hopkins University, the proportion of publications from the universities exceeds the 80% mark. Only at the University of Harvard, the proportion of the publications of the medical research center is comparably high.

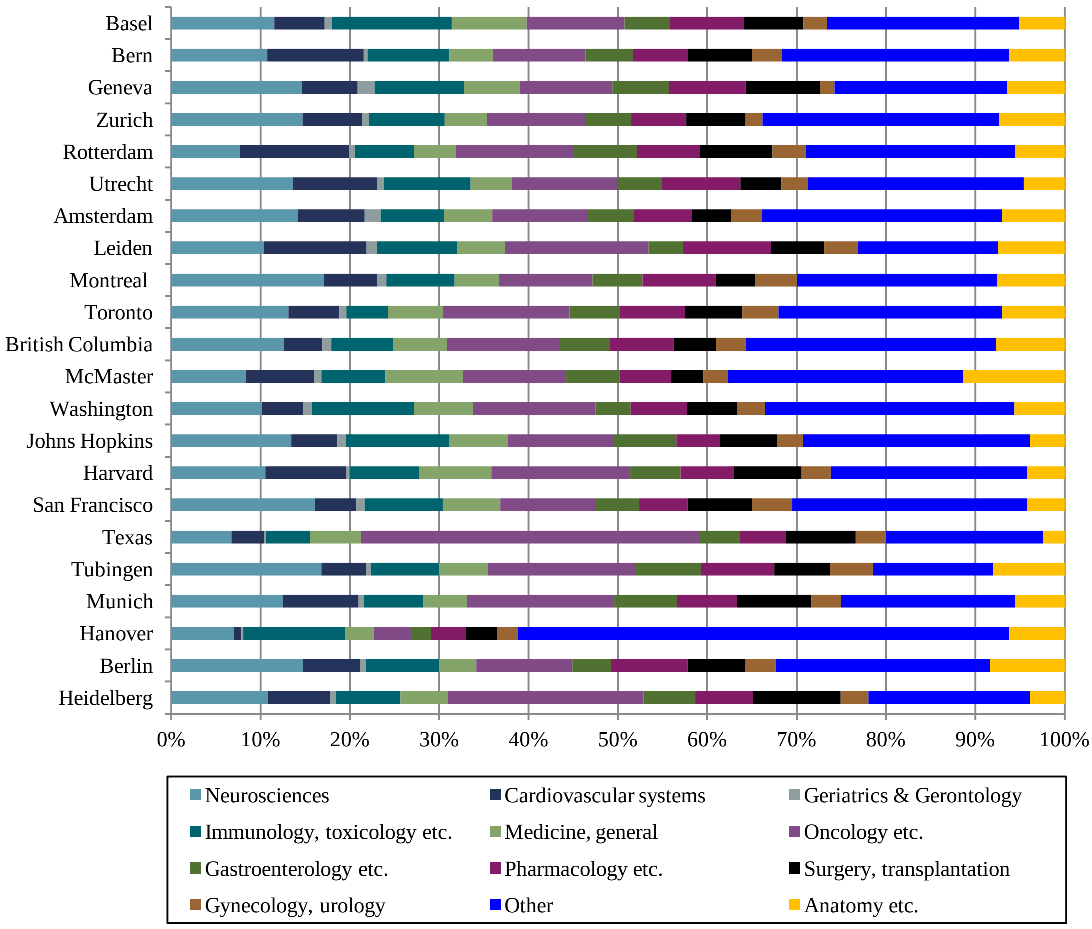
Figure 7 Share of universities and medical research centers in total publications of the respective research location, Germany and USA, 2010-2012



Source: Web of Science, Fraunhofer ISI calculations.

In Figure 8 we take a closer look at the field-specific publication trends within the medical research portfolio of the respective research locations. To be more precise, the shares of publications by scientific disciplines in medical research for the period 2010 to 2012 are plotted. As we can see from the figure, each of the universities has a rather differentiated portfolio and is actively publishing in all of the different sub-disciplines. Among the largest fields differentiated here are – next to the field "others" – neuroscience, immunology, and oncology. Gynecology and urology as well as geriatrics and gerontology are the smallest disciplines across all universities. A large number of research locations publish in neurosciences. Montreal, Tubingen, San Francisco, Berlin, Zurich and Geneva reach shares of more than 15% in this area of medical research. In immunology, the institutions in Basel, Johns Hopkins, Washington, Hanover, Geneva and Utrecht have the highest shares with more than 10% of their publications in this field. Oncology is an outstanding area of engagement in Texas with almost 38%. The German locations Heidelberg (22%), Munich (18%) and Tubingen (18%) also put a certain focus on oncology, similar to Leiden or Harvard. Hanover in Germany has the highest share of about 55% in the field "other", which comprises subfields like andrology, dentistry, dermatology, gerontology, general medicine, pathology, pediatrics, or also veterinary sciences.

Figure 8 Shares of publications by scientific disciplines in medical research, 2010-2012

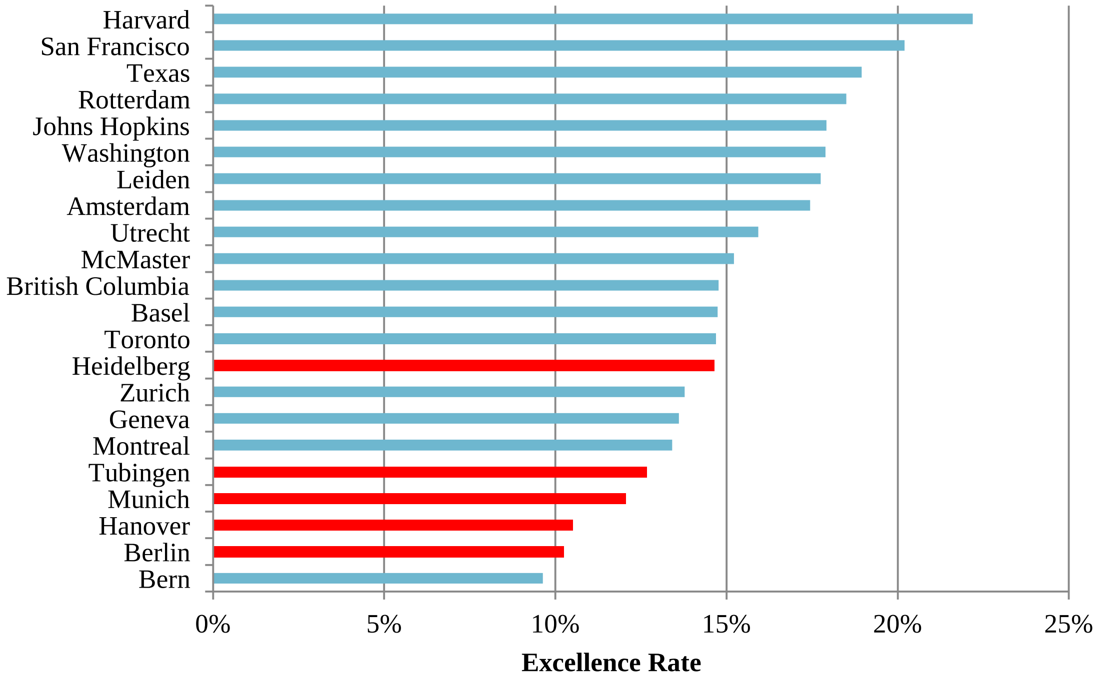


Source: Web of Science, Fraunhofer ISI calculations.

We now switch the focus from the quantitative assessment of the publications of the universities to the quality of the publications. Figure 9 shows the excellence rate of the respective locations for the year 2010. The excellence rate is calculated as the number of publications that belong to the 10% worldwide most cited papers in medicine in relation to all medical publications of the respective location.

The highest excellence rates within medical research are obtained by American universities, especially Harvard University, followed by San Francisco and Texas. The only non-American university which scores in the top group of this indicator is the University of Rotterdam, followed by the Johns Hopkins University and the University of Washington. The German universities mostly score on the lower ranks within our comparison group. The exception is the University of Heidelberg, which is able to claim a place in the mid-field. While the University of Heidelberg publishes less (overall and per capita) than the other locations in Germany, the publications seem to be of the highest quality compared to the remaining German university locations.

Figure 9 Excellence rate of medical research locations, 2010

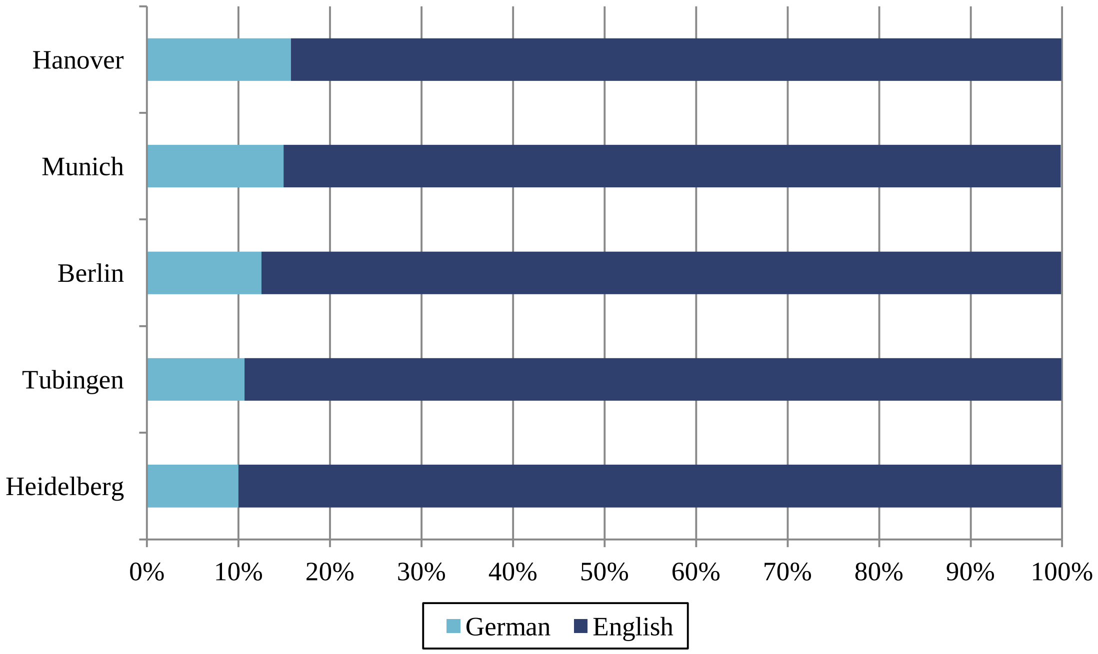


Source: Web of Science, Fraunhofer ISI calculations.

Overall, the ranking by this indicator seems to be rather country-specific. With few exceptions, the highest excellence rates can be achieved by the U.S. universities, followed by the Netherlands, Canada, Switzerland and Germany. However, it has to be noted that publications in journals with an U.S. editorship generally have a broader readership and are cited above the world average (Schmoch et al. 2012), which is at least partly responsible for the ranking at hand. Getting a scientific article published in a U.S. journal is comparatively easier for authors from the United States than for authors from other countries, which is not least also mediated by linguistic differences.

This becomes clearer when looking at Figure 10 which depicts the share of German and English publications in all publications of the respective German universities. We can see that between 80% and 90% of all medical publications from German universities are published in English. The largest share of German publications stems from the University of Hanover, followed by Munich and Berlin. For the University of Tubingen and Heidelberg, only about 10% of all medical publications are published in German, and thus in journals with a smaller potential readership group.

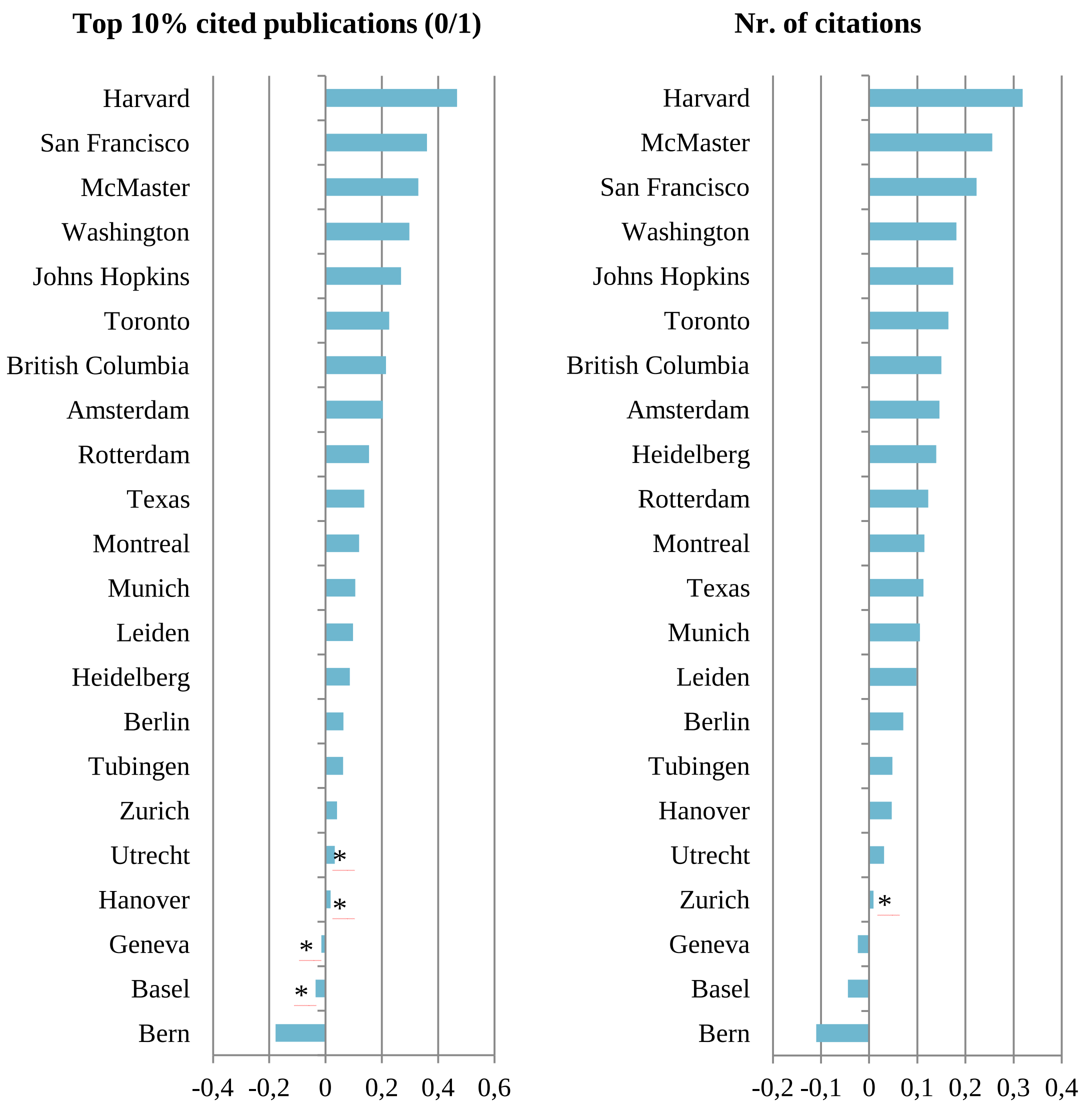
Figure 10 Share of German and English publications in all medical publications by universities, Germany, 2001-2012



Source: Web of Science, Fraunhofer ISI calculations.

This result is in line with the analyses of (Schmoch et al. 2012), who found that German authors increasingly publish in journals with an American editorship, where the citation rates are generally higher. In order to control for this effect, we also performed a multivariate analysis at the level of single publications with the excellence rate (dichotomous) and number of citations a publication receives as dependent variables. Within these regression models (negative-binomial in the case of the number of citations and a logit model in the case of the excellence rate) we were able to control for, country-, period- (2000-2010), as well as field-specific effects, which might also influence the citation rates, in order to isolate the effects of the publications from the different universities. We additionally controlled for the fact if a publication has been published with one or several national and international co-authors, as well as the number of authors named on a publication, as these might also influence the citation rates.

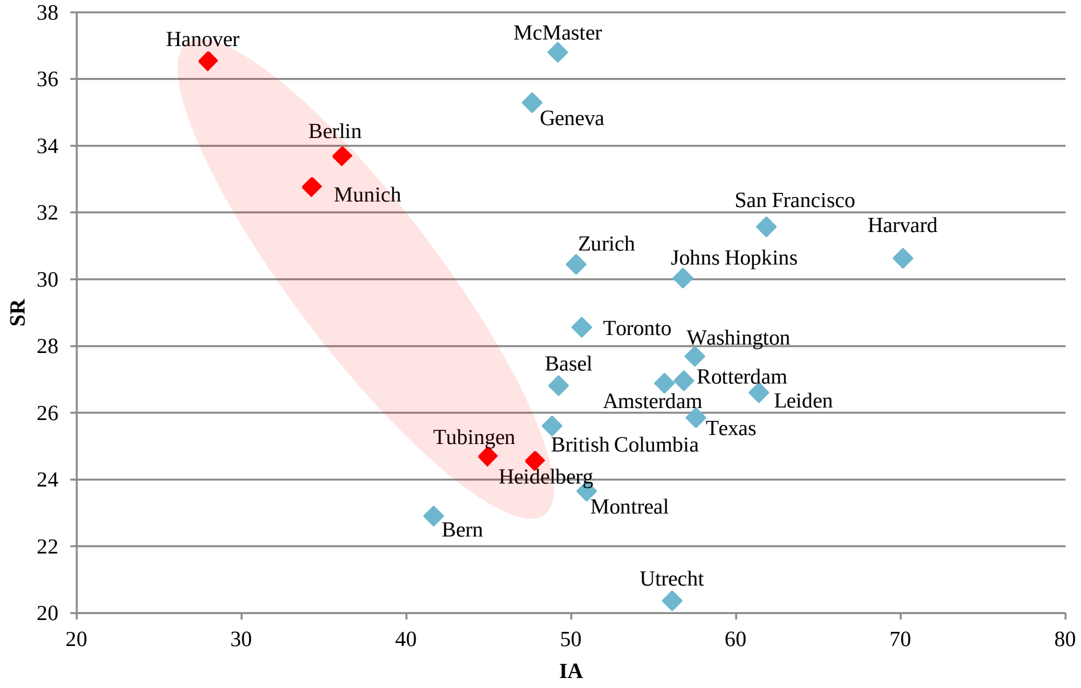
Figure 11 Model Coefficients of the medical research locations



Source: Web of Science, Fraunhofer ISI calculations.
Note: *=effect not significant.

Figure 11 depicts the model coefficients of the universities for the number of citations as well as the variable which shows if a publication belongs to the top 10% most highly cited publications in the field of medicine. The full set of results of the models is provided in the annex. It is evident from the figure, that Harvard University has the highest number of citations and the highest probability to be in the Top10% of the most highly cited journals in medical research, also when controlling for other factors. Similar effects can be found for the remaining U.S. universities that also show high coefficient values on both indicators, except for the University of Texas which scores in the middle ranks. When looking at these two indicators the German universities are mostly located in the medium to lower ranks, although Heidelberg follows up the U.S. and Canadian universities when it comes to the number of citations.

Figure 12 International Alignment (IA) and Scientific Regard (SR) of the medical research locations, 2010



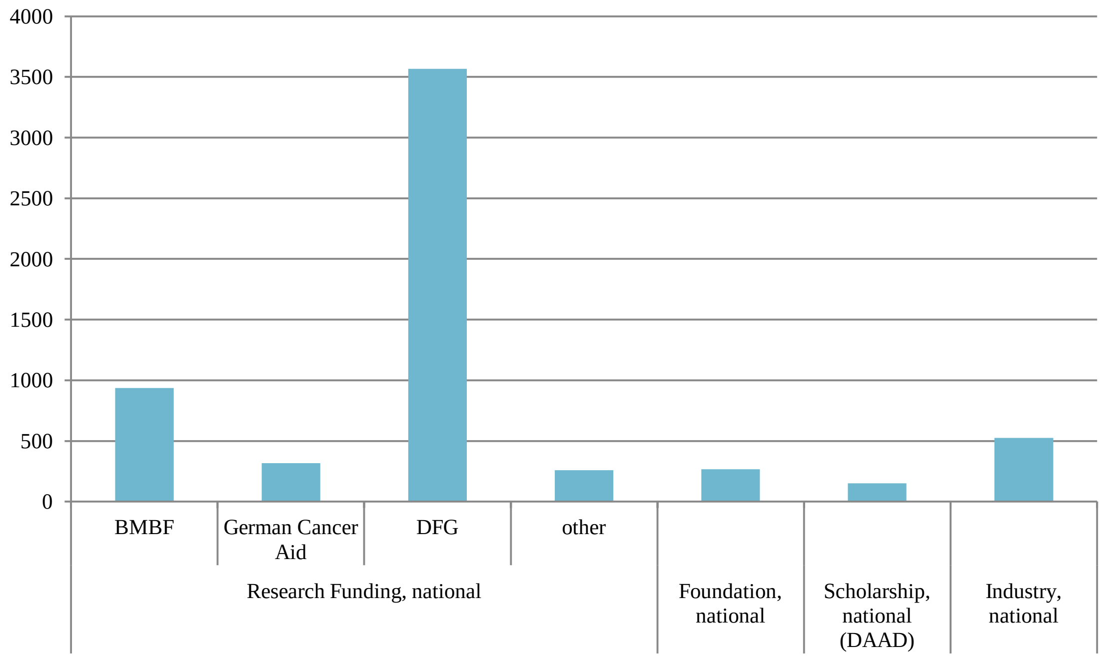
Source: Web of Science, Fraunhofer ISI calculations.

Figure 12 shows the indicators International Alignment (IA) and Scientific Regard (SR) in comparison. While the IA denotes the average dissemination of publications in internationally more or less visible journals, the SR shows the relative citation rate a location receives compared to the average citation rates of the journals in which it publishes (journal normalized citation rates). This implies that high SR values are harder to achieve when IA values are high. High SR values can more easily be accomplished in journals with low average citation rates, which in general are the journals that are internationally less visible. Put more simply, it is hardest to achieve an above average number of citations in journals that are internationally highly cited.

Taking a closer look at Figure 12 reveals that Harvard University has the highest average IA value and still a comparably high SR. This is similar for the University of San Francisco and Johns Hopkins University, which both, however, have slightly lower IA values.

As for the German locations (in red), two rather distinct patterns can be observed. While Hanover, Berlin and Munich reach relatively high citation rates – Hanover even ranks second on this indicator after McMaster University - with an IA-wise low profile, medical locations like Tubingen and Heidelberg are on the other side of the spectrum with a high IA but relatively low SR value. Hanover, Berlin and Munich rather target internationally less visible journals but receive a comparably high number of citations. Heidelberg and Tubingen are more internationally oriented, yet their publications in those journals are cited below average. The locations from the Netherlands all have similar publication profiles with relatively high IA and medium SR values.

Figure 13 National funding sources mentioned in the acknowledgements of German publications in medicine, 2010.

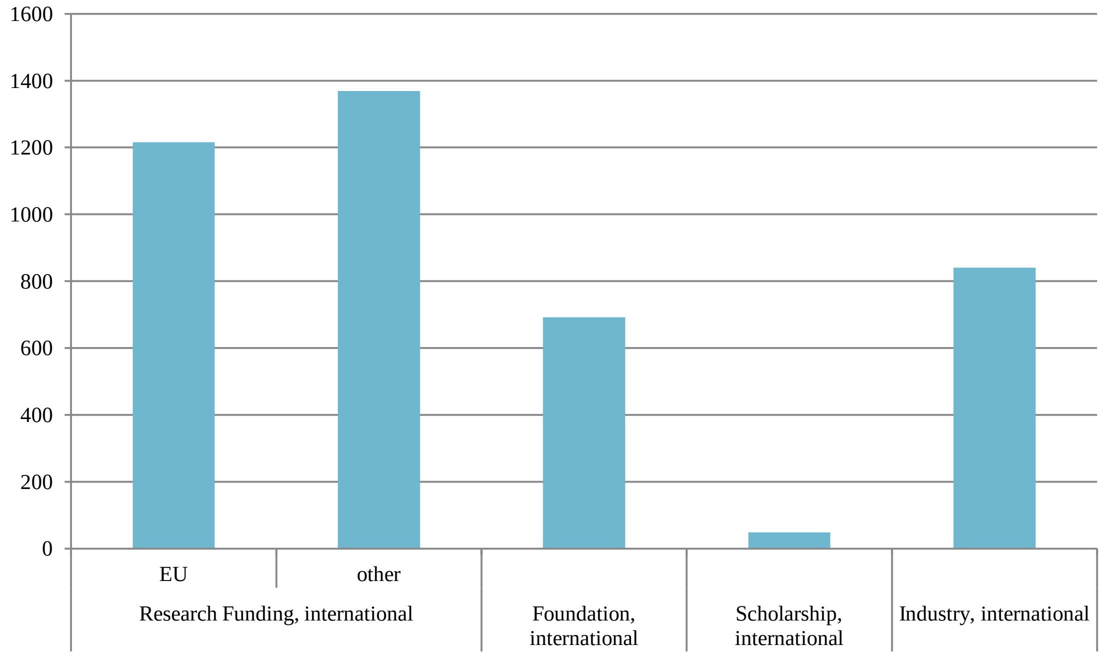


Source: Web of Science, Fraunhofer ISI calculations.

When thinking about publications, another interesting question that comes up is the question of the funding sources for the research on which these publications are based. Figure 13 shows the national funding organizations that are acknowledged in German publications in medicine. It becomes apparent that especially research funding by the German Research Foundation (DFG) as well as the German Federal Ministry for Education and Research (BMBF) are major funding sources for German medical research. However, also the national industry is relatively often mentioned as a funding source. National foundations as well as scholarship programs play a minor role here.

International funding sources (Figure 14) are less common than national funding sources. Still, the EU and other international research funds can be seen as driving forces for funding medical research in Germany. Also funding from international industry plays a major role here, the numbers even exceed national industry funding. To a lesser extent this is similar for international foundations. International scholarships play a rather subordinate role for funding medical research in Germany.

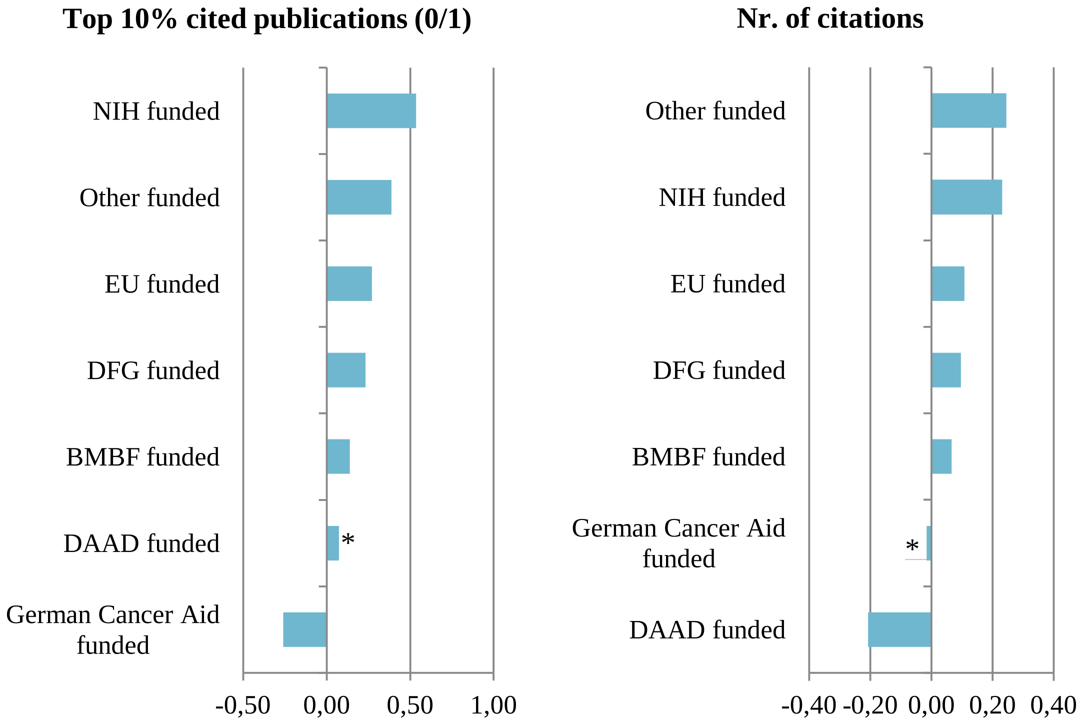
Figure 14 International funding sources mentioned in the acknowledgements of German medicine publications in 2010.



Source: Web of Science, Fraunhofer ISI calculations.

In sum, it can be stated that national research funding by the DFG and the BMBF are the most important funding sources for German medical research, followed by the EU and other international research funding. Industry also plays a role here, although international industry seems to be more important than the national industry, which is also true for international foundations. Scholarships, national as well as international, are relatively rarely used as a funding source for medical research publications in Germany.

Figure 15 Model coefficients for the different funding sources



Source: Web of Science, Fraunhofer ISI calculations.
Note: *=effect not significant.

However, not only the extent of funding from different sources is an important factor in our analyses. It is also important to get an idea of the effects different funding sources can have on the quality of publications. We therefore calculated similar regression models as mentioned above, also including the information which source funded a publication.[4] Yet, we had to restrict the analyses to the years 2009 and 2010 as the information on funding acknowledgements was not available in the previous years. Figure 15 shows the results of these regression models. It is evident that publications from NIH-funded research are most likely to belong to the top 10% cited publications in medical research worldwide, followed by other funding sources and the EU. The national funding sources, i.e. the DFG, BMBF, DAAD and German Cancer Aid, score lower on this indicator. Similar observations can be made for the number of citations. Although "other

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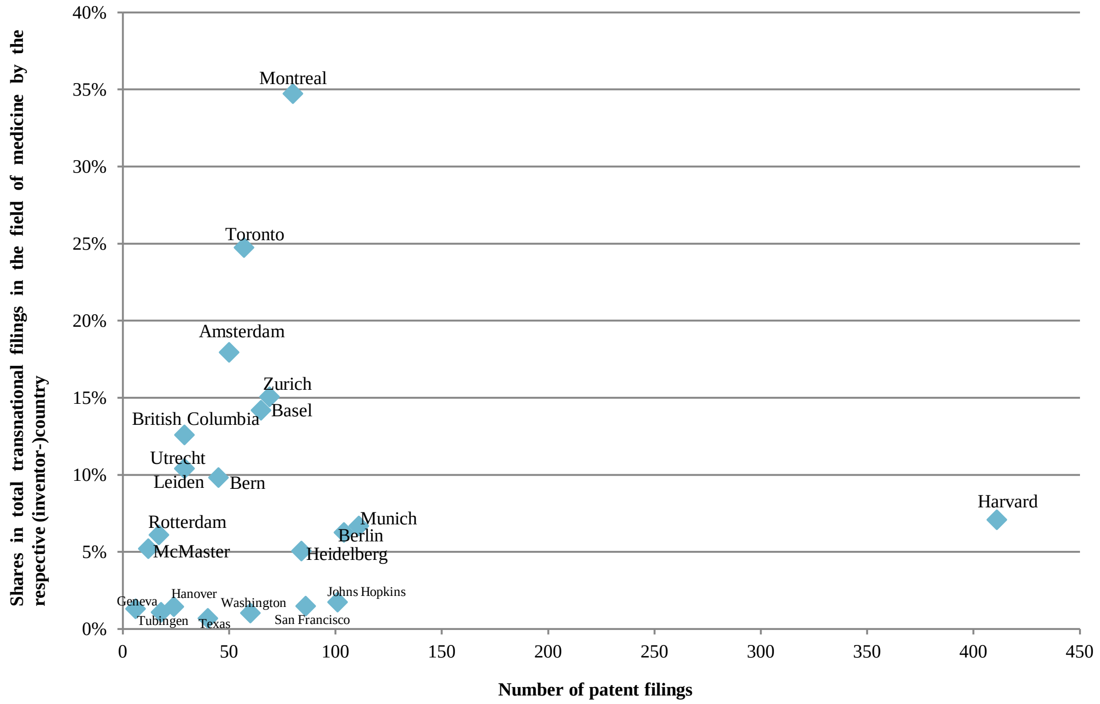
4 We use information from the acknowledgements in publications to find out who funded a particular research project. Since not every source of funding is mentioned in the acknowledgements, i.e. we do not have complete information on the funding, we restrict the analysis to publications which we know have been funded. We thus cannot differentiate between funded and non-funded projects in our analyses but only compare different sources of funding.

funding sources" and the NIH switch ranks, publications stemming from nationally funded research projects receive a smaller number of citations than internationally funded projects, also when controlling for country-, field- and period-specific effects.

3.3 Academic Patents

In this section, the trends in academic patenting for the top locations in medical research will be analyzed. As already stated above, patents indicate the interest in the commercial exploitation of a new finding or a new technology and thus are more strongly focussed on measuring an orientation towards the technological application of a given invention.

Figure 16 Number of transnational patent filings and shares in total transnational filings in the field of medicine by the respective (inventor) country, 2009

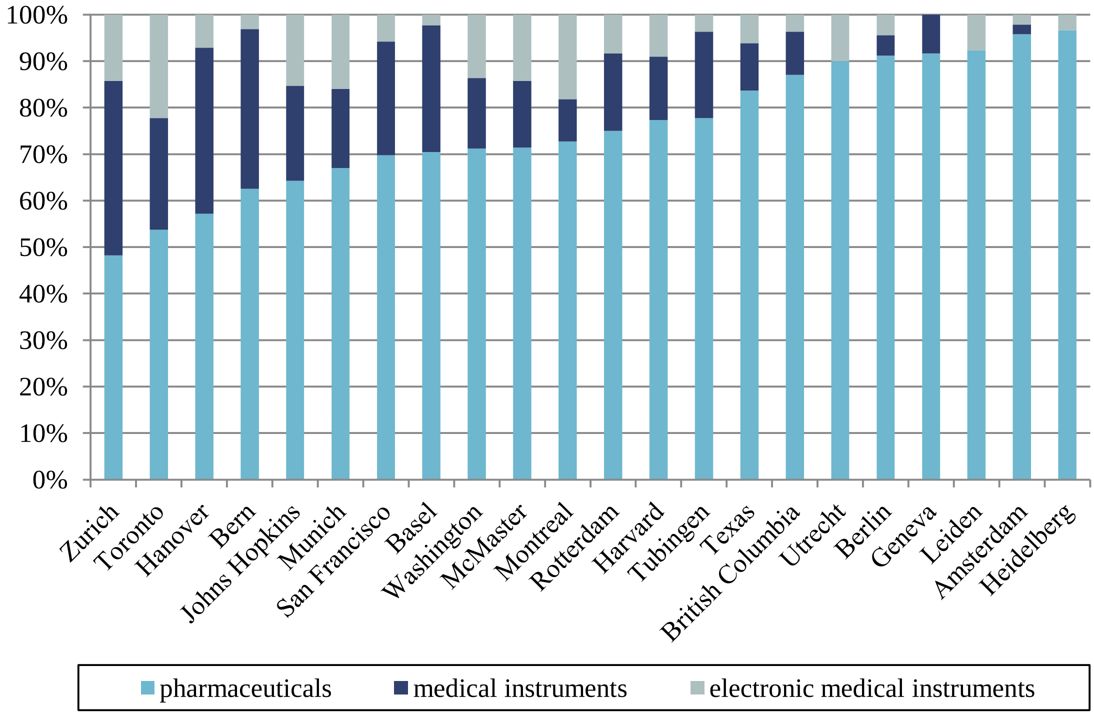


Source: EPO - PATSTAT, Fraunhofer ISI calculations.
Note: The smaller font size of some locations within this figure is only for the sake of better visibility.

In Figure 16, the absolute number of transnational medical patent filings and their shares in total transnational filings in the field of medicine by the respective (inventor) country for 2009 are shown. It is evident that the University of Harvard files the largest number of transnational patents compared to all other locations. It is followed, at least in absolute terms, by the German locations Munich and Berlin, and the Johns Hopkins University. Overall, the German and American universities file the largest number of transnational patents within the field of medicine. Interestingly, however, the patent shares in total transnational filings by the respective (inventor) country show that the German and American locations achieve comparably lower numbers. The highest shares can be found for Montreal, followed by Toronto. In sum, these two locations account for almost 60% of all Canadian transnational patent filings in medicine. Also the locations Amsterdam, Basel and Zurich reach rather high shares in the respective national medical patent portfolio. This means, on the one hand, that medical research in universities is rather concentrated in Switzerland, Canada and the Netherlands, due to a size effect. The two larger countries, Germany and the USA, have a number of research facilities beyond the 4-5 locations we observe in our analysis. On the other hand, this means that the medical research – in these cases mainly in the field of pharmaceuticals – is to a large extent conducted in industry. While Canada and also the Netherlands are not the home of large pharmaceutical companies holding research facilities there, the USA and Germany domicile a number of pharmaceutical and also medical instrument firms with a large patent output. In the case of Switzerland, this explanation is somehow counterintuitive, but Swiss pharmaceutical companies do not conduct all research in Switzerland. So, the locations under observation here are of different relevance for the medical research within the countries with respect to patent output.

In Figure 17 we take a closer look at the field-specific patenting trends within medical research. Therefore, the shares of transnational filings in the field of medicine by the respective subfields for the year 2010 are plotted. It becomes obvious, that the largest share of patents in medicine by universities and adjacent clinics falls into the category of pharmaceuticals. At the universities Heidelberg, Amsterdam, Leiden, Geneva and Berlin this share even exceeds 90%. The smallest shares in pharmaceuticals can be found in Zurich, Toronto and Hanover, where medical instruments play a relevant role. However, also here the shares in pharmaceuticals are in the range of 50%.

Figure 17 Shares of transnational filings by subfields in medical research, 2010

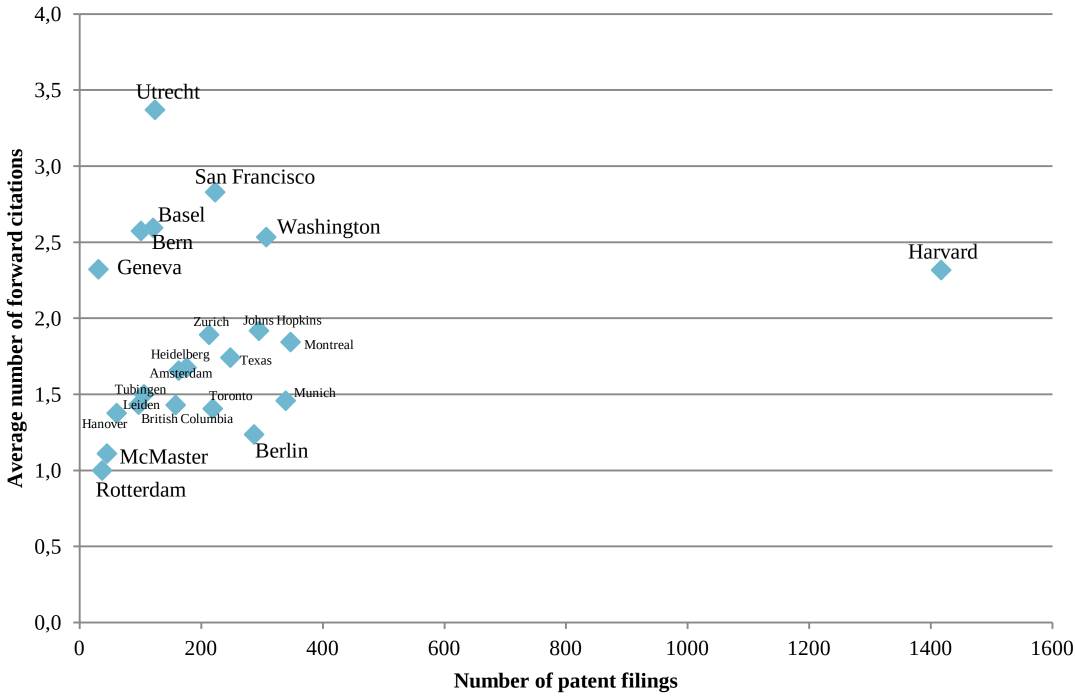


Source: EPO - PATSTAT, Fraunhofer ISI calculations.

Figure 18 shows the number of transnational medical patent applications at the respective locations in relation to the average number of patent forward citations within the period 2005 to 2007. Thus, in addition to the quantity of patent filings here, also the quality dimension is depicted. The number of forward citations indicates the degree to which a patent contributes to the development of further technologies, and thus represents the technological significance of a patent (Albert et al. 1991; Carpenter et al. 1981).

Transnational patent filings by the University of Utrecht are most frequently cited by subsequent patents, even if the absolute number of patents from the University of Utrecht is at the lower end of the scale. Patent filings from the University of Utrecht thus seem to have a rather high technological significance. The same applies to patent filings from San Francisco, Washington and Harvard. The Swiss locations Basel, Bern and Geneva show quite high values on this indicator. These are followed by a great midfield of locations from all countries, with an average between 1.5 and 2 forward citations per patent filing. Rotterdam, McMaster University and Berlin are last on this indicator.

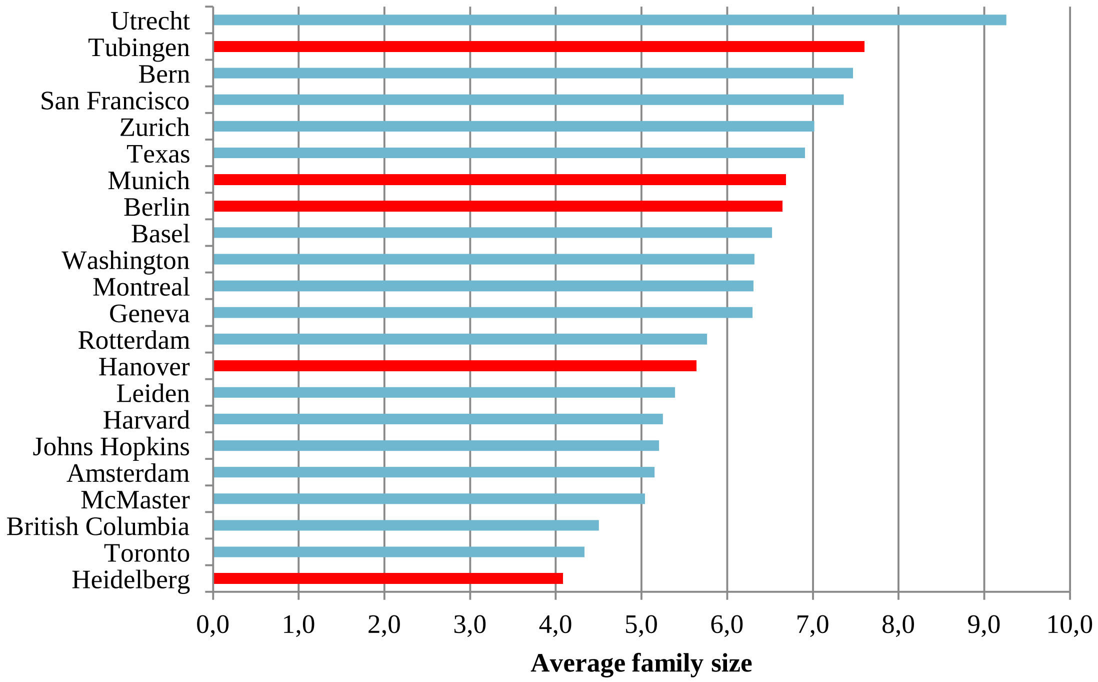
Figure 18 Number of transnational filings within the field of medicine and average number of forward citations, 2005-2007



Source: EPO - PATSTAT, Fraunhofer ISI calculations.
Note: The smaller font size of some locations within this figure is only for the sake of better visibility.

In order to capture the breadth of the universities' patent portfolios in terms of the markets they cover, the average family size of the patent filings in the field of medicine for the time period 2005-2006 is calculated (Figure 19). Usually, patent applicants from smaller countries have larger family sizes on average, i.e. they target more patent offices with their filings, because the domestic market is smaller (Frietsch/Schmoch 2010; Neuhäusler/Frietsch 2012). The largest family sizes can be found for the University of Utrecht. Academic patents filed by the University of Utrecht on average target about 9 different patent offices. The University of Tubingen scores second concerning this indicator with an average family size of 7.5. Similar values can be achieved by the University of Bern and the University of San Francisco. Munich and Berlin almost have the same average family size within the time period 2005-2006. The University of Heidelberg is in last place according to this indicator and thus seems to have a patent profile that is more focused on the national market, at least in the field of medicine. Similar values can be found for the Canadian Universities Toronto, British Columbia and McMaster, which also seem to be operating in a fewer number of markets than most of the other universities in the comparison group. Yet, this could be explained by the adjacent market of the U.S., which still is the largest market for high-technology products worldwide. Next to the Canadian home market, Canadian companies as well as universities seem to perceive it sufficient to protect their IPR there.

Figure 19 Average family size within the field of medicine, 2005-2006

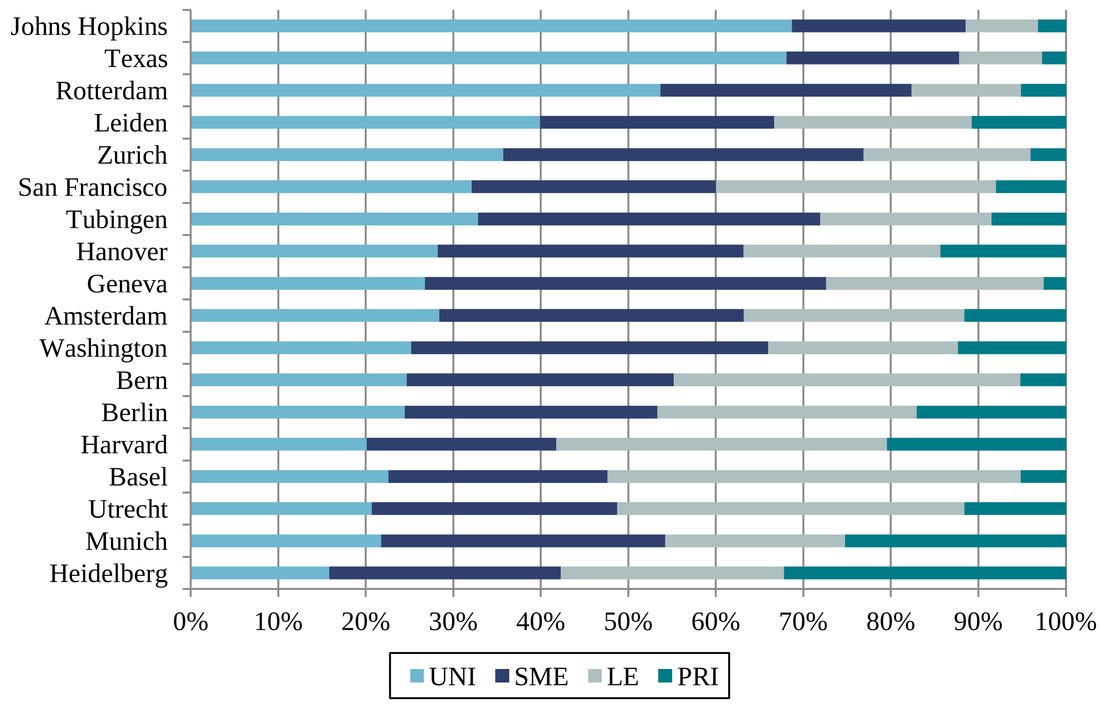


Source: EPO - PATSTAT, Fraunhofer ISI calculations.

In a final step, we differentiate the academic patents of the University locations by the type of the patent applicant. This gives us an idea of how strongly universities cooperate with partners from industry, or public research institutes. Yet, this indicator has to be interpreted very carefully as a large share of inventions commercialized by the university itself does not necessarily mean that the university only has few collaborations. However, this could also point to the fact that it has a commercialization strategy that is focused on filing patents by themselves and commercializing them afterwards by licensing. In addition, the indicator is influenced by different patent laws in the different countries.

To differentiate the type of the applicant, i.e. if it is a small or medium-sized enterprise (SME), a large enterprise (LE), a university (UNI) or public research institute (PRI) (Frietsch et al. 2011), a keyword search of the legal extension (e.g. Inc., Corp., GmbH, AG, etc.) is used. Single inventors, universities and PRI were differentiated by semi-automatic procedures. Applicants with more than 500 employees or more than three patent filings in a three-year time window between the priority years 1996 and 2008 were classified as MNEs. The number of 500 employees corresponds to the German SME definition (Günterberg/Kayser 2004). The remaining applicants with either less than three patent filings in the given time window or less than 500 employees were classified as SMEs.

Figure 20 Share of academic patents by the type of the applicant within the field of medicine, 2001-2010



Source: EPO - PATSTAT, Fraunhofer ISI calculations.

Note: In the case of Canada, the information on the type of the patent applicant is not available. Canadian locations therefore are not included within this figure.

Figure 20 depicts the share of academic patents by type of applicant within the field of medicine for the time period 2001 to 2010. Johns Hopkins University as well as the University of Texas have the largest share of university-filed patents, so the university itself is named as a patent applicant. The largest shares of patents which name SMEs on the patent filing stem from Zurich, Tubingen, Geneva and Washington. Here, it has to be noted that especially filings by SMEs might indicate not only collaborative projects with already existing SMEs. The SMEs that show up as patent applicants on these filings might as well be spin-offs from universities that have emerged within the context of a specific invention. The largest shares of filings which name large enterprises as applicants emerge from the universities Basel, Harvard, Bern and Utrecht. Public research institutes are most often named on filings from Heidelberg, followed by Munich, Harvard and Berlin.

The interpretation of these findings should take the legal framework into account in which universities conduct their commercialization activities. All observed institutions pursue an institutional ownership regime. In 1980, the US government introduced the Bayh-Dole Act which gave US universities the right to exert ownership and to commercialize the inventions made by their employees. This initiative was seen as the main driver behind the growing patent portfolios of US universities. Based on the assumption that the levels of university patenting in Europe were low compared to the US, Germany was among several other European countries which introduced rules similar to Bayh-Dole and abolished the traditional professor's privilege (*Hochschullehrerprivileg*) in 2002. Since then, employee inventions have been owned by the employing university and not by the inventors themselves ((Kenney/Patton 2009; Lissoni et al. 2008)). If, however, research is financed fully or partly by external contractors such as private companies, it remains possible for parties to negotiate the allocation of patent rights between the university, the company and the individual inventor. Switzerland (1911) and the Netherlands (1995) introduced similar laws earlier ((Geuna/Rossi 2011)).

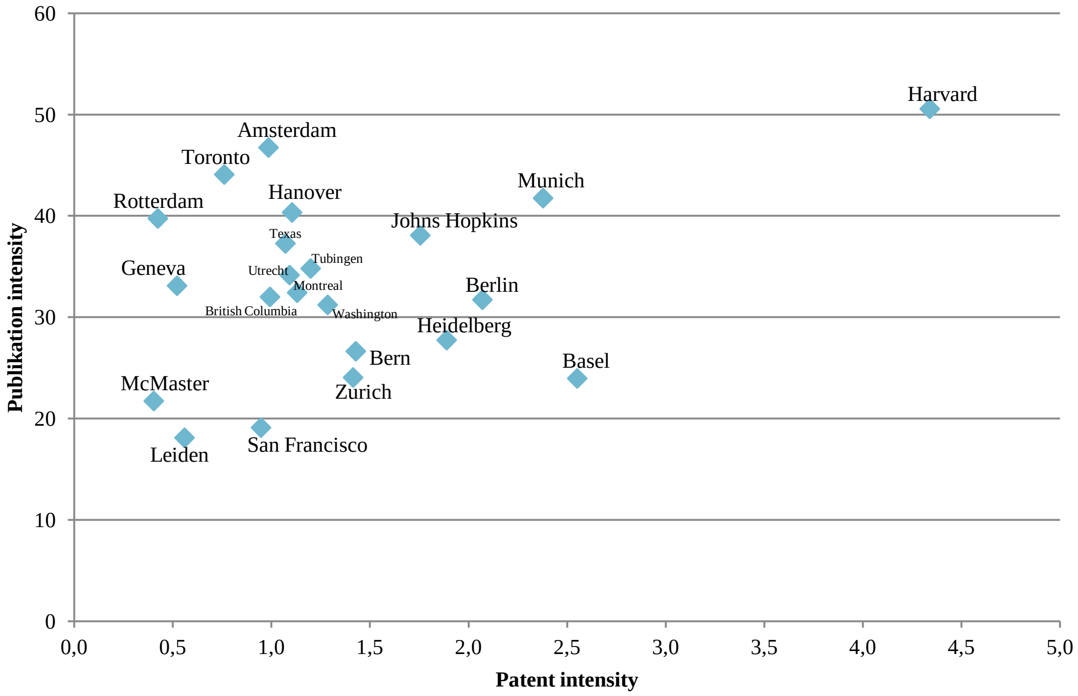
In sum, this might explain why the five institutions with the highest shares of university ownership are located in one of these countries. Nevertheless, the heterogeneous results also show, at least for medical research, that the institutional filing- or rather collaboration-profiles are more institution-dependent than influenced by the duration of the respective ownership regime. To give an example, Harvard being next-to-last in this category, at first sight, might be counterintuitive. However, we know from the analyses above that, in absolute terms, Harvard is the university with the largest number of filings. Thus, the higher share of other applicants only indicates that Harvard employees are involved in an even higher number of inventions which are not filed by the university. Several conclusions might be drawn from these observations. Firstly, simply accounting for patents filed by the university misses a large share of patents from medical research and draws a biased picture. Secondly, the interaction patterns, if at all, only slightly follow country-specific characteristics. For Germany, a higher share of patents is filed outside of the university. Significant institutional differences, however, remain. Thirdly, a high number of university filed patents does not necessarily mean that the universities' contribution to inventions from external institutions is weak.

3.4 Publication- and Patent Intensities – An Integrated Overview

In a final step, the publication and patent data are combined into one analysis. Thereby, the publication and patent output of the individual locations can be directly compared, which allows for an assessment of the scientific and technological output of the top locations of medical research.

Figure 21 shows the patent and publication intensities of the respective locations within the period 2008 to 2010. The publication intensity is defined as the number of medical publications per 100 authors at the respective location. Similarly, the patent intensity calculated as the number of transnational medical patent applications per 100 authors at the respective location.

Figure 21 Patent- and publication intensities (Number of transnational filings/publications per 100 authors, 2008-2010



Source: Web of Science, Scopus, EPO - PATSTAT, Fraunhofer ISI calculations.
Note: The smaller font size of some locations within this figure is only for the sake of better visibility.

Harvard University not only has by far the highest publication intensity, but also the highest patent intensity among the analyzed universities. However, also the location of Munich can be shown to be comparatively patent and publication-intensive and scores third on both indicators in 2009. Basel, Berlin, Heidelberg, and the Johns Hopkins University are relatively patent-intensive, but can only achieve a position in the midfield when it comes to the publication intensity. In sum, the respective locations maintain rather differentiated profiles and are not exclusively limited to scientific publications or patent applications. It rather seems that mostly both strategies are pursued, yet with a different focus.

4 Conclusions

The aim of this study was to give an insight into the scientific and technology-oriented output within the top-locations of medical research in the U.S., Canada, Germany, the Netherlands and Switzerland.

When looking at the scientific profile of the universities under comparison, it becomes evident that mostly the U.S. locations, above all Harvard University, score highest in the rankings. This is true for the quantity of their research output, in absolute terms as well as per capita, and also for the quality of the publications in terms of citations.

As for the German research locations, it can be stated that they generally score in the medium ranks when it comes to the number of publications and publication intensities. Medical research in Munich and Hanover, however, can achieve top ranks in publications per capita, and thus can be seen as highly productive. When looking at the citation indicators, however, the picture slightly changes. Except for the University of Heidelberg, the German locations of medical research under analysis here can only achieve low scores which place them on the lower ranks when looking at the excellence rate, i.e. the share of publications that belong to the top 10% of cited papers. Part of the explanation for this low ranking is that mostly publications in U.S. journals are among the most frequently cited worldwide. The linguistic barrier for publishing in those journals has to be taken into consideration here. Yet, another part of the explanation can be found when looking at the scientific regard and international alignment values of German universities in medical research. Especially the university locations Hanover, Berlin and Munich target internationally less visible journals, yet there reach rather high number of citations.

Most medical research in Germany is funded by national research funding, especially by the DFG and the BMBF. Internationally, most research is funded by the EU as well as other international research funds. Industry also can be seen as an important funding source for medical research in Germany, where international industry plays even a larger role than the national one, which is also true for international foundations.

When taking a closer look at the patent indicators, the picture largely resembles the trends found in the publication analyses. Yet, in terms of patenting, the German research locations, especially Munich and Berlin, seem to be major players besides the U.S. locations, at least when looking at the absolute numbers. Harvard University, followed by Johns Hopkins University, files the largest number of transnational patents compared to all other locations. The patent shares in total transnational filings by the respective (inventor) country, carry a rather heavy weight in the national patent portfolio for medical research at the Canadian and Dutch locations. As for the patent quality measured by forward citations, mostly the U.S. and Swiss locations take the lead, although the highest citation values can be achieved by the University of Utrecht. Although Utrecht files a comparably small number of transnational patents, it also has the largest family sizes, i.e. targeting the largest number of different markets by their patents.

While German universities rather often collaborate with public research institutions, the universities from Switzerland have high shares of university-industry collaborations. The U.S. universities, however, are rather differentiated. Johns Hopkins University and the University of Texas have the largest share of filings where the university itself is named as a patent applicant. Inventors from the University of Washington are often named on patents filed by SMEs, while Harvard University seems to cooperate rather often with public research institutes.

Annex

Table 2 Multivariate Models I – Location-specific effects

	Nr. of citations Negative-binomial model			Top10% cited publication (0/1) Logit model		
	Coef.		Std. Err.	Coef.		Std. Err.
National co-publication	0.123	***	0.002	0.206	***	0.004
International co-publication	0.239	***	0.002	0.318	***	0.004
Nr. of authors	0.079	***	0.000	0.110	***	0.000
Amsterdam	0.146	***	0.007	0.203	***	0.016
Basel	-0.044	***	0.014	-0.036		0.031
Berlin	0.071	***	0.008	0.063	***	0.019
Bern	-0.110	***	0.013	-0.178	***	0.030
British Columbia	0.150	***	0.009	0.214	***	0.020
Zurich	0.009		0.011	0.041	*	0.024
Geneva	-0.023	*	0.013	-0.015		0.029
Hanover	0.047	***	0.012	0.018		0.029
Harvard	0.319	***	0.004	0.467	***	0.008
Heidelberg	0.139	***	0.009	0.086	***	0.021
Johns Hopkins	0.175	***	0.006	0.268	***	0.012
Munich	0.105	***	0.007	0.105	***	0.017
Leiden	0.098	***	0.011	0.097	***	0.024
Montreal	0.115	***	0.007	0.120	***	0.017
McMaster	0.256	***	0.011	0.330	***	0.024
Rotterdam	0.123	***	0.010	0.155	***	0.021
San Francisco	0.223	***	0.006	0.360	***	0.013
Texas	0.113	***	0.007	0.138	***	0.016
Toronto	0.165	***	0.006	0.226	***	0.014
Tubingen	0.048	***	0.011	0.062	**	0.026
Utrecht	0.031	***	0.010	0.032		0.022
Washington	0.181	***	0.006	0.298	***	0.013
CA	-0.178	***	0.004	-0.243	***	0.009
CH	-0.087	***	0.006	-0.117	***	0.015
DE	-0.300	***	0.003	-0.421	***	0.007
NL	-0.148	***	0.004	-0.174	***	0.010
2001	0.044	***	0.004	-0.016	*	0.009
2002	0.090	***	0.004	-0.034	***	0.009
2003	0.118	***	0.004	-0.046	***	0.009
2004	0.142	***	0.004	-0.101	***	0.009
2005	0.180	***	0.004	-0.080	***	0.009
2006	0.182	***	0.004	-0.105	***	0.009
2007	0.192	***	0.004	-0.091	***	0.009
2008	0.187	***	0.004	-0.079	***	0.009
2009	0.183	***	0.004	-0.095	***	0.009
2010	0.156	***	0.004	-0.127	***	0.008
Neurosciences	0.231	***	0.003	0.383	***	0.006
Cardiovascular systems	0.069	***	0.003	0.024	***	0.007
Geriatrics & gerontology	-0.090	***	0.007	-0.100	***	0.018
Immunology, toxicology etc.	0.153	***	0.003	-0.027	***	0.006
Medicine, general	0.283	***	0.003	0.283	***	0.007
Oncology etc.	0.100	***	0.003	0.120	***	0.006
Gastroenterology etc.	-0.109	***	0.003	-0.256	***	0.008
Pharmacology etc.	0.019	***	0.003	-0.089	***	0.006
Surgery, transplantation	-0.430	***	0.003	-0.702	***	0.009
Gynecology, urology	-0.222	***	0.004	-0.457	***	0.010
Other	-0.475	***	0.002	-0.580	***	0.005
Anatomy etc.	-0.189	***	0.003	-0.307	***	0.008
Constant	1.330	***	0.004	-2.242948	***	0.0085799
Number of obs	2471050			2471050		
LR chi2	454551.47			170487.93		
Prob > chi2	0.000			0.000		
Pseudo R2	0.0303			0.0778		

Significance levels: ***p<0.01, **p<0.05, *p<0.1, † marginally significant

Note: Base categories: Institution: Other, Year: 2000, Country: USA

Table 3 Multivariate Models II – Funding Acknowledgements

	Nr. of citations Negative-binomial model			Top10% cited publication (0/1) Logit model		
	Coef.		**Std. Err.**	**Coef.**		**Std. Err.**
National co-publication	0.018	***	0.004	0.054	***	0.010
International co-publication	0.124	***	0.005	0.167	***	0.011
Nr. of authors	0.048	***	0.000	0.079	***	0.001
Amsterdam	0.041	**	0.018	0.092	**	0.041
Basel	-0.047		0.033	-0.021		0.076
Berlin	0.016		0.021	0.002		0.050
Bern	-0.192	***	0.032	-0.310	***	0.079
British Columbia	0.181	***	0.020	0.229	***	0.048
Zurich	0.001		0.026	0.044		0.059
Geneva	-0.053	*	0.032	0.043		0.072
Hanover	-0.007		0.030	-0.007		0.070
Harvard	0.251	***	0.009	0.417	***	0.020
Heidelberg	0.042	**	0.022	0.040		0.051
Johns Hopkins	0.135	***	0.014	0.209	***	0.031
Munich	0.106	***	0.018	0.055		0.043
Leiden	0.043	*	0.026	0.101	*	0.059
Montreal	0.066	***	0.016	0.104	**	0.041
McMaster	0.286	***	0.026	0.419	***	0.061
Rotterdam	0.053	**	0.024	0.038		0.055
San Francisco	0.227	***	0.015	0.349	***	0.033
Texas	0.116	***	0.018	0.166	***	0.039
Toronto	0.147	***	0.014	0.206	***	0.036
Tubingen	-0.105	***	0.028	-0.228	***	0.069
Utrecht	-0.037		0.024	-0.076		0.056
Washington	0.102	***	0.015	0.174	***	0.034
CA	-0.178	***	0.009	-0.303	***	0.023
CH	0.039	**	0.016	-0.011		0.038
DE	-0.040	***	0.008	-0.099	***	0.019
NL	-0.023	*	0.012	-0.009		0.027
2009	0.018	***	0.004	0.014		0.009
Neurosciences	0.100	***	0.006	0.184	***	0.015
Cardiovascular systems	0.010		0.008	0.015		0.019
Geriatrics & gerontology	-0.137	***	0.018	-0.289	***	0.047
Immunology, toxicology etc.	-0.037	***	0.007	-0.155	***	0.016
Medicine, general	0.438	***	0.008	0.347	***	0.018
Oncology etc.	0.043	***	0.007	0.061	***	0.015
Gastroenterology etc.	-0.158	***	0.009	-0.321	***	0.022
Pharmacology etc.	-0.131	***	0.007	-0.260	***	0.016
Surgery, transplantation	-0.357	***	0.011	-0.705	***	0.030
Gynecology, urology	-0.239	***	0.011	-0.367	***	0.028
Other	-0.455	***	0.006	-0.654	***	0.014
Anatomy etc.	-0.280	***	0.008	-0.528	***	0.021
DFG funded	0.097	***	0.014	0.233	***	0.032
BMBF funded	0.066	***	0.020	0.138	***	0.046
EU funded	0.108	***	0.018	0.271	***	0.041
DAAD funded	-0.208	***	0.053	0.074		0.127
Deutsche Krebsforschung funded	-0.015		0.029	-0.260	***	0.071
NIH funded	0.232	***	0.019	0.535	***	0.041
Other funded	0.245	***	0.015	0.388	***	0.034
Constant	1.755	***	0.017	-2.035	***	0.038
Number of obs	267682			267682		
LR chi2	51013.9			18535.6		
Prob > chi2	0.000			0.000		
Pseudo R2	0.028			0.0629		

Significance levels: ***p<0.01, **p<0.05, *p<0.1, † marginally significant

Note: Base categories: Institution: Other, Year: 2010, Country: USA

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