Vetenskapsrådet

THE SWEDISH RESEARCH BAROMETER 2017

THE SWEDISH RESEARCH SYSTEM IN INTERNATIONAL COMPARISON

SWEDISH RESEARCH COUNCIL 2017

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SWEDISH RESEARCH BAROMETER 2017 – THE SWEDISH RESEARCH SYSTEM IN INTERNATIONAL COMPARISON

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FOREWORD

The Swedish Research Barometer provides an overall picture of the state of Swedish research in international comparison, by summarising available data describing both the resources added to the research system in the form of financial funds and personnel and also the results and impact of research in the form of publications and citations.

In the Swedish Research Barometer 2017, we are focusing on the Swedish higher education sector and the research carried out there, but it starts with an overall description of the entire Swedish system for research and development (R&D) in comparison with the equivalent systems in a selection of countries. The intention is to describe how Sweden, as a research nation, is doing in international comparison, and how the Swedish higher education sector relates to the entire research system. The Research Barometer does not have the ambition of providing a representative picture of the whole Swedish system for research and development, where a major part of R&D is both financed and performed within the business enterprise sector.

The data and information presented is obtained primarily from Statistics Sweden, the Swedish Higher Education Authority (UKÄ), OECD, e-CORDA and the publications database Web of Science, and from relevant literature in the field. Where relevant, reference is made to reports and analyses from the Swedish Research Council. This year's Research Barometer is an update and further development of the first barometer, published in 2016. In the future, the Research Barometer will be published every second year; the next Research Barometer will be published in 2019.

I would like to say a big thank you for all the help in the form of data and good advice on the analyses received, to Statistics Sweden, UKÄ and Vinnova in particular. Views from readers of the Swedish Research Barometer 2016 have also been very valuable. I would also like to thank all my colleagues at the Swedish Research Council who have participated in the work of producing the Research Barometer 2017. The work has been considerable, but I also know from the feedback received that the result of the work is very much appreciated!

Sven Stafström
Director General

Stockholm, June 2017

EXECUTIVE SUMMARY

The Swedish Research Barometer is a periodically published overview of the Swedish research base. The first part describes Swedish research in international comparison, and the second part the research conducted within the Swedish higher education sector. Both parts are organised in sections that describe the spending on Research and Development (R&D), the personnel in the R&D system, and the results of research in the form of publications and their citation impact.

Sweden in international comparison

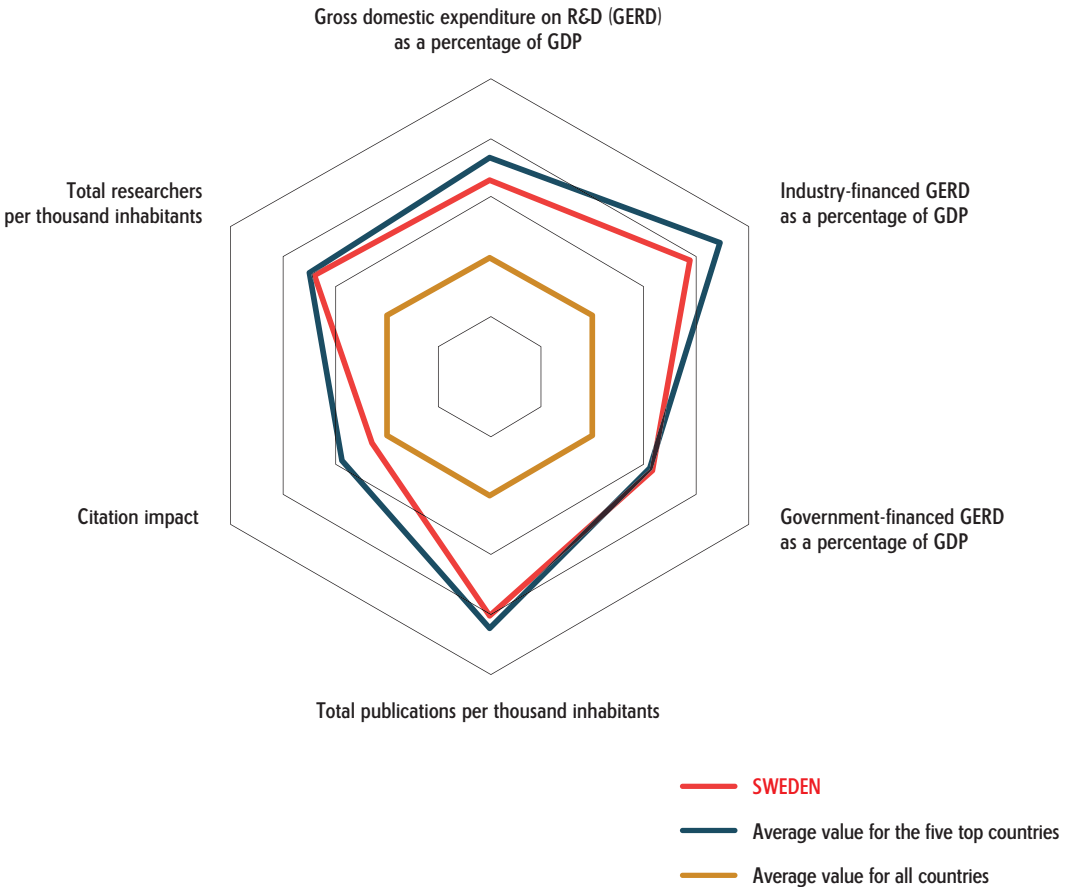

Figure 1. Swedish R&D in an international comparison, using a selection of indicators. Sweden's position is shown in relation to the average value for all OECD countries and the average value for the five top countries in each category.[1] Citation impact compares Sweden's proportion of highly cited articles in relation to the value for all countries in the publication database and the average value for the five top countries. Data from 2015; publication data for articles published 2013–2015. Source: OECD and Clarivate Analytics.

[1] Gross domestic expenditure on R&D (GERD) as a percentage of GDP (top countries: Israel, South Korea, Japan, Sweden, Austria); Industry-financed GERD as a percentage of GDP (top countries: South Korea, Japan, Sweden, Germany, Switzerland); Government-financed GERD as a percentage of GDP (top countries: South Korea, Austria, Sweden, Denmark, Finland); Total publications per thousand inhabitants (top countries: Switzerland, Denmark, Australia, Sweden, Finland); Citation impact (top countries: Singapore, Switzerland, USA, the United Kingdom, the Netherlands); Total researchers per thousand inhabitants (top countries: Israel, Denmark, South Korea, Sweden, Finland).

Sweden is one of the OECD countries with the highest gross expenditure on R&D as a percentage of GDP. The gross expenditure is divided into business expenditure on R&D and government expenditure on R&D, both as a percentage of GDP. In terms of business expenditure, Sweden positions itself within the top five countries in the OECD database. Also for government expenditure, Sweden is among the top five countries.

Sweden also has a high proportion of researchers in the population, and in this respect is among the top countries in the OECD database. In terms of financial and personnel resources for R&D, Sweden performs well in comparison to other nations.

The results from research, and their impact, span a broad spectrum and are difficult to measure. In a more limited sense, the results are often measured by the number of scientific publications per inhabitant, and by their citation impact. Sweden is one of the top five OECD countries with regards to the former indicator. When it comes to citation impact, calculated as the proportion of a country's scientific publications that are among the 10 per cent most cited in the Web of Science database, Sweden's position is closer to the average value for all countries in the database.

R&D spending

Total domestic expenditure on R&D in Sweden in 2015 amounted to 137 billion SEK. Sweden invested 3.26 per cent of its GDP in R&D, which makes Sweden one of the top countries in international comparison. In contrast to several other countries, Sweden has, however, reduced its spending on R&D in relation to GDP over the last 15 years, even though R&D expenditure has increased in real terms. In many countries, the business sector is responsible for the major part of the total increase in R&D spending, but in Sweden this sector has decreased.

The main contributors to Swedish R&D expenditure was the business sector (58 per cent) and the public sector (27 per cent). In international comparison the share or the business sector's expenditure in R&D is higher in for example Japan, China, and Korea than in Sweden, while in for example Norway, Austria, France and the Netherlands, the share of the public sector's expenditure on R&D is higher than in Sweden.

Looking at who performs the R&D, the Swedish business sector was responsible for 70 per cent of expenditure on R&D and the higher education sector for 27 per cent in 2015. Switzerland, Finland, and Austria have similar shares for the business sector. The share of R&D expenditure in the higher education sector is slightly lower in Sweden than in Denmark, the Netherlands, and Norway.

Within the higher education sector, the Government was the largest funder of Swedish R&D in 2015. R&D income for higher education institutions (HEIs) increased by 70 per cent during 2001–2015. The major part (90 per cent) of the funding went to the comprehensive established universities and specialised universities, and the income growth rate was higher for medicine and health and the natural sciences than for the other fields of science and technology, during the period 2011–2015.

Researchers

Just like the other Nordic countries, Sweden has a high proportion of researchers in the population. The distribution of researchers mirrors the R&D structure in Sweden, with a small proportion of public research institutions, a relatively large HEI sector, and an R&D-intensive business sector. In comparison, The United Kingdom and Switzerland have a higher proportion of researchers in HEIs. In Norway, Germany, and China, a comparatively high share of the researchers work in public research institutions, while for example Japan and Korea, just like Sweden, have many researchers working in the business sector.

In Sweden, the share of women in research was lower (33 per cent) than the share of men in research (67 per cent) in 2014. This is similar to many of the countries in our comparison, but the trend is moving towards a more equal gender distribution. In international comparison, the most gender-equal countries when it comes to the research community are the United Kingdom and Norway, with a 37 per cent share of women researchers.

In Sweden, the last decades have witnessed a growth of all personnel categories within HEIs, except subject teachers (adjuncts) and researchers holding career development positions. The number

of teaching and researching personnel was around 35 000 in 2016. The proportion of women has increased gradually in the various personnel categories, and also within recently graduated researchers. The development is slower within the professor category, where 26 per cent were women and 74 per cent men in 2016.

Research publications

Sweden punches above its weight in the production of scientific publications per capita, and is one of the top five OECD countries for the period 2013–2015. The other top countries are Switzerland, Denmark, Australia and Finland. The Netherlands, Norway, Iceland, and Singapore also have comparable publication volumes per capita.

Most Swedish articles in scientific journals are written by researchers working in comprehensive established universities and specialised universities, even though university colleges and new universities increased their publication volume by 8 per cent per year during 2003–2015.

Looking at subject profiles, Sweden, together with the United States and a number of West European countries, is characterised by a broad profile, with a relatively high citation impact in most research areas. In contrast, developing research countries like China and Korea are more specialised in their publication profile. Sweden shows a higher than average level of research activity in health sciences and social sciences, but a lower than average activity in mathematics and chemistry.

When it comes to citation impact, measured as the proportion of highly cited publications, Swedish comprehensive established universities, specialised universities, and institutions in the "others" category (such as companies and government agencies outside the higher education sector) scored above the global average for articles published 2013–2015. For university colleges and the new universities, the proportion of highly cited publications was lower than the global average. Sweden shows a steady growth of highly cited publications, but competition is increasing, as several other countries show even higher growth rates.

Swedish researchers in international co-publications and other international research collaborations

A large proportion, 68 per cent, of all scientific publications (2016) by Swedish researchers are written in collaboration with researchers from other countries. Swedish international co-publications with researchers from the EU countries (plus Norway and Switzerland), have increased as a proportion of all co-publications, but the most significant growth rate is for co-publications with researchers from Asian countries. The single most prominent partner country for Swedish co-publications is, however, The United States. The Swedish tradition of international co-publication is still stronger in subject fields such as biology, geosciences and physics than in humanities and social sciences, but researchers in all subject fields have increased their participation in international co-publications.

Sweden is an active participant in various international collaborations; in this Research Barometer illustrated by Swedish participation in European research infrastructure collaborations.

When it comes to participation and success rate in the EU framework programme for research and innovation, Horizon 2020, Sweden takes a middle position among the EU15-countries.

SAMMANFATTNING

Vetenskapsrådets Forskningsbarometer är en återkommande produkt som syftar till att ge en övergripande beskrivning av svensk forskning och utveckling (FoU) i internationell jämförelse, med tonvikt på forskningen inom den svenska högskolesektorn. Forskningsbarometern består av två delar, där den första ger en beskrivning av hela det svenska FoU-systemet i jämförelse med ett urval länder och den andra mer i detalj beskriver den forskning som bedrivs inom den svenska universitets- och högskolesektorn. Båda avsnitten behandlar förutsättningarna för forskning och utveckling i form av finansiering och den forskande personalens sammansättning, samt forskningens resultat i form av publikationer och deras citeringsgenomslag.

Sverige i internationell jämförelse

Sverige ligger bland de fem toppländerna i OECD när det gäller totala utgifter för FoU som andel av BNP. De totala utgifterna för FoU i ett land är summan av företagens finansiering av FoU, offentliga utgifter för FoU, utländska finansieringskällor och privata icke-vinstdrivande organisationers finansiering av FoU. När det gäller företagens finansiering av FoU och offentliga utgifter för FoU är Sverige bland de fem toppländerna.

Sverige har, i förhållande till folkmängden, en stor andel forskare[2] i både högskolesektorn och företagssektorn, och placerar sig också här bland de fem toppländerna. Sett till finansiella och personella resurser för forskning och utveckling står sig Sverige således väl i internationell jämförelse.

Det förväntade resultatet av forskning och utveckling spänner över ett brett spektrum och över lång tid. Att mäta och värdera forskningens resultat och genomslag är oerhört komplicerat. Forskningens resultat illustreras i Figur 1 med indikatorerna antal vetenskapliga publikationer per tusen invånare (publicerade under perioden 2013–2015) och publikationernas citeringsgenomslag (2013–2015). I det förra fallet placerar sig Sverige bland de fem toppländerna inom OECD. För citeringsgenomslaget, mätt som andelen publikationer som är bland de tio procenten högst citerade, placerar sig Sverige närmare medelvärdet för samtliga länder i publikationsdatabasen Web of Science.

Finansiering av forskning och utveckling

År 2015 uppgick de totala utgifterna för utförd forskning och utveckling (FoU) i Sverige till drygt 137 miljarder kronor. Sverige satsade därmed 3,26 procent av BNP på FoU år 2015, vilket gjorde Sverige till ett av de länder som investerade störst andel av BNP i FoU. Endast Sverige och Österrike nådde 2015 över EU:s treprocentsmål för FoU. Ändå har Sverige, till skillnad från flera andra länder, minskat sina utgifter för FoU i förhållande till BNP över de senaste 15 åren, även om utgifterna för FoU har ökat i absoluta siffror. I många länder är det företagssektorn som står för det mesta av den totala ökningen, men detta är inte förhållandet i Sverige, där företagssektorns satsningar på FoU och därmed också dess andel av den totala FoU-finansieringen har minskat.

I Sverige finansierade företagssektorn merparten av den finansiella FoU-volymen (58 procent) år 2015, medan den offentliga sektorn stod för 27 procent. Andra finansiärer var utländska källor (inklusive EU:s ramprogram för forskning) och privata, icke-vinstdrivande organisationer. I fördelningen av FoU-utgifter på finansierande sektor liknar Sverige flera av jämförelseländerna, men i till exempel Norge och Österrike står staten för en större andel av den totala FoU-finansieringen. I länder som Japan, Kina och Sydkorea finansierar däremot näringslivet en större andel av den totala FoU än i Sverige.

I Sverige låg år 2015 den största andelen av utgifterna för utförd FoU inom företagssektorn (70 procent) samt inom universitets- och högskolesektorn (27 procent). Schweiz, Finland och Österrike hade

[2] Benämningen forskare bygger på Frascatimanualens definition, som utgår från personens arbetsuppgifter, se faktaruta i avsnitt 1.1. Här anges antal forskare som årsverken, inte individer.

en ungefär lika stor del av sina FoU-utgifter inom företagssektorn, medan Sveriges andel av utgifterna för FoU inom högskolesektorn är något lägre än i Danmark, Nederländerna och Norge.

De svenska lärosätena finansieras till största delen av statliga medel och deras FoU-intäkter har, i fasta priser räknat, ökat med 70 procent under perioden 2001–2015. Av finansieringen går 90 procent till de breda etablerade och de fackinriktade universiteten. Intäkterna har ökat mest inom forskningsämnesområdena medicin och hälsovetenskap respektive naturvetenskaper under perioden 2011–2015.

Forskare inom FoU

Sverige, liksom de övriga nordiska länderna, utmärker sig genom en stor andel forskare i befolkningen. Fördelningen av forskare inom FoU-systemet speglar systemets struktur: i Sverige finns en liten offentlig institutssektor, en relativt stor högskolesektor och ett FoU-intensivt näringsliv. Storbritannien och Schweiz har en jämförelsevis stor andel forskare inom högskolesektorn, medan andra länder, som till exempel Norge, Tyskland och Kina, har en större andel forskare än många andra länder inom övrig offentlig sektor, till exempel vid offentliga forskningsinstitut. Liksom Sverige har Sydkorea och Japan en relativt stor andel forskare inom företagssektorn.

Andelen forskande kvinnor var lägre (33 procent) än andelen forskande män (67 procent) i Sverige år 2014. En liknande obalans råder i samtliga jämförelseländer, även om den verkar jämnas ut över tid. Jämnast könsfördelning av jämförelseländerna har Storbritannien och Norge, där 37 procent av forskarna är kvinnor och 63 procent män. I Japan däremot är mindre än 15 procent av forskarna kvinnor.

Under 2000-talet har den forskande och undervisande personalen vid de svenska lärosätena ökat kraftigt i antal. Också sammansättningen av högskolans personal har förändrats under perioden 2001–2016. Alla personalkategorier utom adjunkter och meriteringsanställningar har ökat i omfattning. År 2016 uppgick den forskande och undervisande personalen i den svenska högskolan till ca 35 000 personer.

Andelen kvinnor bland de nydisputerade och inom olika anställningskategorier i den svenska högskolan har successivt ökat under de senaste decennierna, även om andelen kvinnor och män varierar mellan olika forskningsämnesområden. En långsammare förändring av könsbalansen syns i kategorin professorer. År 2016 var fördelningen bland professorer 26 procent kvinnor och 74 procent män.

Vetenskaplig publicering

Sverige hör till de OECD-länder som under perioden 2013–2015 hade högst produktion av vetenskapliga publikationer i relation till sin folkmängd, tillsammans med Schweiz, Danmark, Australien och Finland. Också Nederländerna, Norge, Island och Singapore har en jämförbar publikationsvolym per invånare. I Sverige produceras den allra största andelen artiklar vid de breda etablerade universiteten och de fackinriktade universiteten, även om högskolorna och de nya universiteten ökade sin publikationsvolym med 8 procent per år under perioden 2003–2015.

Sveriges forskningsämnesprofil är bred med en relativt hög forskningsaktivitet inom hälsovetenskap och samhällsvetenskap och med en lägre aktivitet inom matematik och kemi. Vid en jämförelse av ämnesprofiler framträder ett mönster där Sverige, tillsammans med USA och flera länder i Västeuropa, har en bred ämnesprofil som kännetecknas av högt citeringsgenomslag inom de flesta forskningsområden. Framväxande forskningsländer som Kina och Sydkorea är mer ämnesmässigt specialiserade i sin forskningsaktivitet.

De svenska breda etablerade universiteten, de fackinriktade universiteten och gruppen ”övriga” (bland annat företag och myndigheter utanför högskolesektorn) låg under åren 2013–2015 över världsgenomsnittet för andelen högciterade publikationer. För grupperna högskolor respektive nya universitet var andelen högt citerade publikationer under samma period lägre än världsgenomsnittet. I internationell jämförelse har Sverige en relativt stor andel högciterade publikationer, och andelen har ökat något under de senaste åren. Flera andra länder visar dock en ännu större ökning av högciterade publikationer.

Svenska forskare i internationella samarbeten

Sverige hör till de länder som uppvisar en stor andel internationell sampublicering. År 2016 var 68 procent av de svenska vetenskapliga publikationerna ett resultat av internationella samarbeten, vilket kan jämföras med världsgenomsnittet på 25 procent. Andelen publikationer där svenska forskare samarbetar med forskare i EU-länderna (plus Norge och Schweiz) har ökat svagt de senaste 35 åren, och uppgick 2016 till drygt 70 procent av alla svenska internationellt sampublicerade artiklar. Den största ökningen gäller dock sampublikationer med forskare i Asien. Sett till enskilda samarbetsländer är det med forskare i USA som svenska forskare samarbetar mest.

Internationell sampublicering har ökat inom samtliga ämnesområden men variationerna mellan områdena är stora. Det är betydligt vanligare med internationella sampublikationer inom biologi, geovetenskap och fysik än inom humaniora och samhällsvetenskap.

Sveriges deltagande i europeiska samarbeten illustreras i Forskningsbarometern med deltagandet i europeiska forskningsinfrastrukturer. Här deltar Sverige i ett förhållandevis stort antal infrastruktursamarbeten, jämfört med flera andra europeiska länder.

Ländernas deltagande i EU:s ramprogram för forskning och innovation visar på både samarbete och konkurrens. Sverige intar en medelposition bland EU15-länderna (plus Norge och Schweiz) när det gäller beviljat belopp per invånare och beviljandegrad inom det nuvarande ramprogrammet för forskning och innovation, Horisont 2020.

1 SWEDEN IN COMPARISON WITH A SELECTION OF COUNTRIES

Part 1 describes how Swedish research and development (R&D) has developed in international comparison over the latest ten-year period. Sweden is compared with a selection of countries with the help of a number of indicators, highlighting R&D expenditure within the private and public sectors, research personnel resources and the results from research in the form of publications and citation impact. This part also covers the international collaborations of Swedish researchers: co-publications and participation in European collaborations.

1.1 Sweden's research resources in comparison with those of other countries

The resources invested by a country into research and development are often measured as the expenditure on R&D and the number of active researchers. When making comparisons between countries, the expenditure on research can be related to the country's GDP or its population figure. The number of researchers can be related to the size of the workforce, or, as is done here, the number of inhabitants.

Definition of research and development (R&D) and researchers

When making international comparisons of research statistics, the definitions and divisions developed within the OECD are used, which are described in the "Frascati Manual" (Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development. The Measurement of Scientific, Technological and Innovation Activities).

The overall concept of **research and experimental development (R&D)** is defined as "creative and systematic work undertaken in order to increase the stock of knowledge", where **research** is done to seek out new knowledge or new ideas, without any particular application or use in view, while **experimental development** uses research findings, scientific knowledge or new ideas to produce new materials, goods, services, processes, systems, methods or significant improvements of already existing ones.

In the Frascati Manual, **researchers** are defined as "professionals engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques, instrumentation, software or operational methods." Although these skills may have been acquired through post-graduate research education, a research degree is not a necessary criterion.

R&D intensity

Comparison of the investment into R&D in different countries is often done by comparing the total expenditure on R&D to the country's GDP or its population. The total R&D expenditure as a percentage of the country's GDP is known as the country's **R&D intensity**, and is one of five strategic indicators for Europe's strategy for growth and jobs. The aim for research and development in the Europe 2020 strategy is that 3 % of the EU's GDP shall be invested in R&D.

An overview of the R&D resources in a number of countries, in the form of financing and the number of researchers, shows that Sweden and the other Nordic countries have comparatively good resources for research and development.

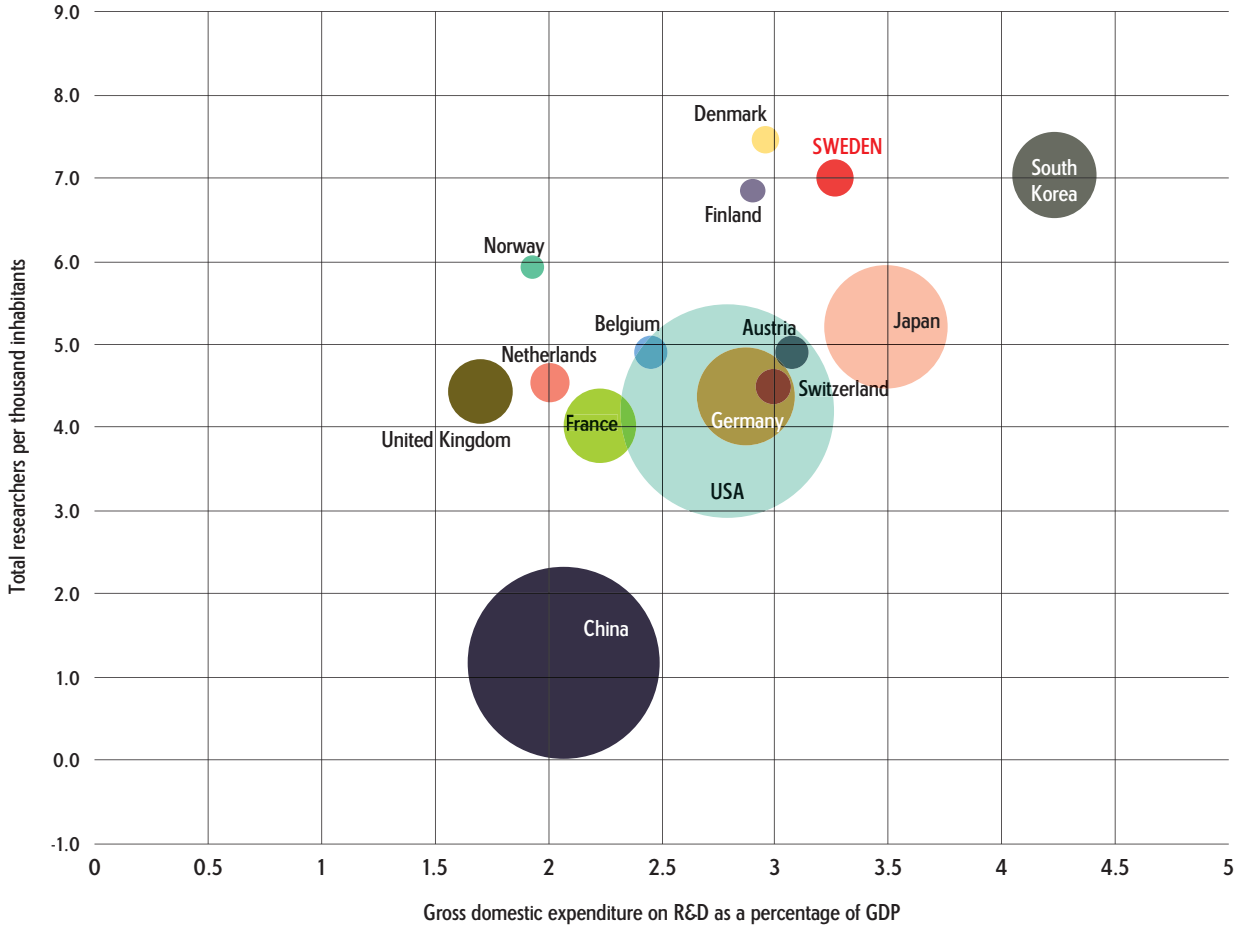

Figure 2. Total researchers (full time equivalent) per thousand inhabitants, and gross domestic expenditure on R&D as a percentage of GDP in 2015. The area of each circle corresponds to that country's share of the total R&D expenditure of all countries included in the figure. Source: OECD.

Figure 2 shows the countries' overall expenditure on R&D as a percentage of GDP, i.e. the country's R&D intensity (see fact box). The number of researchers is shown in relation to the country's population.

Figure 2 also introduces the 15 countries (including Sweden) included in the Research Barometer 2017 to show Sweden in international comparison. A common factor for these countries is that they represent successful research nations. The 14 comparison countries can be roughly divided up into categories: 1) research nations whose size and research prerequisites are somewhat comparable to those of Sweden (Austria, Belgium, the Netherlands, Switzerland, Norway, Denmark and Finland); 2) larger, established successful research nations (the United States, the United Kingdom, Germany, France and Japan); and 3) developing research nations (China and South Korea). A change compared to the Swedish Research Barometer 2016 is the addition of Belgium as a comparison country.

In Figure 2, each country is represented by a circle, the area of which corresponds to that country's share of the total R&D expenditure of all countries included in the figure. Since a few years back, China has the greatest R&D expenditure after the United States, and together the two countries represent around half of all the R&D expenditure of the world's countries.

In the following section, a more detailed picture is provided of the development of R&D expenditure for the comparison countries, but we start with Figure 3, which shows development over time for a smaller number of countries.

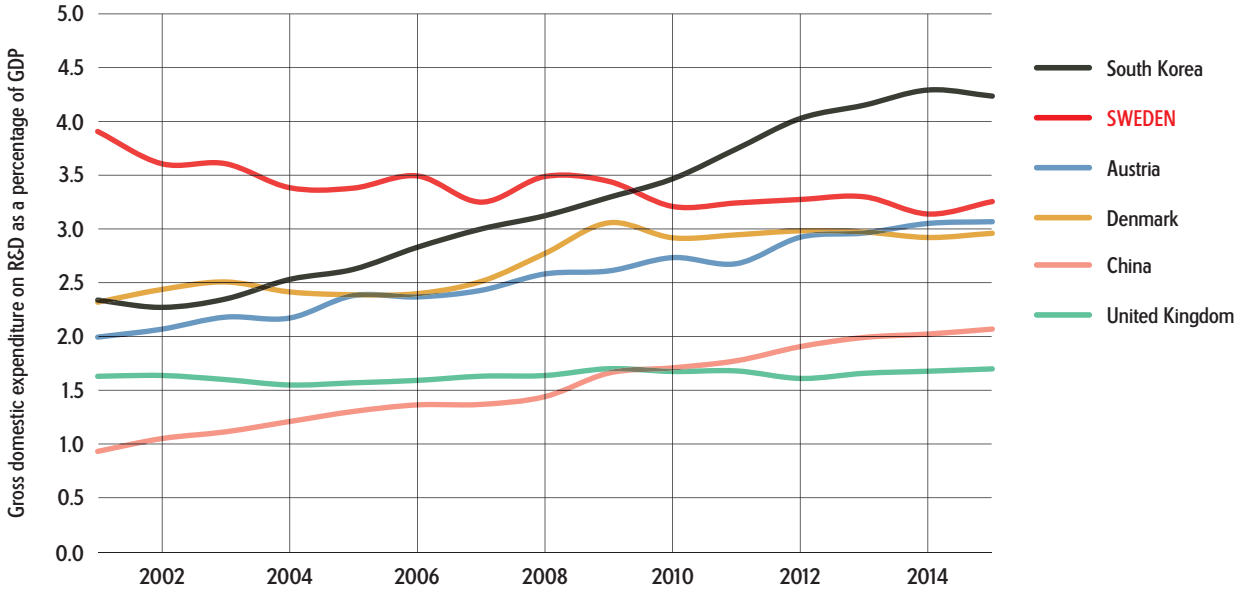

Figure 3. Development of the gross domestic expenditure on R&D as a as a percentage of the country's GDP in the period 2001–2015. Sweden is here compared with a few selected countries in order to clearer illustrate the trend. Source: OECD.

Figure 3 shows that South Korea's and China's expenditure on R&D as a percentage of GDP has increased over time. Austria and Denmark have also increased their R&D intensity, but at a slower rate, while the United Kingdom, a successful research nation in many respects and an important collaboration partner to Sweden, has remained fairly constant over the period. Contrary to many other countries, Sweden, which is still at the forefront internationally, has reduced its expenditure on R&D as a percentage of GDP over the last 15 years.

Sweden and Austria, with a R&D intensity of 3.26 per cent and 3.06 per cent respectively, were the only EU countries in 2015 to exceed the EU target of 3 per cent.[3] South Korea had an R&D intensity of 4.23 per cent. The average for the EU28 countries was just over 2 per cent, which is lower than the corresponding percentage in Japan and the United States. In 2014, China's R&D intensity also passed the average for the EU28 countries.[4]

1.2 Financing of research and development

This section presents the range of R&D expenditure in Sweden compared to a selection of countries. There are considerable differences in terms both of the financial R&D volume, and also the allocation of expenditure between funding bodies and performers of R&D, even between countries that in many respects are similar to Sweden.

The development of a country's R&D intensity over time is affected by its GDP development, which differs significantly between the countries. One example is China, whose GDP has grown to many times its former size over the last 15 years. The development of the countries' R&D intensity is shown in Figure 4.

Population growth in the countries in question has, however, been much more comparable, with an increase of eight per cent on average over the period 2000–2015. Japan brings up the rear, with an almost non-existent population increase, while Norway tops the list with a population increase of 16 per cent. The development of R&D expenditure per inhabitant is shown in Figure 5.

3 The Europe 2020 targets: 3 % of the EU's GDP shall be invested in R&D.

4 Eurostat: Statistics explained. Data extracted in February 2017: http://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_expenditure

The public and private sectors together steer the development of overall R&D expenditure

Figure 4 shows the development of R&D intensity for a selection of countries over the period 2000–2015. The expenditure on R&D is divided up per financing sector. Comparing the R&D expenditure of countries in this way is associated with several complications, and it should therefore be done with some caution. The variation between countries of what is classified as R&D is considerable, but Figure 4 illustrates in particular the development within each individual country.

Figure 4. Gross domestic expenditure on R&D as a percentage of GDP in the period 2000–2015, divided up by financing sector. Source: OECD

Sweden is one of the countries with the highest R&D intensity in the world, even if expenditure on R&D as a percentage of GDP has fallen over the last 15 years.

The selected countries can be divided up into three categories, based on their development over the last 15 years. The first category consists of countries that display a relatively stable structure over time in terms of the R&D share financed by industry (the business enterprise sector), the government, other national sources or foreign sources. This category of countries includes South Korea, Denmark, Germany, the United States, Belgium and the United Kingdom. The overall R&D expenditure in the United States and the United Kingdom has been relatively stable over the last 15 years, while R&D expenditure in Belgium, Germany, Denmark, and, in particular, South Korea has increased over the same period. R&D expenditure has changed equally in all financing sectors. For example, over the last 15 years, South Korea has doubled its R&D expenditure within both the business and the government sectors.

The second category of countries, which consists of Finland, Japan, France, and the Netherlands, the change in R&D intensity is more dependent on the development of the business sector's R&D expenditure, and to some extent foreign R&D funds.

In the third category of countries, China, Austria, Switzerland, Norway and Sweden, the development of R&D expenditure within the various financing sectors has varied more. In China and Austria, R&D expenditure financed by the business sector has increased greatly over the last 15 years, while government funds have also increased, albeit at a slower rate. In China, for example, a tripling of R&D expenditure financed by industry in terms of GDP percentage can be seen, while the corresponding expenditure financed by the government has increased by around 50 per cent over the same period. In Switzerland, expenditure on both privately financed and publicly funded R&D has increased, but the increase in government funds has been so considerable that the emphasis has moved towards a greater share of government-financed R&D from a national perspective. During the period 2000–2015, Sweden and Norway have seen the percentage of expenditure on industry-financed R&D fall, while the percentage of government funds has increased.

Two countries in Figure 4 have seen a negative development of overall R&D intensity during the period 2000–2015: Sweden and Finland. The proportion of R&D expenditure financed by business has fallen to an almost equal extent in both countries, but in Sweden the percentage of R&D expenditure financed by the government has increased, while it has remained more or less constant in Finland. However, Sweden has a smaller share of R&D expenditure financed by abroad compared to Finland.

The differences in R&D expenditure between the leading countries evens out

Figure 5 shows the development of R&D expenditure per country, divided up by financing sector, over the same period as in Figure 4, but expressed as current PPP dollars[5] per inhabitant. The effect of inflation cannot be seen in Figure 5, as current, instead of constant, PPP dollars are used. Using current PPP dollars enables a closer comparison between countries for each individual year, however.

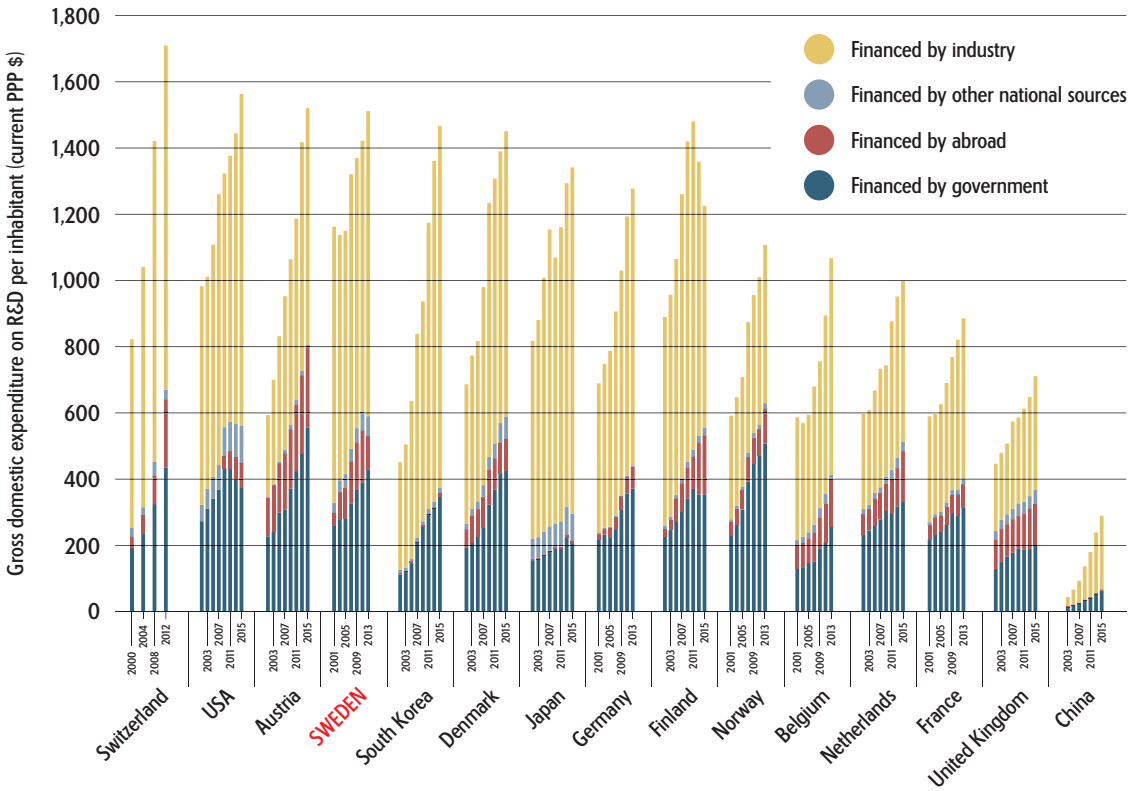

Figure 5. Gross domestic expenditure on R&D per inhabitant in the period 2000–2015, divided up by financing sector. Source: OECD.

5 PPP refers to Purchasing Power Parities. PPP dollars relate to the purchasing power the US dollar has in the USA.

From a 15-year perspective, all countries are showing a positive trend in terms of R&D expenditure in relation to population, even though Finland has fallen back over the last five years. Sweden and Finland have had the lowest growth in R&D expenditure. However, both countries started the period at a higher level than several other countries.

Switzerland, Belgium, Germany and Denmark have more than doubled their R&D expenditure per inhabitant. The most outstanding are Austria, South Korea and China, however. China's R&D expenditure per inhabitant increased tenfold over the last 15 years, but is still considerably lower than the corresponding expenditure for both the EU and the OECD. In terms of R&D expenditure as a percentage of GDP, China is, however, level with the EU.

The higher education sector's share of R&D expenditure is relatively high in Europe

Figures 6 and 7 show the distribution of R&D expenditure on the performing and financing sectors for 2015 for our selection of countries; together, the figures provide a picture of the structure of the R&D system in the various countries. R&D is a broad concept that includes many different activities, depending on the research subject, line of business, national classification, etc. For example, basic research at universities differs drastically from development work within companies. Companies finance their own R&D to a large extent, while government funds are targeted mainly at the higher education (HEI) sector, or other public research performers. Research funding from abroad may go to all national actors, but in Western European countries often consists of foreign funds from business, used to finance industrial research in the country in question. EU funds also make up a considerable part of this category.

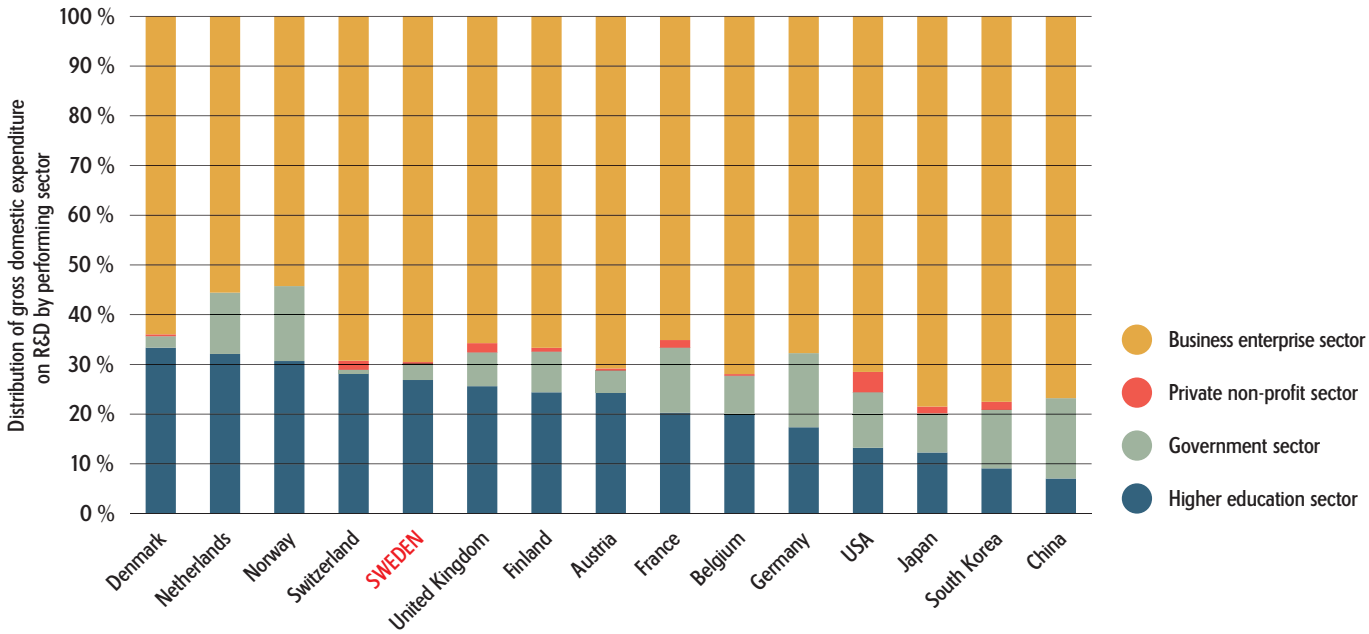

Figure 6. Gross domestic expenditure on R&D in 2015 divided up by performing sector. Source: OECD.

In all European countries in Figure 6, a larger proportion of the R&D expenditure is consumed within the HEI sector than in either the United States or the Asian countries Japan, South Korea and China. In Sweden, Norway and Switzerland, for example, where public R&D expenditure has increased more than private R&D expenditure (see Figure 4), a larger proportion of the country's overall R&D is carried out within the HEI sector than in many other countries.

In Denmark, the allocation of R&D funds in the financing sectors has been relatively stable over the last 15 years, while the allocation to performing sectors has seen a change. The result is that a relatively large proportion of R&D is now carried out within the HEI sector, and a smaller proportion within the rest of the public sector (the government sector).

Structural differences between the research systems of the different countries makes direct comparison between research-performing sectors more difficult. The institute sector, for example, is classified differently in different countries. Some institutes are operated as private companies, some as private non-profitmaking organisations and some as part of the public sector. R&D within the public sector may cover everything from research at a public research institute to development work within a public authority, depending on how R&D is classified in different countries.

Swedish research institutes are found in several of the performing sectors in Figure 6. The Swedish Institute of Space Physics is classified as part of the HEI sector, while other institutes operated as government agencies, such as the Swedish Defence Research Agency and the Swedish Institute for Infectious Disease Control, are classified as government sector (other public sector). Swedish institutes operated as limited companies, such as RISE – Research Institutes of Sweden and the Swerea Research Institutes, are counted as part of the business sector, while private research institutes operated as foundations or non-profitmaking associations, such as the Research Institute of Industrial Economics, are classified as part of the private non-profit making sector.

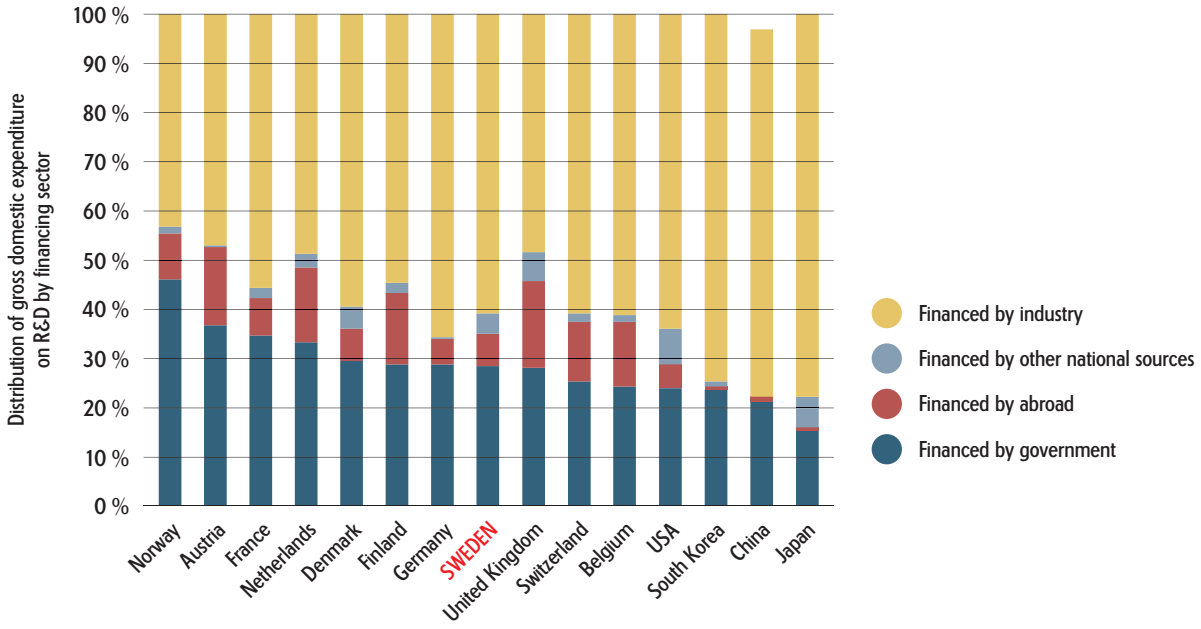

Figure 7. Gross domestic expenditure on R&D in 2015 divided up by financing sector. Data for China does not add up to 100 per cent. Source: OECD.

Figure 7 shows the distribution of overall R&D expenditure by financing sector in 2015. It is clear that the European countries in the selection show a greater proportion of foreign financing than do the United States, South Korea, China and Japan. This is due partly to financing from the EU, but also because foreign industry often chooses to carry out its R&D in these countries. As established earlier, for Sweden and for Switzerland, government funds for R&D have increased compared to funds from the business sector. Norway's proportion of government R&D funding is large in an international comparison (see Figure 5).

1.3 Personnel in the R&D system

This section looks at the number of researchers in relation to the population in the different countries, and at how they are distributed across different sectors of society. The designation "researcher" is based the definition in the Frascati Manual, which is used in OECD statistics.[6] The definition is based on the person's work tasks, and a researcher does not necessarily have a PhD degree.

6 See the fact box in Section 1.1.

In the Nordic countries, a relatively large proportion of the population work as researchers

Figure 8 shows the proportion of researchers in the population as a whole, divided up into men and women. In nearly all the comparison countries, the proportion of researchers increased over the period 2004–2014. At the same time, a change in OECD's classification of researchers was implemented a few years ago. The category "technical personnel" was abolished, and now there are only two personnel categories that work with R&D, namely "researchers" and "R&D personnel". Consequently, the number of researchers increased in the OECD statistics for Sweden. Figure 8 counts researchers as individuals, as data for researchers as full-time equivalents (see Figures 1, 2 and 9) is not available divided up by gender.

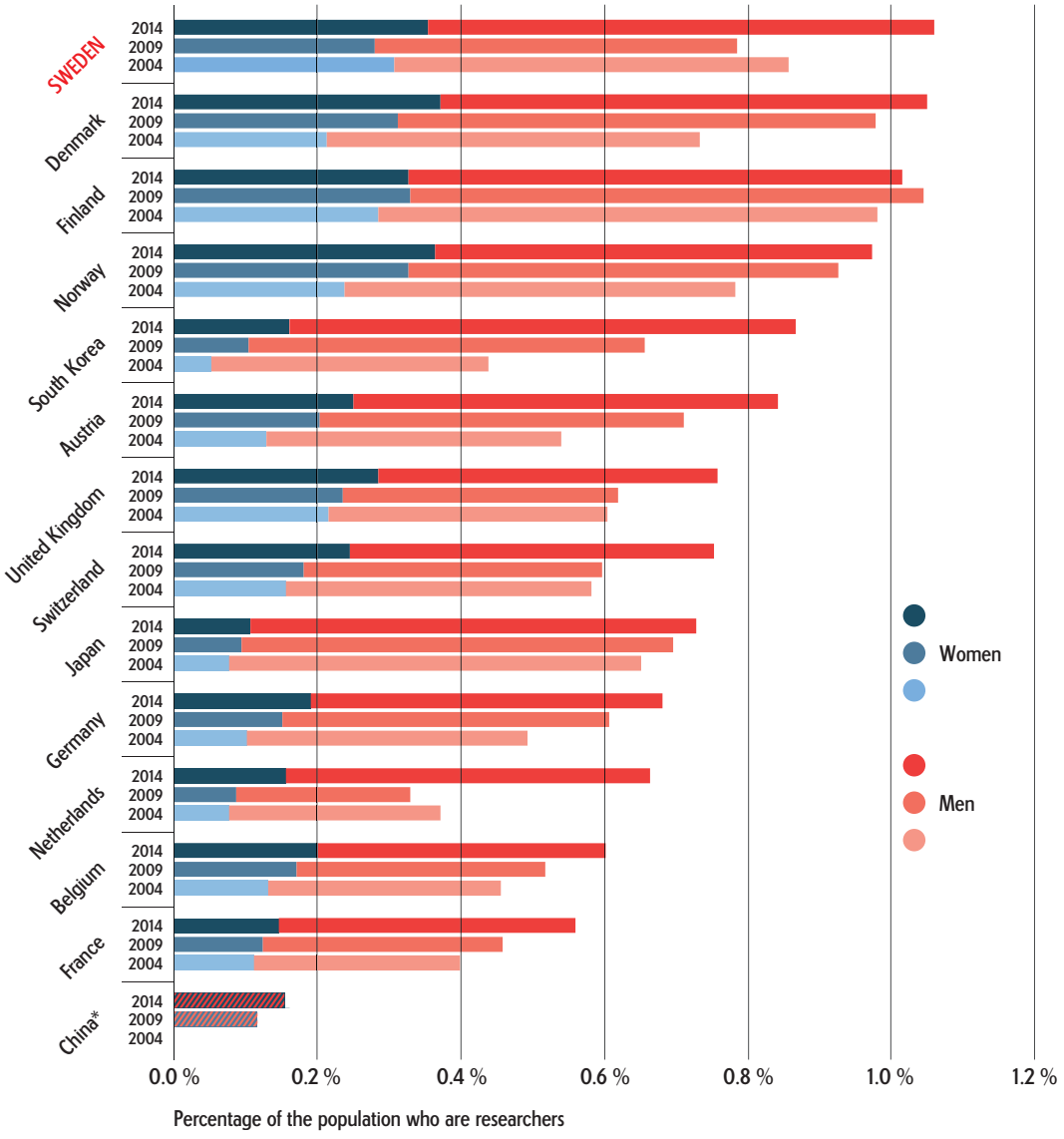

Figure 8. Percentage of the population who are researchers, divided up into women and men, in the years 2005, 2009 and 2014. Data divided up by gender is not available for China. Source: OECD.

The Nordic countries stand out in international comparison, as a large proportion of the population work in research. In Finland, the proportion has been more-or-less constant, while the proportion of researchers has increased to Finland's level in the other Nordic countries. In South Korea and Austria, the proportion of researchers has increased strongly.

In most countries, the balance between men and women is also changing, as the number of researchers who are women is increasing slightly faster than the number of researchers who are men. The largest proportion of researchers who are women can be found in the United Kingdom and in Norway, who each have around 37 per cent. The largest proportion of researchers who are men is found in Japan, South Korea and the Netherlands. In Japan and South Korea, both the number and proportion of women is increasing, while the number and proportion of men has increased slightly since 2009 in Sweden, France and the Netherlands. In Sweden, this is probably due to a reclassification of technical personnel as researchers, as the increase in the number of researchers may be assumed to come from technically focused sectors, where men are over-represented.

A large proportion of researchers work in the business sector in South Korea, Japan and Sweden

Figure 9 shows how researchers are distributed between the business sector, the higher education sector, and the government sector (other public sector). The countries with research systems based on much R&D being carried out at public research institutes rather than within the HEI sector can be expected to have a higher proportion of researchers in government sector establishments.

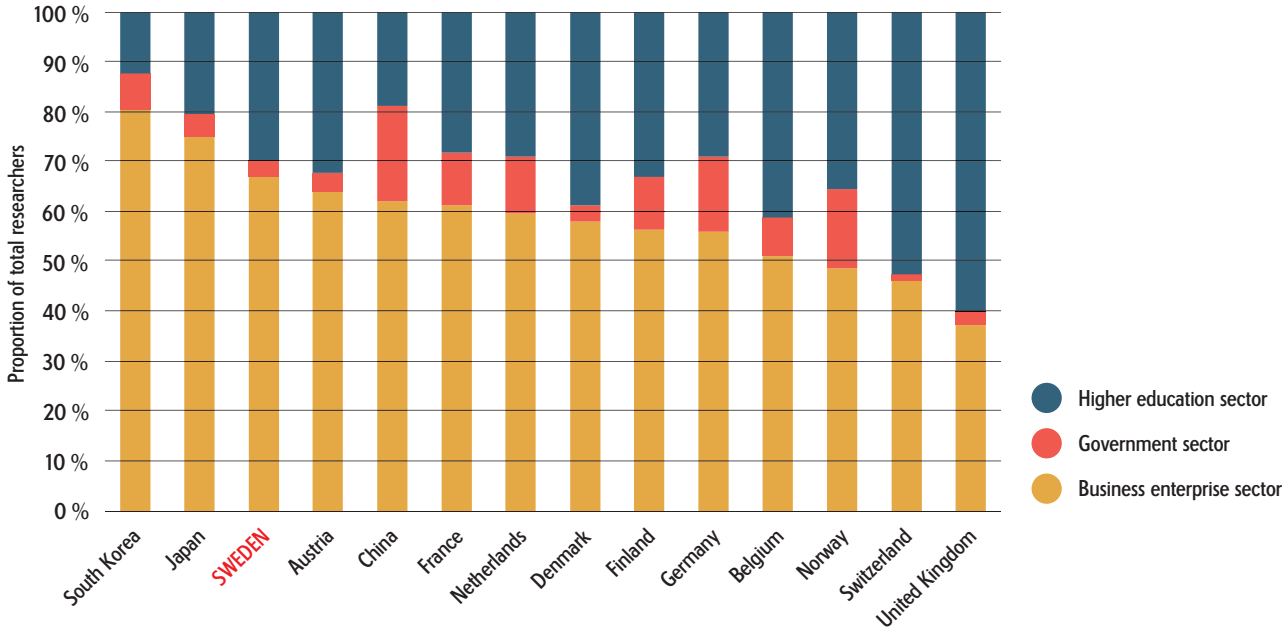

Figure 9. Distribution of researchers (full-time equivalents) between the business sector, the higher education sector, and the government sector. Data from 2014 or latest available year. Source: OECD.

South Korea, Japan and Sweden employ a comparatively large proportion of their researchers in the business sector, while researchers in the United Kingdom and Switzerland are mainly employed in the HEI sector.

It is a well-known fact that Sweden has comparatively little publicly financed research outside the HEI sector, which is also the case in Japan, Switzerland, the United Kingdom and Denmark. In Denmark, a restructuring of the research system was carried out in the in the first decade of the 2000s[7], which led to a sharp drop in the number of researchers in the other public sector. In Germany, much research is carried out at publicly financed research institutes, as is the case in China and Norway, to mention a few countries. In Norway, there is a broad public institute sector, which receives basic financing from the government,

7 DFiR (2016). Links between research policy and national academic performance, Background report, p. 75, CFA, Technopolis Group, NIFU

primarily via the Norwegian Research Council.[8] The researchers employed at these institutes fall into the government sector in Figure 9. Some of the Swedish industrial research institutes are included in the business sector, and researchers employed at these institutes are therefore reported in the business enterprise sector. Such industrial research institutes exist also in other countries, for example Norway.

1.4 Swedish scientific publication in an international perspective

The most common quantitative measurements of research quality in a country are the number of publications and different types of citation indicators. In this section, we describe publication volumes, citation impacts and subject profiles in a selection of countries.

The publication statistics in the Research Barometer is based on the publication database[9] at the Swedish Research Council, where the contents largely correspond to the contents of the database Web of Science (WoS). Hereafter, Web of Science is therefore referenced. The approximately 250 subjects included in the database have here been aggregated into 16 larger subject areas. Coverage in the database of the various subject areas is shown in Figure 34 in the methodology section, which shows the proportion of the references within the various subject areas that are made to other publications in Web of Science. For biomedicine, 86 per cent of the references are found in Web of Science; in this subject area, the database can therefore be assumed to provide a representative picture of the research. In humanities, on the other hand, only 17 per cent of the references can be found in Web of Science, which means that much of the research that is relevant within humanities is not included in the database. In humanities and social sciences, monographs – often written in Swedish – have long been an important publication channel, which is reflected in the coverage of these subjects in the database. Publication statistics focusing on comparisons between the subject areas must always take into account the coverage of the area in question.

Citation impact

To study the scientific impact, the Research Barometer uses an indicator that states how large a proportion of the publications of a country or an organisation that is among the 10 per cent most highly cited publications in Web of Science.

The fact that a publication is among the 10 per cent most highly cited means that it is one of the 10 per cent most cited scientific publications published within the same subject area in one specific year. The global average for this indicator is 10 per cent.

Measuring how large a proportion of a country's publications are among the 10 per cent of publications in the database that have received the most citations is a more stable measurement that average citation, for example, as the use of highly cited publications is not as sensitive to the phenomenon of individual very highly cited articles.

For further details, please see Bibliometric analysis in Methodology, Section 3.4.

Switzerland produces the largest number of publications per inhabitant

A country's publication volume is the number of scientific publications produced over a certain period. Figure 10 compares the number of publications per 1 000 inhabitants, and the proportion of highly cited publications for the period 2013–2015 for a selection of countries. The figure also illustrates the countries' relative size in terms of publication volume.

8 Research Council of Norway (2016) Det norske forsknings- og innovasjonssystemet - statistik og indikatorer p. 65. [The Norwegian research- and innovation system – statistics and indicators]

9 The Swedish Research Council buys raw data from Clarivate Analytics and the contents correspond largely to the contents of Web of Science. When this report mentions Web of Science, it refers to the Swedish Research Council's database, which consists of the following products: Science Citation Index Expanded®, Social Science Citation Index® and Arts and Humanities Citation Index®. These products have been compiled by Clarivate Analytics®, Philadelphia, Pennsylvania, USA© Copyright Clarivate Analytics® 2017. All rights reserved.

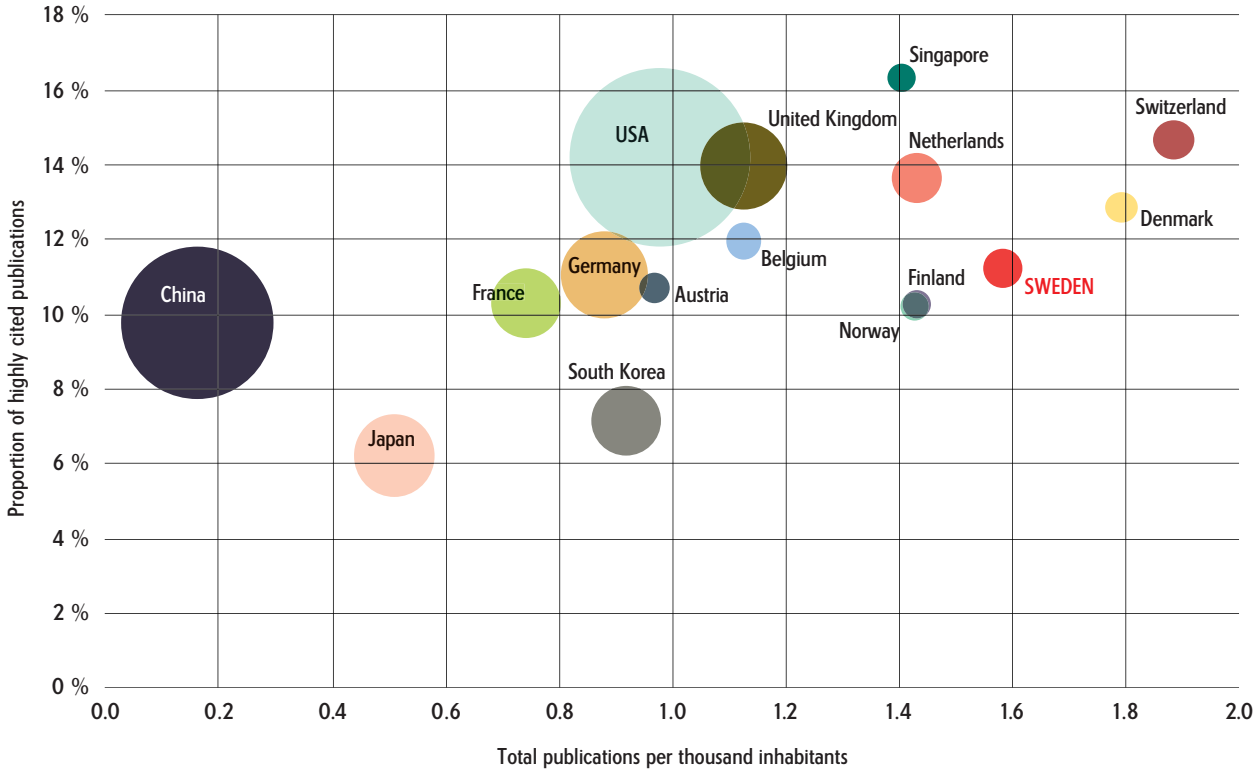

Figure 10. Number of publications per 1 000 inhabitants and citation impact (proportion of highly cited publications). Articles published during the period 2013–2015. The area of the circle is proportional to the country's total number of publications. Source: Clarivate Analytics and UN.

During the period 2013–2015, Switzerland was the country that produced the largest number of publications per 1 000 inhabitants, followed by Denmark and Sweden. In relation to their populations, large research nations such as the United States, China and the United Kingdom have a lower proportion of articles than Switzerland, the Netherlands, Singapore and the Nordic countries. The United States is still the world's largest producer of scientific articles expressed in absolute figures, but over the last 20 years, China has increased its production strongly and is now the second largest producer of articles. Together, the United States and China produced 36 per cent of all publications in Web of Science during 2013–2015. Sweden's share of world production was 1 per cent during the same period. Finland and Norway have practically the same number of publications per inhabitant, the same proportion of highly cited publications and the same publication volume, which means that their circles in Figure 10 almost entirely overlap each other.

Sweden's proportion of highly cited publications is 11 per cent, that is to say, above the global average of 10 per cent. Most of the comparison countries lie, however, further above the world average than Sweden. Japan and South Korea are the only countries in Figure 10 that have a citation impact significantly lower than the world average.

Singapore and China are increasing their proportions of highly cited articles

Figure 11 shows the development of the proportion of highly cited publications between three different periods, in our comparison countries. The figure in brackets shows the country's place among all countries (with more than 300 publications) in Web of Science for the period 2013–2015. Singapore has been included to illustrate the country's strong increase in citation impact.

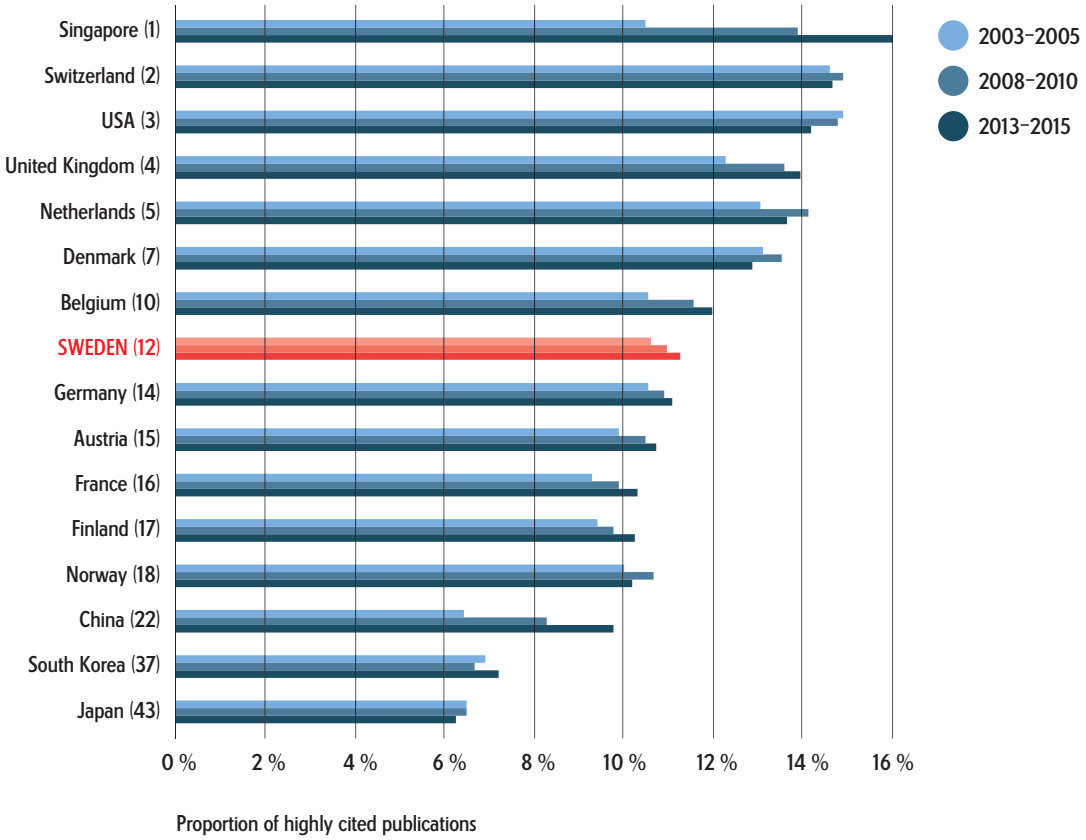

Figure 11. Development of citation impact (proportion of highly cited publications). Citation impact is shown for three periods: 2003–2005, 2008–2010 and 2013–2015. The figures in brackets indicate the country's position among all countries in Web of Science over the period 2013–2015. Source: Clarivate Analytics.

Singapore has by far the greatest increase in citation impact of all the countries in Figure 11. China has increased its proportion of highly cited articles over the years, and is approaching the world average of 10 per cent. The proportion of highly cited articles from Switzerland, the United States, the Netherlands and Denmark fell slightly between the second and the third period, while Sweden's proportion of highly cited publications increased slightly between all periods. Several other countries have seen greater increases though, and Sweden is currently in the category of countries that all have around 11 per cent of highly cited articles and occupy positions 12–15 in the ranking list of the world's countries.

The differences in citation impact between the countries placed close to Sweden on the list are also very small. Marginal changes in statistics can therefore result in a country moving up or down several positions on the ranking list.

Agriculture and biology top the list for Swedish highly cited articles

Sweden is above the world average within most subject areas when it comes to the proportion of scientific publications within each area that are among the 10 per cent most highly cited. Figure 12 compares Sweden to the EU15 countries and the world, i.e. all countries in the database.

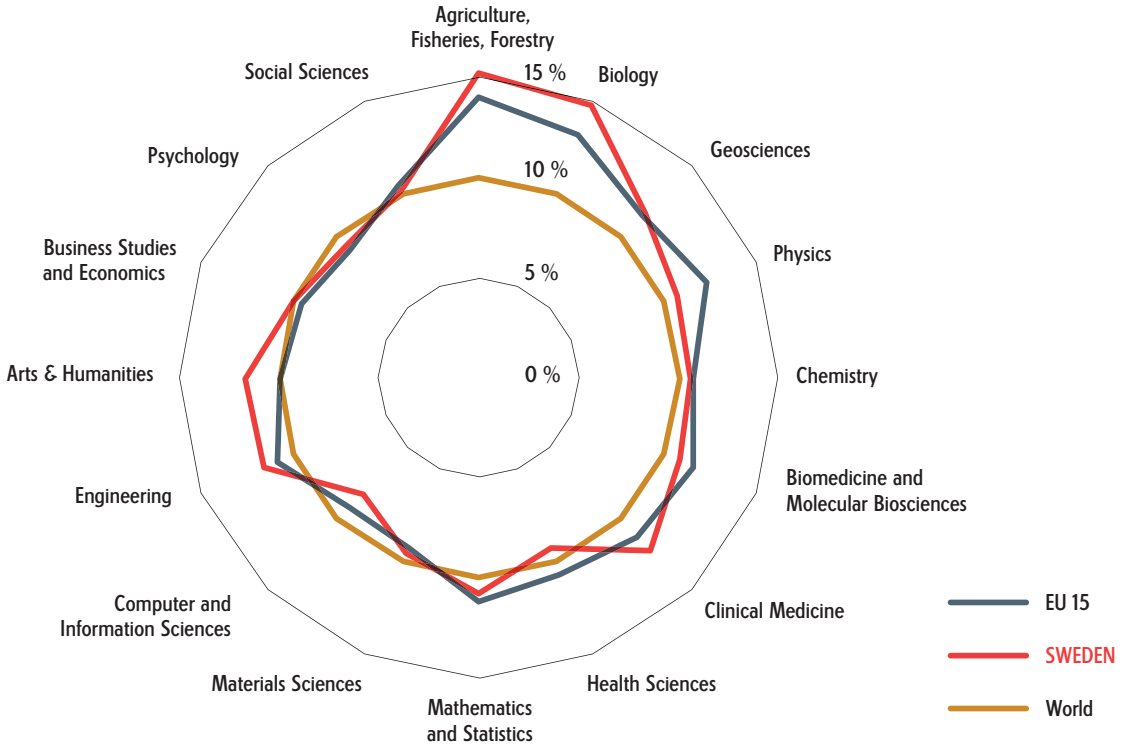

Figure 12. Citation impact (proportion of highly cited publications) for Swedish research within 16 subject areas. Sweden is compared to the average value for the EU15 countries and the world (all countries in the database). Articles published during the period 2013–2015. Source: Clarivate Analytics.

The subject areas where Sweden has the greatest impact are agriculture and biology. They are also the two areas where the EU15 countries have the greatest impact, albeit slightly smaller than that of Sweden. Clinical medicine is also a strong area for Sweden, while the proportion of highly cited Swedish publications within ICT and health sciences is below the world average. Swedish research in the humanities also has a citation impact that is above the average for the EU15 countries and the world.

Western Europe and the United States have a broader subject profile than the emerging research nations in Asia

Sweden, like the United States and the countries in Western Europe, have a well-rounded research subject profile characterised by both breadth of subjects and high citation impact in diverse subject fields. Figure 13 shows the subject profile for Sweden, the United States and China. The degree of subject specialisation is shown on the horizontal axis and the citation impact for articles on the vertical axis. The size of each circle is proportional to the publication volume of the corresponding subject within each country.

If the circle is to the right of the vertical average line (0), this means that the country has a specialisation in the subject area in question; that is, the country's share of publications in this subject is higher than the total share of publications in this subject in the database. Correspondingly, subjects for which the country has a lower rate of specialisation are found to the left of the average line. If the circle is above the horizontal average line (10 per cent), this means that the country's publications within the subject area in question has greater citation impact than the world average (measured as the proportion of highly cited articles in the database). Subjects with lower citation impact than the world average are found below the 10 per cent line.

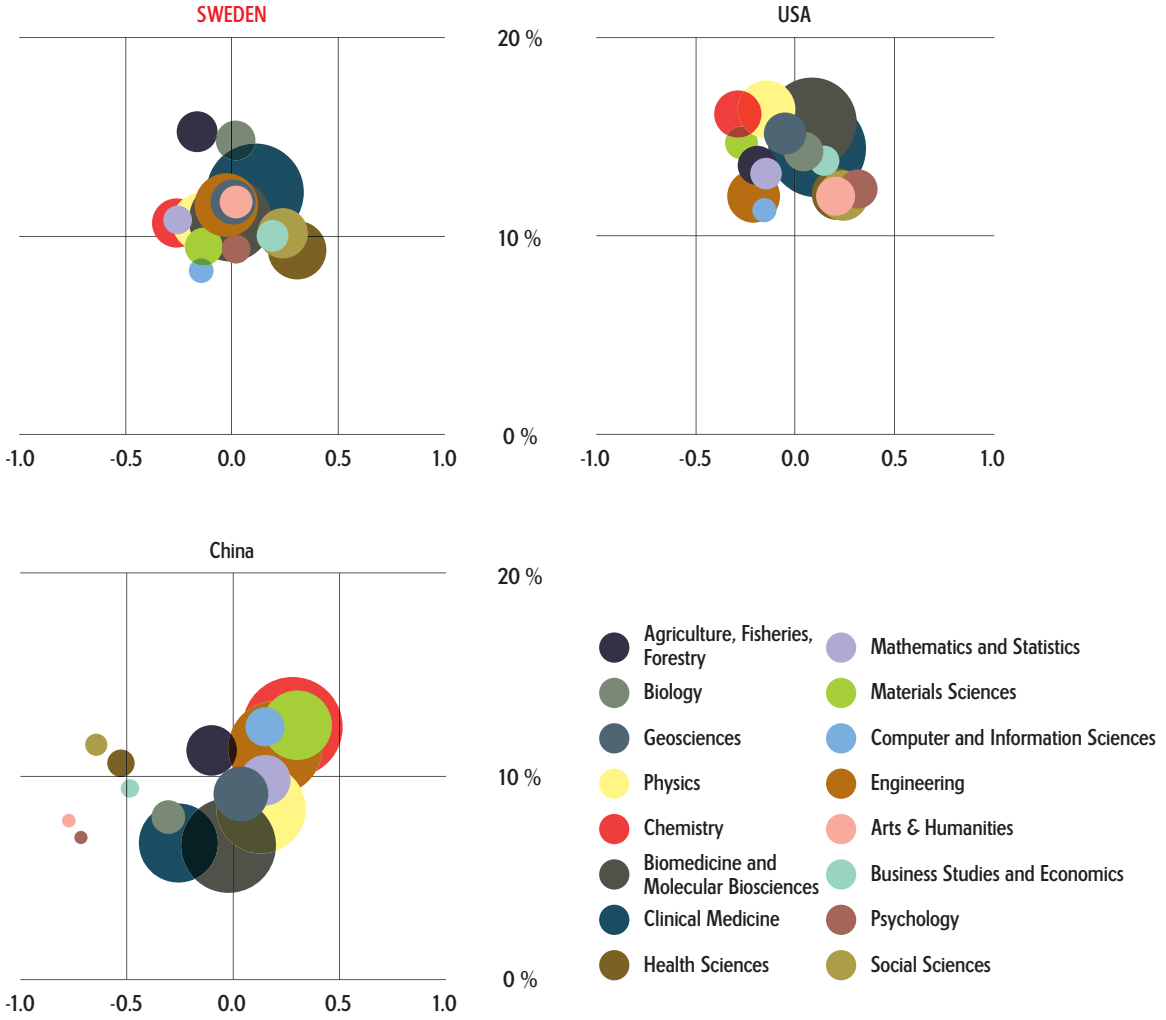

Figure 13. Subject profile and citation impact for Sweden, the United States and China. The horizontal axis shows the country's relative specialisation index (RSI) for 16 subject areas. The vertical axis shows citation impact (proportion of highly cited publications) within the different areas. The size of each circle is proportional to the subject area's share of the country's article volume. Articles published during the period 2013–2015. Source: Clarivate Analytics.

A characteristic of Sweden's subject profile is that the subject circles are concentrated around the middle of the horizontal axis. This means that Sweden's subject profile is reminiscent of the overall subject profile in Web of Science. Compared to the rest of the world, Sweden has a slightly larger proportion of publications within health sciences, and a slightly lower proportion of publications within chemistry. As noted in Figure 12, Sweden's share of highly cited publications within agriculture and biology is considerably larger than the world average.

For the United States, all subject areas have a greater citation impact than the world average. As in Sweden, clinical medicine and biomedicine are the largest subject areas.

The profiles for Sweden and the United States are reminiscent of the well-rounded profiles of several Western European countries, for example Denmark, where clinical medicine and biomedicine are the two largest subject areas, just as in Sweden. And just as for Sweden, agriculture and biology are the subject areas in Denmark that have the highest proportion of highly cited publications.

Emerging research countries, such as China and South Korea, are more specialised subject-wise. Many emerging research countries have a low citation impact, but China's impact is getting close to the world average. As Sweden and the United States, China also has a relatively large proportion of publications in clinical medicine and biomedicine, but chemistry and engineering are the dominating

subjects. China's subject profile is more dispersed horizontally, and, relative to the rest of the database, the country has a small proportion of research within humanities, psychology, social sciences, health sciences and economy. In biomedicine, clinical medicine and physics, which together represent 40 per cent of the Chinese article production, the proportion of highly cited articles is considerably below the world average, while China's share of highly cited articles in chemistry, materials sciences and computer and information sciences is above the world average.

1.5. Swedish researchers in international collaboration

Increased international collaboration within research and innovation is an important priority for many countries, as international collaboration is assumed to raise the quality of the research and to strengthen the competitiveness and attractiveness of the universities. However, comparing the degree of internationalisation of national research systems is not entirely easy, as the countries have such different prerequisites and drivers. There are also few robust indicators that are suited to international comparison.[10]

One established indicator for international research collaboration is international co-publication, that is to say publications with two or more authors from different countries. This section shows how Swedish researchers publish internationally, in collaboration with researchers from other countries. A more in-depth picture is provided by the Swedish Research Council's report *Svenskt publiceringssamarbete i ett globalt perspektiv* (2016) (Swedish co-publication in a global perspective).

Internationalisation of research is characterised by both cooperation and competition, which is shown not least in the countries' commitment and success in international and European collaboration organisations and programmes. In this section, this is illustrated with a comparison between the participation by a selection of EU countries in European infrastructure collaborations and the countries' participation in the framework programme for research and innovation, Horizon 2020. For a more complete picture of Sweden's and other countries' commitment to Horizon 2020, please see Vinnova's *Årsbok 2016: Svenskt deltagande i europeiska program för forskning och innovation* (Annual Report 2016: Swedish Participation in European Programmes for Research and Innovation) and the visualisation tool for Horizon 2020 on Vinnova's website[11].

Swedish researchers co-publish mostly with EU researchers, but collaboration with researchers in Asia is increasing

Sweden is one of the countries with the largest proportion of international co-publishing. The proportion of Swedish co-publications with researchers in the EU countries (plus Norway and Switzerland) has increased slowly over the last 35 years. The greatest increase, however, has been the proportion of articles co-published by Swedish and Asian researchers.

[10] Tillväxtanalys (2014). Indikatorer och strategier för internationalisering av forskning och innovation – en översikt med exempel från flera länder. Tillväxtanalys rapport Svar direkt 2014:09. (Growth Analysis. Indicators and Strategies for Internationalisation of Research and Innovation – a multinational study.)

[11] Hur deltar Sverige i Horisont 2020? Visualisation tool. Vinnova 2017 (How does Sweden participate in Horizon 2020?)

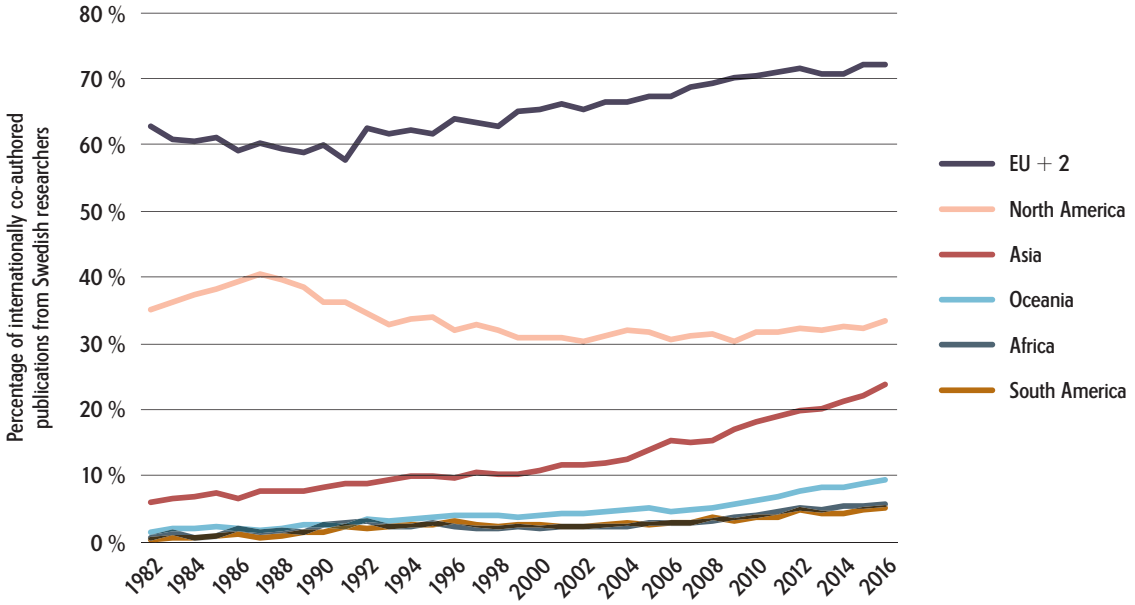

Figure 14. Development of the proportion of internationally co-published scientific publications from Swedish researchers in collaboration with researchers from various regions. Publications during the period 1982–2016. EU+2 refers to the 28 EU countries plus Norway and Switzerland. The publications are full counts, which means that the sum of all co-publications is greater than 100 per cent. Source: Clarivate Analytics.

Figure 14 shows that Swedish researchers primarily publish with European researchers, and that the proportion has been slowly increasing over a long period. Just over 70 per cent of all Swedish internationally co-published articles have been published together with researchers from Europe. Co-publication with researchers in Asia has also increased over the last 35 years – from 6 per cent in 1982 to 24 per cent in 2016. The proportion of co-publications with researchers in the United States and Canada have fallen slightly, however, from 35 per cent to 33 per cent between 1982 and 2016.

The United States is the most popular individual country for Swedish researchers' international collaboration

Figure 15 shows how Swedish researchers collaborate with researchers from individual countries, measured as the number of internationally co-authored scientific publications per year and collaborating country.

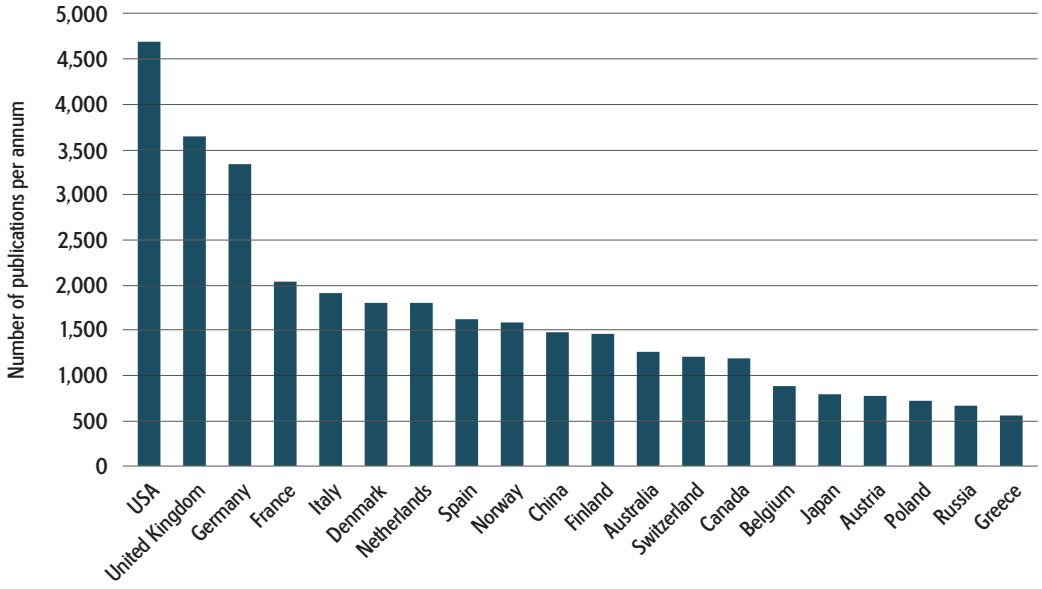

Figure 15. Number of international co-authored scientific publications by Swedish researchers, per collaborating country and year. Number of articles per year is stated as an average for the period 2012–2016. Full counts of publications. Source: Clarivate Analytics.

Figure 15 shows the individual countries that Swedish researchers collaborate with the most. As the United States is the world's largest producer of articles, it is not surprising that Swedish researchers have the greatest number of collaborative articles with US researchers. Just over 4 500 Swedish international co-publications per year during the period 2012–2016 involve at least one author from the United States, which corresponds to around 29 per cent of all of Sweden's international co-publications. Swedish researchers also frequently co-publish with researchers from the United Kingdom, Germany, France, Italy, Denmark and the Netherlands. Swedish researchers collaborate roughly as much with China as with Sweden's neighbouring countries Norway and Finland.

International co-publication by Swedish researchers has increased within all subject areas

The proportion of internationally co-published articles in Sweden has increased from an average of 50 per cent in 2006 to 68 per cent in 2016. Two thirds of all Swedish scientific articles are therefore authored in collaboration with international researchers. This can be compared with the world average, which is around 25 per cent international co-publications.

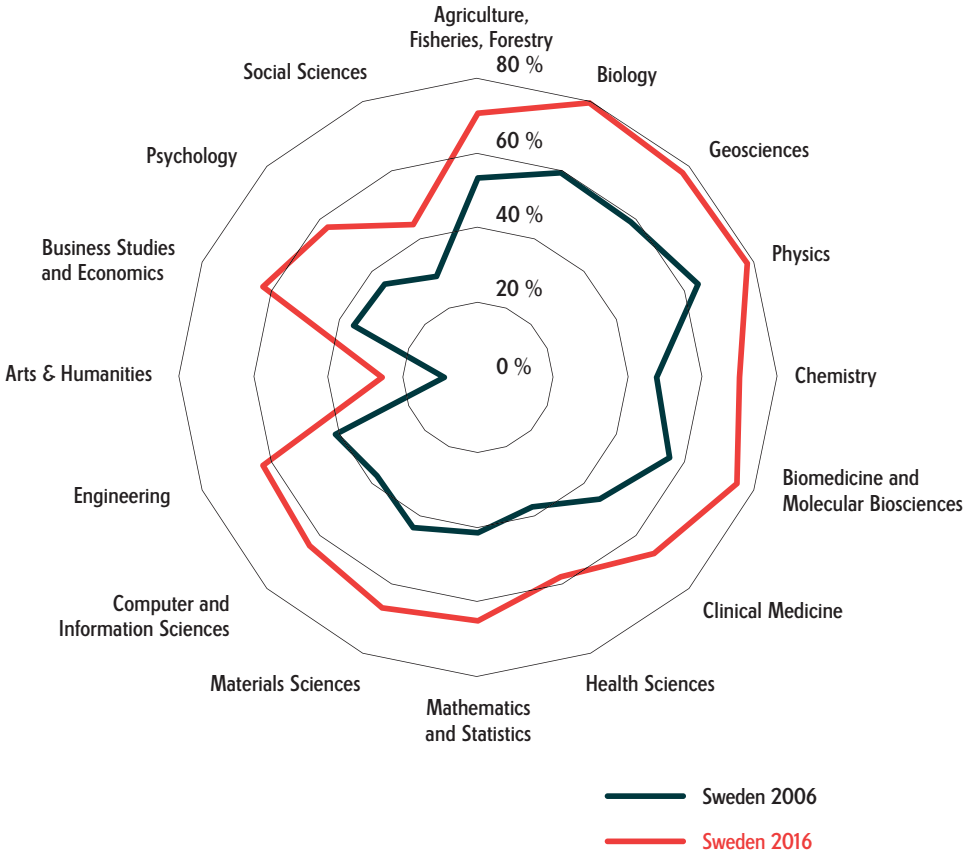

Figure 16. Development of internationally co-authored scientific publications from Swedish researchers within various subject areas, as a proportion of all Swedish publications within the respective subject area. Articles published in 2006 and 2016. Full counts of publications. Source: Clarivate Analytics.

Figure 16 shows that international co-publication by Swedish researchers has increased within all subject areas. The variation between areas is large, however. International co-publication is considerably more common within biology, geosciences, physics and biomedicine than within humanities and social sciences.

Publication traditions vary between research areas. In physics, international co-publication is traditionally common. Collaboration on international infrastructures, such as at the European particle physics laboratory CERN, has made major international collaboration even more common. Other subject areas where international co-publication is common are biology and biomedicine.

Sweden participates actively in collaboration on international research infrastructures

Research infrastructures are facilities, resources and services that are used by the research community to conduct research and foster innovations. It may consist of data collections and registers, large-scale instruments or e-infrastructures.

Many research infrastructures are so large, complex and expensive that several countries have joined together to construct or operate the infrastructure. Research using international research infrastructure is often conducted in the form of major international collaboration. European collaboration within research infrastructure is considered to be of crucial importance for addressing the major challenges facing society. ESFRI (European Strategy Forum on Research Infrastructures) is a European collaboration arena for supporting and facilitating joint initiatives leading to better use and development of research infrastructure within all areas of research. The ESFRI's roadmap for research

infrastructures[12] lists a number of facilities and collaborations where various countries collaborate on developing and financing research infrastructures.

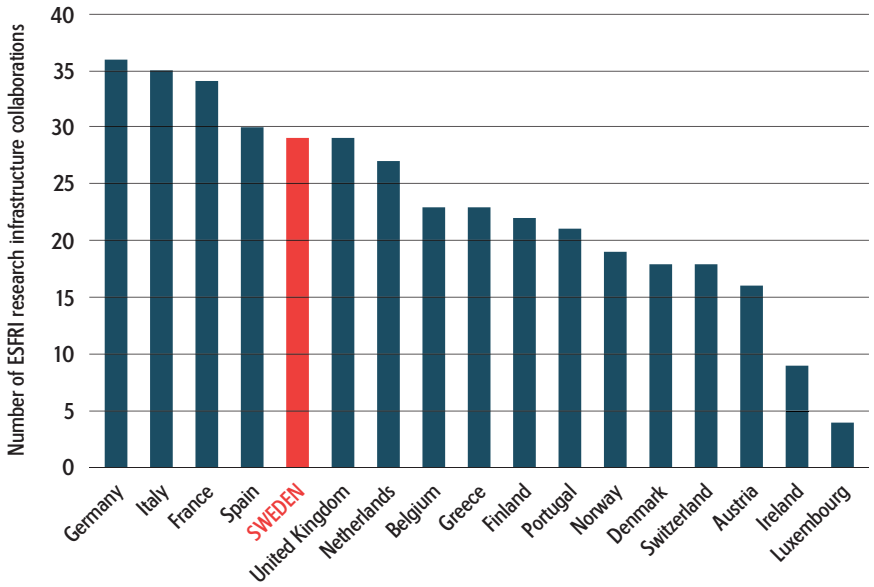

Figure 17. Participation in ESFRI research infrastructures by the EU15 countries plus Norway and Switzerland. Number of research infrastructures out of 45 infrastructure collaborations in total in which the countries participate. Source: ESFRI Roadmap and data summarised by the Swedish Research Council.

Figure 17 shows how the EU15 countries and associated countries Norway and Switzerland participate in the European research infrastructures listed in ESFRI's roadmap. Sweden participates in 30 of the 45 infrastructure collaborations, which indicates active participation. All EU countries, and a large number of other countries, totalling 62 in number, participate in the collaboration on one or several of the ESFRI research infrastructures. Apart from the European infrastructure collaborations, Sweden also participates in many global research infrastructure collaborations.

Sweden's participation in the EU's research programme Horizon 2020

Countries' participation in the EU framework programme for research and innovation is based on collaboration, but at the same time competition is fierce for the research and innovation budget. Germany, the United Kingdom and France top the list of funds granted to date in the current framework programme Horizon 2020. The degree of success of a country in the framework programme can also be illustrated by funds granted as a proportion of population, which together with the success rate, that is to say the proportion of funds awarded compared to funds applied for, provides an indication of the country's relative national competitiveness.

[12] ESFRI Roadmap 2016. Strategy Report on Research Infrastructures: www.esfri.eu

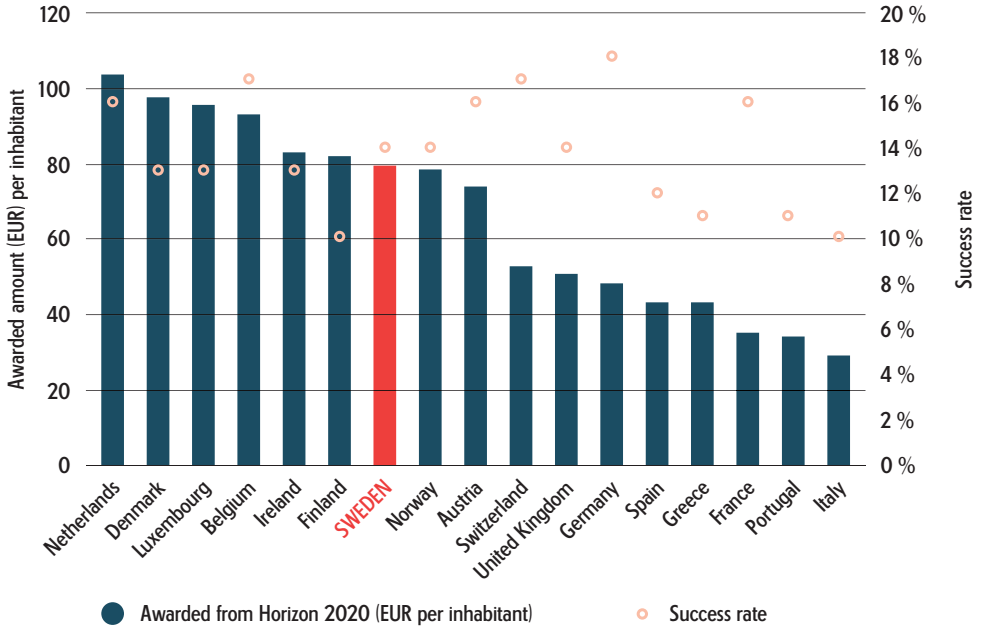

Figure 18. Research funding granted per inhabitant, and success rate in the framework programme Horizon 2020 for the EU15 countries plus Norway and Switzerland. Source: e-CORDA (data from 28 Feb 2017).

Figure 18 shows how Sweden compares in the competition for the EU research and innovation budget in the framework programme Horizon 2020 in terms of funds granted per inhabitant. Sweden is here compared with the EU15 countries and the two associated countries Norway and Switzerland. Sweden occupies an average position among the EU countries. Denmark has been granted more research funds per inhabitant from Horizon 2020 than Sweden, but has a slightly lower award rate. Apart from the countries in Figure 18, the EU member Cyprus and the associated country Israel have a higher amount awarded per inhabitant than Sweden.

Sweden's success rate within Horizon 2020 is 14 per cent, which is the average level for the 17 countries in the figure. Switzerland, whose participation in Horizon 2020 was limited for a period in 2014–2016[13], has a considerably higher success rate, as do Germany, Belgium and France.

Up until February 2017, Swedish organisations had contracted 3.5 per cent of all funds allocated within Horizon 2020, which corresponds to 7 billion SEK.[14]

[13] Switzerland was entitled to participate only in certain programmes within Horizon 2020 between 15 September 2014 and 31 December 2016. As from 1 January 2017, Switzerland once again has full status as an associate EU country, and is entitled to participate in all parts of Horizon 2020.

[14] Årsbok 2016 – Svenskt deltagande i europeiska program för forskning och innovation (Swedish participation in European programmes for research and innovation). Vinnova, May 2017.

2 RESEARCH AT SWEDISH HIGHER EDUCATION INSTITUTIONS

Part 2 uses the financing situation of Swedish research as a whole as the starting point. Thereafter, it concentrates mainly on the research carried out in higher education institutions (HEIs) in terms of financing flows, personnel and publications. Sweden has a large number of universities and colleges, which are all governed by the same Higher Education Ordinance. An important fundamental in the Swedish research system is that all HEIs are part of a uniform national system for higher education, where the HEIs shall have the opportunity to provide education and conduct advanced research of national and international quality. A considerably part of state-financed R&D is carried out within the higher education sector.[15]

[15] Statistics Sweden: Statistiska meddelanden: Forskning och utveckling inom offentlig sektor (Research and development in the government sector) UF 10 SM 1601.

2.1 Resources for research and development in Sweden

Research and development is carried out within all sectors of society. Total expenditure on R&D in Sweden in 2015 amounted to 137.1 billion SEK, which corresponds to 3.26 per cent of GDP. As shown in Sectors 1.1 and 1.2, R&D intensity in Sweden has stayed at a fairly stable level, but with a slight decrease over the last 15 years.

Companies and the public sector are the largest funders of R&D in Sweden

Figure 19 shows how expenditure on R&D in 2015 is divided up between funders and research performers, and the flows from funders to performers.

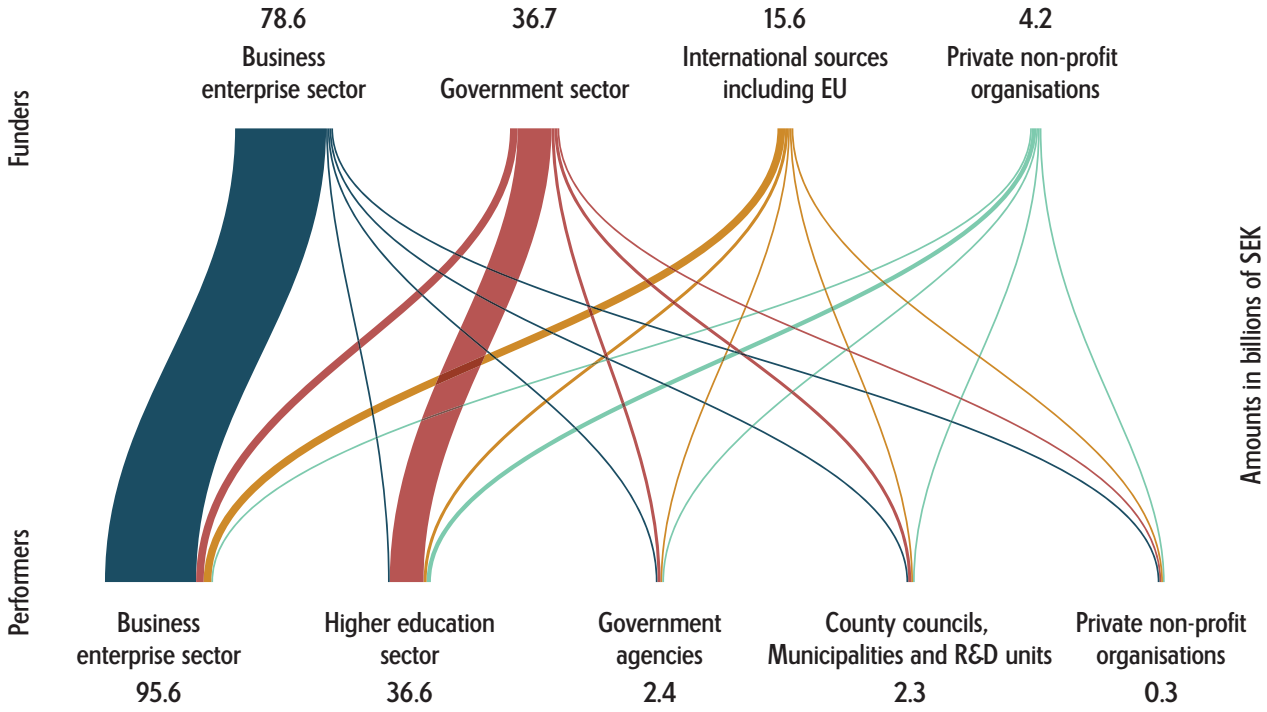

Figure 19. Funding of research and development can be seen from two perspectives: divided up by funder (top edge of figure) or divided up by research performer (bottom edge of figure). The figure shows the financial volume in billion SEK, and the cash flows in the Swedish R&D system for 2015. Source: Statistics Sweden.

The total expenditure on R&D differs between the funding side and the performer side in Figure 19. This is due to period allocation problems – for example, if a performer receives funds in one year, but only uses part of these funds during the same year and the remaining part during the following year.[16] The total expenditure on the performer side (137.1 billion SEK) is counted as the financial volume for the Swedish R&D system in 2015.

The largest funder of R&D carried out within Sweden is the business enterprise sector, which provides 78.6 billion SEK, or 58 per cent of the total funding volume. Of the business sector's research funding within Sweden, 98 per cent or 77 billion SEK, remains within the sector. Consequently, the business sector is also the largest performer of R&D, with 70 per cent of the overall Swedish expenditure on R&D conducted. Among the business sector's performers can be found also the research institutes operated as limited companies, such as RISE and the Swerea institutes.

The public sector is the second largest funder of R&D in Sweden, with 36.7 billion SEK, or 27 per cent of all research funding. Of this, three quarters, around 29 billion SEK, is allocated to the HEI

16 Statistics Sweden: SCB:s statistiska meddelanden UF 16 SM 1701, p. 28

sector, while 5 billion SEK goes to the business sector. Funds from the public sector to Swedish HEIs are allocated partly as direct government funding (block grants), partly via public agencies, research councils and other organisations. A more in-depth analysis of this will follow later in this section.

The remainder of the financing of Swedish R&D comes from international sources (foreign funding bodies) (12 per cent) and domestic private non-profitmaking organisations (3 per cent). Examples of the latter are Knut and Alice Wallenberg Foundation and fundraising organisations, such as the Swedish Cancer Society.

Under the heading International sources including EU can be found for example financing received by Sweden from companies where the head office is abroad, but R&D activities take place in Sweden, and research grants from the European framework programme Horizon 2020. The amount of funds to Swedish research coming from abroad has almost doubled since the last available data set, from 8.5 billion SEK in 2013 to 15.6 billion SEK in 2015.

Increased government funding to HEIs, research funding bodies and civil authorities

National government is the largest financing body of Swedish R&D within the HEI sector. Over the last ten-year period, government financing of the sector has increased by approximately 25 per cent. Figure 20 shows how government funds have developed since 2005. The information is based on the national budget analysis, which is a forecast of funds to R&D in the national budget.

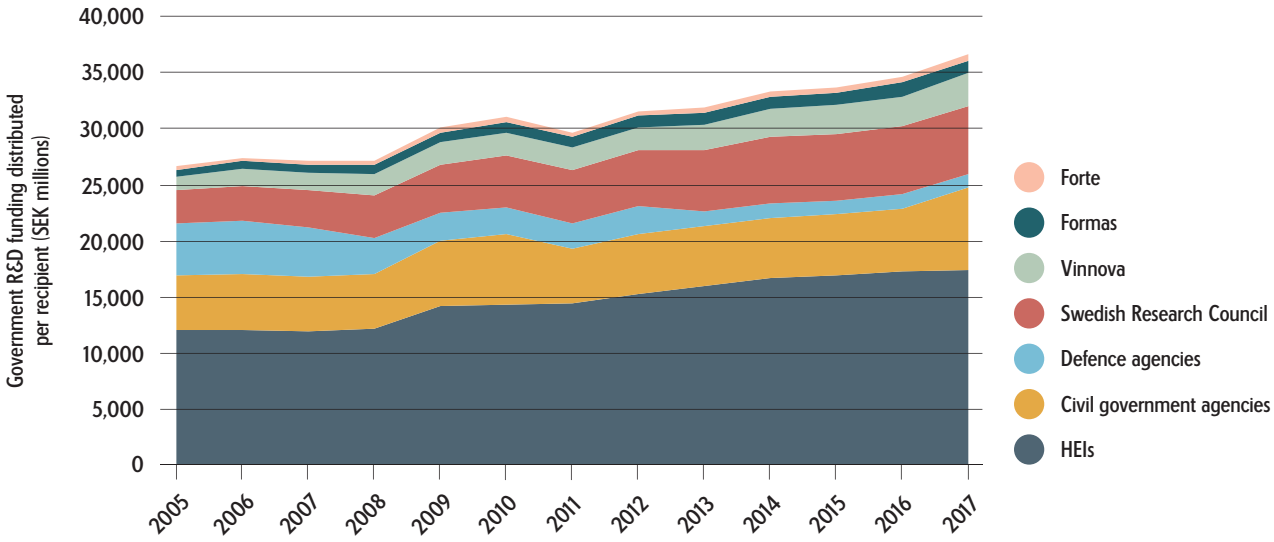

Figure 20. Development (forecast) of Sweden's government R&D appropriations for the period 2005–2017, divided up by recipient. The amounts are stated in million SEK and at 2017 constant prices. Source: Statistics Sweden.

Just under half of the government funds, 17 billion SEK, is allocated direct to HEIs in 2017. The rest is allocated to the research councils Vinnova, Swedish Research Council, Formas and Forte (a total of 11 billion SEK), and to civil authorities (7 billion SEK) and defence authorities (1 billion SEK). Civil authorities with government appropriations can either carry out R&D by themselves, such as the Swedish National Road and Transport Research Institute (VTI) and the Swedish Meteorological and Hydrological Institute (SMHI), and/or finance external R&D, as is the case for the Swedish Energy Agency and the Swedish International Development Cooperation Agency (Sida).

Over the last ten-year period, the largest increase in percentage terms of government financing has been aimed at research funding agencies, which have seen an increase of 45 per cent. Funds from the research funding agencies are then allocated to researchers who are primarily active at HEIs. The increase in direct government R&D funds to HEIs over the same period was 31 per cent, and to civil authorities 35 per cent. The defence authorities have received greatly reduced appropriations, which is mostly explained by the government's changed approach to defence since 2008. The focus on

strengthening operational ability entailed a re-allocation of funds from strategic investments in R&D to investments in unit activities.[17]

Over the period 2005–2017, the R&D appropriation for HEIs has increased by 5.4 billion SEK, for research funding agencies by 4.8 billion SEK and for civil authorities by 2.6 billion SEK. Over the same period, the defence authorities have seen a reduction of 3.2 billion SEK for R&D.

The proportion of direct appropriations to HEIs has remained stable over the last ten-year period

Figures 21 and 22 A and B show R&D income for the Swedish HEI sector for 2015, and the development over time as from 2005. The income refers to operating costs for R&D.[18]

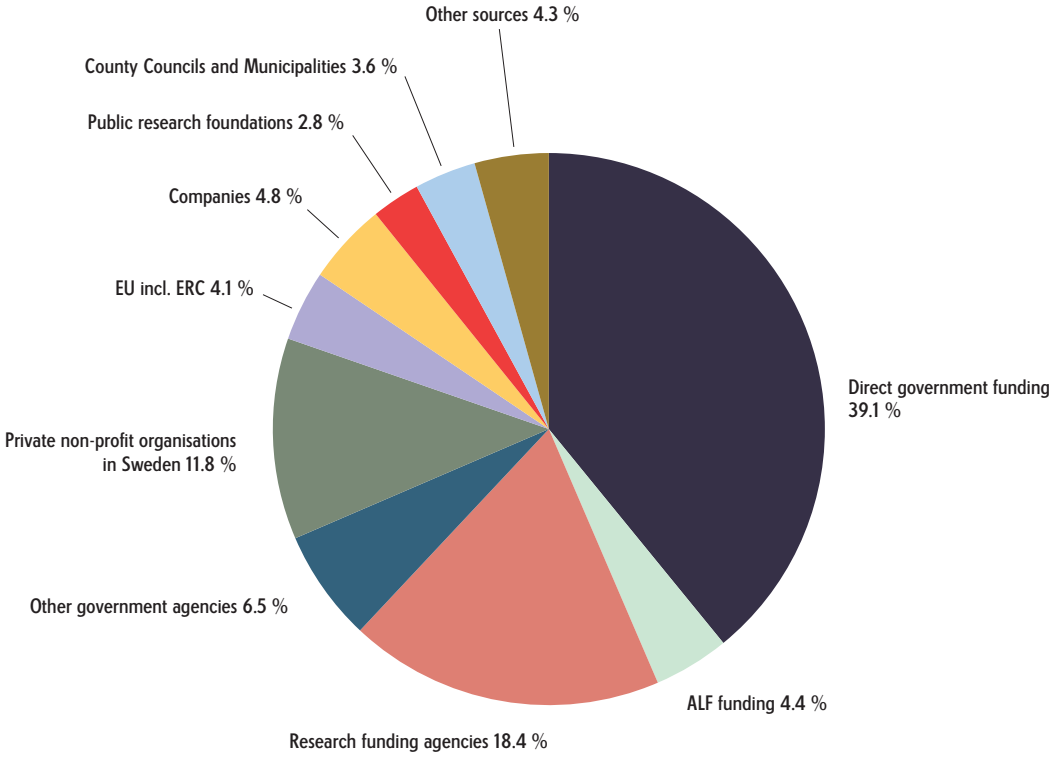

Figure 21. R&D income within the Swedish HEI sector for 2015, divided up by funding body. Source: Statistics Sweden.

Total income for R&D within the Swedish HEI sector amounted to 34.4 billion SEK in 2015. Of these, approximately 75 per cent came from the public sector. Private non-profitmaking organisations accounted for 12 per cent, companies for just under 5 per cent, and EU and its framework programme for research for just over 4 per cent. The remaining just over 4 per cent came from other sources, such as the HEIs' own foundations and transfers between HEIs.

Most of the public funds for R&D were allocated in the form of direct government funding and ALF funds[19], and as grants from government research funding agencies, such as the Swedish Research Council, Vinnova, Formas and Forte.

17 Source: Försvarsforskningsutredningens betänkande *Forskning och utveckling på försvarsområdet* (SOU 2016:90) (Research and development in the defence field)

18 The operating costs correspond to the income for R&D and exclude depreciation and investments.

19 ALF funds (Agreement between County Councils and National Government on Collaboration on Medical Training and Research) are here counted as an income for HEIs. The HEIs then transfer ALF funds to the county councils as compensation for the county council's participation in clinically focused medical research.

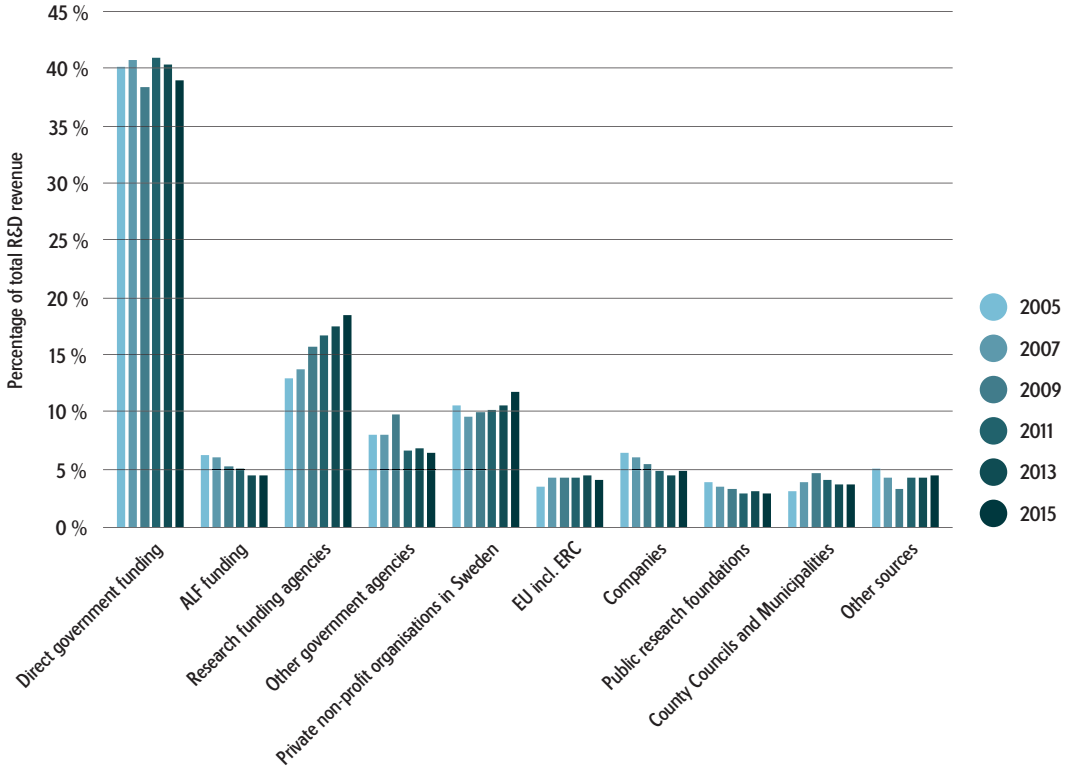

Figure 22 A. Distribution of the HEI sector's R&D income over the period 2005–2015, per funding body and year. The ALF funds are formally part of the direct appropriations, but are here accounted for separately. Source: Statistics Sweden.

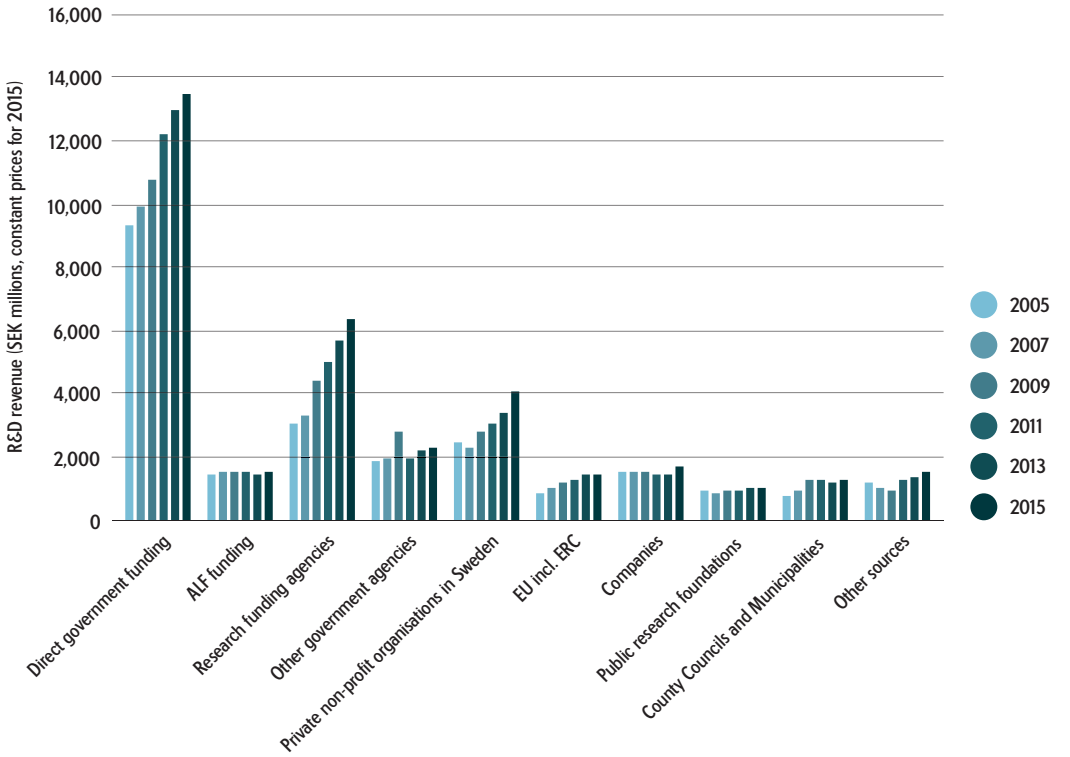

Figure 22 B. Development of R&D income within the HEI sector over the period 2005–2015 in constant prices for 2015, per funding body and year. The ALF funds are formally part of the direct appropriations, but are here accounted for separately. Source: Statistics Sweden.

Figures 22 A and B show the development of the HEI sector's R&D income over time, both as the funding bodies' shares of total R&D income (Figure 22 A) and also as actual expenditure per funding body (Figure 22 B). The proportion of direct government funding (excluding ALF funds, which are here reported separately) of HEIs' overall income from R&D has been fairly stable over the period 2005–2015. The lowest proportion of direct appropriations was 38 per cent (2009) and the highest proportion was 41 per cent (2007 and 2011). The actual direct government funding has, however, increased over the period, from 9.3 billion SEK in 2005 to 13.5 billion SEK in 2015, expressed in 2015 constant prices.

The proportion of the HEI sector's R&D income from research councils has also increased over the period, from 13 per cent of total income in 2005 to 18 per cent in 2015. This entails a doubling, from 3 to 6 billion SEK.

The HEI sector's R&D income from private non-profitmaking organisations has almost doubled over the period, from 2.5 billion SEK to 4 billion SEK. Income from the EU's framework programme Horizon 2020 has increased from 0.8 billion SEK in 2005 to 1.4 billion SEK in 2015.

Increased income for research and development at Sweden's HEIs

Figure 23 shows how income for R&D is allocated between HEIs. Expressed in 2015 constant prices, R&D income for Swedish HEIs has increased from 20 billion SEK to just over 34 billion SEK over the period 2001–2015. That is an increase of 70 per cent. Throughout the period, approximately 90 per cent of the income has been allocated to the comprehensive established universities and the specialised universities, that is to say the universities in Gothenburg, Linköping, Lund, Stockholm, Umeå and Uppsala, and to Chalmers University of Technology, Stockholm School of Economics, Karolinska Institutet, Royal Institute of Technology, Luleå University of Technology and the Swedish University of Agricultural Sciences.

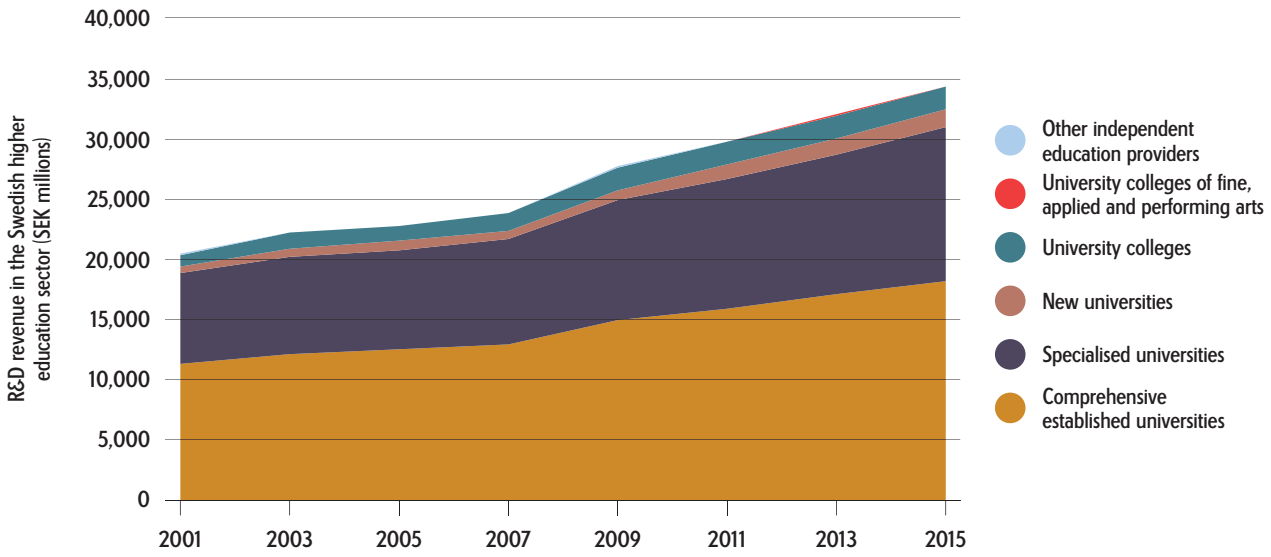

Figure 23. Sweden's government R&D funds divided up by recipient (HEI category). Data for the period 2001–2015. The amounts are stated in million SEK and at 2015 constant prices. Source: Statistics Sweden.

In 2015, the comprehensive established universities received around 53 per cent of the total R&D income for Swedish HEIs, while the corresponding figure for the specialised universities was 37 per cent. Approximately 10 per cent of R&D income was distributed between the four new universities (Linnaeus University, Karlstad University, Mid Sweden University and Örebro University) and the 14 university colleges (see list in Methodology, section 3.7). Other independent education providers and university colleges for the arts together received approximately 0.2 per cent of the total income for R&D at Swedish HEIs.

The R&D income for the comprehensive established universities increased by 60 per cent, and for the specialised universities by 71 per cent over the period; together, these HEI categories thus had an overall increase of 65 per cent. The R&D income for the new universities more than doubled over the period (an increase of 140 per cent), while the income for the university colleges increased by 94 per cent. The greatest increase in percentage terms was seen by the university colleges for the fine, applied and performing arts, whose R&D income almost tripled.

Increased R&D income per field of science – most to medicine and health sciences

When studying the HEIs' income per field of science and technology, it is clear that by far the greatest resources are available in the field of medicine and health sciences. Figure 24 shows the HEI sector's income for R&D per field of science and HEI category for the period 2011–2015.[20]

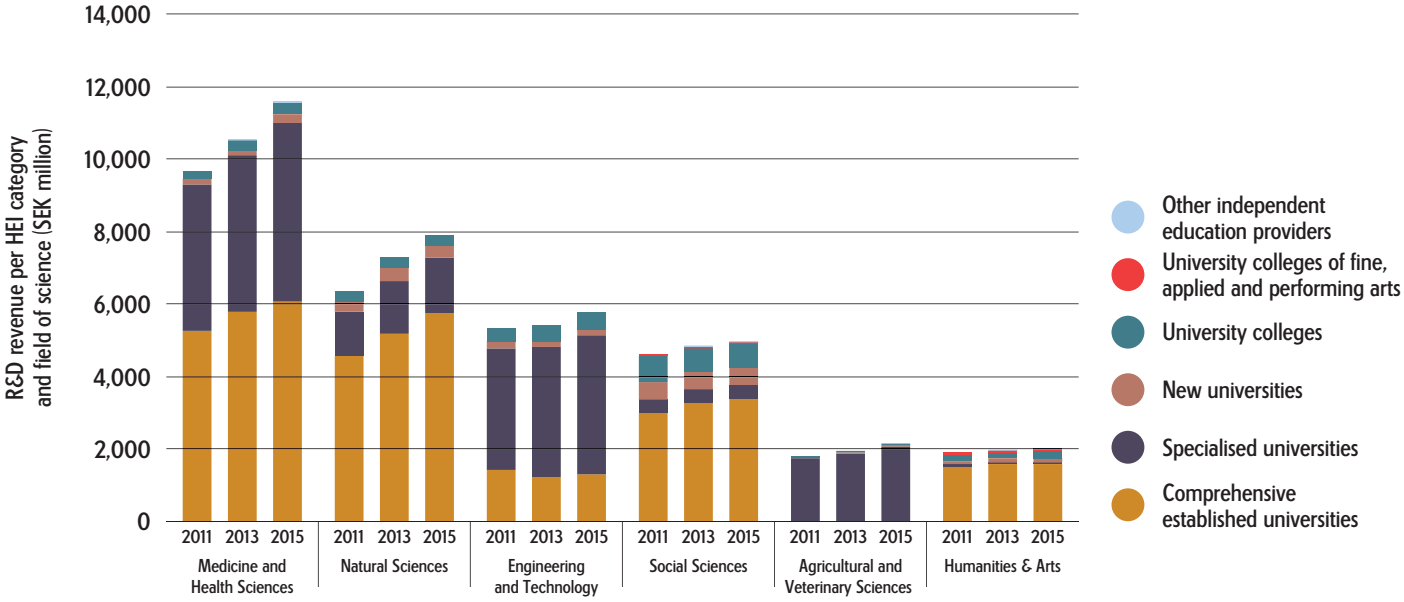

Figure 24. Development of income for R&D within the Swedish HEI sector, divided up by HEI category and field of science. Comparison year: 2011, 2013 and 2015. Source: Statistics Sweden.

Total income for R&D for all HEIs and fields of science and technology amounted to 34.4 billion SEK in 2015. Of these, 11.6 billion SEK went to medicine and health sciences, and 7.9 billion SEK to natural sciences. Engineering and technology and social sciences received 5.8 billion SEK and 4.9 billion SEK respectively. The smallest amount was awarded to agricultural and veterinary sciences, and to humanities and the arts, who each received approximately 2 billion SEK each in 2015.

Over the period 2011–2015, total R&D income for all fields of science and HEIs increased by 4.6 billion SEK, entailing an increase of 16 per cent. In general, the differences between the fields of science are increasing over time when it comes to resources available for R&D. The two areas that received the biggest income previously have also seen the greatest increase, in both absolute and relative terms, over the period 2011–2015. For medicine and health sciences, income increased by 1.9 billion SEK, which represented an increase of 20 per cent. Natural sciences increased its income by 1.5 billion SEK, or 24 per cent. Agricultural and veterinary sciences saw an income increase of 19 per cent, which in absolute terms meant 0.3 billion SEK. The increases for engineering and technology and social sciences amounted to approximately 0.4 billion SEK each, corresponding to an increase of 8 per cent each. Humanities and the arts received a marginal 4 per cent increase over the period, 68 million SEK.

[20] The comparison years are close to each other, as 2011 was a breakpoint for the classification of fields of science and technology in Sweden. Swedish research is now classified into six fields of science and techonology, according to the Standard för svensk indelning av forskningsämnen 2011, published by Statistics Sweden and the Swedish National Agency for Higher Education, updated on 18 November 2012. Comparisons with previous classifications into fields of science and techonology are therefore uncertain.

Figure 24 also shows that the income for medicine and health sciences and for natural sciences together constituted the major part, 34 and 32 per cent respectively, of the total income for R&D at the comprehensive established universities in 2015. The share for social sciences was 19 per cent, and that for humanities and arts was 9 per cent.

At the specialised universities, income for medicine and health sciences and for technology amounted to almost 70 per cent of income for R&D in 2015, while social sciences, natural sciences and technology received most of the R&D income at the new universities.

Within the category university colleges, social sciences received the largest share of income for R&D, followed by engineering and technology, medicine and health sciences and natural sciences.

At the university colleges for the fine, applied and performing arts, the field of humanities and arts dominated, with 70 per cent of income, while other independent education providers focused primarily on medicine and health sciences (63 per cent of R&D income) and social sciences (35 per cent). The field of agricultural and veterinary sciences is found primarily within the specialised universities category (Swedish University of Agricultural Sciences).

2.2 Personnel in the higher education sector in Sweden

In this section, we focus on the research personnel at Swedish HEIs, with special emphasis on gender equality and career structure. During the 2000s, the research and teaching personnel has increased, in particular in employment categories that normally require a doctoral degree. At the same time, several reforms have been implemented, and important policy decisions have impacted on the personnel structure of HEIs.

The number of teaching and research personnel continues to increase

In 2016, the number of teaching and research personnel amounted to approximately 35 000 persons. The number of active doctoral candidates was around 18 000. Around 60 per cent of these were employed as doctoral students. Figure 25 shows how the various personnel categories with teaching and research duties, and doctoral student employees have developed at the HEIs since the early 2000s.

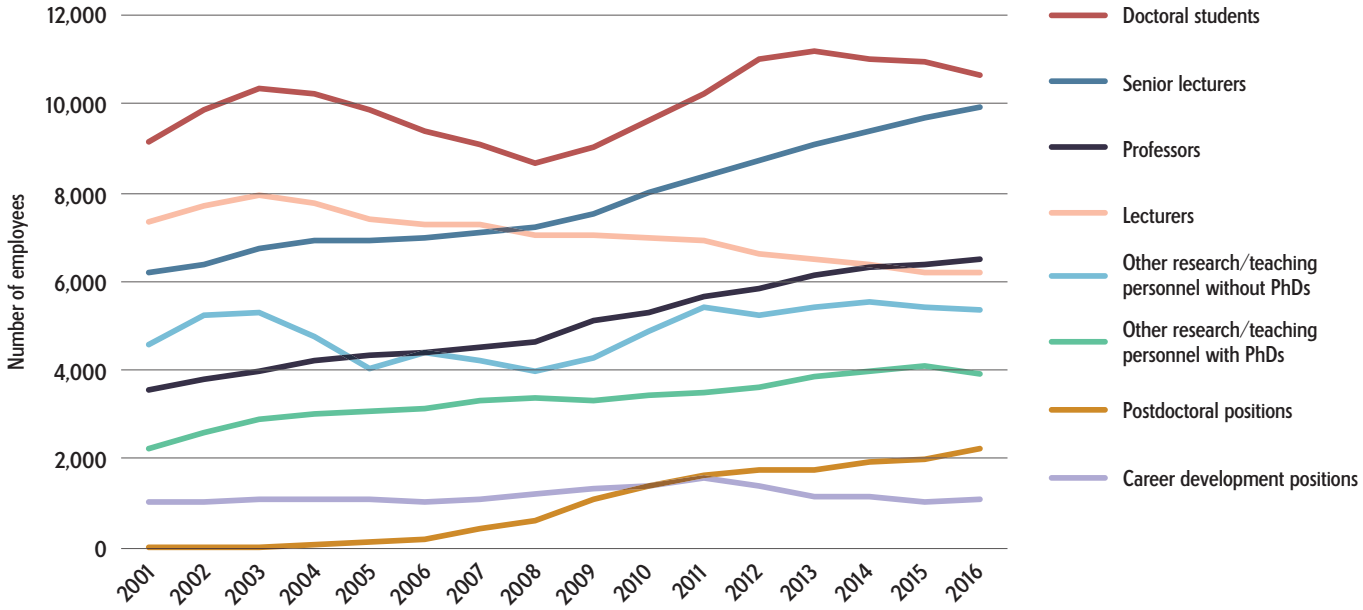

Figure 25. Development of research and teaching personnel and the number of employed doctoral students in Swedish HEIs per employment category, for the period 2001–2016. Source: UKÄ.

It is the research and teaching personnel categories that normally require a doctoral degree (see fact box) that have shown a particular increase. In total, the research and teaching personnel increased by 6 per cent during the period 2011–2016, which is a smaller increase than during the period 2008–2011 (15 per

cent).[21] Since the last Research Barometer, showing data from 2015, the number of senior lecturers has continued to increase, as has the number of professors, although the increase is not as large as previously. Other research and teaching personnel with doctoral degrees (researchers) did not increase. A possible explanation is that young researchers are now to a greater extent employed in postdoctoral positions.

The postdoctoral position was introduced as a two-year employment format for newly qualified researchers in 2008, through an agreement between the parties on the labour market. After this, the number of postdoctoral positions increased rapidly. It emerges from the documentation for a study from the Swedish Research Council (2015)[22] that a large proportion of newly qualified researchers in natural and engineering sciences, who stayed in higher education during the years after obtaining their doctorates, were employed in a postdoctoral position. Within humanities and art, and in social sciences, a senior lecturership is the most common employment category among those who remain in higher education.

The number of career development positions, research assistants (assistant professors) and associate senior lecturers, has fallen since 2011. The career development employment format has been the subject of several changes. In conjunction with the autonomy reform (Govt. bill 2009/10:149), the employment formats career development employee, research assistant and associate senior lecturer were removed from the Higher Education Ordinance. The career development position was reinstated soon thereafter, however, but no great increase in numbers has occurred.[23]

The number of doctoral candidates employed as doctoral students amounted to just over 10 000 in 2016, after having fluctuated quite strongly over the period studied. There is, however, a net increase in the proportion of doctoral candidates employed as doctoral students, from 40 per cent at the start of the period to around 60 per cent in 2016.[24] The number of newly started doctoral students has fallen in recent years.

Teaching and research personnel in higher education

Employment in higher education is regulated in the Higher Education Ordinance (Högskoleförordningen), through agreements between the parties on the labour market or, if otherwise is not stated, in the Employment Protection Act (SFS 1982:80).

Employment categories:

Normally requires a doctoral degree:

Professor (regulated in the Higher Education Ordinance; there is also adjunct professor, visiting professor and combined employment with a healthcare principal)

Senior lecturer (regulated in the Higher Education Ordinance; there is also combined employment with a healthcare principal)

Career development position, often designated assistant senior lecturer or research assistant (assistant professor) (4-year employment, regulated in the Higher Education Ordinance)

Postdoctoral position (2-year employment, regulated via an agreement between the parties on the labour market)

Other research and teaching personnel with doctoral degrees (often designated as researchers) are often regulated in the HEIs' employment regulations.

In addition, there are:

Lecturer

Other research and teaching personnel without doctoral degrees

Adjunct teacher (regulated via an agreement between the parties on the labour market)

Teacher within the fine, applied and performing arts (regulated in the Higher Education Ordinance)

Employment as doctoral student (regulated in the Higher Education Ordinance), not all doctoral candidates are employed as doctoral students.

[21] http://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/hogskolevasende/personal-vid-universitet-och-hogskolor/ (2017-04-27).

[22] Vetenskapsrådet (2015) Forskningens framtid! Karriärstruktur och karriärvägar i högskolan.

[23] Forskarkarriärutredningen. Trygghet och attraktivitet – en forskarkarriär för framtiden (with English Summary). SOU 2016:29.

[24] Statistikdatabasen, UKÄ. (UKÄ statistics database).

The employment structure varies between different HEI categories

The approximately 40 HEIs in Sweden consist of established universities, both comprehensive and specialised, and also of newer universities, university colleges and university colleges for the fine, applied and performing arts. These HEI categories (see Methodology, section 3.7) have differing proportions between research and teaching. This also impacts on the composition of the personnel, as shown in Figure 26.

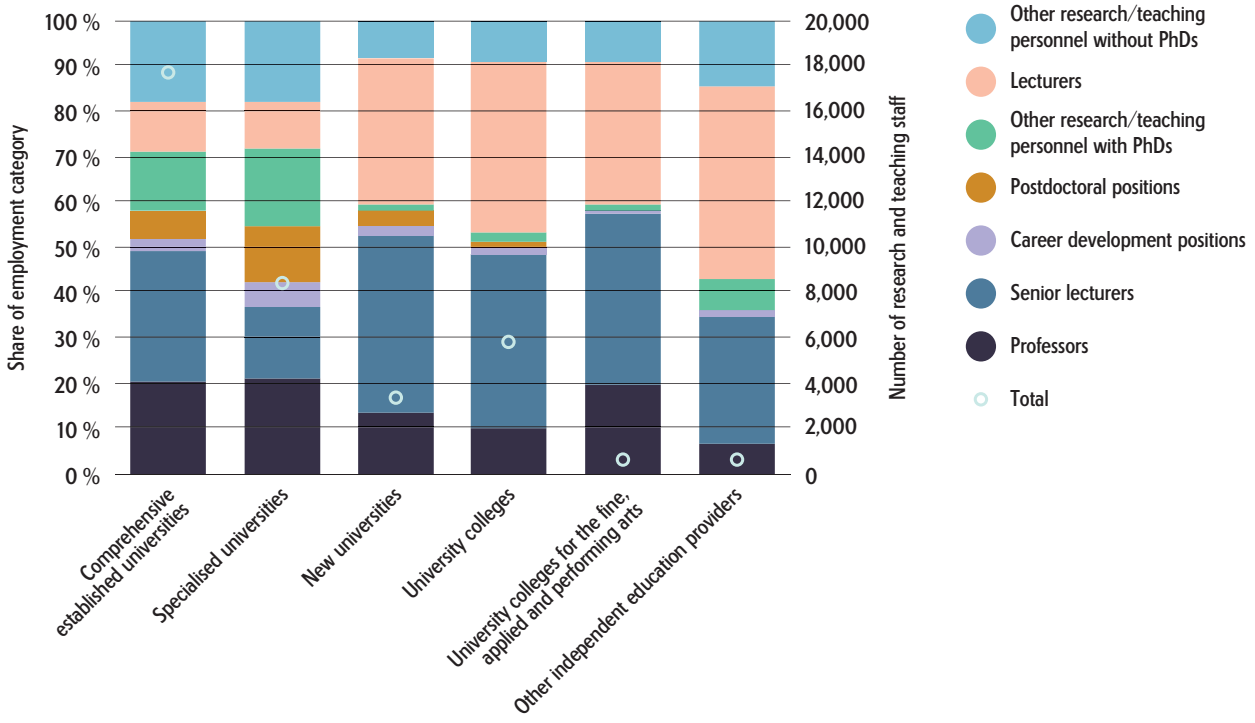

Figure 26. Research and teaching personnel at Swedish HEIs 2016. The left axis shows the relative distribution between employment categories (bars) and the right axis the number of individuals (dots). Source: UKÄ.

Figure 26 shows that the proportion of professors is higher at the established HEIs, while senior lecturers and lecturers form the dominant employment category at the university colleges and the new universities. The fact that research activities are concentrated to the comprehensive established universities and the specialised universities is shown by the personnel categories that are mainly occupied in research being more common there, such as postdoctoral positions and researchers (other research and teaching personnel with doctoral degrees). The regional teaching responsibility is an important component. The new universities and university colleges were responsible for 38 per cent of the educational volume measures as full-year students in 2015.

HEI careers are becoming increasingly gender equal

Gender equality in higher education was one of the profile issues in the Government's research policy bill 2016.[25] Women and men having equal opportunities to develop in the higher education system is one aspect of a gender equal higher education sector. Gender equality is of course not just a question of equal gender distribution among the personnel, but also an issue of good prerequisites for both men and women to teach and conduct research in higher education. This might entail aspects such as access to networks, resources and mentorships.[26]

[25] *Kunskap i samverkan för samhällets utmaningar och stärkt konkurrenskraft* (Collaborating for knowledge – for society's challenges and strengthened competitiveness). Govt. bill 2016/17:50, p. 25

[26] See for example *Svart på vitt – om jämställdheten i praktiken*, SOU 2011:1 (with English Summary).

It is also an indication of a gender equal higher education system if there are equal numbers of men and women at all career stages. In total, the number of teaching and research personnel in employment categories that normally require a doctoral degree amounted to just over 9 500 women and 14 000 men in 2016. Figure 27 shows the proportion of men and women respectively at the various career stages of higher education, from doctoral degree holder to professor.

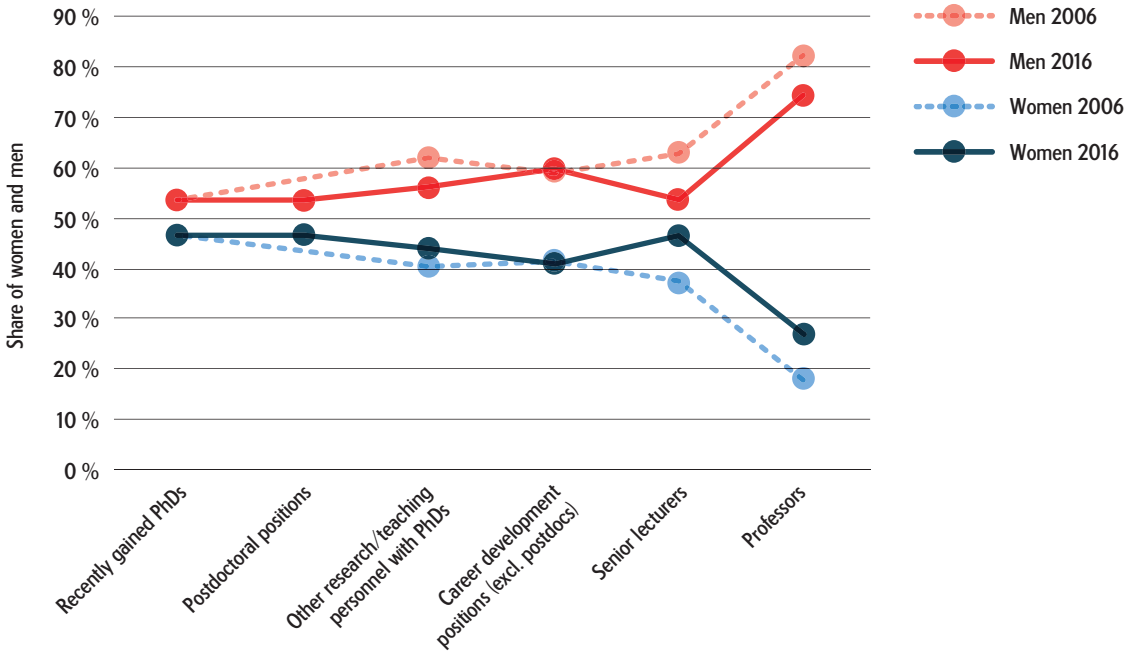

Figure 27. Gender distribution among new doctoral degree holders and among research and teaching personnel at Swedish HEIs in 2006 and 2016. Source: Statistics Sweden and UKÄ.

Approximately the same number of men and women are awarded a doctoral degree; the distribution has been constant over the last ten years. Of the men and women who were employed in postdoctoral positions in 2016, the gender balance is also even. Among researchers (other research and teaching personnel with doctoral degrees), the proportion of women and men was 40/60 per cent in 2006, but was approaching 50/50 per cent in 2016. There is still a slight preponderance of men among persons employed in career development positions (such as research assistants (assistant professors) and assistant senior lecturers). The biggest change is among senior lecturers, where the proportion of women has increased the most; gender balance is now equal there. The development is also moving towards increasingly equal gender balance among professors, but the change is slower. Already 20 years ago, the gender balance among persons with doctoral degrees was more even (33 per cent women and 67 per cent men) than the gender balance among professors is today (26 per cent women and 74 per cent men).

Teaching takes up more time for personnel within social sciences and humanities

Figure 28 shows the relative distribution of annual full-time equivalents spent by personnel on R&D within the various fields of science and technology (including time for applying for research grants), teaching at various levels, and other activities (including administration and expert assignments). The right axis shows the total number of annual full-time equivalents for R&D . The distribution of the different tasks is shown for women and men.

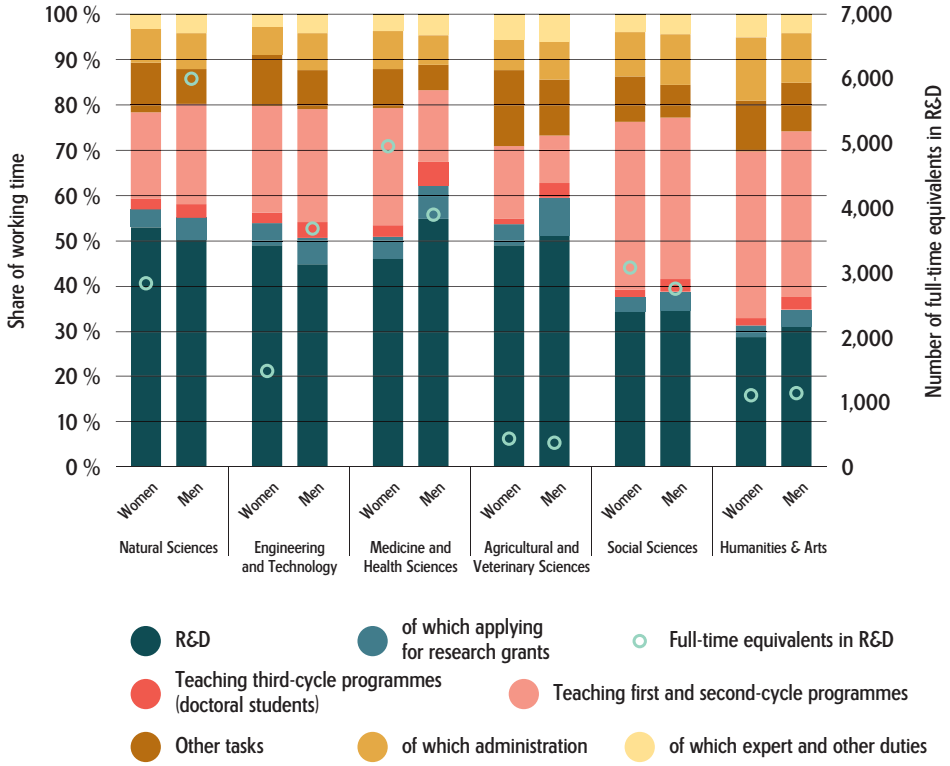

Figure 28. Relative distribution of annual full-time equivalents spent on R&D, teaching and other activities within different fields of science and technology, for women and men in 2015 (left axis). Number of R&D annual full-time equivalents (right axis). Source: Statistics Sweden.

Within natural sciences, engineering and technology, medicine and health sciences, and within agricultural and veterinary sciences, the personnel spend just over half their annual full-time equivalents on research and development activities. Within these fields, the differences between men and women is insignificant. Within medicine and health sciences, women spend a slightly smaller proportion of their time on applying for funds. In return, they use a larger proportion of their annual full-time equivalents for teaching at first and second cycle programme level. The lowest proportion of teaching is carried out by men within medicine and health sciences, and the personnel within agricultural and veterinary sciences.

Within social sciences and humanities and art, teaching occupies a much more prominent part of the annual full-time equivalents than within other fields of science. In rough terms, the research and teaching personnel spend equal amounts of time on teaching and on research within these fields of science. There are no major differences between men and women.

The largest fields of science and technology, in terms of annual full-time equivalents spent on R&D, are natural sciences and medicine and health sciences. Within natural sciences, men dominate, while a slightly larger number of annual full-time equivalents are carried out by women within medicine and health sciences. The fact that women carry out a slightly higher proportion of the teaching – and in particular more than twice as many annual full-time equivalents on teaching at first and second cycle programme level – is largely due to there being many senior lecturers and lecturers who are women within health sciences; these personnel categories carry out a large proportion of teaching in their employments.[27]

The employment structure varies with the field of science

Figure 29 shows the career age distribution for professors, senior lecturers, career development positions, postdoctoral positions, other research and teaching personnel with doctoral degrees and lecturers with doctoral degrees, divided up by gender, for the different fields of science and technology. The

[27] Statistics Sweden's website visited on 9 May 2017 and UKÄ's Table 2A.

Methodology section 3.3 describes how we have handled the persons where there is no information about doctoral degree or doctoral degree award year.

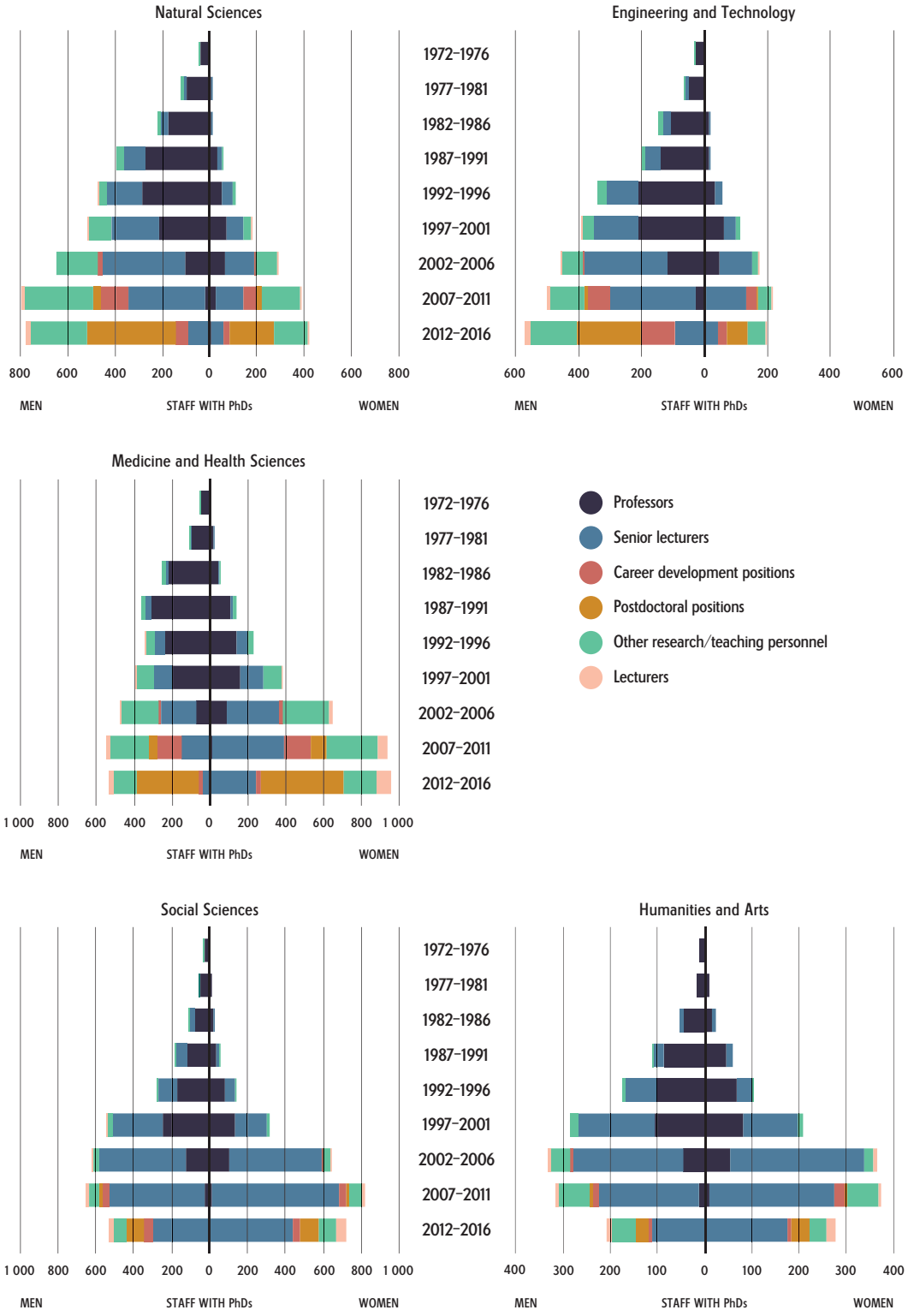

Figure 29. Research and teaching personnel with doctoral degrees, according to doctoral degree award year, employment category, gender and field of science in 2016. Source: Statistics Sweden. See also Methodology, Section 3.3.

The category research and teaching personnel with doctoral degrees has expanded greatly since 2001, in particular on the research side. This can also be seen in the personnel structure of higher education, where there is a strong bulge in the number of personnel with doctoral degree award years from 2002 and later. Among those who were awarded a doctoral degree in 2002 or later, women dominate particularly within medicine and health sciences, social sciences, and humanities and arts, while men dominate within the category with earlier doctoral degree award years. Within engineering and technology and natural sciences, there are more men in general.

Within social sciences, and humanities and arts, employment as senior lecturer is common already during the first five years after the doctoral degree was awarded. Within natural sciences, engineering and technology, and medicine and health sciences, postdoctoral positions, career development positions and researcher positions dominate in the first five years after the doctoral degree was awarded.

Established HEIs recruit primarily from among themselves

Figure 30 shows the degree of internal, national and international recruitment at four different types of HEIs.

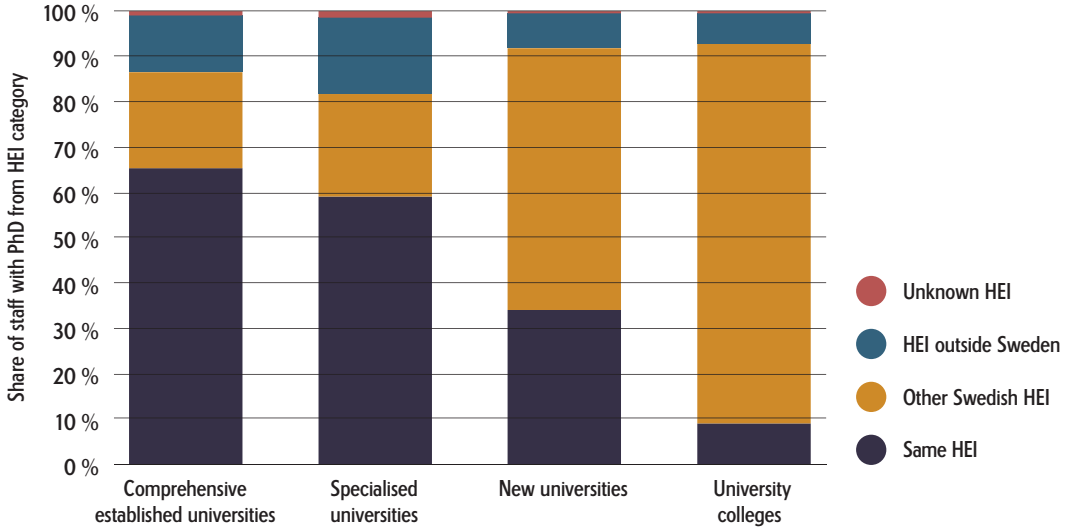

Figure 30. Relative proportion of doctoral degree holders from the same HEI, other Swedish HEI and foreign HEI within the personnel at different HEI categories in 2016. Source: Statistics Sweden.

The comprehensive established universities mainly recruit personnel who have been awarded doctoral degrees at the own HEI. Around 65 per cent of their personnel have a doctoral degree awarded from the same HEI. The specialised universities also largely recruit from their own ranks, while the new universities and in particular the university colleges recruit from other Swedish HEIs.

The comprehensive established universities, and in particular the specialised universities, recruit persons with foreign doctoral degrees to a larger extent than the other HEI categories, and to a lesser extent from other HEIs in Sweden.

The differences between the fields of science (not shown in Figure 30) is not particularly large when it comes to recruitment of persons with doctoral degrees from the own HEI. The smallest recruitment proportion of personnel with doctoral degrees from the own HEI occurs within natural sciences, which is due to recruitment of persons with foreign doctoral degrees rather than recruitment of personnel from other Swedish HEIs. Just over 25 per cent of the personnel within natural sciences at the comprehensive established universities and specialised universities had a doctoral degree from another country.

2.3 Publication by Swedish HEIs

Sweden is one of the countries with the largest production of scientific publications in relation to its population. By far the most articles are produced at the comprehensive established universities and the specialised universities. The proportion of Swedish articles produced by the new universities and university colleges is small, but the annual increase is greater than for the established HEIs.

The comprehensive established universities have a subject profile close to the global average, i.e. they carry out research activities within all subject areas. The greatest specialisation is, as can be expected, at the specialised universities.

New universities and university colleges are increasing their production of scientific publications, but are responsible for a small proportion of the total volume

The comprehensive established universities and the specialised universities are responsible for around 80 per cent of the total Swedish article production. Figure 31 shows the production of scientific publications for the years 2003 and 2015.

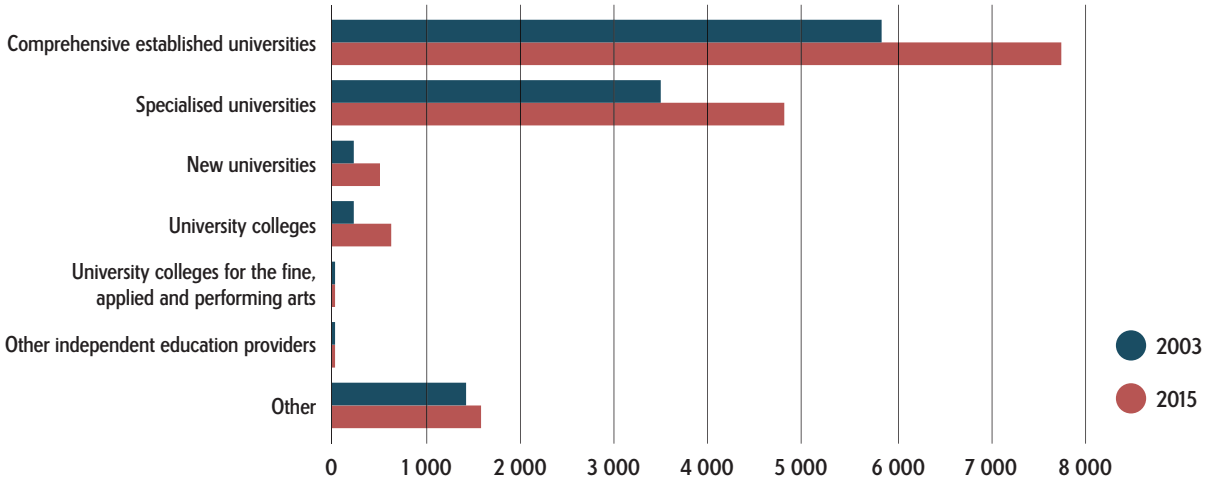

Figure 31. Production of scientific publications in Sweden in terms of number of publications in 2003 and 2015 per HEI category. The category Other includes mainly companies, hospitals (not university hospitals) and public authorities outside the HEI sector. Source: Clarivate Analytics.

The comprehensive established universities are responsible for just under half of the total Swedish article production, and the specialised universities for one third. The four new universities together publish slightly fewer scientific publications than the 14 university colleges together; the two latter categories contribute around 4 per cent each to Swedish article production.

University colleges for the fine, applied and performing arts and other independent education providers have very few scientific publications included in Web of Science. This is partly because their primary focus is on teaching, and partly because the university colleges for the arts publish their research findings via channels that are not included in the database.

The final category, Other, contains the institutions not included in the other categories. This includes companies, hospitals (not university hospitals) and public authorities outside the HEI sector. In 2015, this category was responsible for around 10 per cent of the overall article production.

The university colleges, closely followed by the new universities, are responsible for the greatest increase in the number of scientific publications – an annual increase of just over 8 per cent during the period 2013–2015. Their share of the Swedish article production increased from 4 to 8 per cent during this period. For the comprehensive established universities and the specialised universities, the annual increase has been around 2 per cent per year during the same period.

The citation impact for comprehensive established universities and specialised universities is above the world average

Figure 32 shows the citation impact of the HEIs measured as the proportion of highly cited scientific publications, i.e. the proportion of each HEIs' publications that is among the 10 per cent most frequently cited in Web of Science. The university colleges of the fine, applied and performing arts and the independent education providers had too few publications to be included in the figure.

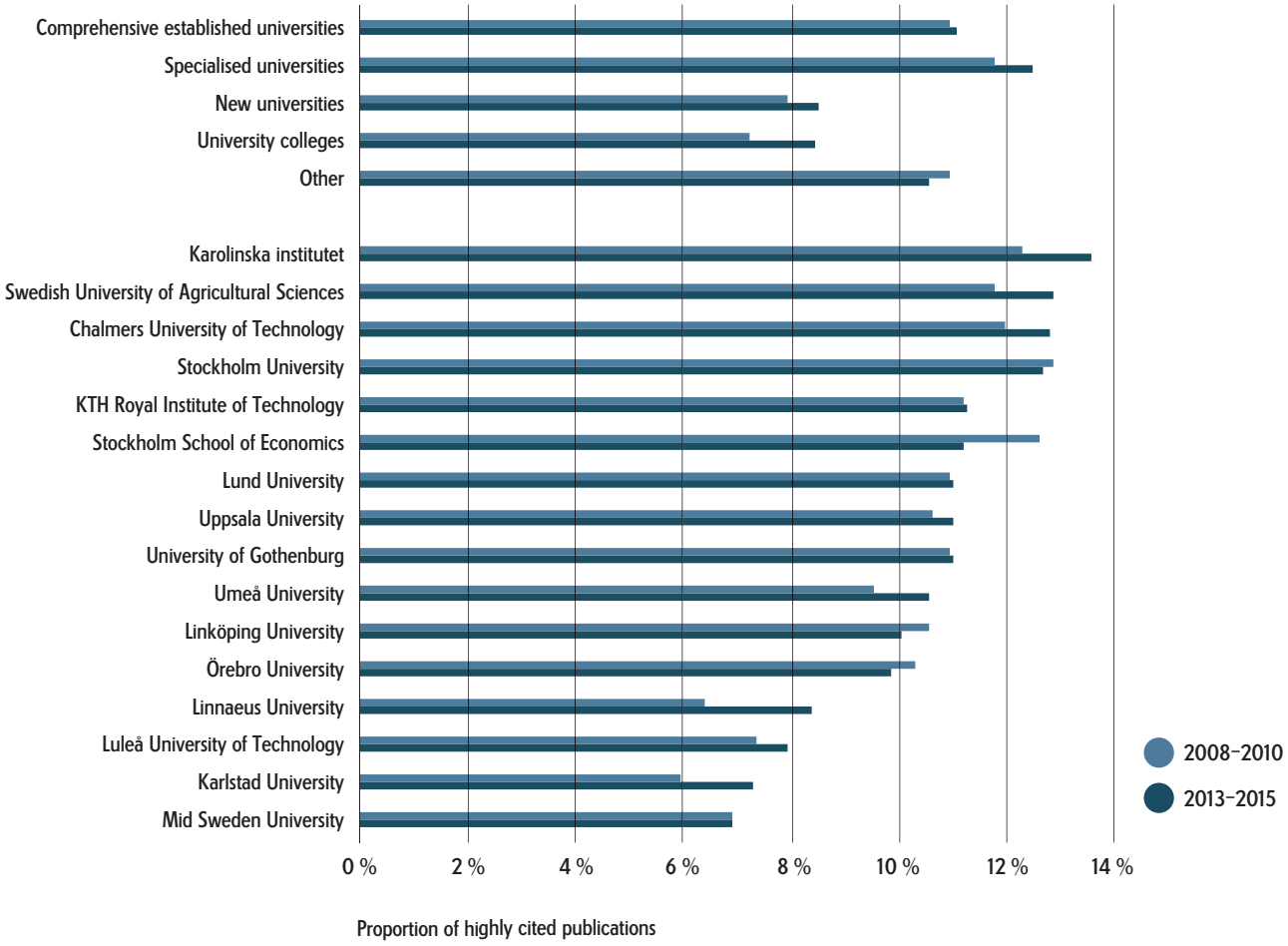

Figure 32. Development of citation impact (proportion of highly cited publications) for different HEI categories and a number of individual HEIs in Sweden. Articles published during the periods 2008–2010 and 2013–2015. The category Other includes mainly companies, hospitals (not university hospitals) and public authorities outside the HEI sector. Source: Clarivate Analytics.

Karolinska Institutet had the highest citation impact for publications published 2013–2015, and increased its share of highly cited publications from 12 per cent for the period 2008–2010 to 14 per cent for the period 2013–2015. It is followed by the Swedish University of Agricultural Sciences, Chalmers University of Technology and Stockholm University. Linnaeus University increased its citation impact from 6 to 8 per cent during these time periods.

All the comprehensive established universities and specialised universities have a citation impact of around or above 10 percent, which is the world average. The university colleges and the new universities have lower proportions of highly cited publications.

No obvious links between degree of specialisation and citation impact

Figure 33 shows the HEIs' degree of subject specialisation measured as relative specialisation index on the horizontal axis and citation impact on the vertical axis. The 16 subject areas are shown in different

colours in the figure. Only subjects in which the HEI in question had at least 30 publications during 2013–2015 have been included. The 14 HEIs in the university college category have been added together into one unit. University colleges for the fine, applied and performing arts and independent education providers have too few publications to be included. The publications of the university hospitals are included with the respective university.

If the proportion of publications within a certain subject is the same for an HEI as for the database Web of Science as a whole, the circle representing it is shown at the average value in the centre of the horizontal axis. If the circle is to the left of the vertical average line (0), the HEI has a smaller proportion of the subject than the database as a whole. If, conversely, the circle is to the right of the average line, the HEI has a specialisation in this subject. The area of each circle is proportional to each subject's share of the HEI's overall article volume.

Correspondingly, subject areas where the citation impact is higher than the world average are above the horizontal average line (10 per cent), while those that have a lower citation impact are below it.

An analysis of how citation impact is distributed across subject areas and HEIs shows no obvious links between degree of specialisation and citation impact. HEIs with high citation impact are often above the world average within several subject areas.

It is hardly surprising that the greatest specialisation can be found in the specialised universities, where practically all of the Stockholm School of Economics' publications are within economics, and the Swedish University of Agricultural Sciences has a considerably higher proportion of publications within agriculture and biology than the database as a whole. For Karolinska Institutet, the proportion of clinical medicine and health sciences is considerably higher than for the database overall. The universities of technology have a slightly broader subject profile, but with a relatively large proportion of engineering and materials sciences. Here, Luleå University of Technology differs from the Royal Institute of Technology and Chalmers University of Technology by having a proportion for physics that is below the average for the whole database.

For several of the comprehensive established universities, the circles are gathered together close to the centre, which means that they have a subject profile that is relatively similar to the global average. The HEIs that lack a faculty of technology (such as the University of Gothenburg and Stockholm University) have a small proportion of technical subjects. HEIs with a university hospital have a relatively high proportion of medical publications. For the new universities, the range across subject areas is fairly wide, but all have a relatively large proportion of social sciences.

Karolinska Institutet has a citation impact above the world average within most subject areas. Stockholm University is also quite highly placed within most subject areas. The Swedish University of Agricultural Sciences is above the world average within agriculture and biology.

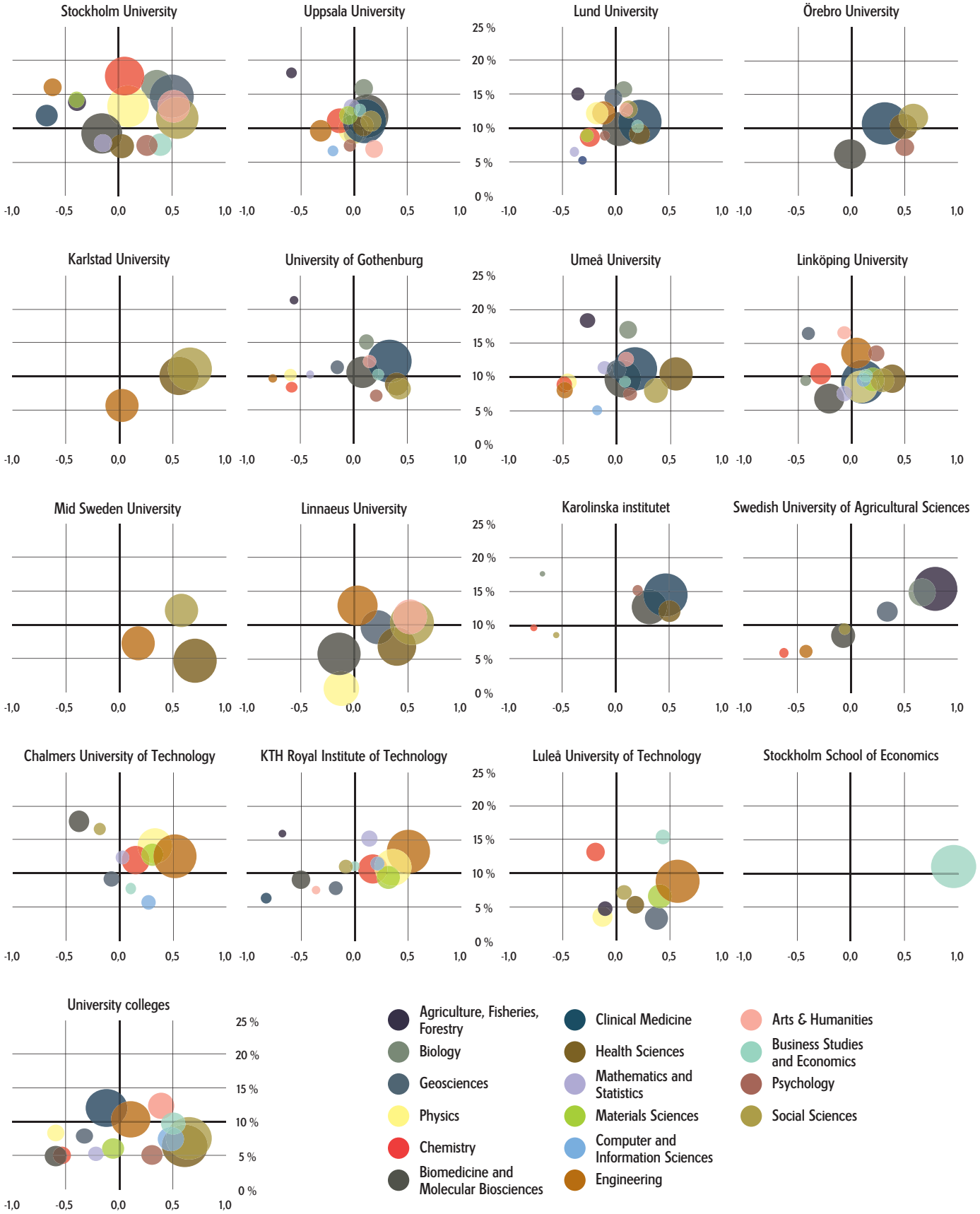

Figure 33. Subject profile and citation impact for a selection of Swedish HEIs and for the 14 university colleges combined into one unit. Articles published during the period 2013–2015. The horizontal axis shows the HEI's relative specialisation index (RSI). The vertical axis shows citation impact (proportion of highly cited publications within the different subject areas). The area of each circle is proportional to each subject's share of the HEI's overall article volume. Only subject areas where the HEI published at least 30 articles during 2013–2015 are included in the figure. Source: Clarivate Analytics.

3 METHODOLOGY

3.1 Choice of indicators

The Research Barometer presents a selection of indicators for the purpose of providing an overview of Swedish research in international comparison. Some base indicators are provided in a comparison between research countries – for example how much of Sweden's GDP is invested in R&D, how the government's research appropriations are allocated or what the proportions of women and men are within the research and teaching personnel at HEIs. Others have been selected based on the Swedish Research Council's own analyses, for example indicators relating to citation impact and mobility.

This second edition of the Swedish Research Council's Research Barometer includes minor changes to the selection of indicators compared to the Research Barometer 2016. The idea is that a number of indicators will be constant, and repeated in each Research Barometer to enable comparison over time.

3.2 Choice of countries

No countries are fully comparable, as each country's educational and research systems differ, as do their business structure. Despite these differences, comparisons between countries can provide valuable information and constitute a basis for analyses and standpoints.

So which countries are best suited for international comparison from a Swedish perspective? For example, should Sweden be compared with the best research countries, or with the countries that resemble Sweden the most? Too narrow a selection of similar countries risks being limiting, and comparison only with the best can be difficult to relate to. The Research Barometer 2017 uses a "base list" consisting of 15 countries, including Sweden.[28] A common factor for these countries is that they represent active research nations. The 14 comparison countries can be roughly divided up into categories: 1) successful research nations that are roughly the same size as Sweden, and also have other prerequisites similar to those of Sweden (Austria, Belgium (new), the Netherlands, Switzerland, Norway, Denmark and Finland); 2) larger, established successful research nations (United States, United Kingdom, Germany, France and Japan); and 3) developing research nations (China and South Korea). In some bibliometric comparisons, Singapore has also been included.

3.3 Data sources

Funding and personnel statistics in the international comparisons were taken from the OECD database *Main Science and Technology Indicators* (MSTI). International statistics are provided with some delay, as they are based on individual countries' reporting to the OECD. The most recent more-or-less *comprehensive* data for R&D investments date from 2015, and for personnel from 2014. Figures based on data from the OECD do not always include data for all years. When data are missing, they have sometimes been calculated on the basis of the closest available year before and after the year in question.

In terms of *national* data on funding and personnel, the figures are taken from Statistics Sweden and the Swedish Higher Education Authority (UKÄ). Funding statistics are updated every two years. Funding data for Swedish R&D in the Research Barometer is based on data published in December 2016, and relates to data from 2015. UKÄ summarises statistics for income from and depreciation of research and research education. These statistics are further processed by Statistics Sweden, which uses UKÄ's data as the basis for producing actual income from R&D excluding costs for the educational items of research education.

[28] Austria, Belgium, China, Denmark, Finland, France, Germany, Japan, Netherlands, Norway, Switzerland, South Korea, Sweden, United Kingdom, USA. In some bibliometric comparisons (citation impact), Singapore has also been included.

Personnel statistics are collected annually by Statistics Sweden on behalf of UKÄ. The statistics are based on personnel data from the HEIs' salary reporting system for October. The most recent data is from October 2016.

To produce statistics for the personnel resources invested in R&D within the higher education sector, Statistics Sweden conducts a survey directed to employees within universities and university colleges. The survey forms the basis for calculating the number of annual full-time equivalents active within R&D in the sector. Statistics Sweden conducts the survey every two years and the most recent one relates for data for 2015.

The data regarding "degree award year" and "HEI for doctoral degrees of higher education personnel" is produced and processed by Statistics Sweden. This two variables have a certain degree of missing values, partly due to unknown degree award year, and partly due to lack of information on doctoral degree. The degree of missing values due to unknown degree award year is 5 per cent for professors, and 2 per cent for senior lecturers, other research and teaching personnel with doctoral degrees, and lecturers. For career development employees, the degree of missing values is 1 per cent and for postdocs 0 per cent. Information on doctoral degree contains missing values for 11 per cent of professors and senior lecturers, while the corresponding figure for career development employees is 17 per cent and for postdocs 26 per cent. In Figure 29 on career age, we have assumed the same relative distribution of degree award year for individuals with missing values as for individuals with data on doctoral degree award year, and have therefore allocated them proportionally across the various doctoral degree award year intervals.

The bibliometric analyses in the Research Barometer are based on the Swedish Research Council's database, which is in turn based on the same material as *Web of Science* (which is provided by Clarivate Analytics). The database at the Swedish Research Council is updated in April/May every year. The most recent update was done in April 2017. The content of the databased used in this edition of the Research Barometer corresponds to the content of *Web of Science* on 30 March 2017.

3.4 Bibliometric analysis

The way in which the bibliometric indicators have been calculated and used in the Research Barometer is summarised below. For a more detailed description of how bibliometrics are used at the Swedish Research Council, please see *Riktlinjer för användning av bibliometri vid Vetenskapsrådet [Guidelines for the use of bibliometrics at the Swedish Research Council]*[29] and *the bibliometric database at the Swedish Research Council – contents, methods and indicators*.[30]

The Research Barometer counts the publications of the Swedish university hospitals as belonging to their respective universities.

The Swedish Research Council's database for bibliometrics

The Swedish Research Council buys raw data from Clarivate Analytics and the contents correspond largely with the contents of Web of Science (WoS). Each periodical in the database is classified by Clarivate Analytics into one or several of around 250 subjects. An article in a periodical is classified according to the periodical's subject classification. In the Research Barometer, the subject classifications in WoS are aggregated into 16 larger subject areas.[31] The Swedish Research Council reclassifies the periodicals classified by WoS as *Other/Multi-disciplinary*. Following reclassification of multi-disciplinary periodicals, very few publications remain in this category, and they have been excluded from the statistics in the Research Barometer. Figure 34 shows the proportion of the references within the various research areas that are made to other publications in the database. For example, 86 per cent of

[29] Vetenskapsrådet (2014). Riktlinjer för användning av bibliometri vid Vetenskapsrådet. 2014-12-15. Dnr 113-2014-7357. [Guidelines for the use of bibliometrics at the Swedish Research Council]

[30] Vetenskapsrådet (2015). The bibliometric database at the Swedish Research Council – contents, methods and indicators 2015, 2015-09-18. Dnr 113-2010-6148.

[31] Agriculture, Fisheries, Forestry; Biology; Geosciences: Physics; Chemistry; Biomedicine and Molecular Biosciences; Clinical Medicine; Health Sciences; Mathematics and Statistics; Materials Sciences; Computer and Information Sciences; Engineering; Arts and Humanities; Business Studies and Economics; Psychology; Social Sciences.

all references in biomedicine are to publications in the database. We can therefore assume that a major part of the research that is relevant within biomedicine is represented. For humanities, on the other hand, only 17 per cent of the references can be found there, that is to say 83 per cent of the articles found relevant by researchers within humanities are not included in the database.

Every publication in WoS is also classified as one of 39 different document types. The Swedish Research Council's statistics are based on publications of the types *Article or Review*, which are added together into a joint document type.

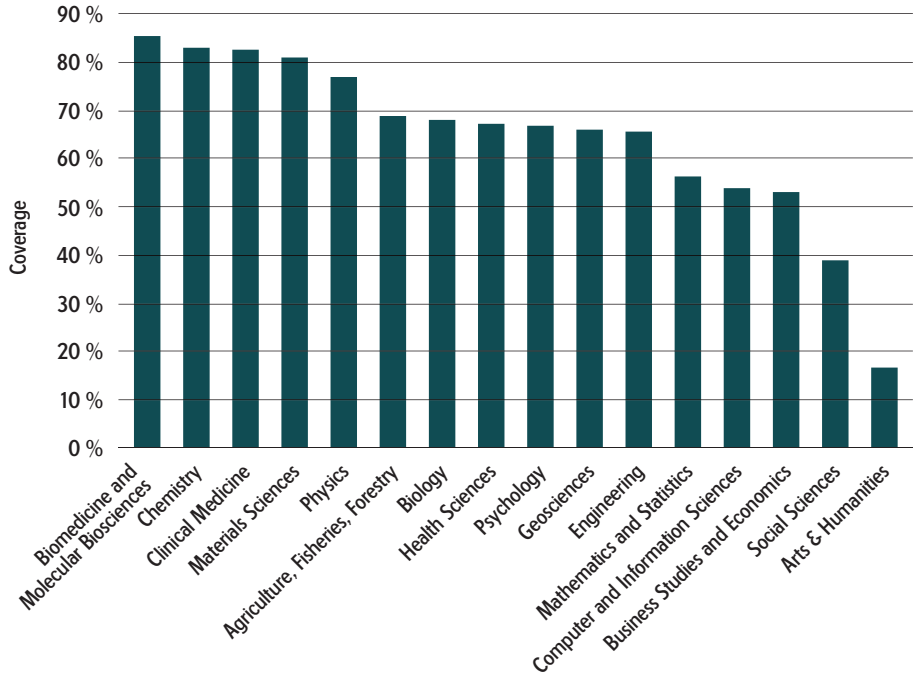

Figure 34. Coverage of the various research areas is shown as the proportion of the references within the various research areas that are made to other publications in Web of Science. Articles published 2013–2015. Source: Clarivate Analytics.

Publication volume and fractioning

Many figures in the Research Barometer show indicators based on the number of publications. One challenge of counting the number of publications is that a publication can have authors from different countries. The sum of the number of publications from the different countries is then larger than the total number of publications. The same challenge arises in comparisons that include the number of publications within different research areas, as a publication may be classified as belonging to several subject classifications. This means that the sum of the number of publications within the individual subjects is larger than the total number of publications. One way of handling this is to divide each publication into smaller parts, fractions, where each fraction only has one address and one subject classification.

Relative specialisation index

To describe the subject specialisation of a country's (or an organisation's) publications, a relative specialisation index (RSI) is used. This is a symmetrical indicator that varies between -1 and +1 and is based on a country's (or an organisation's) activity index (AI). The AI for a specific country is calculated by dividing the proportion of publications it has within a specific subject by the proportion that the subject constitutes in WoS as a whole. If 50 per cent of Sweden's publications were classified as physics, while the corresponding figure for the whole of WoS is 25 per cent, then Sweden's activity index for physics will be 2. In this example, Sweden therefore has double the amount of physics compared to WoS. AI is an unsymmetrical measure that can assume values between 0 and infinity. To make the figures easier to compare, we use RSI instead, which is calculated as follows:

$$RSI = \frac{(AI-1)}{(AI+1)}$$

If RSI < 1, the country (or the organisation) has a lower proportion of publications within the subject than the world average. If RSI > 1, the proportion is higher than the world average.

The indicator 10 per cent most highly cited

To study the impact of publications, the Research Barometer uses an indicator that states how large a proportion of the publications of a country or an HEI that is among the 10 per cent most cited scientific publications in Web of Science.

The proportion of highly cited scientific publications is a suitable way of measuring citation impact, as, contrary to the citation average, it is not significantly impacted on by one-off extremely frequently cited publications.

The fact that a publication is among the 10 per cent most highly cited means that it is one of the 10 per cent most cited scientific publications published within the same subject in one specific year. If a publication is classified in two subjects, half the publication is compared to one subject, and the other half to the other subject. If the publication only has author addresses in Sweden and is among the 10 per cent most highly cited within one of the subjects, the publication will contribute the weighting 0.5 to the number of Swedish publications that are among the 10 per cent most highly cited. The proportion of publications among the 10 per cent most highly cited is then calculated by dividing the sum of all weightings for a country's publication fractions that are among the 10 per cent most highly cited with the sum of the country's total publication fractions.

3.5 Figure and indicator list with sources

Figure 1. Swedish R&D in an international comparison, using a selection of indicators. Sweden's position is shown in relation to the average for the OECD countries and to the average for the five top countries. Data from 2015; publication data for articles published 2013–2015. Indicators: 1) Overall expenditure on R&D as a percentage of GDP (OECD: GERD as a percentage of GDP); 2) Industry-financed R&D as a percentage of GDP (OECD: Industry-financed GERD as a percentage of GDP); 3) Government-financed R&D as a percentage of GDP (OECD: Government-financed GERD as percentage of GDP); 4) Number of scientific publications published 2013–2015 per thousand inhabitants (Clarivate Analytics; OECD); 5) Citation impact for articles published 2013–2015 (proportion of the country's total scientific publications that are among the 10 per cent most highly cited in the database) (Clarivate Analytics); 6) Number of researchers (annual full-time equivalents) per thousand inhabitants (OECD: Total researchers (FTE) per thousand inhabitants).

Figure 2. Number of researchers (full-time equivalents) per thousand inhabitants and gross domestic expenditure on R&D as a percentage of GDP in 2015. The area of each circle corresponds to that country's share of the total R&D expenditure of all countries included in the figure (OECD: Total researchers (FTE) per thousand inhabitants; GERD as a percentage of GDP).

Figure 3. Expenditure on R&D as a percentage of the country's GDP in the period 2001–2015 (OECD: GERD as percentage of GDP).

Figure 4. Expenditure on R&D as a percentage of GDP in the period 2000–2015, divided up by financing sector: industry, government, abroad and other national sources (OECD GERD as percentage of GDP; Percentage of GERD financed by industry; Percentage of GERD financed by government; Percentage of GERD financed by abroad; Percentage of GERD financed by other national sources).

Figure 5. Expenditure on R&D per inhabitant in current PPP dollar in the period 2000–2015, divided up by financing sector: industry, government, abroad and other national sources (OECD: GERD per capita population Current PPP$).

Figure 6. Expenditure on R&D 2015 divided up by performing sector: business sector, private non-profit sector, higher education sector and other public sector (OECD: Percentage of GERD performed by the business enterprise sector; Percentage of GERD performed by the higher education sector; Percentage of GERD performed by the government sector; Percentage of GERD performed by the private non-profit sector).

Figure 7. Expenditure on R&D 2015 divided by financing sector: industry, government, other national sources and abroad (OECD: Percentage of GERD performed by the business enterprise sector; Percentage of GERD performed by the higher education sector; Percentage of GERD performed by the government sector; Percentage of GERD performed by the private non-profit sector).

Figure 8. Percentage of the population who are researchers (individuals), divided up into women and men, 2004, 2009 and 2014 (OECD: Total researchers (headcount); Women researchers as a percentage of total researchers (headcount); Population statistics).

Figure 9. Distribution of researchers (full-time equivalents) between the business sector, higher education sector, and other public sector 2014 or most recent available year (OECD: Business enterprise sector: Total researchers (FTE); Government sector: Total researchers (FTE); Higher education sector: Total researchers (FTE)).

Figure 10. Number of publications per 1 000 inhabitants and citation impact (proportion of highly cited publications, i.e. the proportion of the country's total scientific publications that are among the 10 per cent most frequently cited in the database). Articles published 2013–2015. The area of the circle is proportional to the country's total number of publications. Fractioned publications (Clarivate Analytics; OECD: Population statistics).

Figure 11. Citation impact (proportion of highly cited publications, i.e. the proportion of the country's total scientific publications that are among the 10 per cent most frequently cited in the database). Publications during 2003–2005, 2008–2010 and 2013–2015. Fractioned publications (Clarivate Analytics).

Figure 12. Citation impact for Swedish research within 16 research areas (proportion of Sweden's scientific publications within the area that are among the 10 per cent most frequently cited in the database). Publications during 2013–2015. Fractioned publications (Clarivate Analytics).

Figure 13. Subject profile (relative specialisation index, RSI) and citation impact (proportion of the country's scientific publications within the area that are among the 10 per cent most frequently cited in the database) for Sweden, the United States and China within 16 subject areas. Publications during 2013–2015. Fractioned publications (Clarivate Analytics).

Figure 14. Proportion of internationally co-authored scientific publications from Swedish researchers during the period 1982–2016, in collaboration with researchers from the regions EU+2 (EU countries plus the associated countries Norway and Switzerland), North America, Asia, Oceania, Africa and Latin America. Full counts of publications (Clarivate Analytics).

Figure 15. Number of international co-authored scientific publications by Swedish researchers, per collaborating country and year. Number of articles per year stated as an average for the period 2012–2016. Full counts of publications (Clarivate Analytics).

Figure 16. Internationally co-authored scientific publications from Swedish researchers within 16 subject areas, as a proportion of all Swedish publications within each subject area. Publications from 2006 and 2016. Full counts of publications (Clarivate Analytics).

Figure 17. Participation in ESFRI research infrastructures (ESFRI Roadmap; Swedish Research Council's summary of available data).

Figure 18. Funds awarded (EUR per inhabitant) and success rate from the EU's framework programme for research and innovation, Horizon 2020. EU15 countries + Norway and Switzerland (OECD: population statistics; e-CORDA: H2020 Applicants and Requested EC Financial Contribution by Country 2017-02-28).

Figure 19. Sweden's R&D financing in billion SEK, divided up by funding body and research performer 2015 (SCB: Forskning och utveckling i Sverige – översikt och internationella jämförelser; Finansiering av FoU utförd i Sverige; UF 16 SM 1701).

Figure 20. Sweden's government R&D appropriations for the period 2005–2017, divided up by recipient. 2017 constant prices (SCB: Statliga anslag till forskning och utveckling 2017).

Figure 21. R&D income within the Swedish HEI sector for 2015, divided up by funding body (Statistics Sweden).

Figure 22 A. The HEI sector's R&D income over the period 2005–2015, per funding body and year. ALF funding is reported separately. Proportion of total R&D income (Statistics Sweden).

Figure 22 B. The HEI sector's R&D income over the period 2005–2015, per funding body and year. Income in constant 2015 prices, million SEK (Statistics Sweden).

Figure 23. Government R&D income (operating costs) in the Swedish HEI sector over the period 2001–2016, divided up by recipient HEI category. Income in constant 2016 prices, million SEK (Statistics Sweden: Forskning och utveckling inom högskolesektorn).

Figure 24. R&D income (operating costs) in the Swedish HEI sector, divided up by HEI category and field of science and technology. Comparison years: 2011, 2013 and 2015 (Statistics Sweden: Forskning och utveckling inom högskolesektorn).

Figure 25. Research and teaching personnel and the number of employed doctoral students in Swedish HEIs per employment category for the period 2001–2016 (UKÄ: source documents for official statistics on higher education).

Figure 26. Research and teaching personnel at Swedish HEIs 2016, divided up by employment category and HEI category (UKÄ: source documents for official statistics on higher education).

Figure 27. Gender distribution among new doctoral degree holders and among research and teaching personnel at Swedish HEIs in 2006 and 2016 (UKÄ: source documents for official statistics on higher education; Statistics Sweden).

Figure 28. Distribution of annual full-time equivalents spent on R&D, teaching and other activities within different fields of science and technology 2015 (Statistics Sweden).

Figure 29. Research and teaching personnel with doctoral degrees, according to doctoral degree award year, employment category, gender and fields of science and technology in 2016 (Statistics Sweden, processed).

Figure 30. Proportion of doctoral degree holders from the same HEI, other Swedish HEI and foreign HEI within the personnel at different Swedish HEI categories in 2016 (Statistics Sweden).

Figure 31. Production of scientific publications in Sweden in terms of number of publications in 2003 and 2015 per HEI category. Fractioned publications (Clarivate Analytics).

Figure 32. Citation impact (proportion of the HEI's total publications that are among the 10 per cent most frequently cited in the world) per HEI category and for 16 universities over the periods 2008–2010 and 2013–2015. University colleges for the fine, applied and performing arts and independent education providers are not shown due to having too small a number of publications (fewer than 55 per category during both periods). Fractioned publications (Clarivate Analytics).

Figure 33. Subject profile (relative specialisation index, RSI) and citation impact (proportion of the country's scientific publications within the area that are among the 10 per cent most frequently cited in the database) for a selection of Swedish HEIs and for the university college category (14 in number) at aggregated level. Publications during 2013–2015. Only subject areas where the HEI published at least 30 articles (10 per year) are included in the figure. Fractioned publications (Clarivate Analytics).

Figure 34. Number of references within 16 subject areas made to other publications in the database. Publications during 2013–2015 (Clarivate Analytics).

3.6 Explanations of abbreviations and concepts

Activity index (AI): Calculated for a specific country by dividing the proportion of publications it has within a specific subject by the proportion that the subject constitutes in the Swedish Research Council's database as a whole. See also Relative specialisation index.

Career development employment: A new personnel category in UKÄ's personnel statistics from 2012, consisting of the former category of research assistants (including assistant senior lecturers) and postdocs, which previously belonged to the category other research and teaching personnel.[32]

Constant or fixed prices: Prices corrected for variations in the value of money over time, as opposed to current prices, which are the actual prices at the time in question.

Current prices: Current prices are the actual prices at the time in question, as opposed to constant or fixed prices, where the price level is kept constant in order to adjust for price inflation. Data reported in constant prices therefore describe the growth over time in real values. For example, current price data shown for 1990 are based on 1990 prices, and data for 2000 are based on 2000 prices. Data reported as constant 2010 prices show data for 1990, 2000 and all other years in 2010 prices.

Emerging research countries: Countries with rapidly growing economies and increasing R&D volumes.

EU15: The member states of the European Union before the expansion with ten new countries on 1 May 2004: Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom and Austria.

[32] Universitetskanslersämbetet. Personal vid universitet och högskolor 2012. Statistiskt meddelande 2013-06-13. http://www.uka.se/om-oss/publikationer--beslut/statistiska-meddelanden/statistiska-meddelanden/2013-06-13-personal-vid-universitet-och-hogskolor-2012.html

EU15 + 2: The EU15 countries plus the associated countries Norway and Switzerland.

EU28: The countries that were part of the European Union on 1 July 2013: Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Croatia, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, the United Kingdom, Sweden, Czech Republic, Germany, Hungary and Austria.

Field of science and technology: Classification of Swedish R&D according to the Standard för svensk indelning av forskningsämnen (Standard for Swedish Classification of Research Subjects) (HSV and Statistics Sweden, 2011). All R&D is classified at one, three and five digit level. Fields of science and technology (at 1-digit level) are: Natural sciences, Engineering and technology, Medicine and health sciences, Agricultural and veterinary sciences, Social sciences, and Humanities and the arts.

Frascati Manual: OECD's guidelines for statistics within R&D. The most recent version is Frascati Manual 2015.

GERD: Gross domestic Expenditure on Research and Development designates the total national expenditure on R&D carried out within a country over a specified period.

Gross domestic product (GDP): The value of all goods and services produced within the geographical borders of a country.

ICT: Information and Communications Technology.

Income for R&D: See operating costs.

Indicator: A measurable occurrence that shows or indicates the condition in a larger system.

Operating costs: Operating costs correspond to the income for R&D and exclude depreciation and investments.

Publication volume: Number of scientific publications over a specified period.

Research and teaching personnel: The section on HEI personnel in Sweden uses the designation research and teaching personnel according to UKÄ's definition. See the fact box in Section 2.2.

Researcher: In the Frascati Manual, researchers are defined as professionals engaged in the conception or creation of new knowledge with the help of advanced knowledge and skills. Although these skills may have been acquired through post-graduate research education, a research degree is not a necessary criterion. Frascati Manual (2015): "Professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned."

Research profile: A country's research profile is based on the "Relative Specialisation Index" (see below) and shows the country's production of scientific articles within different subject areas.

R&D – Research and development activities: The overall concept of **research and experimental development (**R&D**)** is defined as "creative and systematic work undertaken in order to increase the stock of knowledge", where **research** is done to seek out new knowledge or new ideas, with our without a particular application or use in view, while **experimental development** uses research findings, scientific knowledge or new ideas to produce new materials, goods, services, processes, systems, methods or significant improvements of already existing ones.

Relative specialisation index (RSI): A symmetrical indicator that varies between -1 and +1 and is based on a country's (or an organisation's) activity index (AI) (see above). RSI shows whether a country publishes more or less than expected within a specific subject area. See Section 3.4 for a more detailed explanation.

Scientific publication: In the bibliometric analyses, the publication types *Article* and *Review* are added together into a common document type, which the Research Barometer designates as *Scientific publication*. This does not include monographs or other types of scientific publications.

Subject area: The bibliometric analyses uses 16 major subject areas, which are aggregated from 250 subject classifications in *Web of Science*. These are the same areas as those used in the report *Comparing research at Nordic higher education institutions using bibliometric indicators*. Please see this report of a list of the subjects included in each subject area. The 16 subject areas used in the Swedish Research Barometer 2017 are: Agriculture, Fisheries, Forestry; Biology; Geosciences: Physics; Chemistry; Biomedicine and Molecular Biosciences; Clinical Medicine; Health Sciences; Mathematics and Statistics; Materials Sciences; Computer and Information Sciences; Engineering; Arts and Humanities; Business Studies and Economics; Psychology; Social Sciences.

Organisations, companies and public agencies

Clarivate Analytics: A company that publishes *Web of Science*, a publication database with citation indices. *Web of Science* was formerly published by the company Thomson Reuters.

ESFRI: European Strategy Forum on Research Infrastructures.

Formas: Swedish research council for environment, agricultural sciences and spatial planning.

Forte: Swedish research council for health, working life and welfare.

OECD: Organisation for Economic Co-operation and Development – an international organisation with 34 member countries.

Statistics Sweden (SCB): Government agency responsible for producing official statistics relating to Sweden.

Sida: Swedish International Development Cooperation Agency.

UKÄ: Swedish Higher Education Authority.

UNESCO: United Nations Educational, Scientific and Cultural Organization.

Vinnova: Swedish government innovation agency.

3.7 HEI categories

All companies, organisations, etc. not listed below are part of the category "Other".

Comprehensive established universities
University of Gothenburg
Linköping University
Lund University
Stockholm University
Umeå University
Uppsala University

Specialised universities
Chalmers University of Technology
Stockholm School of Economics
Karolinska Institutet
Royal Institute of Technology
Luleå University of Technology
Swedish University of Agricultural Sciences

New universities
Karlstad University
Linnaeus University (merger between Växjö University and University of Kalmar on 1 January 2010)
Mid Sweden University (before 1 January 2005 Mid Sweden University College)
Örebro University

University colleges
Blekinge Institute of Technology
Swedish Defence University
Swedish School of Sport and Health Sciences, GIH
Dalarna University
University of Borås
University of Gävle
Halmstad University
Jönköping University
University of Skövde
Kristianstad University
Campus Gotland (from 1 July 2013 Uppsala University)
University College West
Malmö University College (from 1 January 2018 Malmö University)
Mälardalen University College
Södertörn University

University colleges for the fine, applied and peforming arts
Beckmans College of Design
University College of Arts, Crafts and Design
Royal Institute of Art
Royal College of Music
Stockholm University of the Arts (until 31 December 2013, the School of Dance and Circus, the University College of Opera, and the Stockholm Academy of Dramatic Arts)

Independent education providers
Ericastiftelsen (Erica Foundation)
Ersta Sköndal Bräcke University College
Gammelkroppa skogsskola (Gammelkroppa Forestry School)
Högskolan Evidens (Evidens University College)
Johannelunds teologiska högskola (Johannelund School of Theology)
Swedish Red Cross University College
The Newman Institute University College
Skandinaviens Akademi för psykoterapiutveckling (Scandinavian Academy of Psychotherapy Development)
Sophiahemmet University
Stockholm University College of Music Education
Swedish Institute for CBT & Schema Therapy
Stockholm School of Theology
Örebro teologiska högskola (Örebro University College of Theology)

University hospitals – counted together with the university
Akademiska Hospital in Uppsala
Karolinska University Hospital (Stockholm)
Linköping University Hospital
Norrland University Hospital (Umeå)
Sahlgrenska University Hospital (Göteborg)
Skåne University Hospital (Lund) (merger of Lund University Hospital and University Hospital MAL in Malmö on 1 January 2010)
Örebro University Hospital

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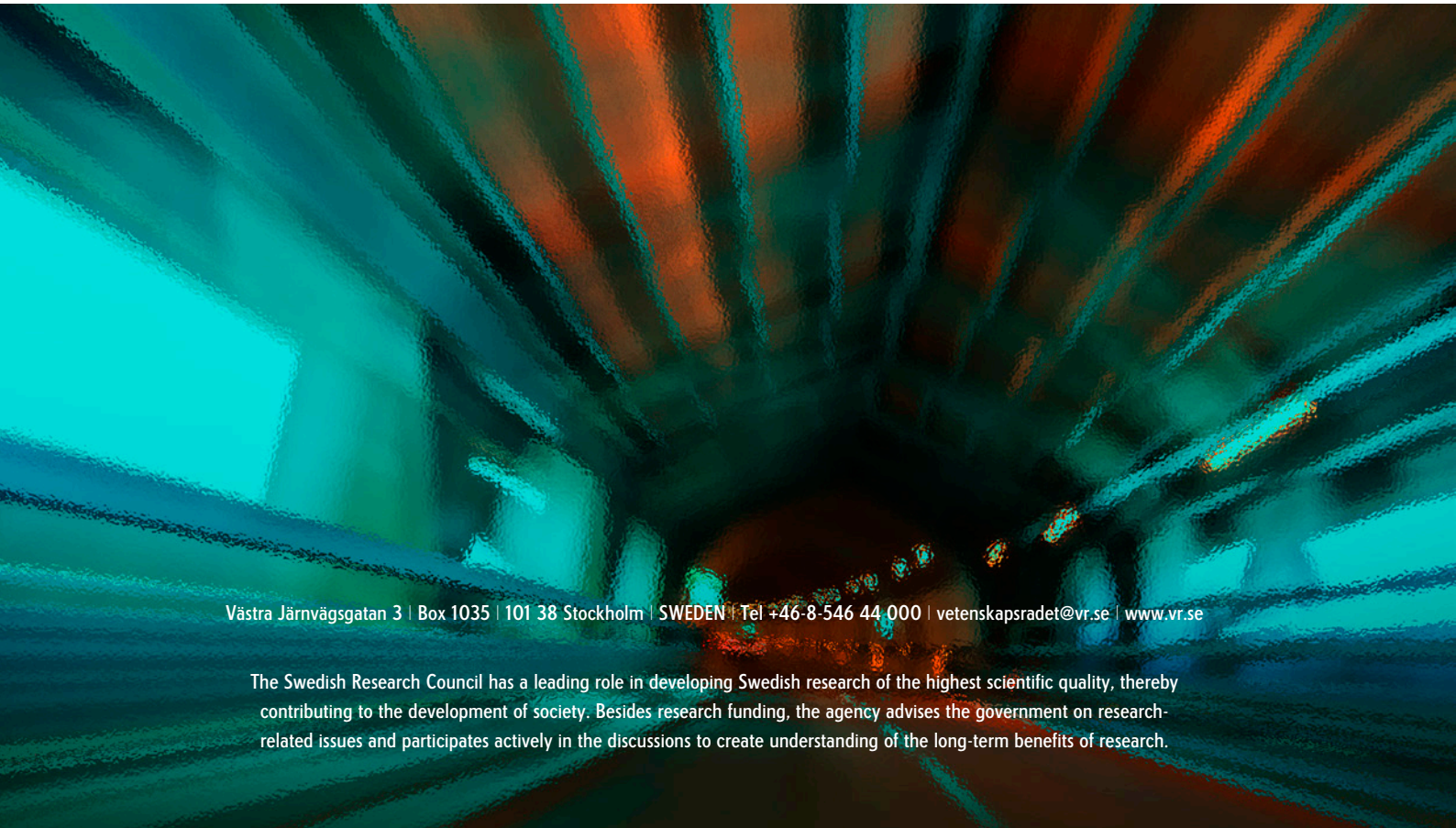
The Swedish Research Barometer provides a picture of the state of Swedish research through some thirty indicators. Focus is on public funding of research, and research carried out at universities and university colleges. The Swedish Research Barometer describes three parts of the research system: financial resources, the personnel in the system and the results that are generated in terms of publications. The compilation is based on national and international data, relevant to research policy, previously not presented in this form. Selected parts of the contents are also available on the Web (vr.se/forskningsbarometern2017). There, the reader can filter and visualise the data in interactive graphs.



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