



Vetenskapsrådet

THE SWEDISH RESEARCH BAROMETER 2016

**AN OVERVIEW OF THE
SWEDISH RESEARCH SYSTEM
IN INTERNATIONAL COMPARISON**

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INTERNATIONAL COMPARISON**

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THE SWEDISH RESEARCH BAROMETER 2016 – AN OVERVIEW OF THE SWEDISH RESEARCH SYSTEM IN INTERNATIONAL COMPARISON

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PREFACE

The Swedish Research Council's Research Barometer gives a picture of the state of Swedish research using a range of some 30 indicators. A regularly published Research Barometer that measures changes based on a number of indicators can be used to monitor how Sweden is developing as a research nation over time compared with other countries. The Research Barometer thus contributes to creating a basis for recommendations made at various levels within the field of research policy.

The Swedish Government's assignment to the Swedish Research Council includes submitting a brief report and analysis of the position of Swedish research from an international perspective, as well as of international trends in various areas. The Research Barometer presents this information in an easily accessible way. I also hope that not just the Government, but also higher education institutions, research funding bodies, government agencies, the media and others who want to get a picture of the current position and development of Sweden as a research nation will value and make use of the information in the Research Barometer.

The aim of the Swedish Research Council's Research Barometer is not to provide a complete set of data, but to highlight the indicators that the Council considers most relevant with respect to research policy. National data is supplied by Statistics Sweden and the Swedish Higher Education Authority (UKÄ) – the two authorities respectively responsible for research and higher education statistics. The primary source of statistics for the Research Barometer's international comparisons is the OECD. Publication data, i.e. information about how researchers publish their work, comes from the Swedish Research Council's database that is based on the same basic data as *Web of Science* (Thomson Reuters). A detailed description of data and methods can be found in the methods section.

This is the first version, and we intend to continue developing the Research Barometer in order to collate and report relevant information about the research system in a clear and easily accessible way. Future versions might also have room for detailed qualitative discussions as a complement to the indicators reported. Selected parts of the content are also available online (vr.se/forskningsbarometern2016). There, the reader can filter and visualise the data themselves in interactive diagrams.

I would like to thank my colleagues at the Swedish Research Council who have participated in the work of producing this first Research Barometer. A big thank you also to the members of the reference group that has been linked to the project, in particular Statistics Sweden and UKÄ.¹ We have also learned much from the research barometers in Finland, Denmark and Norway. At the Swedish Research Council, we are now looking forward to working together with all of these actors in future efforts to develop the Research Barometer.

Sven Stafström
Director General

Stockholm, June 2016

¹ The following organisations have been represented in the reference group: Formas, Forte, Statistics Sweden, Growth Analysis, Swedish Higher Education Authority (UKÄ), the Ministry of Education and Research and Vinnova.

EXECUTIVE SUMMARY

Government agencies, companies and other organisations that fund and carry out research and development (R&D) are part of the R&D system. The Research Barometer's focus is on the public funding of research, and research performed at Higher Education Institutions (HEIs), i.e. emphasis is on the research part of the R&D system.

The Research Barometer gives an overview of the Swedish research system in international comparison. It also provides deeper information about the research system in Sweden, focusing particularly on the last decade. The Research Barometer describes three parts of the system: financial resources, the personnel in the system and the results that are generated in terms of publications. Publications are of course only one form of research results but it is the only indicator easily available for international comparisons. A discussion on the bibliometric analyses is provided in section 1.4.1 and 3.4 of this Research Barometer.

The Research Barometer consists of three sections: the first section describes Swedish R&D in international comparison while section two presents in-depth information about the Swedish research system. The last section consists of a discussion on methods.

In short, the Research Barometer shows that Sweden is doing well as a research nation when compared with other countries. Investments in R&D are among the highest in the world in relation to GDP. In addition, the proportion of researchers among the Swedish population is high and gender equality in the research community has increased. Results in terms of publications and citations give a picture of Sweden as being one of the more prominent research nations. However, the business sector's R&D investments have gone down and when it comes to highly cited articles, there are several countries just behind Sweden which have shown stronger developments in recent years.

Sweden in international comparison

R&D spending

In contrast to several other countries, Sweden has reduced its spending on R&D in relation to GDP during the last decade. This reduction is caused by a decline in the business sector's contribution to R&D. Despite this, Sweden is still one of the countries that invests most in R&D in relation to GDP – 3.3 percent in 2013 – and allocates most government funding to R&D in relation to GDP (0.9 percent).

In the countries included in the Research Barometer, most R&D is carried out within the business sector. The figure is about 70 percent in Sweden, as in Switzerland, Finland and Austria. When it comes to R&D within the higher education sector, the proportion in Sweden is relatively high, just as it is in Switzerland, Finland, Austria, Denmark, the UK, the Netherlands and Norway. In all these countries, the figure is around 30 percent of all R&D.

The personnel in the R&D system

Sweden and the other Nordic countries have a comparatively large proportion of researchers in relation to the total population. Sweden now has the largest share of researchers (just over 1 percent), followed by Finland, Denmark and Norway.

Women are a minority among the researchers in all of the countries compared in the Research Barometer. In Japan, for example, less than 15 percent of the researchers are women. Of all the countries, the UK has the most equal gender distribution with 38 percent female and 62 percent male researchers. The Nordic countries follow closely after the UK.

The UK and Switzerland have a comparatively high proportion of researchers in the higher education sector, while other countries employ a larger proportion of researchers in the public sector, such as Norway, Germany and China. In Korea, Japan and Sweden the largest proportion of researchers are active in the business sector. The distribution of researchers in Sweden reflects the structure of

the R&D-system, with little R&D in the government sector outside the higher education sector, and a R&D-intensive industry.

Swedish publications in an international perspective

Research results can be defined and described in many different ways. The Research Barometer focuses on scholarly article production in terms of volume, research profile and citation impact. Citation impact is measured as the proportion of scholarly article production that is found among the 10 percent most cited publications in the world, within each subject area and year.

During the period 2002–2004, Sweden and Switzerland shared the top spot if countries are ranked based on the number of publications in relation to the population. Since then, Sweden has dropped to a fourth place, while Switzerland, Denmark and Australia have assumed first, second and third place.

Sweden has a large share of highly cited publications and this proportion has increased somewhat in recent years. However, several other countries have had even bigger increases. Sweden now belongs to a group right behind the leading countries in the world. Singapore, Switzerland, the USA, the Netherlands and the UK are at the top of the list.

Sweden's research profile is broad, with a relatively high research activity within clinical medicine and social sciences, and with less activity within mathematics and chemistry. If research profiles are compared, a pattern emerges where Sweden, together with the USA and several countries in Western Europe, has a profile characterised by high citation impact within most research areas. Emerging research countries, like China and Korea, are more specialised.

International co-publication

Sweden is one of the countries with the highest share of international co-publications. The proportion of Swedish publications that were co-published with researchers in the EU countries (with the addition of Norway and Switzerland) has increased slightly over the last 35 years. In 2015, they amounted to more than 70 percent of all Swedish international co-published articles. However, the largest increase has been for co-publications with researchers in Asia. When it comes to individual countries, the USA is the country with which Swedish researchers co-publish the most.

Swedish researchers' international co-publishing is increasing in all research areas. The average of internationally co-published articles was 64 percent of all articles in 2015. However, there is great variation between the areas. International co-publishing is considerably more common within geosciences and physics, than within the humanities and the social sciences.

The Swedish research system

R&D spending in Sweden

The total national expenditure for R&D in Sweden in 2013 amounted to just under SEK 125 billion. The business sector provided SEK 76 billion while the public sector contributed with SEK 36.5 billion.

Within the higher education sector, the government was the largest funder of Swedish R&D. State funding has increased by 25 percent during the last decade. Of the SEK 34 billion government spending in 2016, about half went directly to HEIs. The rest was distributed to research funding bodies, civil government agencies and defence agencies.

Some 80 percent of the R&D funding to Swedish HEIs come from the state. The EU and Swedish companies provide just under 5 percent each.

R&D funding to Swedish HEIs, calculated as fixed prices, has increased by as much as 54 percent from 2001 to 2013. This increase has not led to any redistribution among the different categories of institutions. 90 percent of R&D funding within the higher education sector still goes to the comprehensive universities.

If the increase in funding to the HEIs is distributed per field of research, it is seen that medicine and health sciences, as well as natural sciences, have had greater increases from 2011 to 2013 than the other areas.

The personnel in the Swedish research system

The composition of the personnel at Swedish HEIs has changed radically from 2001 to 2015. All staff categories apart from lecturers and career development positions have increased in number. Within the category “Research and teaching staff”, the growth was almost 80 percent. In 2015, 35 000 people belonged to this category.

Doctoral students devote about 70 percent of their working time to R&D. As they comprise the largest staff category (some 18 000 altogether in 2015), this means that about 37 percent of all R&D at Swedish HEIs is performed by doctoral students.

When different categories of HEIs are compared, the degree of domestic recruitment of researchers and teachers (i.e. with a degree from another Swedish HEI) is greatest at university colleges and new universities. It is lowest at comprehensive universities and specialised universities.

The proportion of women among recent PhD graduates and within various staff categories in the higher education system has gradually increased in recent decades and is now approaching 50 percent, even if the proportion of women varies in the different fields of research. The exception is the category “Professor”, where only 25 percent are women.

Scholarly publications at Swedish HEIs

Sweden is one of the countries that has the largest production of scholarly articles in relation to its population. By far the largest share of articles is produced at the comprehensive universities and specialised universities. The university colleges and new universities show an annual increase in publication volume of some 8 percent during the period 2002–2014. Their combined share of the production of articles in Sweden has increased from 4 to 8 percent during that time.

When it comes to the proportion of highly cited publications, the comprehensive universities, the specialised universities and the category “others” (for example, companies and government agencies outside the higher education sector) score over the global average during the years 2012–2014. For university colleges and new universities, the share of highly cited publications was lower than the global average during the same period.

An analysis of how citation impact is distributed over the different research areas and HEIs shows that there is no obvious correlation between the degree of specialisation and citation impact. The areas that have a high degree of citation impact are often relatively small. Universities that have a high citation impact are generally above the global average in many areas.

Approximately 13 percent of all Swedish publications are joint publications by Swedish HEIs and other sectors of society. Joint publications are most common in clinical medicine, and least common in mathematics and the arts and humanities.

SAMMANFATTNING

De myndigheter, företag och övriga organisationer som finansierar och utför forsknings- och utvecklingsverksamhet (FoU) utgör huvudaktörerna i FoU-systemet. Forskningsbarometerns fokus ligger på den offentliga forskningsfinansieringen och på den forskning som bedrivs vid universitet och högskolor, vilket innebär att tyngdpunkten ligger på forskningsverksamheten i FoU-systemet.

Forskningsbarometern ger en överblick av det svenska forskningssystemet i internationell jämförelse. Den ger också djupare information om svenska förhållanden med tonvikt på den senaste tioårsperioden. Forskningsbarometern beskriver tre delar i systemet: finansiella resurser, personalen i systemet och de resultat som genereras i termer av publikationer. Publikationer är naturligtvis bara en form av forskningsresultat, men det är den enda indikator som enkelt finns att tillgå för internationella jämförelser. För en diskussion kring de bibliometriska analyserna, se avsnitt 1.4.1 och 3.4 i denna Forskningsbarometer.

Forskningsbarometern består av tre avsnitt: det första avsnittet presenterar svensk FoU i internationell jämförelse och det andra avsnittet visar en närbild av det svenska forskningssystemet. Det sista avsnittet består av en metoddiskussion och referenser.

Sammanfattningsvis visar Forskningsbarometern att Sverige står sig väl som forskningsnation i internationell jämförelse. Investeringarna i FoU hör till de högsta i världen som andel av bruttonationalprodukten (BNP). Även andelen forskare i befolkningen är hög och forskarkåren blir alltmer jämställd. Utfallet i form av publikationer och citeringar ger en bild av Sverige som en av de mer framstående forskningsnationerna. Företagssektorns FoU-investeringar har dock minskat och i fråga om högciterade artiklar finns strax efter Sverige flera länder som visat en starkare utveckling de senaste åren.

Sverige i internationell jämförelse

FoU-satsningar

Sverige har till skillnad från flera andra länder minskat sina utgifter för FoU som andel av BNP under det senaste decenniet, vilket beror på minskad företagsfinansiering. Trots det tillhör Sverige fortfarande den grupp av länder som investerar störst andel av BNP på FoU – 3,3 procent år 2013 – och avsätter mest offentliga medel till FoU som andel av BNP (0,9 procent).

Bland jämförelseländerna i Forskningsbarometern är det inom företagssektorn som den mesta av FoU utförs. Den andelen är omkring 70 procent i Sverige, liksom i Schweiz, Finland och Österrike. När det gäller den andel av FoU som bedrivs inom högskolesektorn är den jämförelsevis stor i Sverige, precis som i Schweiz, Finland, Österrike, Danmark, Storbritannien, Nederländerna och Norge. I alla dessa länder utgör den runt 30 procent av all FoU.

Personalen i FoU-systemet

Sverige och de nordiska länderna utmärker sig genom en generellt hög andel forskare i befolkningen. Sverige placerar sig numera i topp (med drygt 1 procent), precis före Finland, Danmark och Norge.

Kvinnor utgör en minoritet bland forskarna i alla Forskningsbarometerns jämförelseländer. I Japan är till exempel mindre än 15 procent av forskarna kvinnor. Den mest jämställda sammansättningen bland jämförelseländerna har Storbritannien, där 38 procent av forskarna är kvinnor och 62 procent män, följt av de skandinaviska länderna.

Storbritannien och Schweiz har en jämförelsevis hög andel forskare inom högskolesektorn, medan andra länder har större andel forskare i offentlig sektor, t.ex. Norge, Tyskland och Kina. Sydkorea, Japan och Sverige har högst andel forskare inom företagssektorn. Fördelningen av forskare speglar FoU-systemets struktur i Sverige, med en liten offentlig institutssektor, en relativt stor högskolesektor och ett FoU-intensivt näringsliv.

Svensk publicering i ett internationellt perspektiv

Resultatet av forskning kan fångas på många olika sätt. Forskningsbarometern fokuserar på den vetenskapliga produktionen – i första hand artiklar – i termer av volym, ämnesprofil och genomslag. Genomslaget mäts som den andel av den vetenskapliga produktionen som finns med bland de 10 procenten högst citerade publikationerna inom respektive ämnesområde.

Under perioden 2002–2004 publicerade Sverige och Schweiz flest vetenskapliga publikationer som andel av befolkningen. Sedan dess har Sverige halkat ned till en tredje plats, medan Schweiz och Danmark ligger på första respektive andra plats.

Sverige har en globalt sett stor andel högciterade publikationer och andelen har ökat något under de senaste åren. Flera andra länder har dock haft ännu större ökning. Sverige tillhör nu en grupp som ligger strax efter de ledande länderna i världen. Singapore, Schweiz, USA, Nederländerna och Storbritannien toppar listan.

Sveriges ämnesprofil är bred med en relativt sett hög forskningsaktivitet inom klinisk medicin 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 profil som kännetecknas av överlag högt citeringsgenomslag inom de flesta ämnesområden. Framväxande forskningsländer som Kina och Sydkorea är mer specialiserade ämnesmässigt.

Internationell sampublicering

Sverige hör till de länderna med högst andel internationell sampublicering. Andelen svenska sampubliceringar med forskare i EU-länderna samt Norge och Schweiz har ökat svagt de senaste 35 åren. År 2015 uppgick de till drygt 70 procent av alla svenska internationellt sampublicerade artiklar. Störst ökning syns dock när det gäller sampubliceringar med forskare i Asien. Sett till enskilda samarbetsländer är USA det land med vilket svenska forskare samarbetar mest.

Inom alla ämnesområden ökar svenska forskares internationella sampublicering. Den genomsnittliga andelen internationella sampubliceringar låg på 64 procent av samtliga publikationer 2015. Variationerna är dock stora mellan områden. Det är betydligt vanligare med internationella sampubliceringar inom geovetenskap och fysik, än inom humaniora och samhällsvetenskap.

En närbild av det svenska forskningssystemet

FoU-resurser i Sverige

De totala utgifterna för FoU i Sverige uppgick 2013 till knappt 125 miljarder kronor. Av detta stod företagssektorn för 76 miljarder kronor och den offentliga sektorn för 36,5 miljarder kronor.

Inom högskolesektorn är staten den största finansiären av svensk FoU. Den statliga finansieringen har ökat med 25 procent under den senaste tioårsperioden. Av de 34 miljarder kronor som fördelas 2016, går hälften direkt till universitet och högskolor. Resterande del fördelas på forskningsfinansiärer samt civila myndigheter och försvarsmyndigheter.

Ungefär 80 procent av FoU-medlen till svenska lärosäten kommer från den offentliga sektorn. EU och svenska företag står för knappt 5 procent av finansieringen vardera.

Svenska lärosätens intäkter för FoU har, i fasta priser räknat, ökat med hela 54 procent under perioden 2001 till 2013. Ökningen har inte inneburit någon omfördelning mellan olika kategorier av lärosäten. Fortfarande går ca 90 procent av intäkterna för FoU till de forskningsintensiva lärosätena.

Om man fördelar lärosätenas intäktsökningar per forskningsämnesområde framgår att medicin och hälsovetenskap samt naturvetenskap har haft större ökning mellan åren 2011 och 2013 än vad övriga områden haft.

Högskolans personal i Sverige

Sammansättningen av högskolans personal har förändrats radikalt under perioden 2001–2015. Alla personalkategorier utom adjunkter och meriteringsanställningar har ökat i omfattning. Inom kategorin "Forskande och undervisande personal" var tillväxten nästan 80 procent. År 2015 tillhörde 35 000 personer denna kategori.

Doktorander lägger uppskattningsvis ungefär 70 procent av sin arbetstid på FoU. Eftersom de också utgör den största personalkategorin (ungefär 18 000 totalt år 2015) innebär det att omkring 37 procent av all FoU vid svenska lärosäten utförs av doktorander.

Vid en jämförelse mellan lärosäteskategorier framgår att graden av nationell rekrytering av forskare och lärare (dvs. med doktorsexamen från annat svenskt lärosäte) är högst vid högskolor och nya universitet. Vid breda etablerade universitet och fackuniversitet är det vanligast med rekrytering av personer med doktorsexamen från samma lärosäte som de är anställda vid.

Andelen kvinnor bland de nydisputerade och inom olika anställningskategorier i högskolan har successivt ökat de senaste decennierna, även om andelen kvinnor varierar mellan olika ämnesområden. Undantaget är det högsta steget i karriärtrappan: bland professorerna är endast 25 procent kvinnor.

Svenska lärosätens publicering

Sverige hör till de länderna som har högst produktion av vetenskapliga publikationer i relation till sin folkmängd. Den allra största delen artiklar produceras vid de breda etablerade universiteten och fackuniversiteten. Kategorierna högskolor och nya universitet ökade sin publikationsvolym med drygt 8 procent under perioden 2002–2014. Dessa lärosäteskategoriers sammantagna andel av den svenska artikelproduktionen ökade från 4 till drygt 8 procent under samma period.

De breda universiteten, fackuniversiteten och kategorin övriga (bland annat företag och myndigheter utanför högskolesektorn) låg under åren 2012–2014 över världsgenomsnittet när det gäller andelen högciterade publikationer. För högskolor och nya universitet var andelen högt citerade publikationer lägre än världsgenomsnittet under samma period.

En analys av hur citeringsgenomslaget fördelas över olika ämnesområden och lärosäten visar inga uppenbara samband mellan specialiseringsgrad och citeringsgenomslag. De ämnen som har högst citeringsgenomslag är ofta relativt små. Lärosäten med ett högt genomslag överlag, ligger ofta över världsgenomsnittet inom många områden.

Ungefär 13 procent av samtliga svenska publikationer är sampubliceringar mellan svenska lärosäten och andra samhällssektorer. Sampublicering är vanligast inom klinisk medicin och minst vanlig inom matematik och humaniora.

1 SWEDISH RESEARCH – AN INTERNATIONAL COMPARISON

With an emphasis on the past ten years, this section describes how Sweden has developed in comparison to other countries in terms of expenditure on research and development (R&D)², number of researchers³ and research results. It begins with an overview of the number of researchers and domestic R&D expenditure in a number of countries and uses a selection of indicators to show how Sweden is placed internationally compared with the leading countries.

² Research and development (R&D): A systematic effort to look for new knowledge or new ideas with or without a specific application in mind. This includes systematic efforts that utilise research results, scientific knowledge or new ideas in order to create new materials, goods, services, processes, systems and methods, or to achieve significant improvements to those that already exist. (Definition from Statistics Sweden).

³ In this section, which contains international comparisons, the term researchers is used in line with the definition provided in the Frascati Manual, i.e. people who work with R&D. Formal title or educational level are not decisive in terms of whether or not someone is classified as a researcher. Doctoral students are included, for example, as are other staff who work with R&D such as technicians or other support staff. In addition, not all those who have a doctorate work as researchers. "Researchers are 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." OECD. Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities. OECD Publishing, Paris. 08/10/2015, p. 164.

1.1 Increased investment in R&D and tougher competition

The three largest economic regions, North America, Europe and Asia (primarily China, Korea and Japan), account for 92 per cent of global investments in R&D. As many countries increase their investment in R&D, the relationships between the research nations are changing.⁴ China's R&D budget has increased sharply, for example. In 2014, 2 per cent of GDP was allocated to R&D, an increase of 9 per cent. Korea's investment in R&D as a percentage of GDP increased to 4.3 per cent in 2014, more than double the OECD average.⁵

In spite of global economic growth being hard to predict, the forecast is for investment in R&D to continue increasing in the majority of countries. As a result of the increased investment, the number of researchers is growing, as is the number of research publications. An increasingly large proportion of these publications are international co-publications.⁶

⁴ Casassus, Barbara. China predicted to outspend the US on science by 2020. *Nature*. 14/11/2014.

⁵ OECD. R&D intensity: Gross Domestic Expenditure on R&D as a percentage of GDP 2000–2014. Main Science and Technology Indicators: Latest News. Last update: MSTI 2015/2, January 2016.

⁶ Ware, Mark and Mabe, Michael. The STM Report, Fourth Edition. March 2015 (revised November 2015).

1.1.1 There is a strong link between R&D expenditure and the number of researchers

Countries such as Sweden, Finland, Denmark and Korea are similar in that they all devote a large proportion of GDP to R&D and have a large pool of researchers. On the other hand, China has low R&D expenditure in relation to its strongly growing GDP and a small number of researchers in relation to the size of its population.

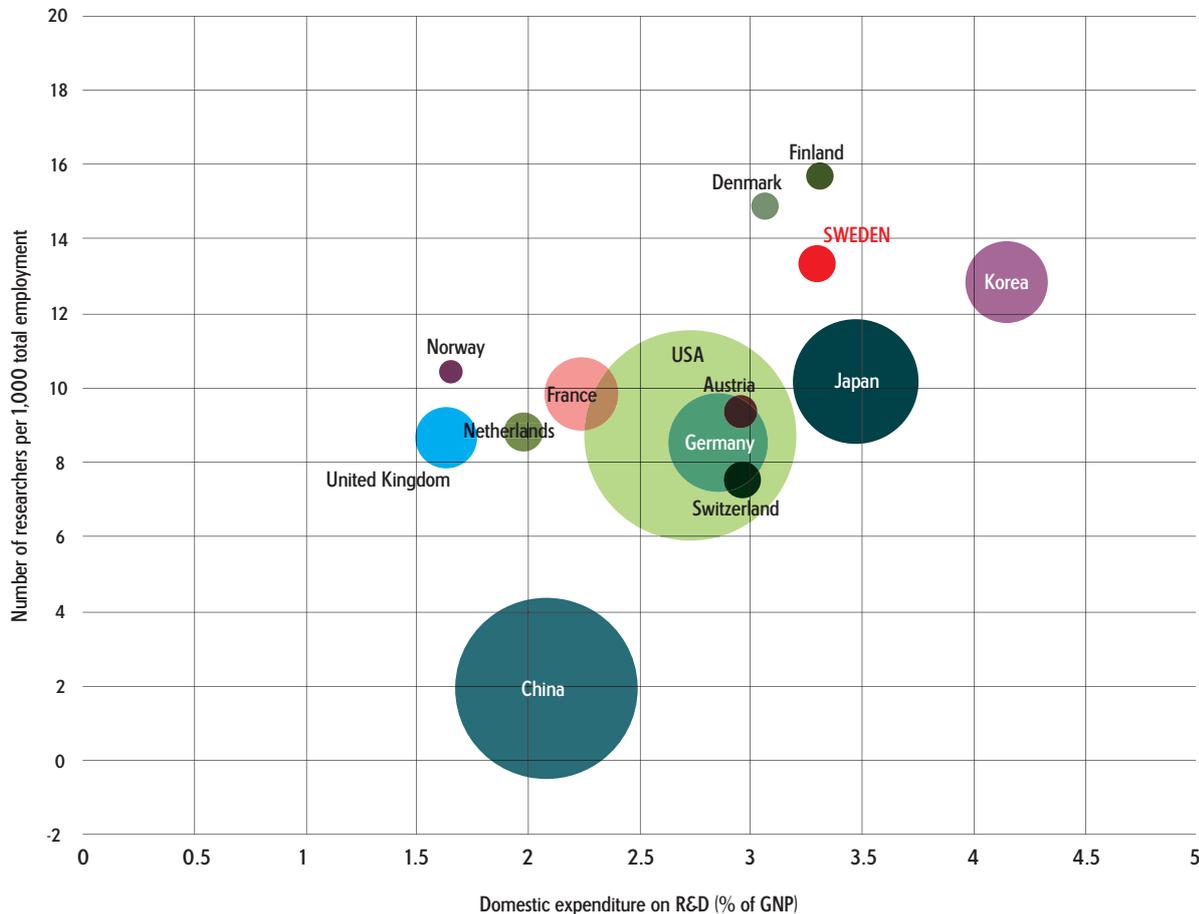


Figure 1. Number of researchers per thousand total employment in relation to domestic expenditure on R&D as a percentage of GDP in 2013. Sweden is compared with a selection of other countries. The area of each circle corresponds to that country's share of the total R&D expenditure of all the countries included in the figure. Source: OECD.

Figure 1 shows the number of researchers⁷ per thousand working people in relation to domestic R&D expenditure as a percentage of GDP in a number of countries. The countries are shown as circles, the size of which indicates each country's proportion of total R&D investments for the countries included in the figure. The United States and China together account for about half of the world's total R&D expenditure: the United States for 29 per cent and China for 21 per cent.⁸ On average, the OECD countries invested just over 2 per cent of their GDP on R&D.

Sweden is among the top countries in terms of R&D expenditure as a percentage of GDP. Of the EU countries, Finland (3.31 per cent), Sweden (3.30 per cent) and Denmark (3.06) were top-ranked in 2013.⁹ Korea (4.15 per cent) and Japan (3.47 per cent) were even higher. Israel (not included in Figure 1) was also among the top countries. Relatively speaking, the United Kingdom, Norway and the Netherlands have both lower R&D expenditure and a lower number of researchers than Sweden.

⁷ In accordance with the Frascati Manual's definition of researchers.

⁸ Of all the countries in the database. OECD. Gross Domestic Expenditure on R&D as a percentage of GDP. 27/05/2013.

⁹ Forecasts show that Sweden's R&D expenditure as a percentage of GDP has decreased somewhat – from 3.3 per cent in 2013 to 3.16 per cent in 2014. OECD. Main Science and Technology Indicators. GERD as a percentage of GDP.

1.1.2 Sweden is a strong research nation, but competition is becoming tougher

In an international comparison, Sweden is among the five leading countries with respect to, for example, R&D investments (public and private) and number of publications, as well as researchers in relation to the population. Sweden stands out, however, as being one of few OECD countries in which the business enterprise sector's proportion of domestic R&D expenditure has decreased in the past ten years. Sweden is also outside the top five countries in the category citation impact.



Figure 2. 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 countries in the database and the average value for the five top countries in each category. More detailed information about the indicators is provided in the List of Figures and Indicators. Source: OECD (2013 and 2014) and Thomson Reuters (publication year: 2012–2014).

Figure 2 provides a snapshot of Sweden's position in comparison to other countries, partly in terms of investments in R&D in relation to GDP, as well as the number of researchers in the system, and partly in terms of results in the form of publications and their impact measured as citations. Please note that Sweden's position in Figure 2 is stated as the country's *relative* position, in relation both to the average value for all countries in the category and to the average value for the five countries that are at the top of each category. A more detailed description of the indicators in Figure 2 is provided in the List of figures and indicators.

In an international comparison, Sweden is in fourth place in terms of total *domestic expenditure on R&D (GERD) as a percentage of GDP*. The countries that are at the top are Korea, Israel, Japan, Sweden and Finland.

Sweden is also in fourth place when it comes to *industry-financed GERD as a percentage of GDP*, behind Korea, Japan and Taiwan. Finland is in fifth place. The top countries' average value is pulled up by Korea and Japan, who both had strong growth in industry financed R&D.

Government-financed GERD as a percentage of GDP is led by Austria and Korea, with Sweden in third place ahead of Denmark and Finland.

In terms of *publications per 1,000 inhabitants*, Sweden is in fourth place among the OECD countries, after Switzerland, Denmark and Australia.

Sweden is around the world average in terms of *citation impact*, in a group occupying positions 11–16. The five top countries are Singapore, Switzerland, the United States, the United Kingdom and the Netherlands.

The *number of researchers per thousand employment* in Sweden is high in an international comparison. Only Finland and Denmark have more researchers in relation to the size of their *working* population.

1.2 Financing of R&D

R&D is regarded as an increasingly important resource for society and many countries are continuing to increase their total investments in R&D. It is primarily the business enterprise sector that is responsible for this increase in R&D investment around the world. Preliminary OECD data from 2015 indicate that government R&D budgets have continued to decrease since 2010.¹⁰ However, the opposite is true for Sweden; government funding has increased, while the business enterprise sector has decreased its financing of R&D.

The distribution between research and development varies between different sectors. Companies' R&D often has a greater emphasis on development than is the case in the higher education sector (please also refer to R&D resources in Sweden, section 2.1).

1.2.1 R&D is undertaken in various sectors of society – in Sweden, largely within companies and higher education

In all countries used for comparison, the majority of R&D takes place in the business enterprise sector. In Sweden the proportion is around 70 per cent, the same as in Switzerland, Finland and Austria. In terms of the proportion of R&D that is carried out within the higher education sector, this is comparatively large in Sweden, just as in Switzerland, Finland, Austria, Denmark, the United Kingdom, the Netherlands and Norway. In all of these countries, it accounts for around 30 per cent of total R&D expenditure.

¹⁰ OECD. Main Science and Technology Indicators: Latest News. Last update: MSTI 2015/2, January 2016.

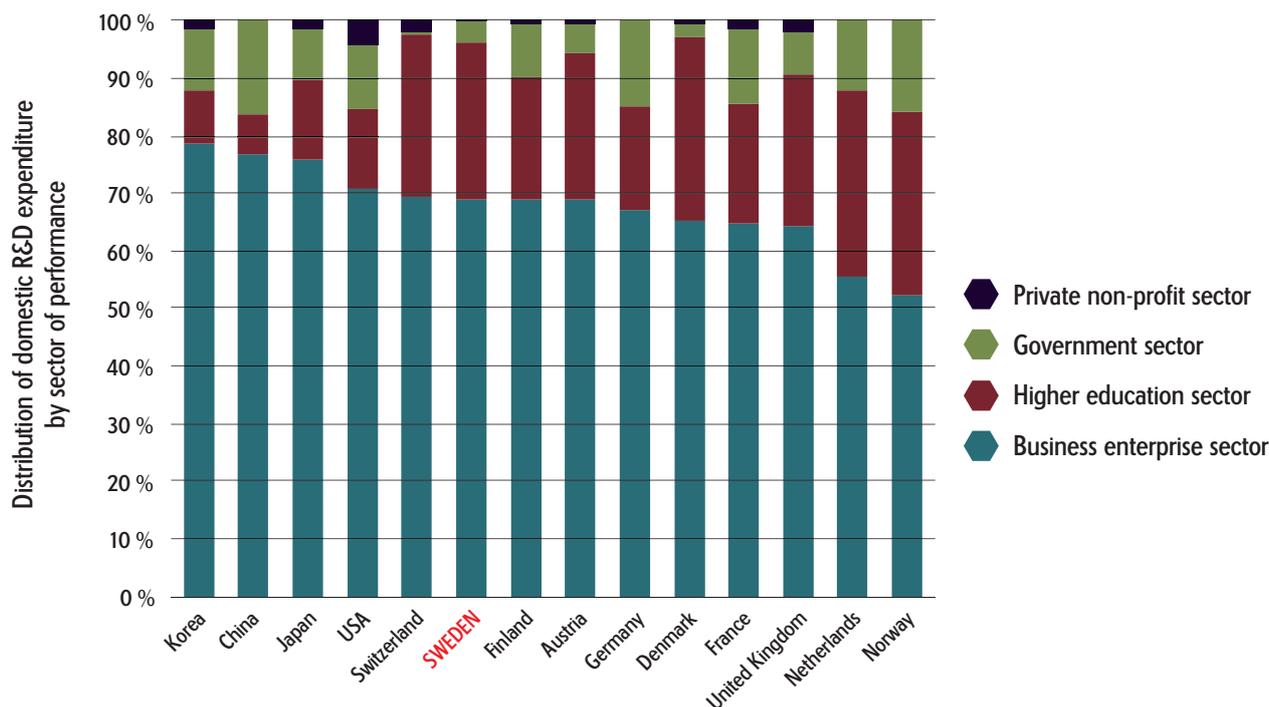


Figure 3. Distribution of domestic R&D expenditure by sector of performance 2013. Sweden is compared with a selection of other countries. Source: OECD.

Figure 3 shows the extent to which R&D is performed within the various sectors in a number of countries (it does not indicate which actor finances the R&D). In several countries, among them Sweden, the majority (around 70 per cent) of R&D activities are performed within the business enterprise sector.¹¹ The higher education sector is thus relatively large in Sweden (27 per cent), while activities within government research institutes and other government agencies (listed as government sector in Figure 3) constitute less than 4 per cent of Swedish R&D activities. This is lower than the equivalent proportion in many other countries.

In Germany, Norway, France and the Netherlands, a relatively large proportion of R&D (c. 12–15 per cent) is undertaken in government research institutes. In Korea, China and Japan, a large proportion (just over 75 per cent) of R&D is performed in the business enterprise sector. A significant proportion is thus also performed in government research institutes. Only a small proportion of R&D is performed in the higher education sector in these countries; in China the figure is 7 per cent.

1.2.2 Sweden is one of the countries that invests the highest percentage of GDP in R&D, in spite of reduction
 In contrast to many other countries, Sweden has reduced its R&D expenditure as a percentage of GDP in the past decade. In spite of this, Sweden still belongs to the group of countries that invest the highest percentage of GDP in R&D.

¹¹ Research institutes that run as limited companies are included in the business enterprise sector, while those that are regarded formally as government authorities are reported in government sector. The Swedish Institute for Space Physics is classified as belonging to the higher education sector and some institutes are found in the category private non-profit sector.

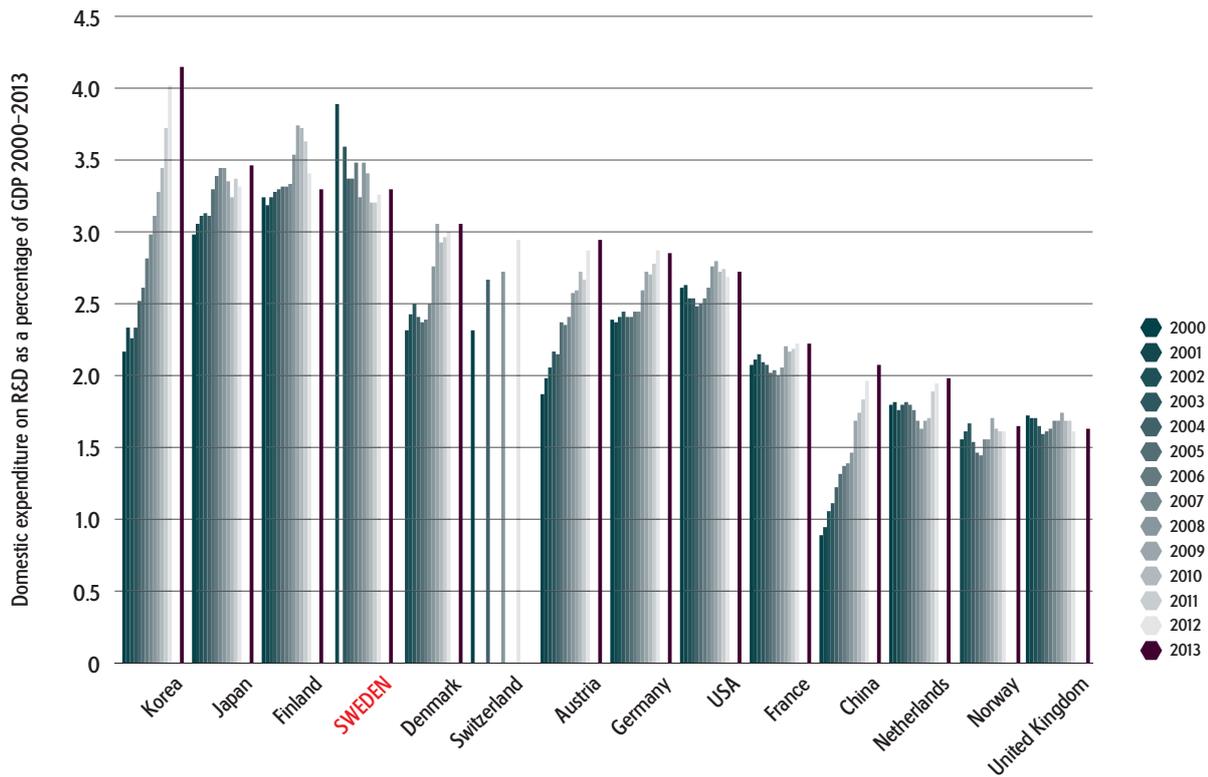


Figure 4. Trend in domestic expenditure on R&D as a percentage of the country's GDP in the period 2000–2013. Sweden is compared with a selection of other countries. Source: OECD.

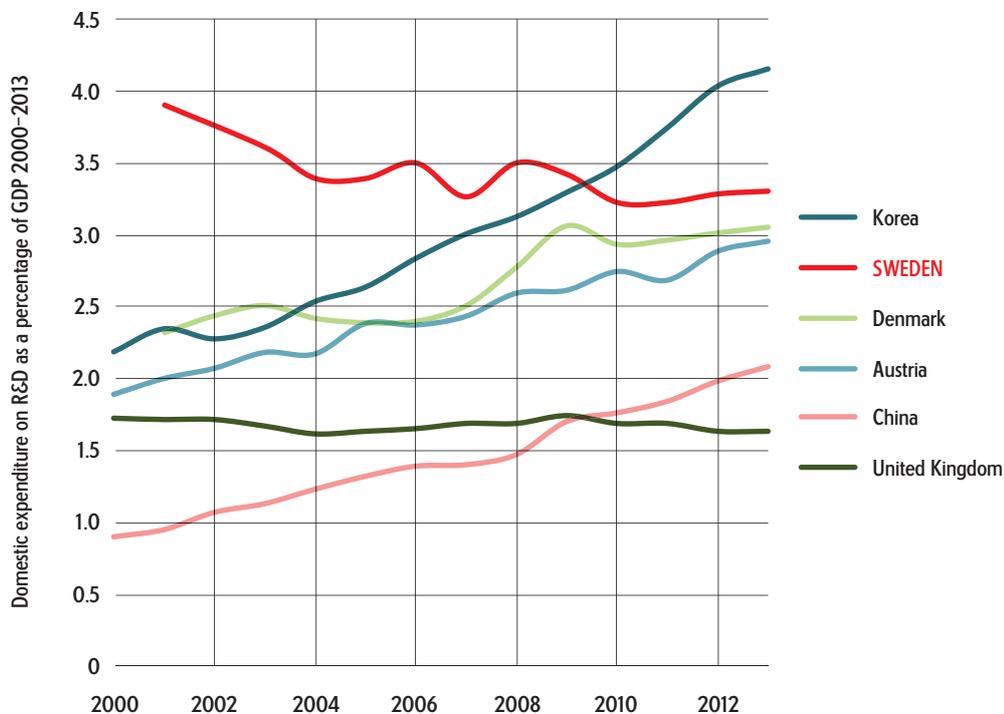


Figure 5. Trend in domestic expenditure on R&D as a percentage of the country's GDP in the period 2000–2013. Sweden is compared here with a few selected countries in order to make the trend clearly visible. Source: OECD.

Both Figure 4 and Figure 5 show total domestic expenditure on R&D as a percentage of GDP for a selection of countries in the period 2000–2013, but in slightly different ways. The focus in Figure 5 is on a smaller number of countries in order to clearly illustrate the trend in Sweden.

Swedish R&D expenditure's percentage of GDP is among the highest in the world, in spite of Sweden, in contrast to many other countries that are investing heavily in R&D, having reduced its R&D expenditure in relation to GDP in the past decade. Denmark and Austria have increased their investments over the years and are closing in on Sweden.

In contrast to e.g. the United Kingdom, where R&D financing as a percentage of GDP has remained relatively constant over this period, the increase in Korea is striking. China's investments in R&D have increased strongly, both in relation to GDP and especially in absolute terms, as the country's GDP has increased sharply.

Looking at domestic R&D expenditure per number of inhabitants, Sweden is in third place in the world, after Switzerland and Singapore, although Korea and China are growing rapidly in this respect.

1.2.3 Industry's R&D financing is declining in Sweden and Norway – but increasing in Korea and China

Sweden and Norway have reduced their domestic R&D expenditure in relation to GDP. This reduction has taken place within the business enterprise sector and has not been completely compensated for by the increased revenues within the higher education sector that we have seen in both Sweden and Norway over the past ten years. Nevertheless, Sweden remains at a high level.

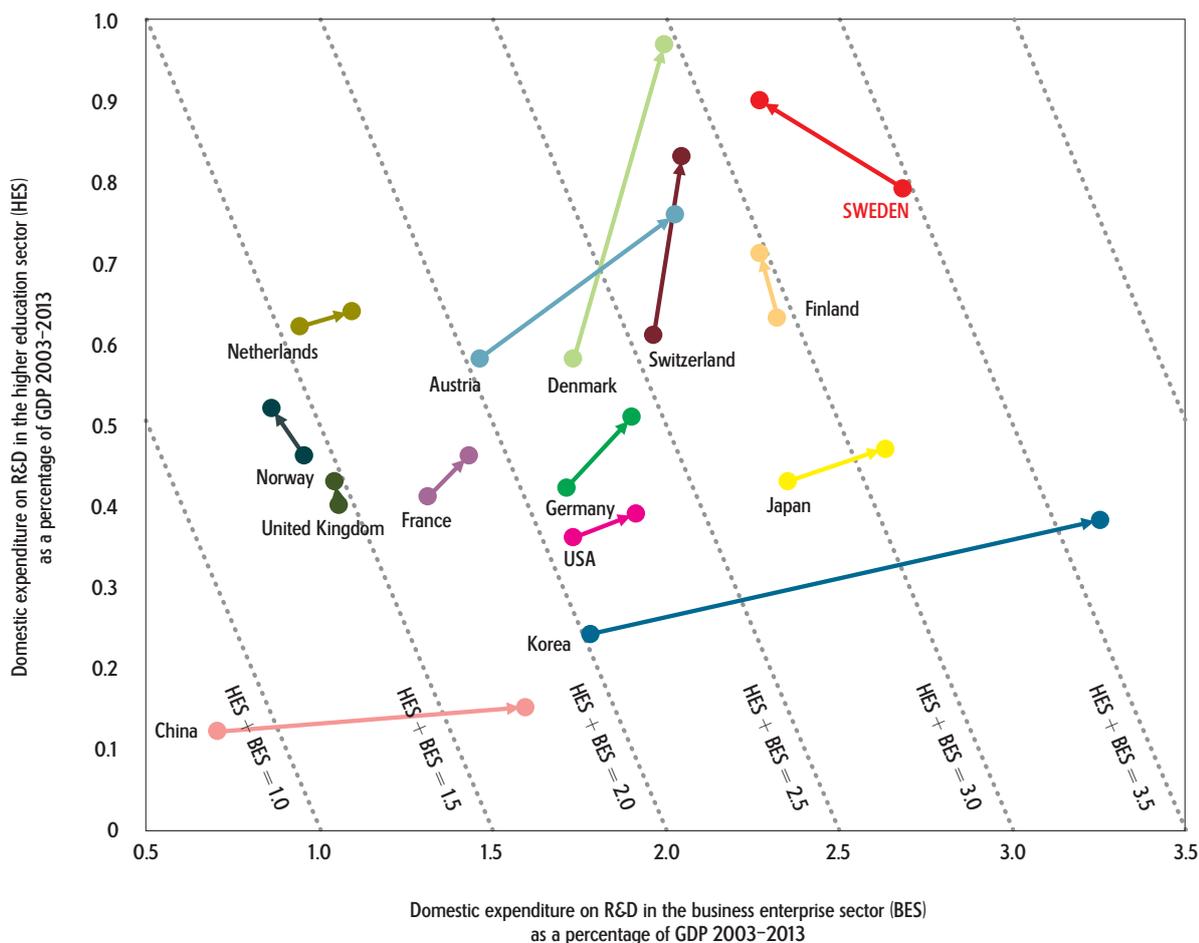


Figure 6. Trend in domestic expenditure on R&D as a percentage of the country's GDP, distributed by R&D within the higher education sector (HES) and business enterprise sector (BES). Sweden is compared with a selection of other countries. The starting point of the arrows represents 2003 and their end 2013. The broken support lines in the diagram indicate the total sum of R&D expenditure for HES and BES. Source: OECD.

Figure 6 shows how the countries' R&D expenditure has changed over the course of the period 2003–2013 within the business enterprise sector and the higher education sector. The broken diagonal lines in the diagram show the total R&D expenditure for both sectors as a percentage of GDP. Please note that total R&D expenditure within the higher education and business enterprise sectors equate to around 85–95 per cent of total domestic R&D expenditure. The R&D that takes place at government research institutes or in the private non-profit sectors is not included in Figure 6 (cf. Figure 3).

Apart from Sweden and Norway, all countries have increased their R&D expenditure in relation to GDP over the course of the period. Nevertheless, Sweden remains at a high level, with R&D investments totalling just over 3 per cent of GDP. In both Sweden and Norway, the reduction has been caused by reduced R&D expenditure within the business enterprise sector (i.e. along the horizontal axis in Figure 6). This reduction has not been completely compensated for by increased expenditure within the higher education sector over the same period (i.e. growth along the vertical axis in Figure 6).

Both Korea and China have increased their R&D financing very strongly over this ten-year period. This growth has taken place primarily in the business enterprise sector. Other countries such as Denmark and Switzerland are characterised by a strong growth within the higher education sector.

1.2.4 Government funding of R&D increased in many countries during the economic crisis 2008–2009

Sweden increased its government appropriation to R&D during the economic crisis 2008–2009, but not as much as a number of other countries. Sweden is one of the countries that allocate the highest level of government funding to R&D.

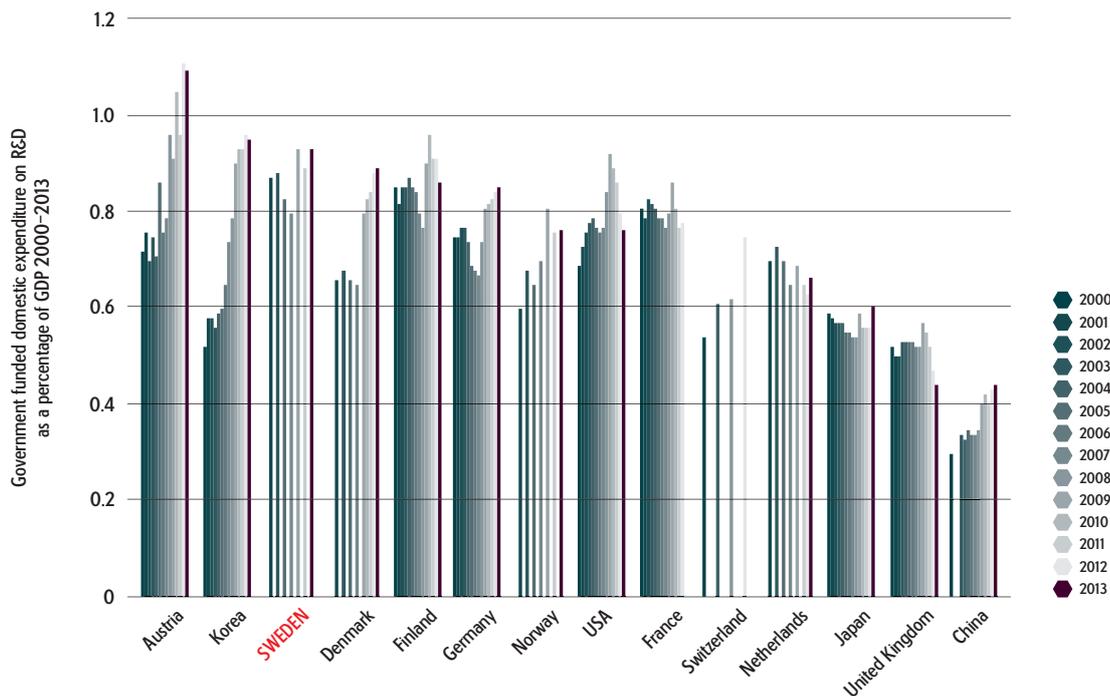


Figure 7. Trend in government funding of domestic expenditure on R&D as a percentage of the country's GDP in the period 2000–2013. Sweden is compared with a selection of other countries. Source: OECD.

Figure 7 illustrates how the government-funded proportion of total expenditure on R&D developed in a number of countries between 2000 and 2013. Sweden is one of the countries that allocates the highest level of government funding to R&D in relation to GDP (0.9 per cent of GDP). As indicated, several countries, Sweden included, increased their government investments in R&D during and following the economic crisis 2008–2009. China and Korea made extensive investments, although the increase in government investment constituted only a small proportion of these countries' total increase in R&D financing.

1.3 Human resources in the R&D system

A country's investment in R&D is strongly linked to the number of researchers¹² in its population. The total number of researchers in the world is estimated at between 7 and 9 million and is thought to increase at a rate of around 4–5 per cent per annum.¹³ The increase in the emerging research nations in Asia is estimated to be around 8–12 per cent per annum, while in North America and Western Europe, it is less than one per cent. These regions are together home to close to 80 per cent of the world's researchers.¹⁴ Around 28 per cent of the world's researchers are women and around 72 per cent are men, but there are major regional differences.¹⁵

Sweden, together with Switzerland, Austria and the United States, is among those countries that have the population with the highest proportion of doctorates. These countries are also notable for having an even gender distribution among those with doctorates. 1.4 per cent of Sweden's working population aged 25–64 has a PhD.¹⁶

1.3.1 The Nordic countries have populations with a high proportion of researchers

Sweden and the other Nordic countries are notable in that they have populations with a generally high proportion of researchers. In the last ten-year period, the proportion of researchers in Sweden's population has not increased as much as in, for example, Denmark and Norway, although a sharp increase is noted for Sweden in the last year measured.

¹² In accordance with the Frascati Manual's definition.

¹³ Ware, Mark and Mabe, Michael. The STM Report, Fourth Edition. March 2015 (revised November 2015).

¹⁴ UNESCO Institute for Statistics. Human Resources in R&D. November 2015, No 35.

¹⁵ UNESCO Institute for Statistics. Women in Science. November 2015, No 34.

¹⁶ OECD. Science, Technology and Industry Scoreboard 2015. Doctorate holders in the working age population, 2012.

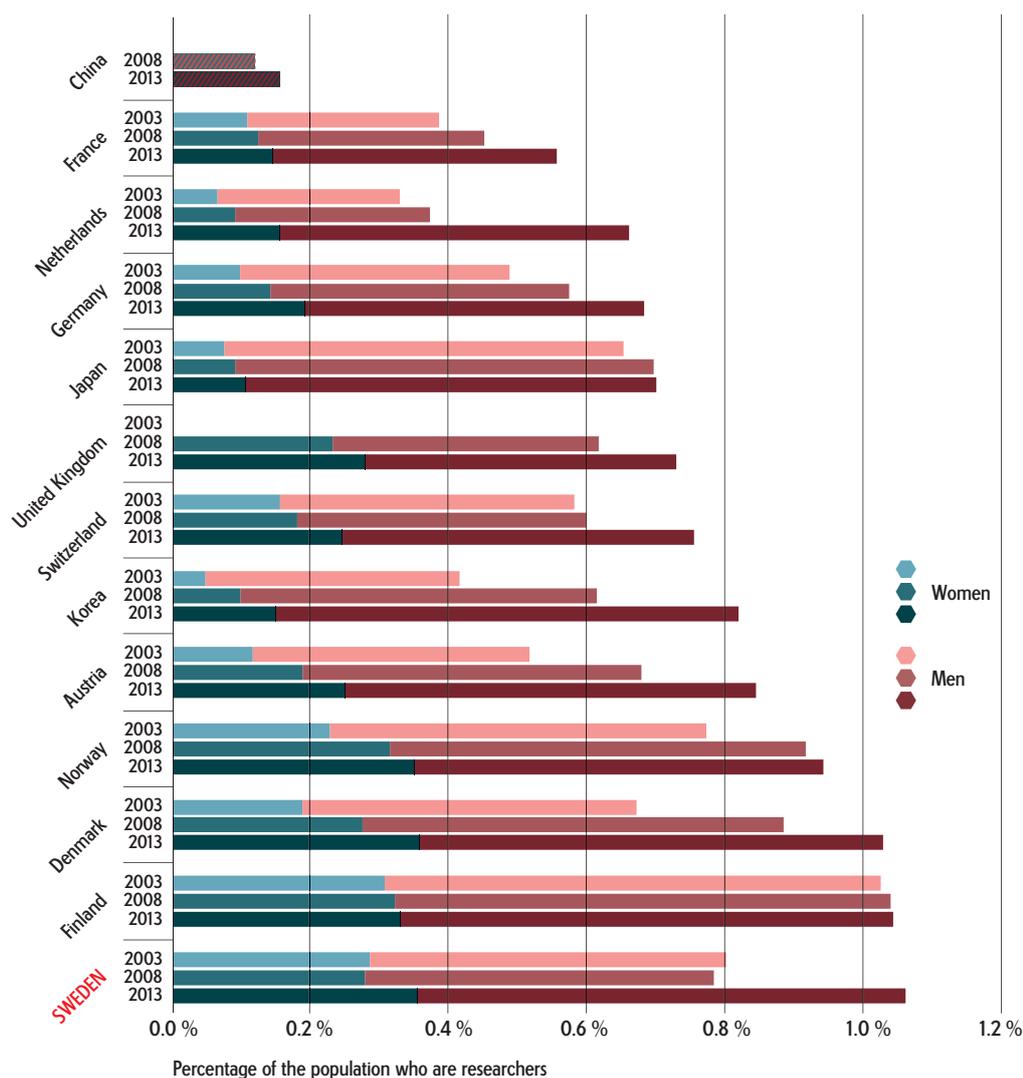


Figure 8. Percentage of the population who are researchers, distributed by women and men, in the years 2003, 2008 and 2013. Sweden is compared with a selection of other countries. Data distributed by gender is not available for China. Source: OECD.

Figure 8 shows the proportion of the population who are researchers in a selection of countries in 2003, 2008 and 2013. The data include researchers in all sectors of society, i.e. the business enterprise sector, the government sector, the higher education sector and the private non-profit sector.

Sweden and the other Nordic countries are notable in that they have populations with a generally high proportion of researchers. A sharp increase is seen for Sweden in the last year measured, which places Sweden at the top, with researchers now making up just over 1 per cent of the population.¹⁷ The proportion of researchers has increased sharply in Denmark, Korea, Austria, Switzerland and the Netherlands, while the change in countries such as Finland and Japan has been more modest. This is consistent with there having been a stagnation in terms of R&D resources in the latter countries.

There are major gender differences within the research community, with women being in the minority among researchers in all of the countries used for comparison in the Research Barometer. In Japan, for example, less than 15 per cent of researchers are women. The most gender equal composition of researchers among the countries used for comparison is found in the United Kingdom, where

¹⁷ The sharp increase in the number of researchers in Sweden in 2013 is partly due to an increase in the number of researchers in the higher education sector, but also because a reclassification has resulted in technical experts now being included in the researchers' category. Statistiska centralbyrån. Forskning och utveckling inom företagssektorn. Statistiska meddelanden UF 14 SM 1401. 17/12/2014 (revised 11/5/2015). [Statistics Sweden. Research and Experimental Development in the Business Enterprise Sector].

38 per cent of researchers are women and 62 per cent men, followed by Norway (37 per cent women and 63 per cent men) and Denmark (35 per cent women and 65 per cent men). The gender distribution in Sweden is 33 per cent women and 66 per cent men.

1.3.2 A comparatively small proportion of Swedish researchers work in the government sector

The United Kingdom and Switzerland have a comparatively high proportion of researchers within the higher education sector, while other countries have larger proportions of researchers in the government sector, for example Norway, Germany and China. Korea, Japan and Sweden have the highest proportion of researchers in the business enterprise sector.

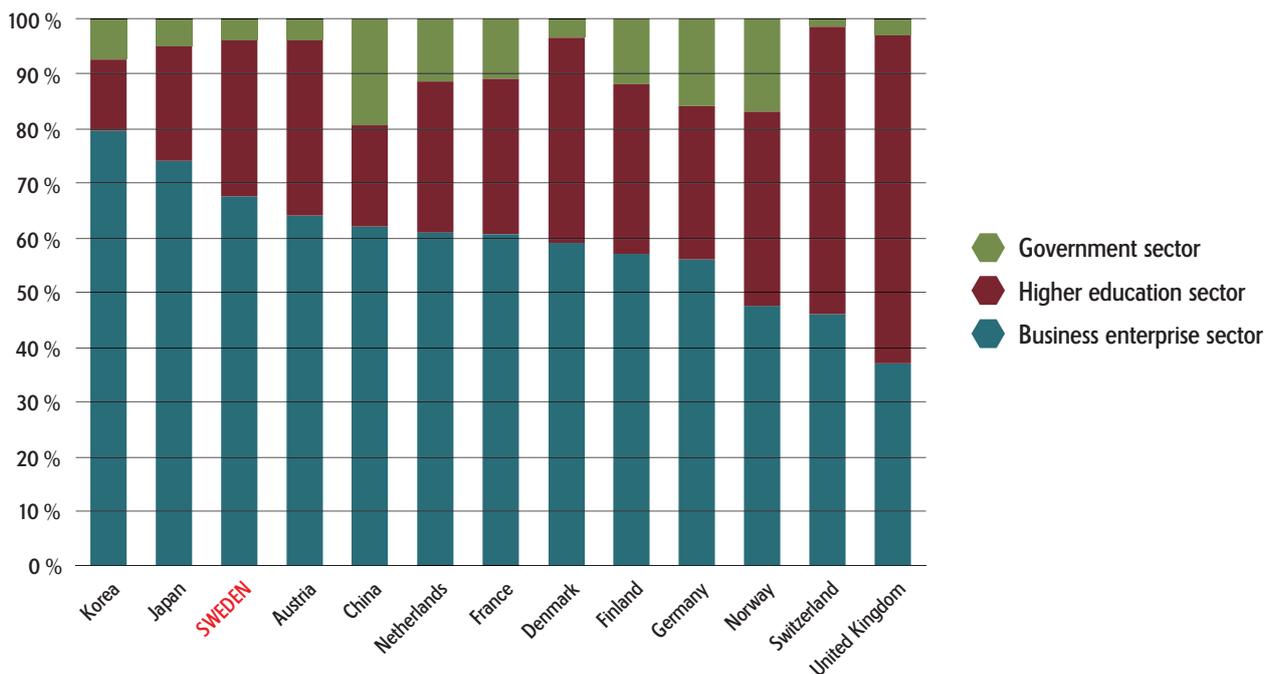


Figure 9. The distribution of researchers between the business enterprise sector, the higher education sector and the government sector in 2013. Sweden is compared with a selection of other countries. Source: OECD.

Figure 9 shows the distribution of the number of researchers between the business enterprise sector, the higher education sector and the government sector.

Some countries, for example Korea and Japan, are notable in that they have a high proportion of researchers in the business enterprise sector. Korea has close to 80 per cent and Japan 73.5 per cent. Sweden also has a high proportion of researchers in the business enterprise sector – a little over 67 per cent.

The United Kingdom and Switzerland instead have a high proportion of researchers in the higher education sector – 59 and 52 per cent, respectively.

Other countries have large government institute sectors that employ large numbers of researchers, for example China, Norway and Germany.

The distribution of researchers reflects the structure of the R&D system in Sweden, with a small government institute sector, a relatively large higher education sector and a business enterprise sector that is R&D intensive.

In the Swedish public sector, including HEIs, there are about as many women as men working as researchers, while men outnumber women among the business enterprise sector's researchers.

1.4 Swedish scholarly publication from an international perspective

Total global production of scholarly articles has increased dramatically. The growth in the number of articles is estimated at around 3 per cent per annum, while the number of scholarly journals is increasing by 3.5 per cent per annum. A total of 2.4 million articles are estimated to have been published in 2013, written by a total of 4.2 million unique authors.¹⁸

This section presents different types of publication statistics for Sweden and the countries that appeared in the previous sections. The indicators and underlying data are described in more detail in the methods section.

1.4.1 Humanities and social sciences cannot be measured in the same way

When research areas are compared, it is important to remember that the arts and humanities and large parts of the social sciences do not have the same coverage in the publication databases as the other fields.

In the humanities, and parts of the social sciences, international journals are not the most important publication channel. But at the same time, it is in these areas that the Swedish publications in *Web of Science* are increasing most in relative terms. The rate of increase between 2002 and 2014 was 10 per cent per annum for both fields. This can be compared with a rate of increase of 2 per cent per annum for the total number of Swedish articles in the same period. In 2002, publications in the humanities and social sciences constituted 1 and 5 per cent of all Swedish publications, respectively. In 2014, the equivalent proportions had increased to 2 and 10 per cent. However, the number of publications in the database in these areas are still small; in 2014 there were just over 400 publications within the humanities and just over 1,600 within the social sciences, out of a total of around 15,000 Swedish publications.¹⁹ Consequently, the bibliometric analyses, especially for the humanities, are to be interpreted with caution.

When it comes to artistic research, there are too few publications in the database to report, primarily because the publication of research results in this area takes place in channels other than those included in the database.

1.4.2 Ranking by the number of scholarly publications per capita – Sweden is falling

In the period 2002–2004, Sweden and Switzerland were the two OECD countries that produced the highest number of publications in relation to the size of their populations. Denmark and Australia (not included in Figure 10) has since overtaken Sweden, which in the period 2012–2014 was in fourth place. Switzerland remains at top of the list.

¹⁸ Ware, Mark and Mabe, Michael. The STM Report, Fourth Edition. March 2015 (revised November 2015).

¹⁹ Fractional counts of publications. Full counts of publications amounted to 25,000 in 2014.

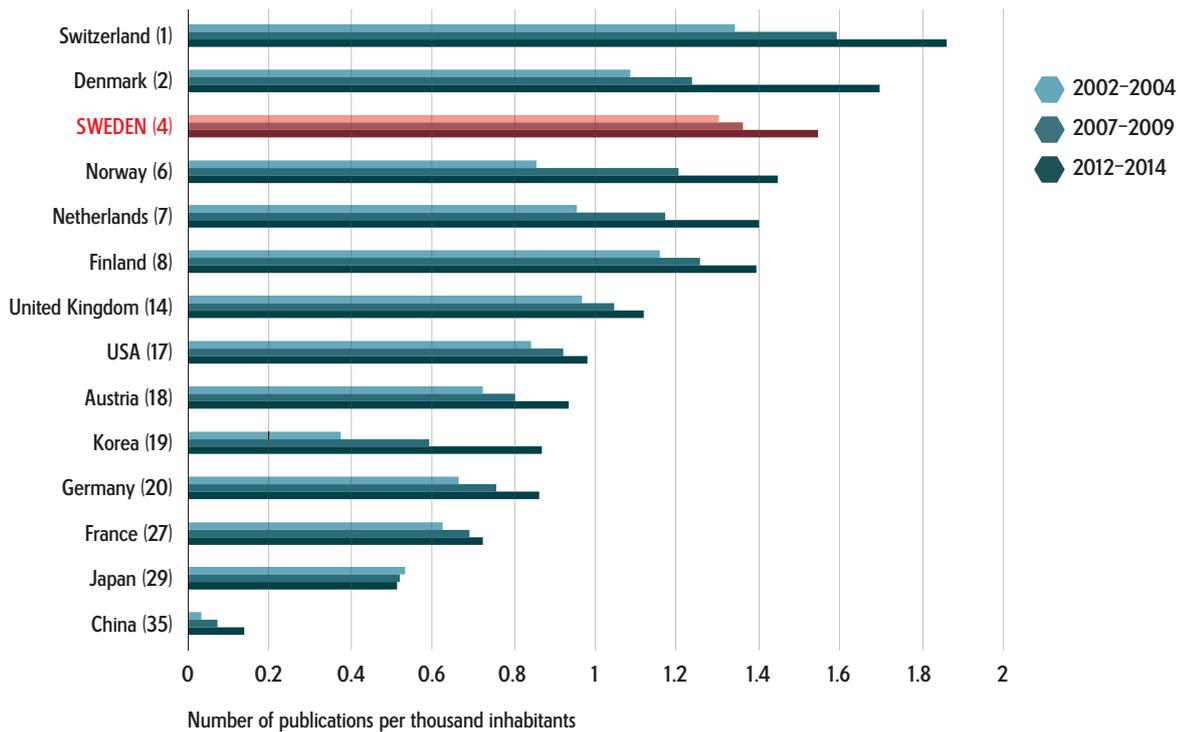


Figure 10. Trend in the number of scholarly publications. Sweden is compared with a selection of other countries. Number of publications is listed per thousand inhabitants for three periods: 2002–2004, 2007–2009 and 2012–2014. The figure in parenthesis refers to the country's position among the OECD countries in the database. Source: Thomson Reuters and OECD.

Figure 10 shows the number of publication per 1,000 inhabitants for 14 countries and three time periods. Sweden is among those countries that have the highest production of scholarly journal articles in relation to the size of their population.

Using this metric, major research nations such as the United States, the United Kingdom and Japan have a lower production of articles than Sweden. Just after the turn of the millennium (2002–2004), Sweden and Switzerland published about the same number of scholarly publications as a proportion of the population, but production in Switzerland has subsequently increased more than in Sweden. Denmark has also shown a sharp increase in the number of scholarly publications and had a higher production than Sweden for the most recent period (2012–2014). Japan is the only country among those used for comparison in the Research Barometer whose production decreased somewhat between the periods.

The United States is still the world's largest producer of scholarly articles in terms of actual numbers, but the competition is intensifying. China, which has shown a strong growth in terms of scholarly production in the past 20 years, does still have a very low production of articles in proportion to its population – less than a tenth that of Sweden. Sweden's proportion of the world's total scholarly articles (fractional counts of publications) was 1 per cent in 2014.

1.4.3 Swedish research has a high citation impact, but other countries have seen greater increases

In global terms, Sweden has a high proportion of highly cited publications and the proportion has increased somewhat in recent years. However, several countries have had greater increases and Sweden is now in a group that is just behind the leading countries in the world.

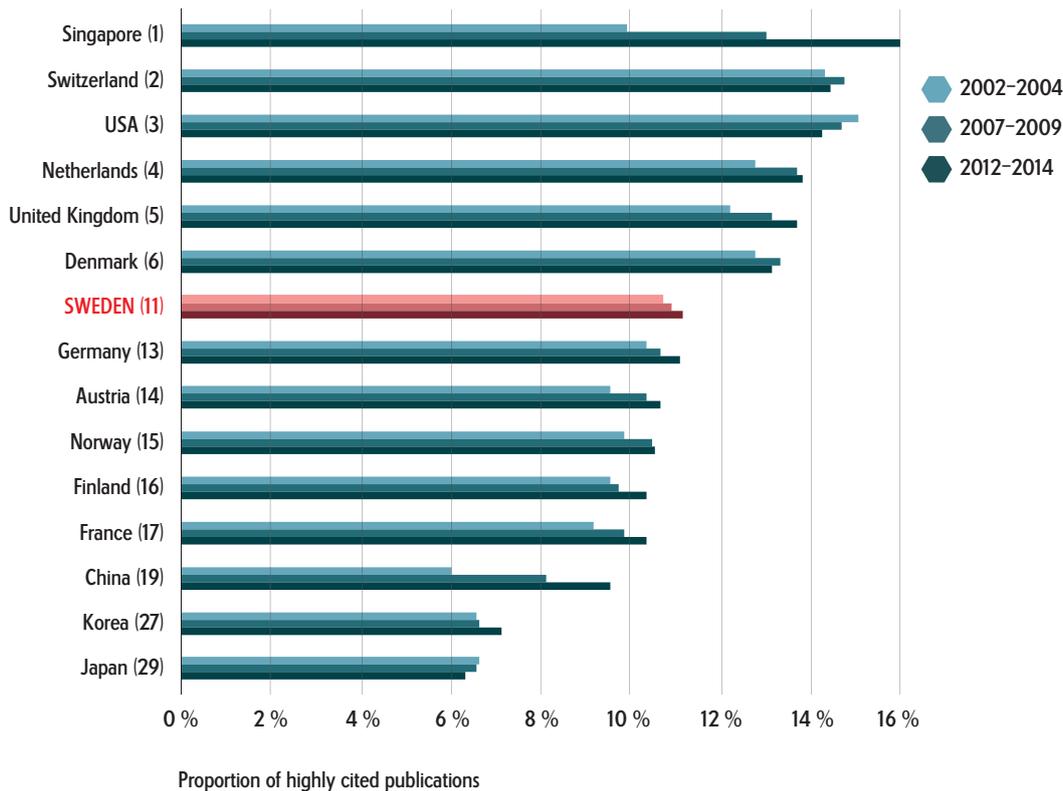


Figure 11. Trend in citation impact (proportion of the country's scholarly publications that are among the 10 per cent most highly cited in the world). Sweden is compared with a selection of other countries. Citation impact is listed for three periods: 2002–2004, 2007–2009 and 2012–2014. The figure in parenthesis refers to the country's position among the OECD countries in the database. Source. Thomson Reuters.

Figure 11 shows that Swedish publications have a relatively high impact, measured as the proportion of highly cited articles. For the last period in the figure above (2012–2014), the proportion of highly cited articles was somewhat higher than in the two previous periods. However, several countries have shown greater increases over the course of the entire period 2002–2014. Singapore stands out, but the United Kingdom has also increased its proportion of highly cited articles. Sweden has therefore dropped several positions in the list of countries ranked by proportion of highly cited articles. In addition, there are several countries just behind Sweden that have shown a stronger trend in recent years, for example Germany and Austria.

The proportion of highly cited articles decreased somewhat for Switzerland, the United States and Denmark over the course of the period 2012–2014. Sweden is currently among a group of countries occupying positions 11–16 in the rankings of the world's countries²⁰, with all countries in this group having 11 per cent highly cited articles. This means that they are 10 per cent above the world average. Accordingly, Singapore that has 16 per cent of its publications among the 10 per cent most cited, is 60 per cent above the world average.

The differences in citation impact between countries that are close to Sweden in the ranking are very small. Consequently, marginal changes in the statistics can result in a country moving several positions up or down.

Studies show that, on the whole, women produce fewer publications than men, but that there are no consistent differences between women and men in terms of citation levels.²¹

²⁰ Countries with at least 150 fractionally counted publications in the period 2012–2014. Australia, Belgium, Ireland and Canada are behind Denmark and ahead of Sweden in the ranking, but are not included in Figure 11.

²¹ Vetenskapsrådet. Forskningens framtid! Svensk vetenskaplig produktion och publiceringsmönster i ett internationellt perspektiv. 2015. [Swedish Research Council. The Future of Swedish Research! Swedish scholarly production and publication patterns from an international perspective].

1.4.4 Sweden publishes comparatively more within clinical medicine and social sciences

Sweden's research profile is broad, with a relatively high level of research activity within clinical medicine and social sciences, but a lower level of activity within mathematics and chemistry.

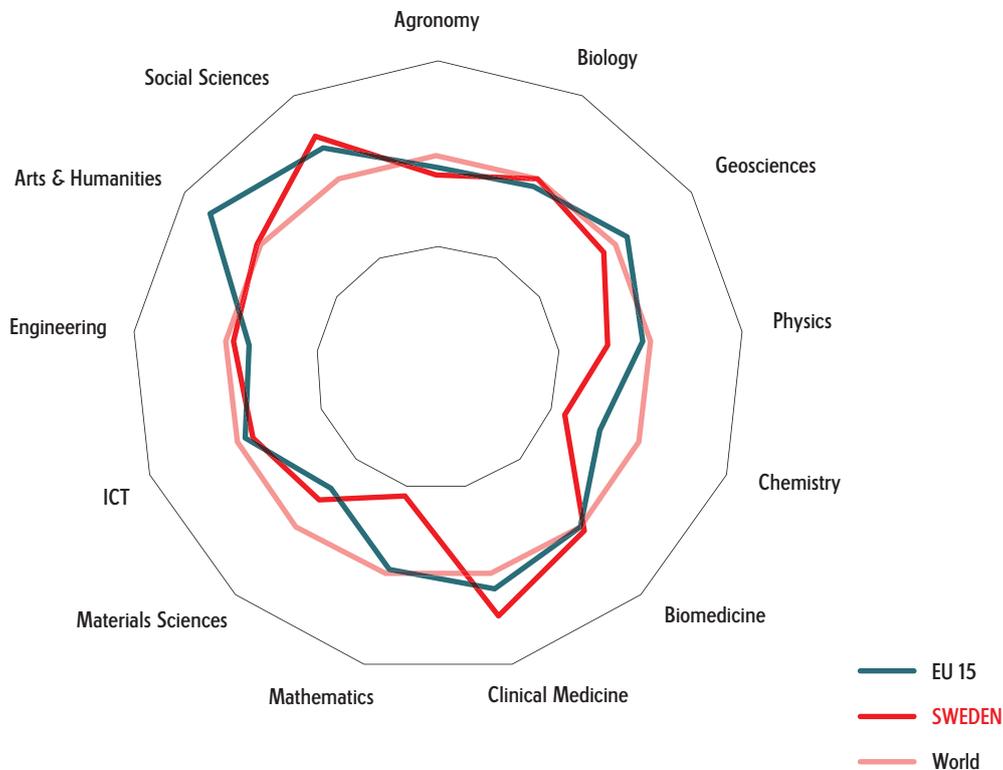


Figure 12. Research profile for Swedish research (Relative Specialisation Index RSI for various research areas). Sweden is compared with the EU 15 countries and the world. Publication years: 2012–2014. Source: Thomson Reuters.

A Relative Specialisation Index shows a country's research profile in terms of research areas by comparing one area's proportion of the country's total number of publications, with the same area's proportion of the total number of publications in the database. The Research Barometer uses 13 research areas (please refer to Section 3.4.1 for a more detailed description).

Sweden, like many other established research countries, has a broad profile in the sense that there is significant research activity within the majority of the research areas. Figure 12 shows that Sweden published more scholarly articles than the global average and the average for the EU 15 countries²² within clinical medicine and social sciences, but significantly fewer within mathematics and chemistry.

1.4.5 Swedish articles have a consistently high citation impact, especially within agronomy and biology

Sweden is above the global average within the majority of research areas in terms of the proportion of scholarly production that is among the 10 per cent most highly cited in the world.

²² The EU 15 countries are the European Union's member states prior to its expansion on 1 May 2004: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

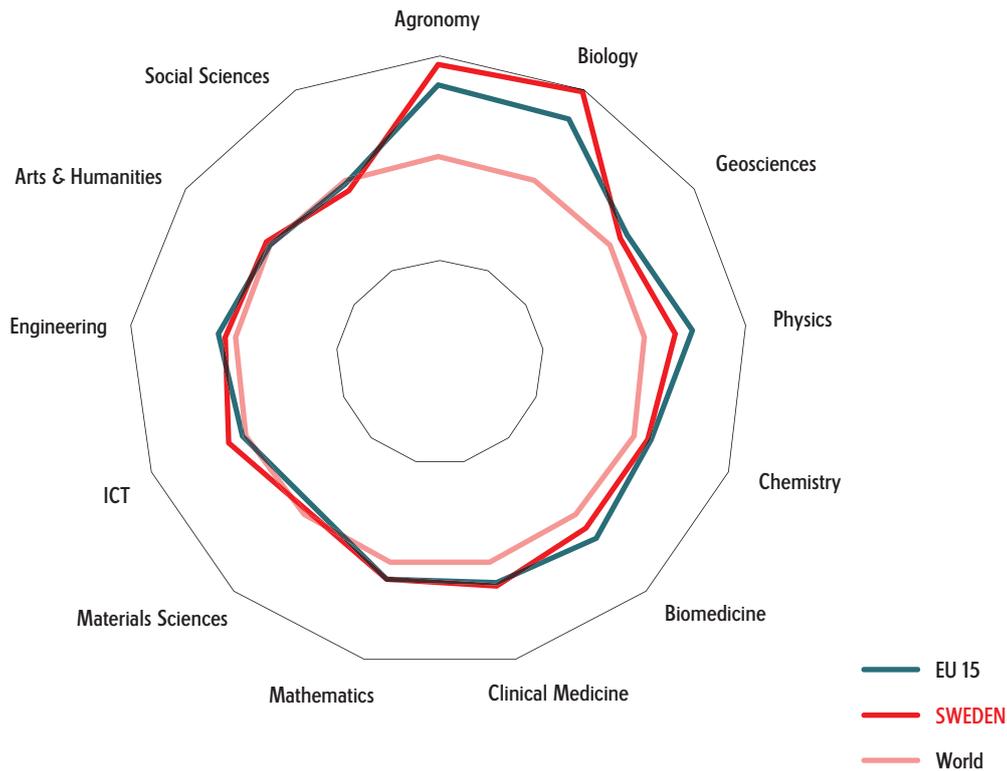


Figure 13. Citation impact of Swedish research within various research areas (proportion of the country's scholarly publications within the area that are among the 10 per cent most highly cited in the world). Sweden is compared with the EU 15 countries and the world. Publication years: 2012–2014. Source: Thomson Reuters.

One aspect of citation impact, the proportion of articles that are among the 10 per cent most cited publications in the world within various research areas, is illustrated in Figure 13 for Sweden and the EU 15.

The areas in which Sweden has the highest impact are agronomy and biology. These are also the two areas in which the EU 15 have the highest impact, although somewhat lower than that of Sweden.

Both Sweden and the EU 15 have a somewhat higher citation impact than the global average for the majority of other research areas. Sweden is somewhat below the EU 15 for physics and biomedicine.

1.4.6 Broader research profile in Western Europe and the United States than in emerging research countries in Asia

In a comparison of research profiles, a pattern emerges in which Sweden, as well as the United States and the countries in Western Europe, have broad research profiles and generally high citation impact. Emerging research countries such as China and Korea have narrower research profiles. Many of the emerging research countries have a low citation impact, but China's impact is approaching the global average.

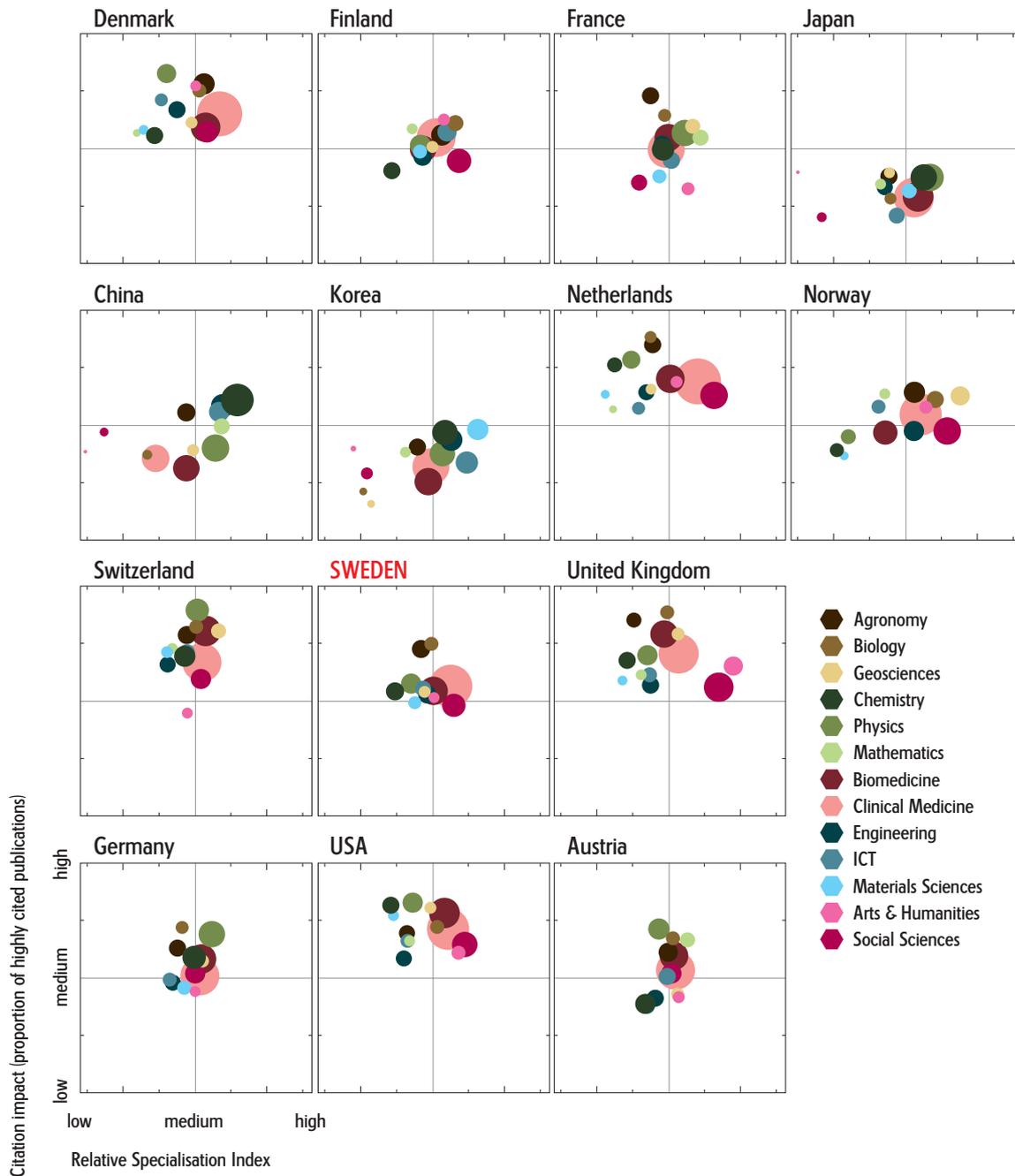


Figure 14. Research profile and citation impact by country. Sweden is compared with a selection of other countries. The horizontal axis shows the country's Relative Specialisation Index (RSI). The vertical axis shows the proportion of the country's scholarly publications that are among the 10 per cent most highly cited in the world within various research areas. The area of a circle is proportional to that research area's share of each country's total article volume. Publication years: 2012–2014. Source: Thomson Reuters.

A combination of the Relative Specialisation Index (Figure 12) and citation impact (Figure 13) that provides a more detailed picture of the research profile of a country is shown in Figure 14 where the profile of Sweden is compared to the profiles of the other countries in the study.

Along the horizontal axis the figure shows the various countries degree of specialisation within certain research areas and along the vertical axis the citation impact of articles in those areas. The

area of a circle is proportional to the corresponding research area's percentage of each country's total publication volume.

If a circle is to the right of the vertical average line, this means that the country specialises in the research area in question, i.e. publishes more articles than expected in that area. If a circle is above the horizontal average line, this means that the country's publications within the area in question have a greater than expected citation impact (measured as percentage of articles that are among the 10 per cent most highly cited articles in the database). Correspondingly, the research areas for which the country has a lower degree of specialisation are to the left of the average line. Areas with a lower citation impact than expected appear under the horizontal average line.

As is the case for the majority of other established research nations, Sweden has about the same activity within all research areas and the circles in Figure 14 are thus grouped close to the vertical average line. The emerging research countries such as China and Korea have a greater proportion of physics and chemistry, while they are less active within the arts and humanities, and social sciences. In China, an increasing amount is being published within biomedicine and clinical medicine. A large proportion of the scholarly publication in the United States and Europe takes place within medicine, primarily in clinical medicine. The proportion of arts and humanities and social sciences is also greater than in the Asian countries.

Highly cited countries such as Denmark, the United States, Switzerland and the United Kingdom have a relatively high citation impact within the majority of areas. Lowly cited countries such as Japan and Korea are under the global average within all areas.

The United Kingdom shows a high degree of activity within the arts and humanities and social sciences. The United States also has a relatively large focus on these fields. One explanation of this is of course that the international databases focus on English language journals. Researchers from English-speaking countries thus find it easier to find publication channels within the arts and humanities and social sciences that are covered by the major international publication databases. However, Figure 14 indicates that the Netherlands and Norway also have a high level of research activity within the social sciences.

1.5 International co-publications

Research is characterised by both collaboration and competition. Research groups, businesses and networks collaborate with a joint expertise and shared resources in order to tackle complex problems. At the same time, countries and universities compete with each other for prestige, resources and the best students and researchers. Globally, there is strong political pressure to increase the internationalisation of research.

Measuring national research systems' degree of internationalisation is not entirely simple as there are few robust indicators that are suitable to use for international comparisons. Nevertheless, one established indicator of international research collaboration is international co-publication, i.e. publications with two or more authors from different countries.²³

1.5.1 Swedish researchers co-publish most frequently with EU researchers, but collaboration with researchers in Asia is increasing the most

Sweden is among those countries that have the highest percentage of international co-publication. The percentage of Swedish co-publications with researchers in the EU countries, Norway and Switzerland has increased modestly over the past 35 years. However, the largest increase has taken place in terms of the percentage of articles that Swedish researchers have co-published with researchers in Asia.

²³ Tillväxtanalys. 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.]

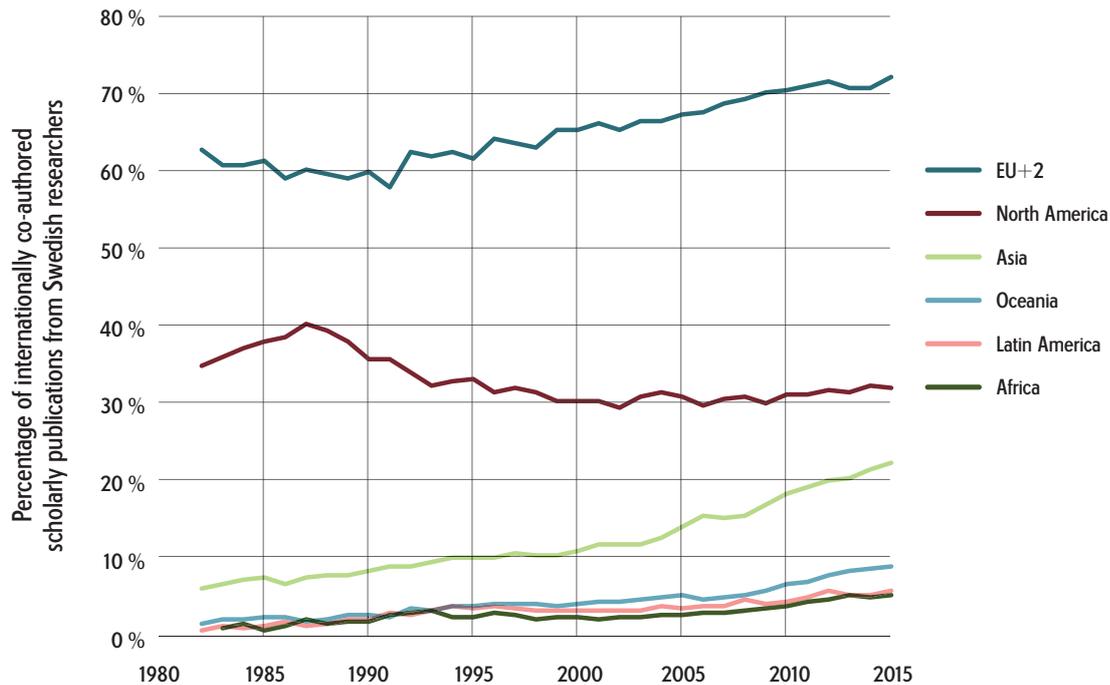


Figure 15. Trend in the percentage of international co-authored scholarly publications from Swedish researchers in collaboration with researchers from various regions. Publications in the period 1982–2015. EU+2 denotes the 28 EU countries, Switzerland and Norway. Full counts of publications means that the sum of all co-publications exceeds 100 per cent. Source: Thomson Reuters.

Figure 15 shows that Swedish researchers primarily publish together with European researchers and that the percentage has been increasing modestly for a long time. Just over 70 per cent of all Swedish international co-published articles have been published together with researchers from Europe. Co-publication with researchers in Asia has also increased in the past 15 years – from 6 per cent in 1982 to 22 per cent in 2015. However, the percentage of co-publications with researchers in the United States and Canada has decreased marginally, from 35 per cent in 1982 to 32 per cent in 2015.

1.5.2 Researchers from the United States are the most common international partners for Swedish researchers
 The United States is the individual country with which Swedish researchers have the most internationally co-authored publications. Behind the United States come the United Kingdom, Germany, France, Italy, Denmark and the Netherlands.

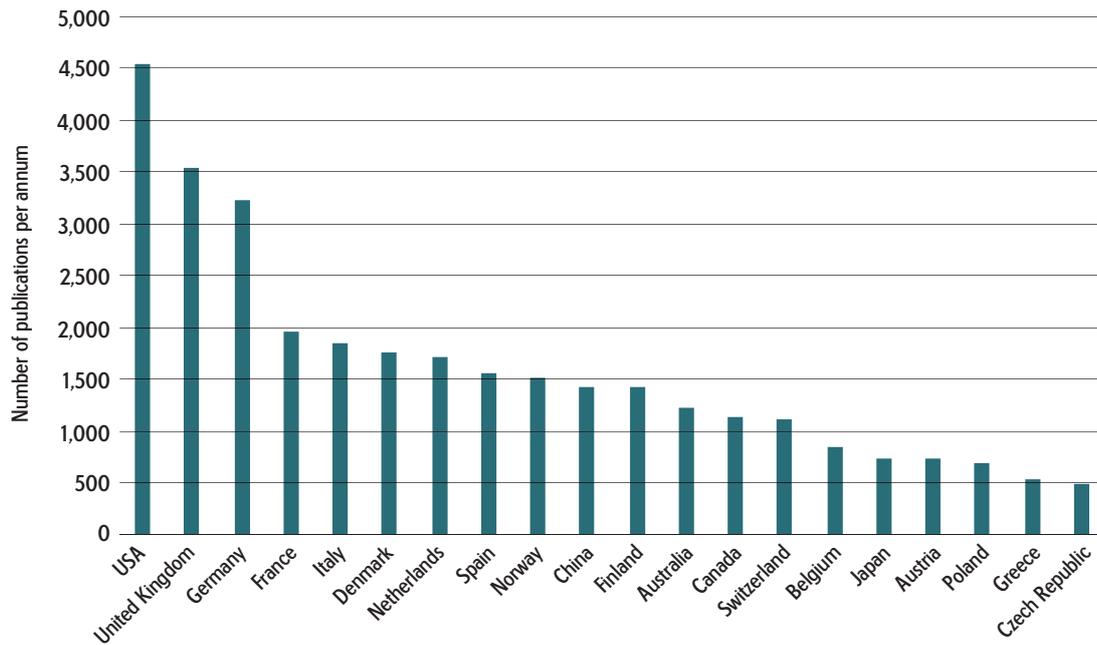


Figure 16. Number of international co-authored scholarly publications from Swedish researchers per partner country per annum. Number of publications per annum is stated as an average value for the years 2011–2015. Full counts of publications. Source: Thomson Reuters.

Figure 16 shows the individual countries that Swedish researchers collaborate most with. As the United States is the world’s largest producer of articles, it is not surprising that it is researchers from the United States that Swedish researchers have co-authored the most with. Just over 4,500 Swedish international co-publications involve at least one author from the United States, which is equivalent to around 26 per cent of Sweden’s total number of international co-publications. Swedish researchers also publish a great deal with researchers from the United Kingdom, Germany, France, Italy, Denmark and the Netherlands.

1.5.3 Swedish researchers’ international co-publication has increased within all areas

Swedish researchers’ international co-publication is increasing within all research areas. However, there are major variations. International co-publications are significantly more common within physics and geosciences than within the arts and humanities and social sciences.

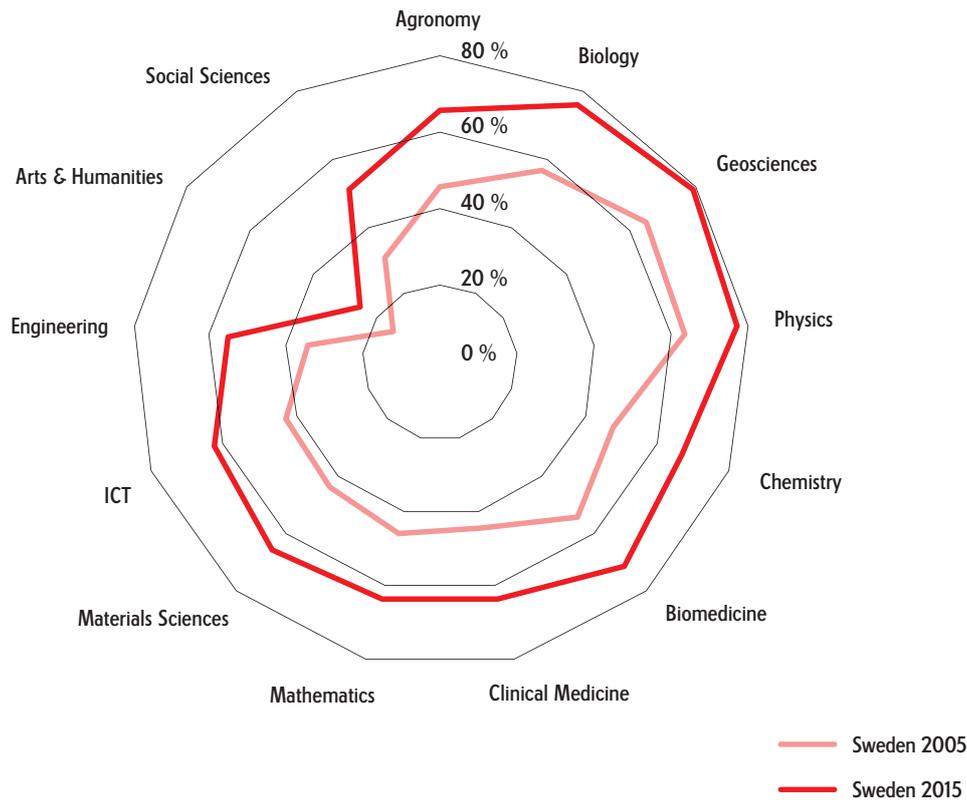


Figure 17. International co-authored scholarly publications from Swedish researchers within various research areas as a percentage of the total number of Swedish publications within the respective area. Publication years: 2005 and 2015. Full counts of publications. Source: Thomson Reuters.

Figure 17 shows that the percentage of international co-published articles in Sweden has increased within all research areas, from an average of 48 per cent in 2005, to 64 per cent in 2015. Accordingly, close to two thirds of all Swedish scholarly publications are written in collaboration with international researchers. This can be compared with the global average, which is around 25 per cent.

Publication traditions vary between different areas. In physics, international co-publication is traditionally common. Collaboration on international infrastructures such as the European particle physics laboratory CERN has made international collaboration even more common. In the humanities and social sciences, monographs, often written in Swedish, have long been a common publication channel. As mentioned earlier, the effect of this is present in the Swedish Research Council’s database, where the arts and humanities and social sciences do not have the same degree of coverage as other areas. As a natural consequence, co-publications are most common within physics and geosciences and least common within the arts and humanities and social sciences.

2 A CLOSE-UP VIEW OF THE SWEDISH RESEARCH SYSTEM

This section contains a more detailed account of the Swedish research system. Here, too, the basic premise is to study financing, human resources and research results. Higher education is the largest government employer and specific attention is devoted in the Research Barometer 2016 to its human resources, focusing on researchers and teachers.

2.1 R&D resources in Sweden

As indicated in the first part of the Research Barometer, Sweden, in contrast to many other countries, has had a trend of increased government appropriations for R&D and reduced industry funding in relation to GDP.

The proportion of industry funded R&D in Sweden is around 60 per cent of the country's total investments in R&D. The majority of R&D activity in the business enterprise sector is, however, concerned with development, rather than research. Only 2 per cent of the business enterprise sector's R&D activity is focused on basic research and 12 per cent to applied research. The remaining 86 per cent is classified as development.²⁴

2.1.1 Companies and the government are the largest funders of R&D in Sweden

Total expenditure on R&D in Sweden amounted to just under SEK 125 billion in 2013, of which the business enterprise sector accounted for SEK 76 billion and the government sector for SEK 36.5 billion.

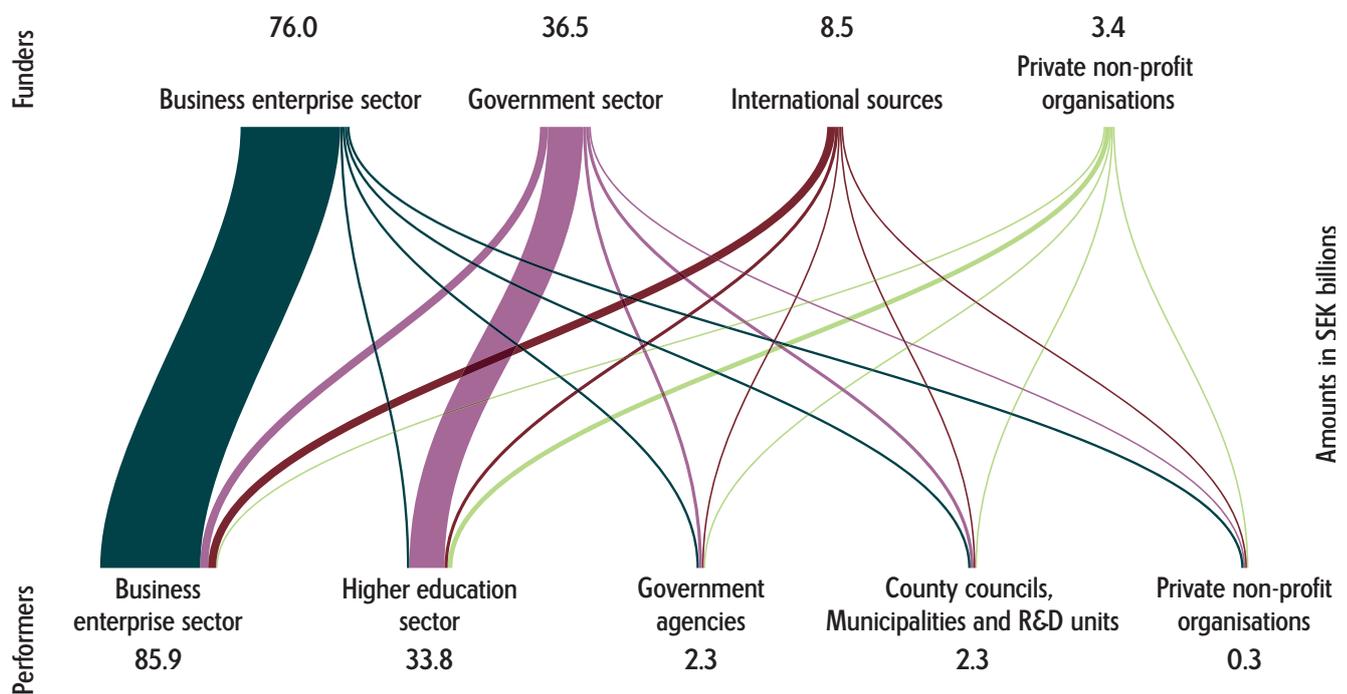


Figure 18. Financial volume in the Swedish R&D system in 2013, distributed by funder (the figure's top edge) and research performer (the figure's bottom edge). The amounts are stated in SEK billions. Source: Statistics Sweden.

Figure 18 shows the cash flow in the Swedish R&D system. The two principal funders are the business enterprise sector and the Swedish government. The two chief performers are the business enterprise sector and HEIs.

Of the SEK 125 billion devoted to R&D in Sweden in 2013, SEK 86 billion was allocated to domestic companies, SEK 34 billion to HEIs, SEK 2.3 billion to other government agencies and SEK 0.3 billion to private non-profit organisations.

The business enterprise sector largely finances its own R&D, but also receives grants from the government, private non-profit organisations and international sources, primarily the EU. HEIs are primarily financed through government appropriations and grants, but also receive funding from com-

²⁴ Statistiska centralbyrån. Utgifter för egen FoU efter typ av FoU och sektor, år 2013 (revised 11/5/2015). [Statistics Sweden. Intramural R&D distributed by type of R&D and sector.]

panies, private non-profit organisations, municipalities and county councils. In addition, the higher education sector receives research funding from international sources, primarily the EU. In an international comparison, the proportion of domestic R&D financing that comes from abroad is relatively small – 6.7 per cent in 2013, compared with an average of 11.1 per cent for the OECD countries.²⁵

2.1.2 Increased government appropriations to HEIs, research funding bodies and civil government agencies, but less to defence agencies

The government is the largest funder of Swedish R&D within the higher education sector. Government financing has increased by around 25 per cent in the past ten years. About half of the government funding for R&D goes directly to HEIs. The remaining funding is allocated by research-funding bodies, civil government agencies and defence agencies.

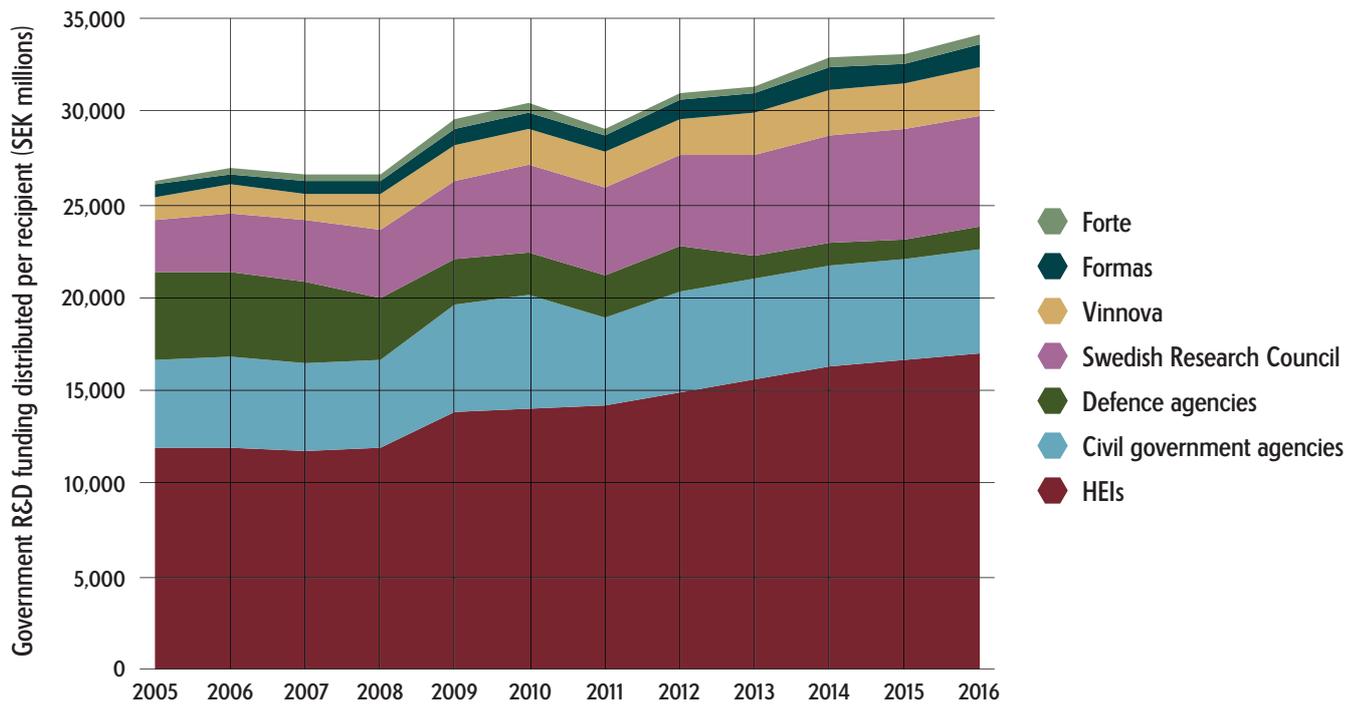


Figure 19. Sweden's government R&D funding distributed by recipient. Data for the period 2005–2016. Amounts are stated in SEK millions and at constant prices for 2016. Source: Statistics Sweden.

Figure 19 shows how the government R&D funding is allocated to various recipients. Between 2005 and 2016, Swedish government financing of R&D has increased from SEK 26 to 34 billion per annum at constant prices for 2016.²⁶

Half of the government funding is provided directly to HEIs (known as direct government funding, or block funding) and approximately 30 per cent is allocated to the government research funding agencies, the majority of which is then distributed on to HEIs. The approximately 20 per cent that remains is allocated to other civil government agencies and defence agencies. The civil agencies that receive government R&D support may have their own R&D operations, for example the Swedish National Road and Transport Research Institute and the Swedish Meteorological and Hydrological Institute (SMHI), and/or fund external R&D, for example the Swedish Energy Agency or the Swedish International Development Cooperation Agency (Sida).

²⁵ OECD 2013, Main Science and Technology Indicators. Percentage of GERD financed by abroad.

²⁶ This equates to an increase from SEK 24 to 34 billion at current prices.

The Swedish Research Council is Sweden's largest research funding authority (SEK 6.4 billion was disbursed in 2015), followed by Vinnova, Formas and Forte, in terms of R&D funding distributed. Over the past ten-year period, the funding allocated directly to the higher education sector has increased from 45 to 50 per cent of total government R&D funding, at the same time as the proportion distributed through the government research funding bodies increased from 19 to 30 per cent. Over the same period, the proportion of government funding allocated to civil government agencies and defence agencies decreased from 36 to 20 per cent, where the reduction have occurred in the defence agencies.

2.1.3 The HEIs are funded largely by the government

Around 80 per cent of R&D funding for Swedish HEIs comes from the government sector. Private non-profit organisations in Sweden and abroad are responsible for close to 11 per cent. The EU and Swedish companies each account for just under 5 per cent of the funding.

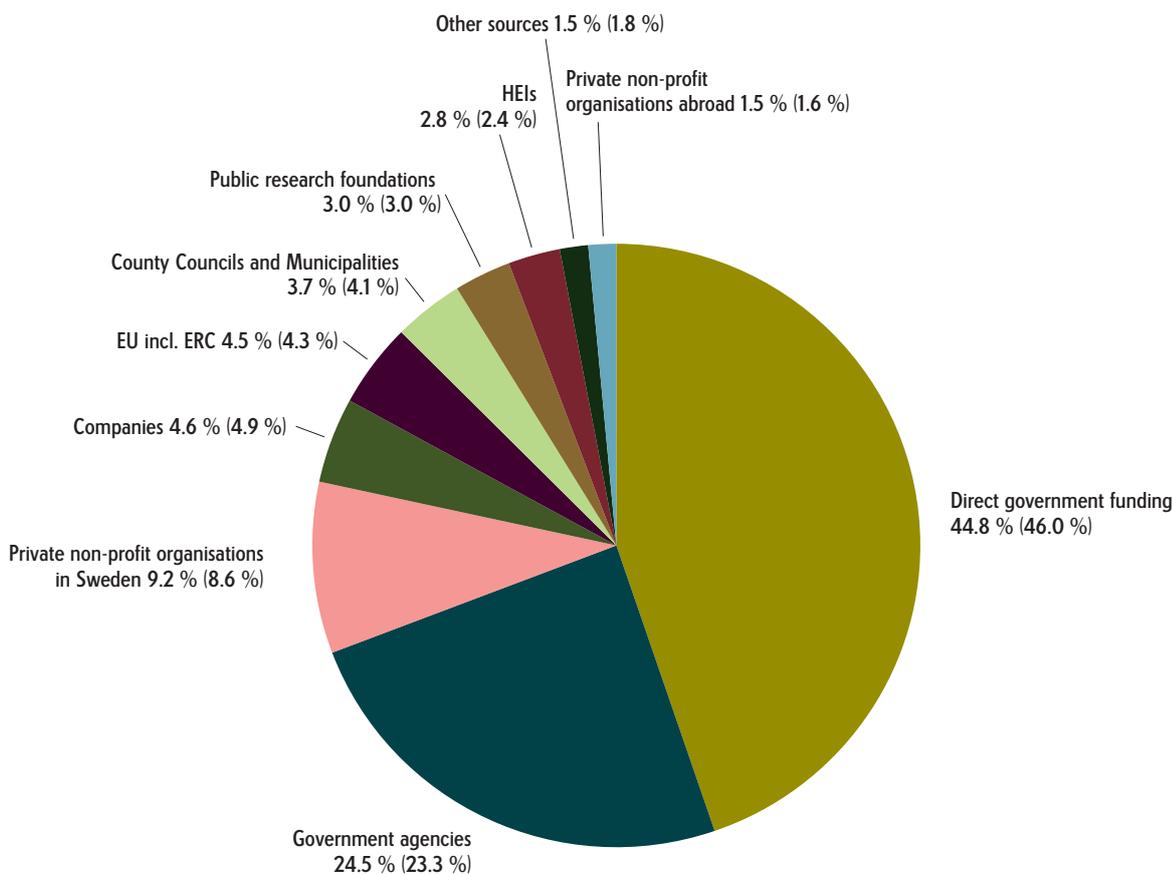


Figure 20. R&D revenues within the Swedish higher education sector in 2013, distributed by funder. The figures for 2011 are stated in parentheses. Source: Statistics Sweden.

Figure 20 shows that R&D at Swedish HEIs have a large number of funders. In 2013, around 80 per cent of the higher education sector's total R&D revenue of SEK 32 billion came from public funds. The bulk was distributed in the form of government appropriations and grants from government research funding agencies such as the Swedish Research Council, Vinnova, Formas and Forte. A significant proportion of the financing (10.7 per cent) came from private non-profit organisations in Sweden and abroad, for example foundations and fund-raising organisations. The EU and its framework programme funded just under 5 per cent of the R&D conducted at HEIs and industry funding was at about the same level.

2.1.4 Increased R&D revenues for the country's HEIs – the major part distributed to comprehensive universities and specialised universities

Swedish HEIs' R&D revenues increased in real terms by 54 per cent between 2001 and 2013. This increase has not involved any redistribution between different HEI categories. It is still the case that around 60 per cent of revenues for R&D go to the comprehensive universities and to the specialised universities.

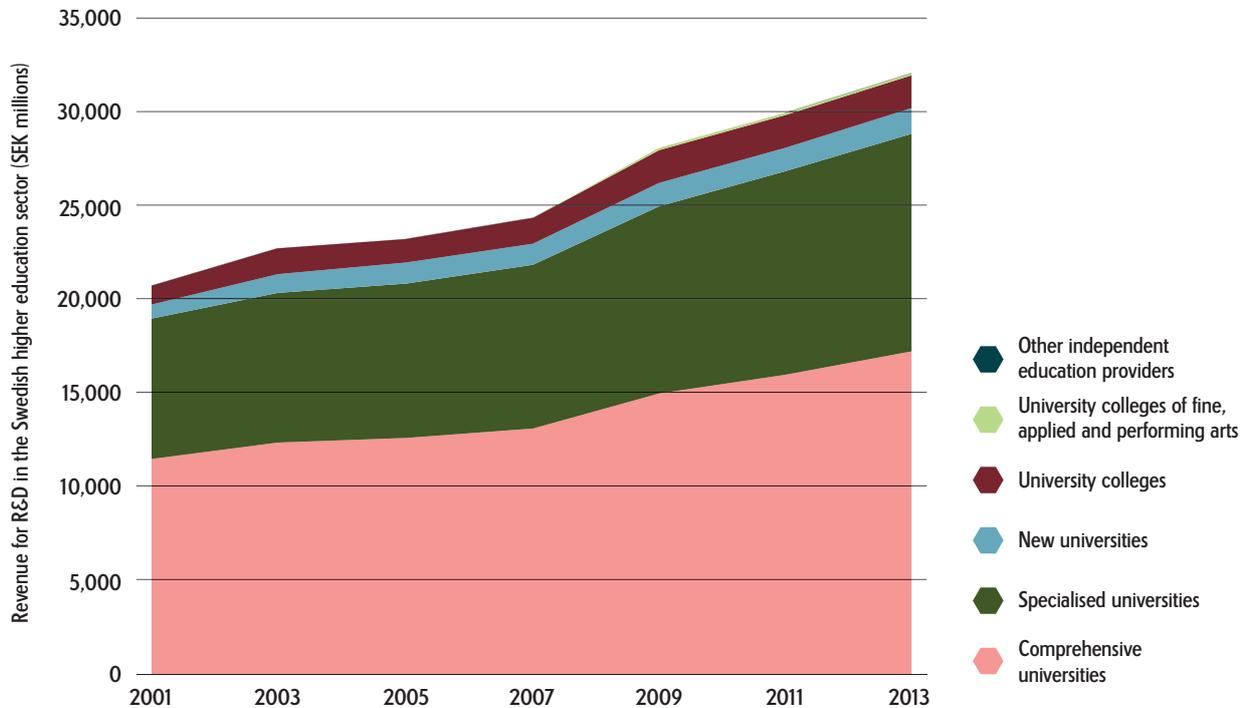


Figure 21. Revenue (operating costs) for R&D in the Swedish higher education sector in the period 2001–2013, distributed by HEI category. Source: Statistics Sweden.

As can be seen in Figure 21, R&D revenue at Swedish HEIs has increased substantially during the last decade, from SEK 21 to 32 billion kronor at constant prices for 2013.²⁷

The total increase has not been accompanied by any major redistributions of the funding between different HEI categories.²⁸ The comprehensive universities in/of Gothenburg, Linköping, Lund, Stockholm, Umeå and Uppsala together with the specialised universities Chalmers University of Technology, Stockholm School of Economics, Karolinska institutet, KTH Royal Institute of Technology, Luleå University of Technology and Swedish University of Agricultural Sciences account for 90 per cent of the total R&D revenues within the HEI sector, and have done so during the last decade. The university colleges and the new universities – over twenty in total – account for the remaining 10 per cent.

2.1.5 R&D revenues have increased most within medical and health sciences and natural sciences

Om man fördelar lärosätenas intäktsökningar per forskningsämnesområde framgår att medicin och hälsovetenskap samt naturvetenskap har haft större öknings mellan åren 2011 och 2013, än vad övriga områden haft.

²⁷ This equates to an increase from SEK 18 billion in 2001, to SEK 32 billion at current prices.

²⁸ A list of the HEI categories can be found in the section Glossary and abbreviations.

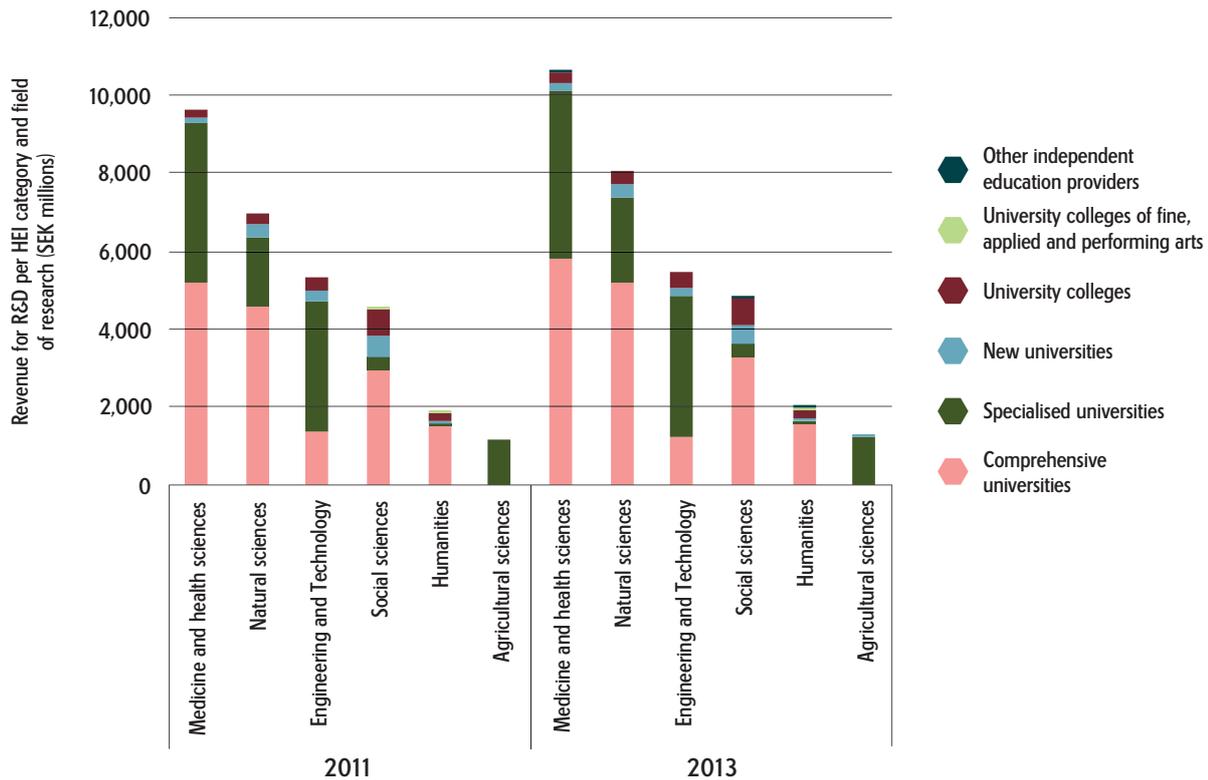


Figure 22. Trend in revenue (operating cost) for R&D within the Swedish higher education sector, distributed by HEI category and field of research. Years compared: 2011 and 2013 Source: Statistics Sweden.

Figure 22 shows the higher education sector's revenue for R&D by field of research and HEI category. From 2011 to 2013, R&D revenue increased by a total of approximately SEK 2.5 billion.²⁹ In both relative and absolute terms, this increase was most extensive within the two largest fields, medical and health sciences and natural sciences. The increases were significantly smaller within the other fields.

Furthermore, it appears that medical and health sciences dominate among the comprehensive universities and the specialised universities, with around 33 per cent of total R&D revenue. Among the specialised universities, there is a high proportion of engineering and technology, both in absolute terms and in terms of the percentage distributed. Among the university colleges, a relatively large proportion of R&D revenues are classified as engineering and technology. In absolute terms, however, this proportion is small.

Humanities and social sciences equate to 29 per cent of the comprehensive universities' R&D revenues and constitute a relatively high proportion – 45 per cent – of R&D revenues among new universities and among university colleges.

²⁹ The years compared are close together because 2011 constitutes a turning point for the classification of research in Sweden. Swedish research is now classified into six fields of research in accordance with Statistiska centralbyrån och Högskoleverket. Standard för svensk indelning av forskningsämnen 2011. Revised August 2016. [Statistics Sweden and Swedish National Agency for Higher Education. Swedish standard classification of fields of research, 2011.] Consequently, it is difficult to compare the distribution of funding among the different fields prior to 2011 and such comparisons involve a certain amount of uncertainty.

2.2 The personnel in Swedish higher education

The number of higher education personnel with research and teaching duties increased by 32 per cent in the period 2001–2015. This increase has taken place in all staff categories, with the exception of lecturers and career-development positions. If a stricter definition of “researchers and teachers” is used that only includes staff categories that normally require a doctorate – professors, senior lecturers, career-development positions, postdoctoral positions and other research and teaching personnel with doctorates (usually referred to here as researchers) – the growth is almost 80 per cent. The proportion of women among those who have recently gained a doctorate and among the research and teaching staff in higher education has increased gradually in recent decades, although the proportion of women varies between different fields of research. In 2015, only 25 per cent of those on the top step of the career ladder in teaching (i.e. professor) were women.

2.2.1 There has been an increase in the number of researchers and teachers in higher education, but doctoral student remains the largest staff category

The significant boost in R&D resources from 2008 has resulted in a major increase in higher education staff with research and teaching duties.

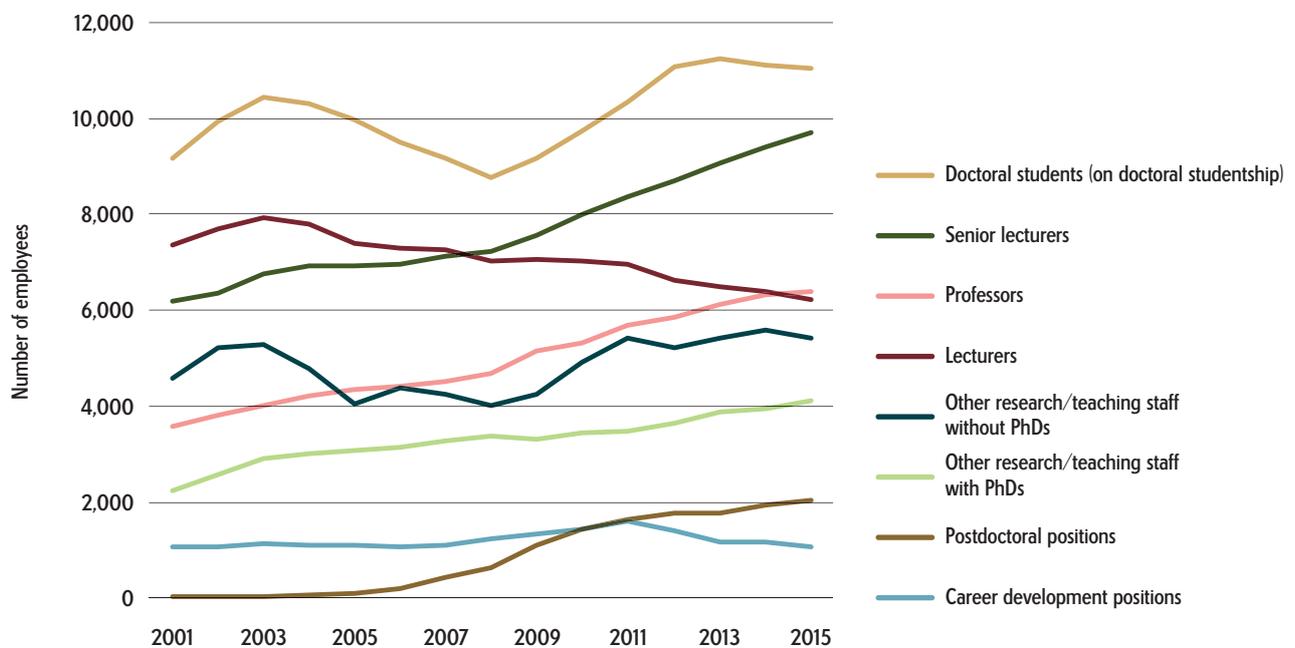


Figure 23. Trend in research and teaching staff and doctoral students in Swedish higher education by employment category in the period 2001–2015. Source: UKÄ.

Figure 23 shows how the total number of research and teaching staff and doctoral students with doctoral studentship increased in the period 2001–2015. The number of research and teaching staff was 35,000 in 2015, with about the same number of women as men. This figure expressed as full-time equivalent employees is close to 29,000. At the same time, there were just over 11,000 doctoral students with doctoral studentships.

The number of doctoral students fluctuated over the course of the period studied and the total is a small net increase. It should be stressed that doctoral students with doctoral studentships only constitute a portion of the total number of active doctoral students, which was 18,000 in 2015.³⁰ Doctoral

³⁰ Statistiska centralbyrån. Universitet och högskolor. Doktorander och examina i högskoleutbildning på forskarnivå. 18/4/2016. [Statistics Sweden. Higher education institutions. Doctoral students and degrees at third cycle studies.]

students can also be part of other personnel groups in higher education, for example lecturers or other research and teaching staff without doctorates. There are also externally employed doctoral students and doctoral students who are funded by scholarships.³¹

A clear shift can be noted among the higher education sector's researchers and teachers, with the number of lecturers having decreased, while personnel numbers in categories that normally require a doctorate having increased. As a consequence of this, an increasing proportion of R&D in the higher education sector is performed by staff with PhDs.

The total number of full-time equivalents in R&D has also increased. Doctoral students accounted for 37 per cent of the total number of full-time equivalents in higher education. The number of full-time equivalents performed by senior lecturers and other research and teaching staff with PhDs has increased, while the number of full-time equivalents performed by technical and administrative staff has decreased.³²

2.2.2 The proportion of professors is highest among the comprehensive universities and specialised universities

There are major differences in the composition of staff between the different HEI categories. Among the more educationally intensive institutions – new universities, university colleges, university colleges focused on the arts and other independent education providers – senior lecturers and lecturers are the largest staff categories.

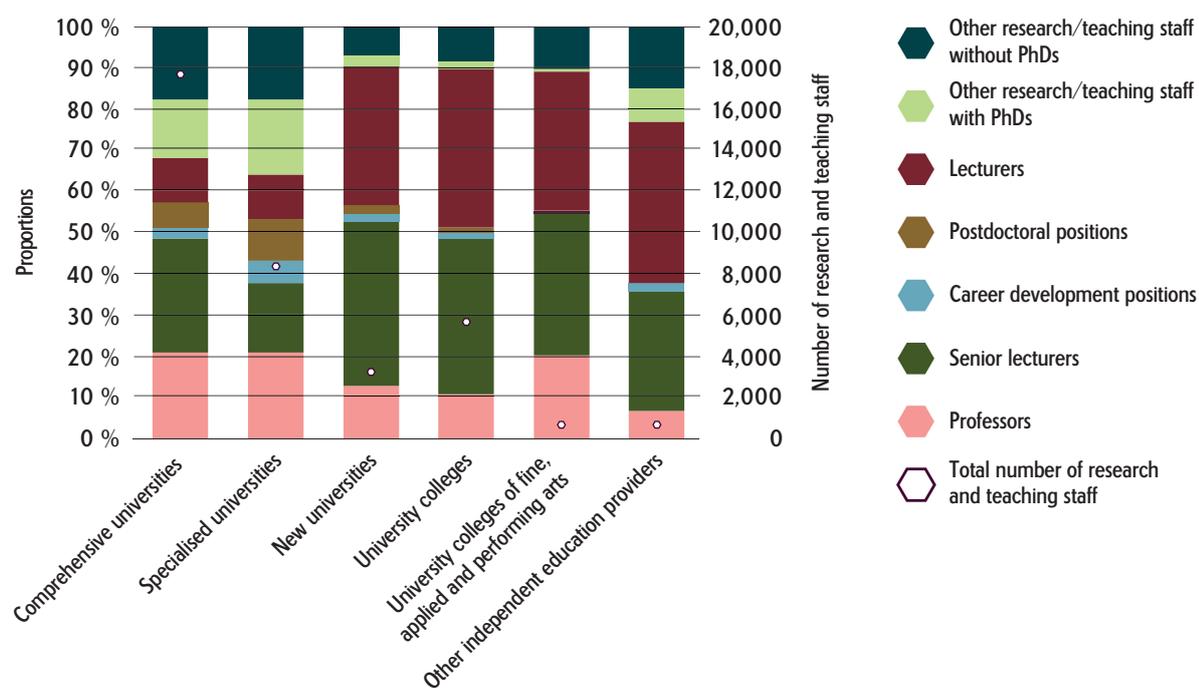


Figure 24. Research and teaching staff in Swedish higher education in 2015, distributed by employment category and HEI category. The figure states the proportions (left axis) and number (right axis) for the various categories. Source: UKÄ.

Figure 24 shows how Sweden's research and teaching staff are distributed between the employment categories among different HEI categories.

The comprehensive universities employ by far the most personnel, approximately 17,500 people. The smallest group of employees is found among the university colleges focused on the arts and among other independent education providers. These categories each employ around 400 research and teaching staff.

³¹ Please refer to, for example, the Research Career Inquiry's official report SOU 2016:29. Forskarkarriäretredningen. *Trygghet och attraktivitet – en forskarkarriär för framtiden* [The Research Career Inquiry. *Security and attractiveness – a research career for the future.*]

³² Statistiska centralbyrån. *Forskning och utveckling inom högskolesektorn 2013: Ökade medel till FoU inom universitet och högskola. Statistiknyhet från SCB. Nr. 2014:324. 17/12/2014.* [Statistics Sweden. *Research and development in the higher education sector 2013: Increased funding for R&D in the higher education sector. Statistical news from Statistics Sweden*]

The composition of personnel varies between the different HEI categories. At the comprehensive universities, the specialised universities and the university colleges focused on the arts, professors constitute around 20 per cent of the total number of employees.

The specialised universities have a lower proportion of senior lecturers than the other HEI categories. They also have a higher proportion of other research and teaching staff with PhDs, postdoctoral positions and career-development positions.

Among the new universities and the university colleges, as well as the university colleges focused on the arts, the proportion of lecturers and the proportion of senior lecturers are significantly higher. These HEI categories have a greater emphasis on teaching in relation to research compared with the comprehensive universities and specialised universities.

2.2.3 All staff categories are becoming increasingly gender equal

An analysis of gender equality in the higher education staff categories shows that all of these categories are becoming increasingly gender equal. Nevertheless, the category “Professors” is still not gender equal.

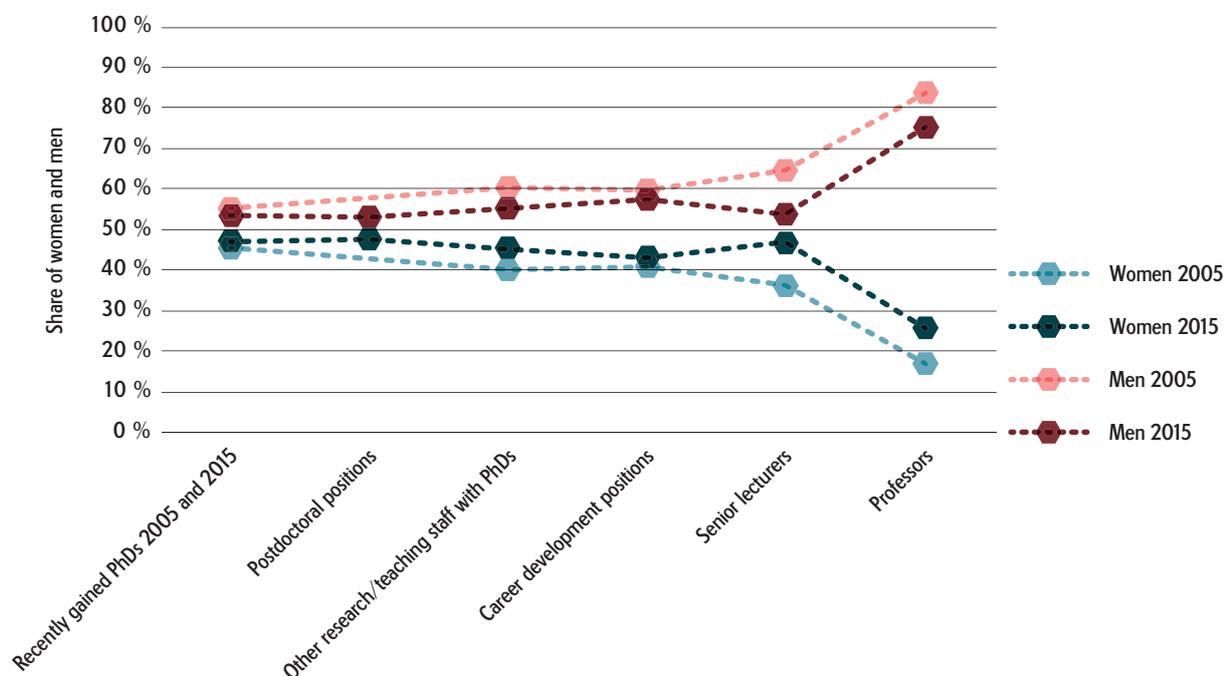


Figure 25. The gender distribution among those who have recently gained a PhD and among the research and teaching staff with PhDs in Swedish higher education. Data for 2005 and 2015. Source: Statistics Sweden and UKÄ. There is no data on the number of postdoctoral positions for 2005.

Figure 25 shows the percentage of men (pink line) and the percentage of women (blue line) among those who have recently gained doctorates and among the various employment categories that normally require a PhD. The years compared are 2005 and 2015.

In total, the distribution between women and men in the research and teaching staff is relatively equal. The proportion of women with PhDs among higher education personnel has also increased faster than the proportion of men with PhDs. Between 2005 and 2015, the gender distribution became increasingly equal, both among those who have recently gained a doctorate and among all employment categories that normally require a PhD.

The proportion of women within the employment category professor has also increased, but slowly. Men still dominate significantly – 75 per cent of professors are men and 25 are women. Several longitu-

dinal studies show that women have more difficulty advancing to the highest positions in academia.³³ The fact that men more frequently become professors applies to the majority of fields of research, and career development also takes longer for women than for men. However, the differences appear to have been evened out somewhat in recent years.³⁴

2.2.4 Männerna dominerar inom naturvetenskap och teknik

The greatest number of researchers and teachers within all employment categories that normally require a PhD are found in medical and health sciences. Agricultural sciences has the lowest number of employed researchers and teachers. The gender distribution is relatively equal within all fields of research, apart from natural sciences and engineering and technology, where women are in the minority.

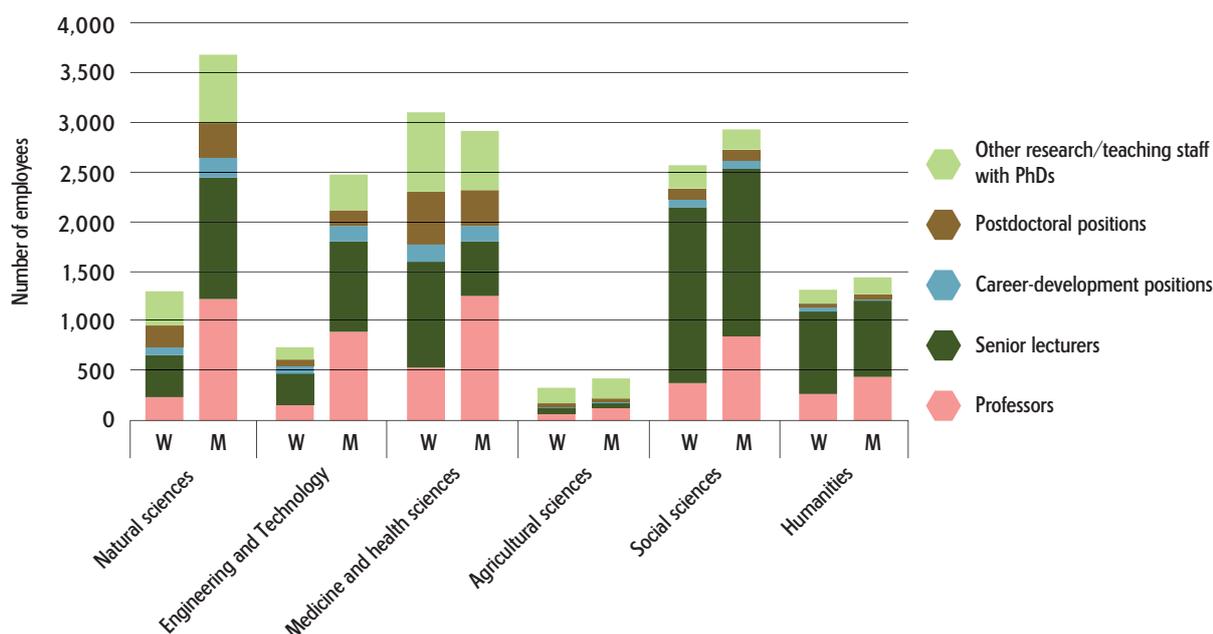


Figure 26. Number of women and men (stated as number of people) among the research and teaching staff in Swedish higher education in 2015, distributed by field of research and employment category. Source: UKÄ.

Figure 26 shows the number of women and men in the various employment categories that normally require a PhD, distributed by field of research.

Medical and health sciences have the largest number of researchers and teachers, while agricultural sciences has the lowest number. The gender distribution is relatively equal within the humanities, social sciences and medical and health sciences. The gender distribution is less equal within natural sciences and engineering and technology.

However, there are large variations within the fields. Within natural sciences, biology, for example, has a gender distribution of 38 per cent women and 62 per cent men, while it is 16 per cent women and 84 per cent men in physics. There is also a large variation within engineering and technology; industrial biotechnology has 38 per cent women and 62 per cent men and civil engineering has 35 per cent women and 65 per cent men. Electrical engineering, electronic engineering, information engineering have 10 per cent women and 90 per cent men.

³³ Högskoleverket. Forskarkarriär för både kvinnor och män? – statistisk uppföljning och kunskapsöversikt. Report 2011:6 R. 2011. [Swedish National Agency for Higher Education. Research career for both women and men? – statistical follow-up and literature review].

³⁴ Vetenskapsrådet. Forskningens framtid! Karriärstruktur och karriärvägar i högskolan. 2015. [Swedish Research Council. The Future of Swedish Research! Career structure and career paths in higher education.]

Significantly more men than women are professors within all fields of research. There are twice as many senior lecturers within medical and health sciences who are women than those who are men. The latter is largely due to the fact that the bulk of senior lecturers are found within health sciences, where the proportion of women is greater than the proportion of men.

2.2.5 Greater gender equality among those who have recently gained PhDs

The gender distribution is equal across the various employment categories among those who have recently gained PhDs. The farther back in time the doctorate was gained, the greater the proportion of men among the pool of professors.

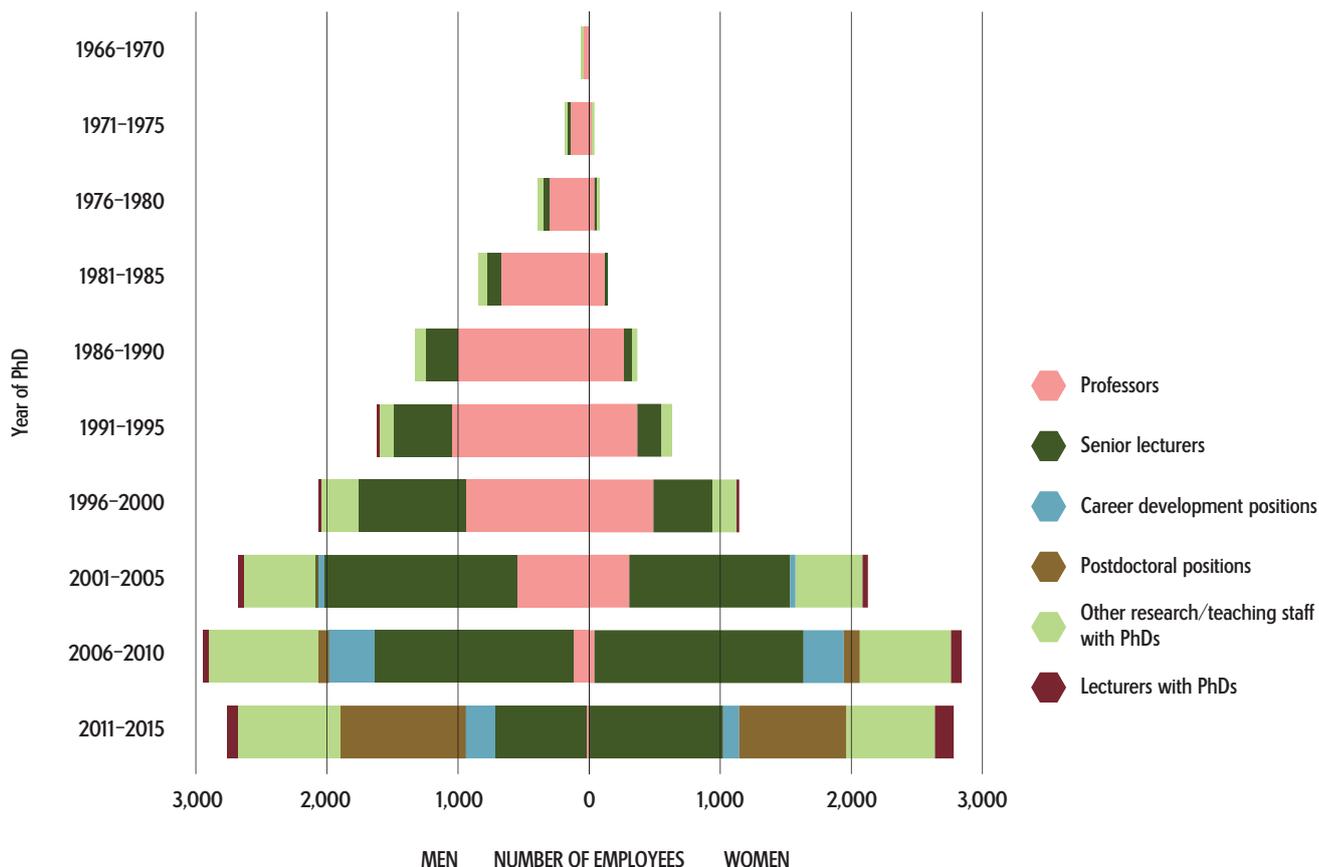


Figure 27. Number of women and men among the research and teaching staff in Swedish higher education in 2015, distributed by year of PhD and employment category. Source: Statistics Sweden.

Figure 27 shows research and teaching personnel organised by year of PhD (divided up into five-year periods), distributed by gender and employment category.

As indicated in the figure, the gender distribution is equal at the beginning of the careers of those who have recently gained their PhD (year of PhD 2011–2015). There are about as many women as men in this group and the employment structure is relatively similar for women and men. However, an increasing proportion of men is seen among those researchers and teachers at later stages of their career. The proportion of men employed as professors is, however, somewhat higher than the proportion of women employed as professors within almost all of the intervals.

2.2.6 Doctoral students perform a large proportion of R&D at Swedish HEIs

Doctoral students devote an estimated 70 per cent of their working time to R&D. As they also constitute the largest staff category, this means that about 37 per cent of all R&D at Swedish HEIs is performed by doctoral students.



Figure 28. The distribution of working time for women and men within the various employment categories with research and teaching duties in 2013 (left axis). Number of full-time equivalents in R&D within each category (right axis). Source: Statistics Sweden.

Figure 28 shows the division of working time for women and men who work with R&D and teaching in higher education. The proportion “other” includes such duties as administrative tasks.

Postdocs devoted the greatest proportion (around 80 per cent) of their working time to R&D in 2013. Doctoral students, who performed around 7,000 full-time equivalents, thus devoted the majority of their working time, approx. 70 per cent, to R&D. Career development positions and other research and teaching staff, both with and without doctorates, also devoted a large proportion of their working time to R&D. Professors, who perform the second largest proportion of full-time equivalents in R&D, devoted around 40 per cent of their working time to R&D.

Postdoctoral positions, career-development positions, other research and teaching staff with PhDs and professors devote more time to writing applications for research funding than senior lecturers, lecturers or technical and administrative personnel do. The distribution of working time is relatively even between women and men within all staff categories.

2.2.7 University colleges and new universities have the highest degree of domestic recruitment

A comparison of HEI categories shows that the degree of domestic recruitment, i.e. recruitment of people with PhDs from other Swedish HEIs, is highest among university colleges and new universities. It is lowest among comprehensive universities and specialised universities.

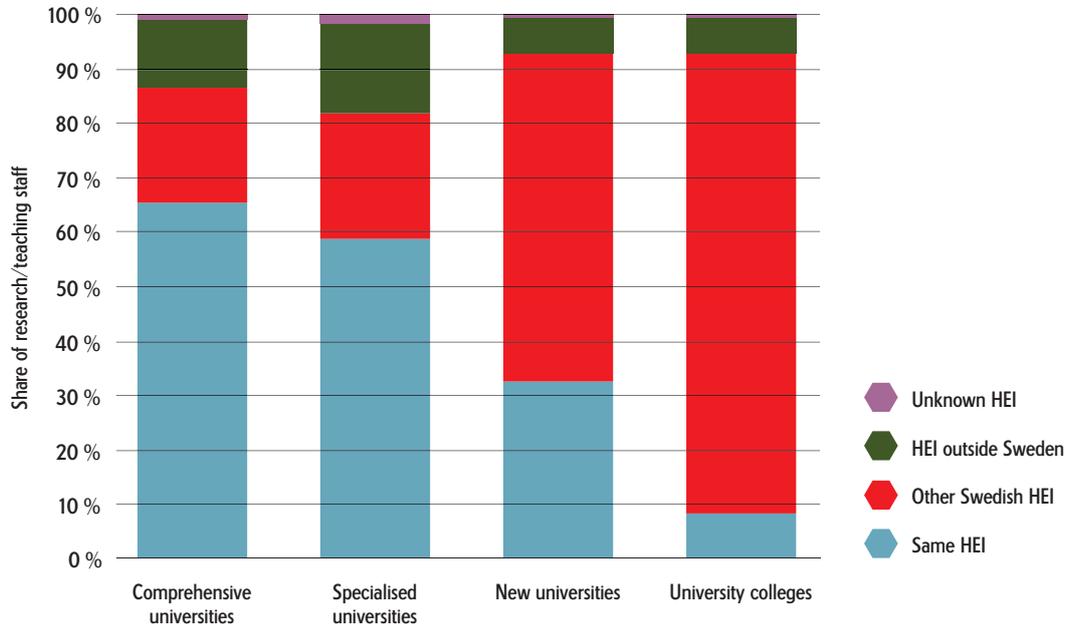


Figure 29. Recruitment of research and teaching staff with PhDs in Swedish higher education in 2015, by HEI category. Percentage of doctorates from the same HEI, from another Swedish HEI or from abroad. Source: Statistics Sweden.

One way to illuminate the extent to which higher education personnel move between different HEIs, as well as the extent to which foreign researchers and teachers are recruited into Swedish higher education, is to investigate the HEIs' recruitment patterns.

Figure 29 shows the degree of internal, domestic and international recruitments of research and teaching staff, divided into the categories comprehensive universities, specialised universities, new universities and university colleges. Other HEI categories are not included due to the selection being too small. In this context, internal recruitment denotes the recruitment of people who have a PhD from the same HEI as that at which they are employed.³⁵ Domestic recruitment refers to people who have a PhD from another Swedish HEI, while international recruitment refers to people who have a PhD from another country.

The comprehensive universities and the specialised universities recruit their own doctors to a significantly greater degree than the other HEIs. Just over 65 per cent of research and teaching staff at the comprehensive universities were recruited internally in 2015. At the specialised universities, the corresponding figure was just under 60 per cent. At the same time, the latter HEIs display the highest degree of international recruitment; around 13 per cent are recruited internationally at the comprehensive universities and around 16 per cent at the specialised universities. International recruitment is increasing.

The high degree of domestic recruitment at university colleges (just over 84 per cent) and new universities (close to 60 per cent) is, naturally, largely due to the fact that many of these institutions have only gained the right to award doctorates in the past 15 years.

Of course there are individuals who have moved through having been employed at a HEI other than the one which awarded their PhD and who have then returned to the same HEI that awarded their doctorate. There are also those that have moved through changing department/equivalent at the same HEI at which their PhD was awarded. This type of mobility is not captured within these statistics.

³⁵ SOU 2016:29 the Research Career Inquiry *Trygghet och attraktivitet – en forskarkarriär för framtiden* concludes that among all those who have moved, fewer than 10 per cent, have moved more than once. It is thus estimated that very few of those who have moved have then returned to the HEI at which their PhD was awarded.

2.3 Scholarly publications at Swedish HEIs

Sweden is among those countries that have the highest production of scholarly publications in relation to the size of its population. The vast majority of articles are produced at the comprehensive universities.

The HEI categories university colleges and new universities demonstrate an annual increase in publication volume of just over 8 per cent in the period 2002–2014. These categories' proportion of the total Swedish production of articles increased from 4 to 8 per cent over the course of the same period.

The comprehensive universities have a research profile close to the global average, i.e. they have research activity within all areas. The greatest specialisation is, as expected, among the specialised universities.

Only a small proportion of Swedish publications are co-published between HEIs and other sectors of society. Collaboration outside of academia in terms of co-publications is most common within clinical medicine and least common within the humanities.

2.3.1 University colleges' production of scholarly publications has increased the most, but only accounts for a small proportion of the total volume

The comprehensive universities and the specialised universities account for a total of around 80 per cent of the Swedish production of articles.

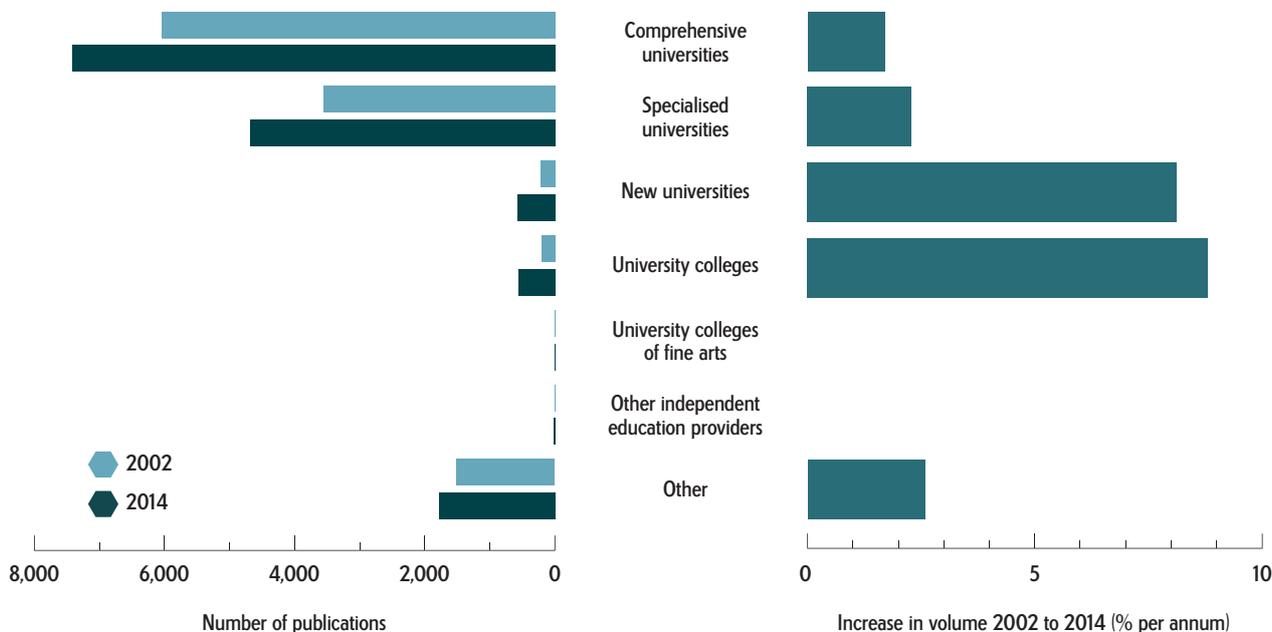


Figure 30. Production of scholarly publications in Sweden in terms of total volume (number of publications during 2002 and 2014) and increase in volume (2002–2014) by HEI category. The increase in volume for university colleges of fine arts and other independent education providers is not reported because of its low volume. The category Other includes primarily companies, hospitals (not university hospitals) and government agencies outside the higher education sector. Source: Thomson Reuters.

Figure 30 shows the size of article production for the years 2002 and 2014, as well as the yearly percentual increase in volume over the course of the period 2002–2014 for various HEI categories.

The comprehensive universities account for just under half of the total Swedish production of publications and the specialised universities for 29 per cent. The four new universities together produce the same number of scholarly publications as the 15 university colleges, and each contribute approximately 4 per cent of the total.

The university colleges of the arts and the other independent education providers have very few scholarly publications in the Swedish Research Council's database. This is partly due to them having a primary focus on education, and partly because the university colleges of the arts publish their research results in channels that are not included in the database.

The last category, other, includes those that are not included in the other categories. This includes companies, hospitals (not university hospitals) and government agencies outside of the higher education sector. In 2014, they accounted for approximately 18 per cent of the total production of publications.

University colleges, closely followed by the new universities, are the groups with the largest increase in the number of scholarly publications – just over 8 per cent per annum since the turn of the millennium, as seen in the right part of Figure 30. The annual increase for the comprehensive and specialised universities was around 2 per cent over the same period.

2.3.2 Highest citation impact for comprehensive universities and specialised universities

The comprehensive universities, specialised universities and the category other (includes companies, hospitals and government agencies outside of the higher education sector) had a proportion of highly cited publications that was above the global average for the publication years 2012–2014. The proportion of highly cited papers for university colleges and new universities was lower in the same period.

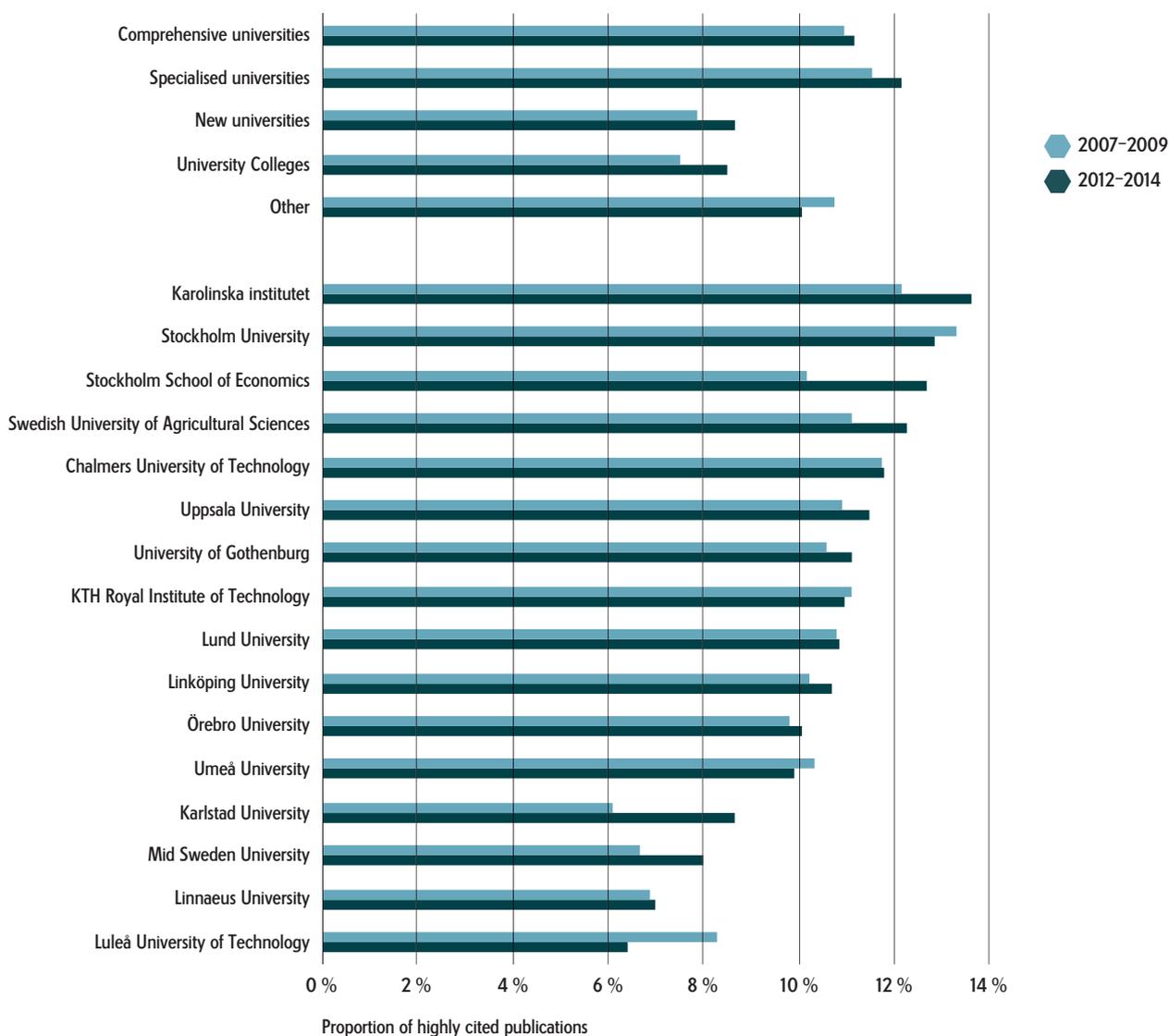


Figure 31. Trend in citation impact (proportion of all the higher education institution's scholarly publications that are among the 10 per cent most highly cited in the world) by HEI category in Sweden. The data concerns the periods 2007–2009 and 2012–2014. The category Other includes primarily companies, hospitals (not university hospitals) and government agencies outside the higher education sector. University colleges of fine arts and independent education providers are not reported, due to their low publication volume. Data: Thomson Reuters.

Figure 31 shows the higher education institutions' citation impact measured as a proportion of highly cited scholarly publications, i.e. how large a proportion of each HEI's publications that is among the 10 per cent most highly cited in the database. The university colleges focused on the arts and independent education provides had too few publications (fewer than 50 per category) in both periods to be included in Figure 31.

Karolinska Institutet had the highest citation impact for publications published between 2012 and 2014, increasing its share from 12 per cent in the previous period to 14 per cent. It is followed by Stockholm University and the Stockholm School of Economics.

All of the comprehensive universities and specialised universities have a high proportion of highly cited publications that lie close to or over the global average, around 10 per cent. The university colleges and the new universities have lower proportions of highly cited publications. It is not uncommon for many of the smaller HEIs to have relatively large variations over time as the lower publication volume of these institutions means that a few highly or lowly cited articles affect the average substantially.

2.3.3 No obvious association between degree of specialisation and citation impact

An analysis of how citation impact is distributed across research areas and HEIs shows no apparent association between degree of specialisation and citation impact. The areas that have the highest citation impact are often relatively small. HEIs with a high impact in general, are often above the global average in many areas.

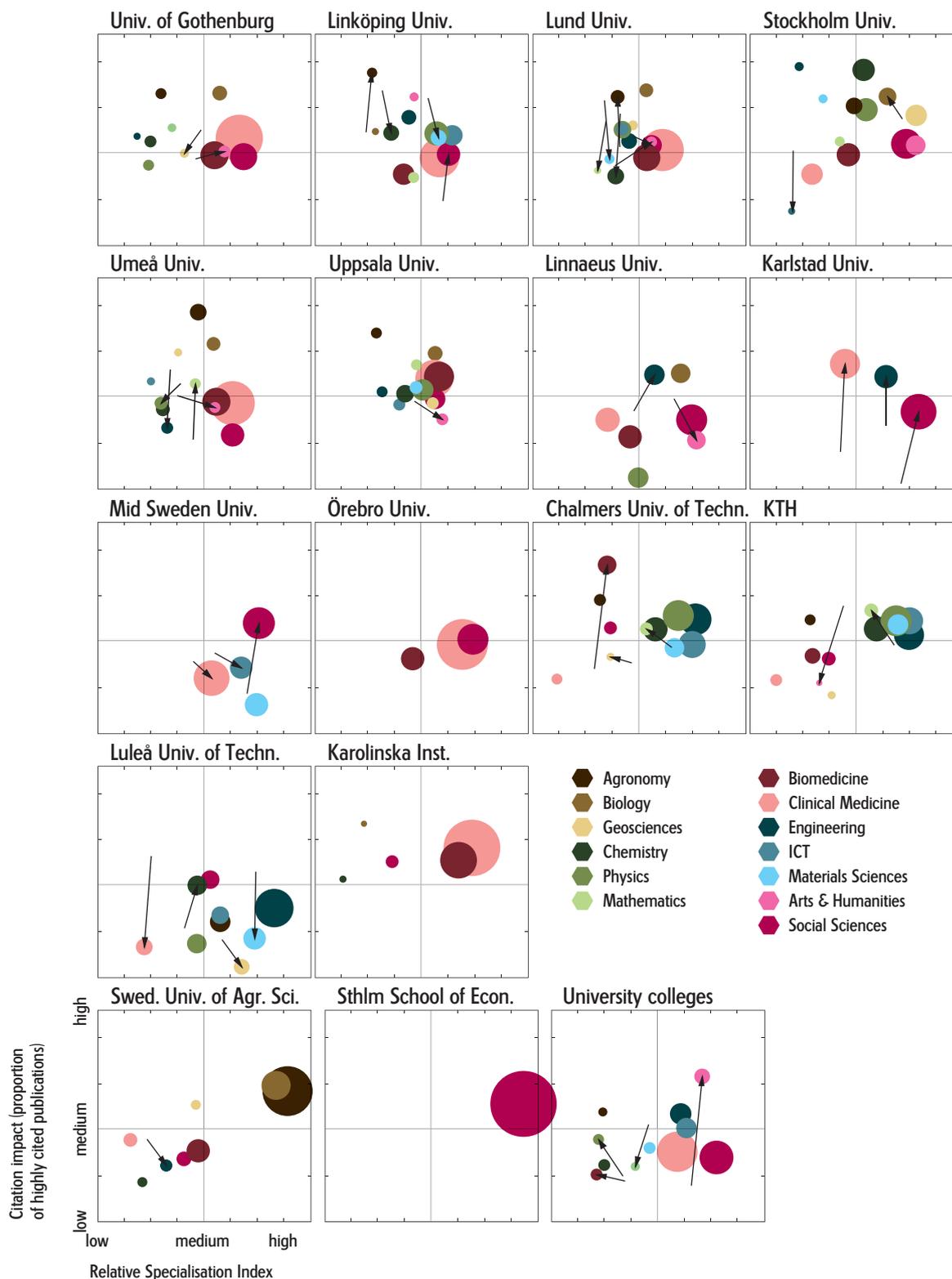


Figure 32. Research profile and citation impact of a selection of Swedish HEIs and for the group of 15 university colleges on an aggregated level. The arrows show a trend from 2007–2009 to 2012–2014 for the circles whose position has changed most during this period. The horizontal axis shows the institution's Relative Specialisation Index (RSI). The vertical axis shows the proportion of the institution's scholarly publications that are among the 10 per cent most highly cited in the world within various areas. The area of a circle is proportional to that research area's share of each institution's total article volume. Only research areas in which each institution has at least 30 publications (10/year) are included in the figure. Source: Thomson Reuters.

Figure 32 shows higher education institutions' degree of specialisation, measured as Relative Specialisation Index along the horizontal axis and citation impact on the vertical axis. The various research areas are stated with different colours in the figure. If the proportion of a certain area is the same for a HEI as for the Swedish Research Council's database as a whole, the circle ends up on the average value in the middle of the horizontal axis. If the circle is to the left of the grey vertical average line, the institution has a lower proportion of the area than the database total. If the circle is instead to the right of the average value, the institution has a specialisation towards this research area. The area of a circle is proportional to that research area's percentage of each HEI's total article volume.

Citation impact is shown in a corresponding manner, measured as a percentage of publications that are among the 10 per cent most highly cited in the database. The areas in which the citation impact is higher than the global average are located over the grey horizontal line and those that have a lower average are under it. University colleges of the arts and other education providers have too few publications to be included. University hospitals' publications are included in those of the respective university.

Not unexpectedly, the greatest specialisation is found among the specialised universities, with Stockholm School of Economics publishing mainly within the social sciences and the Swedish University of Agricultural Sciences (SLU) having a significantly higher proportion of publications within agronomy than the database as a whole. The proportion of biology is also high for SLU. Karolinska Institutet has a higher proportion of biomedicine and clinical medicine than the database as a whole. The universities of technology have a slightly broader research profile, but with a relatively large proportion of physics, chemistry and mathematics.

For many of the comprehensive universities (in the upper part of Figure 32), the points are gathered close to the middle of the axes, which means that they have a research profile relatively similar to the global average. It can be noted that those HEIs that lack a faculty of engineering (e.g. the University of Gothenburg and Stockholm University), have a low proportion of engineering and technology publications. All HEIs with a university hospital have a relatively high number of publications within medicine.

The new universities have a quite large spread across the research areas, but all have a relatively high proportion of social sciences. Three of them (Karlstad University, Linnaeus University and Mid Sweden University) have highly cited publications within engineering sciences.

Karolinska Institutet has a higher citation impact than the global average within its areas. Stockholm University is also highly cited with the majority of areas over the global average. Stockholm School of Economics is above the global average within social sciences, as is SLU within agronomy and biology. The comprehensive universities are relatively tightly gathered around a point just over the global average.

2.3.4 The highest number of co-publications with other sectors are in clinical medicine

Around 13 per cent of all Swedish publications are co-publications between Swedish HEIs and other sectors of society. Co-publication is most common in clinical medicine and least common in mathematics and the humanities.

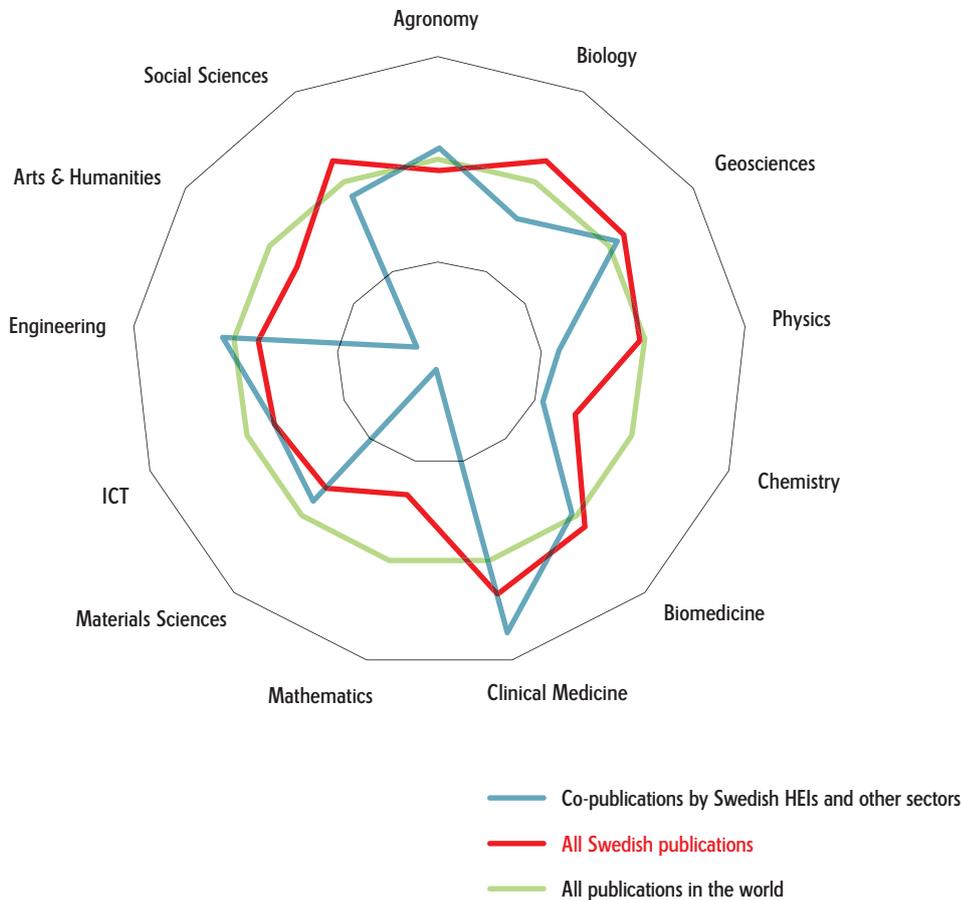


Figure 33. Research profile (Relative Specialisation Index RSI) for scholarly co-publications, (published between 2013 and 2015), in collaboration between HEIs and other sectors of society. Co-publications are compared with the RSI of all Swedish scholarly publications within each research area and with the global average. University hospitals are included in the HEI category. Full counts of publications. Source: Thomson Reuters.

As seen in Figure 33, the collaboration between HEIs and other sectors, measured as the share of co-publications among the total number of Swedish publications, is most common within clinical medicine followed by geosciences, engineering and agronomy. Co-publication between academia and other sectors is more unusual in mathematics, the humanities, chemistry and physics.

The high level of activity in clinical medicine is explained by collaboration with hospitals and the healthcare sector. The medical field is also largest in the business enterprise sector; Pfizer and AstraZeneca are the companies that publish the highest number of scholarly publications in Sweden.

The degree to which articles are published together with researchers in higher education or with researchers outside of academia is one way to estimate the impact the research has outside of academia. It is not necessarily the case that co-publication between academia and other sectors of society means that the research results are spread more widely outside of academia. Nevertheless, the probability of this being the case should be greater if one or more of the authors work outside of academia.

3 METHODS SECTION

3.1 Selection of indicators

The Research Barometer presents a selection of indicators with the aim of providing an overview of the Swedish research system in an international comparison. Some basic indicators are evident – e.g. how much of Sweden’s GDP is being invested in R&D, how the government research appropriations are allocated and how women and men are distributed within the higher education sector’s research and teaching staff. Others have been selected on the basis of the Swedish Research Council’s own analysis, for example indicators that concern citation impact and mobility.

This is the first edition of the Swedish Research Council’s Research Barometer. The indicators and presentation of the results will be developed continually in future editions. The idea is for a number of indicators to be permanent and return in each Research Barometer in order to make comparisons over time possible. In each Research Barometer, there could also be room for more detail to be provided in one or more thematic areas, which means that certain indicators may appear in one Research Barometer, but not necessarily in the next.

The focus in the Research Barometer is on the government R&D funding and on the research conducted at HEIs, even though the proportion of R&D funding in Sweden that comes from the business enterprise sector constitutes 60 per cent of the country’s total R&D investments. The majority of R&D activity in the business enterprise sector is, however, concerned with development, rather than research. Sweden’s R&D activity outside of higher education is relatively small compared with that of many other countries. Around 6 per cent of the Swedish scholarly publications in the Swedish Research Council’s publication database did not have a HEI address in the period 2012–2014.

3.2 Selection of countries

No countries are entirely comparable as there are often major differences between a country’s education and research systems. In spite of these differences, comparisons between countries can still provide valuable information and constitute a basis for analyses and opinions.

Which countries are most appropriate for international comparisons from a Swedish point of view? Is Sweden to be compared, for example, with the best research countries or with those countries that are most similar to Sweden? A far too narrow selection of similar countries risks becoming limiting and comparisons with only the best can be difficult to relate to. That is why the Research Barometer has a pragmatic approach and compares Sweden with countries that provide the most relevant and interesting comparison, depending on which aspect is highlighted in the section. However, the Research Barometer departs from a “basic list” consisting of 14 countries, including Sweden.³⁶ What these countries share is that they represent active research nations. These 14 research nations include those that are large and small, established and emerging, geographically close and those that are further away.

3.3 Data sources

Funding and personnel statistics in the international comparisons come from the OECD. International statistics are supplied with a little delay as they are based on individual countries’ reporting to the OECD. The most recent *comprehensive* data available for both R&D investments and staff are from 2013. Figures based on data from the OECD do not always include information for all years. When there is a lack of information, data have in some cases been calculated on the basis of the closest available years prior to and subsequent to the year in question.

³⁶ Austria, China, Denmark, Finland, France, Japan, the Netherlands, Norway, Korea, Switzerland, the United Kingdom and the United States.

When it comes to *national* data concerning funding and staff, the statistics come from Statistics Sweden (SCB) and the Swedish Higher Education Authority (UKÄ). Funding statistics are updated every other year. The Research Barometer's data concerning funding of Swedish R&D is based on data from December 2015, concerning information from 2013. UKÄ compiles statistics concerning revenue and write-downs for research and postgraduate education. These statistics are processed further by Statistics Sweden, which uses UKÄ's data as the basis for producing information concerning the actual revenue for R&D, excluding the cost of the education element of postgraduate education.

The personnel statistics are collected annually on behalf of UKÄ by Statistics Sweden. The statistics are based on personnel data from the HEIs' salary reporting systems for the month of October.

In order to produce statistics covering the human resources devoted to R&D within the higher education sector, a survey is conducted that is directed at employees in HEIs. The survey then forms the basis on which the number of full-time equivalents in R&D in the sector is calculated. The survey is conducted by Statistics Sweden every other year. The most recent one available concerns 2013.

In some cases, the data in the Research Barometer is based on processing conducted by Statistics Sweden, for example data regarding the distribution by employment categories in the survey concerning the use of working time and higher education personnel's year of doctorate and institution of doctorate.

The bibliometric analyses in the Research Barometer are based on the Swedish Research Council's database, which in turn is based on the same basic material as *Web of Science* (Thomson Reuters).³⁷ The database at the Swedish Research Council is updated in April/May each year. The most recent update was made in April 2016. The content of the database used in this edition of the Research Barometer equates to the content in *Web of Science* on 30 March 2016.

For details concerning data in the figures, you are referred to the separate List of figures and indicators.

3.4 Bibliometric analysis

A summary of how the bibliometric indicators have been calculated and used in the Research Barometer is provided below. For a more detailed description of how bibliometrics are used at the Swedish Research Council, you are referred to "Guidelines for using bibliometrics at the Swedish Research Council"³⁸ and "The bibliometric database at the Swedish Research Council – contents, methods and indicators".³⁹

The Research Barometer counts Swedish university hospitals' publications as belonging to their respective university.

3.4.1 The Swedish Research Council's database for bibliometrics

Every journal in the database is classified by Thomson Reuters into one or more of approximately 250 subject areas.⁴⁰ An article in a journal is classified in accordance with the journal's subject classification. In the Research Barometer, the 250 subject classes in *Web of Science* are aggregated into 13 larger research areas.⁴¹ The journals that are classified as *Other/multidisciplinary* by *Web of Science* are reclassified by the Swedish Research Council. Following the reclassification of multidisciplinary journals, there are very few publications in this category and these have been excluded from the statistics in the Research Barometer.

³⁷ Some data included here originate from Science Citation Index Expanded®, Social Science Citation Index®, Arts and Humanities Citation Index®, Conference Proceedings Citation Index® and Conference Proceedings Citation Index – Social Sciences & Humanities®, produced by Thomson Reuters®, Philadelphia, Pennsylvania, USA. © Copyright Thomson Reuters® 2016. All rights reserved. The Swedish Research Council is aware that there are other actors in the marketplace, for example Scopus (Elsevier).

³⁸ Vetenskapsrådet. Riktlinjer för användning av bibliometri vid Vetenskapsrådet. 15/12/2014. Ref. no. 113-2014-7357. [Swedish Research Council. Guidelines for using bibliometrics at the Swedish Research Council.]

³⁹ Vetenskapsrådet. The bibliometric database at the Swedish Research Council – contents, methods and indicators 2015, 18/09/2015. Ref. no. 113-2010-6148.

⁴⁰ Please refer to the translation table for converting between Web of Science subject areas and OECD fields of science and technology: http://incites.isiknowledge.com/common/help/h_field_category_oecd_wos.html

⁴¹ Agronomy, biology, geosciences, physics, chemistry, biomedicine, clinical medicine, mathematics, materials science, ICT, engineering sciences, arts and humanities, and social sciences.

Each publication is also classified by Thomson Reuters as one of 39 different document types. The Swedish Research Council's statistics are based on publications of the types *Article* and *Review*, which are combined into a common document type.

3.4.2 Humanities and social sciences

Humanities and large parts of the social sciences have a low degree of coverage in the *Web of Science* database. To some extent, the coverage will improve with time as *Web of Science* includes more journals. *Web of Science* includes some books, but this part of *Web of Science (Book Citation Index)* is not purchased by the Swedish Research Council and not included in the data used in the Research Barometer. As the major commercial databases primarily focus on English language journals, research production published in Swedish language journals and a large part of the production in book form will, however, continue to be unavailable in the future. This means that the international databases need to be complemented with domestic databases. In the future, development of the domestic publication database SwePub will make it possible to conduct some analysis that include books, artistic work and publications written in Swedish.

3.4.3 Publication volume and fractional counting

Many figures in the Research Barometer are based on the counting of publications. One challenge in counting the number of publications is that one publication may have authors from more than one country. The sum of the number of publication from the various countries then becomes greater than the total number of publications. The same challenge exists when counting the number of publications in different areas, as one journal may be classified as belonging to more than one subject area. The sum of the number of publication within the individual subjects is then greater than the total number of publications. One way to deal with this is to divide each publication into small pieces, known as fractions, with each fraction only having *one* address and *one* subject area.

3.4.4 Relative Specialisation Index

A Relative Specialisation Index (RSI) is used in order to describe the specialisation of a country's (or an organisation's) publications. 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 activity index of a specific country is calculated by dividing the proportion of publications the country has in a certain subject by the proportion of publications in the subject in the whole database. If 50 per cent of Sweden's publications are classified as physics, while the equivalent figure for the database as a whole is 25 per cent, Sweden's activity index for physics will be 2. In this example, Sweden therefore has a proportion of physics that is double that of the database as a whole. The activity index is an asymmetrical measure that can have a value of between zero and infinity. In order for the figures to be easier to compare, we instead used RSI, which is calculated as:

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

If the $RSI < 0$, the country (or organisation) has a lower proportion of publications within the subject than the global average. If the $RSI > 0$, the proportion is higher than the global average.

3.4.5 The indicator 10 per cent most highly cited

In order to study the impact of publications, an indicator is used in the Research Barometer that states how large a proportion of a country's or a HEI's publications are among the 10 per cent most highly cited scholarly publications in the database. In order to determine whether an article is among the 10 per cent most cited, the article is compared with all the articles in the database in the same area that were published in the same year.

The proportion of highly cited publications is an appropriate way to measure citation impact because, as opposed to mean citation rate, it is not affected appreciably by individual extremely highly cited publications.

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

Measuring the country's proportion of the 10 per cent most highly cited of publications in the database is a more selective measure for comparing different countries' citation impact, than measuring the country's total number of publications and the number of citations those publications have received in the years after their publication. In the case of Sweden, the differences between these measures are small. Sweden's proportion of the total number of field-normalised citations ⁴² was 1.14 per cent in 2014, while the equivalent value for the 10 per cent most highly cited scholarly publications was 1.16 per cent.

⁴² All mean citations rates are field-normalised, i.e. the number of citations for a publication is divided by the mean citation rate for all publications in the database in the same field, year and type publication. Field normalisation is conducted in order to adjust for variations in terms of citation tradition between different fields. Accordingly, field normalisation means that a publication that received the same number of citations as the mean rate for the field has a field normalised citation that is equal to 1.0. A publication that received 50 per cent more citations than the mean for the field has a value of 1.5. (Vetenskapsrådet. Den svenska produktionen av högt citerade vetenskapliga produktioner. 2010. Vetenskapsrådets lilla rapportserie 1:2010.) [Swedish Research Council Swedish production of highly cited scientific publications.]

3.5 List of figures and indicators

Table 1. List of figures and indicators with explanations and sources

Figure	Indicator	Explanation	Source
1	Number of researchers per thousand total employment in relation to domestic expenditure on R&D as a percentage of GDP in 2013.	Sweden is compared with a selection of other countries. The term researchers is used here in line with the definition in the Frascati Manual 2015. The area of a circle is proportional to that country's share of the total expenditure on R&D.	OECD MSTI: Total researchers per thousand total employment; GERD as a percentage of GDP.
2	<i>(The figure consists of six indicators, described in detail below.)</i>	Swedish R&D as regards six indicators in international comparison. Sweden's position is shown in relation to the average value for all countries in the database and the average value for the five top countries in each category.	OECD MSTI; Thomson Reuters.
2a	Domestic expenditure on R&D as a percentage of the country's GDP in 2013.	Total investment in R&D that is performed within the country over a set period as a proportion of GDP. Sweden: 3.3 %, average: 1.93 %. Top countries in the OECD database: Korea, Israel, Japan, Sweden, Finland.	OECD MSTI: GERD as a percentage of GDP.
2b	Industry funding of domestic R&D as a percentage of the country's GDP in 2013.	Industry funding of domestic R&D, independent of performer. Sweden: 2.01 %, average: 1.03 %. Top countries in the OECD database: Korea, Japan, Taiwan, Sweden, Finland.	OECD MSTI: Industry financed GERD as a percentage of GDP.
2c	Government funding of domestic R&D as a percentage of the country's GDP in 2013.	Government funding of domestic R&D, independent of performer. Sweden: 0.93 %, average: 0.61 %. Top countries in the OECD database: Austria, Korea, Sweden, Denmark, Finland.	OECD MSTI: Government-financed GERD as a percentage of GDP.
2d	Number of scholarly publications per thousand inhabitants 2012–2014.	The average value for all countries is calculated from the number of publications and inhabitants in the OECD countries (2014). The average value for the five top countries is based on the number of publications and inhabitants in Switzerland, Denmark, Australia, Sweden and Iceland. Number of publications and number of inhabitants for the years 2012–2014.	OECD MSTI; Thomson Reuters.
2e	Citation impact (proportion of all the country's scholarly publications that are among the 10 per cent most highly cited in the world).	Citation impact (proportion of all the country's scholarly publications that are among the 10 per cent most highly cited in the world). Top countries in the publication database: Singapore, Switzerland, the United States, the United Kingdom, the Netherlands. Publication years: 2012–2014.	Thomson Reuters.
2f	Number of researchers per thousand total employment in 2013.	The term researchers is used here in line with the definition in the Frascati Manual 2015. Sweden: 13.74, average: 8.15. Top countries in the OECD database: Finland, Denmark, Sweden, Taiwan and Korea.	OECD MSTI: Total researchers per thousand total employment.

Figure	Indicator	Explanation	Source
3	Domestic data for R&D in 2013 distributed by sector of performance: business enterprise sector, higher education sector, government sector, private non-profit sector.	Sweden is compared with a selection of other countries. Data for 2013 (or most recent available year).	OECD MSTI: 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.
4	Domestic expenditure on R&D as a percentage of the country's GDP in the period 2000–2013.	Sweden is compared with a selection of other countries.	OECD MSTI: GERD as a percentage of GDP.
5	Domestic expenditure on R&D as a percentage of the country's GDP in the period 2000–2013. The same indicator as in Figure 4.	Sweden is compared with a smaller selection of countries than in Figure 4 in order to illustrate the trend in the period 2000–2013. These countries are: Korea, Sweden, Denmark, Austria, China and the United Kingdom.	OECD MSTI: GERD as a percentage of GDP.
6	Domestic expenditure on R&D as a percentage of the country's GDP in the period 2003–2013, distributed by R&D within the higher education and business enterprise sectors, respectively.	Sweden is compared with a selection of other countries. In the figure, the starting point of the arrows equates to 2003 and their end to 2013. The broken supporting lines in the figure indicate the sum of expenditure on R&D performed in the higher education and business enterprise sectors as a percentage of the country's GDP.	OECD MSTI: HERD as a percentage of GDP; BERD as a percentage of GDP.
7	Government funding of domestic expenditure on R&D as a percentage of the country's GDP in the period 2000–2013.	Sweden is compared with a selection of other countries.	OECD MSTI: Government-financed GERD as a percentage of GDP.
8	Percentage of the population who are researchers, distributed by women and men, in the years 2003, 2008 and 2013.	Sweden is compared with a selection of other countries. Data for the years 2003, 2008 and 2013 (or most recent available year).	OECD MSTI: Total researchers (headcount); Women researchers as a percentage of total researchers (headcount); Population statistics.
9	Distribution of researchers between the business enterprise sector, the higher education sector and the government sector in 2013.	Sweden is compared with a selection of other countries. Data for 2013 (or most recent available year).	OECD MSTI: Business enterprise sector: Total researchers (headcount); Government sector: Total researchers (headcount); Higher education sector: Total researchers (headcount).
10	Number of scholarly publications per thousand inhabitants in the periods 2002–2004, 2007–2009 and 2012–2014.	Sweden is compared with a selection of other countries. Fractional counts of publications.	Thomson Reuters; OECD: Population statistics.
11	Citation impact by country (percentage of all the country's scholarly publications that are among the 10 per cent most highly cited in the world) in the periods 2002–2004, 2007–2009 and 2012–2014.	Sweden is compared with a selection of other countries. Fractional counts of publications.	Thomson Reuters.

Figure	Indicator	Explanation	Source
12	Research activity as Relative Specialisation Index (RSI) for 13 research areas.	Sweden is compared with the EU 15 countries (Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom) and the world (all countries in the publication database). Research areas: please refer to the methods section under Bibliometric analysis. Publication years 2012–2014. Fractional counts of publications.	Thomson Reuters.
13	Citation impact (percentage of the country's scholarly publications within the research area that are among the 10 per cent most highly cited in the world) in 13 research areas.	Sweden is compared with the EU 15 countries and the world (all countries in the publication database). Research areas: please refer to the methods section under Bibliometric analysis. Publication years: 2012–2014. Fractional counts of publications.	Thomson Reuters.
14	Research profile (Relative Specialisation Index) and citation impact (percentage of the country's scholarly publications within the research area that are among the 10 per cent most highly cited in the world) in 13 research areas.	Sweden is compared with a selection of other countries. The figure's horizontal axis shows the country's Relative Specialisation Index (RSI). The vertical axis shows the proportion of the country's scholarly publications that are among the 10 per cent most highly cited in the world within various research areas. The area of a circle is proportional to that research area's proportion of each country's total article volume. Research areas: please refer to the methods section under Bibliometric analysis. Publication years: 2012–2014. Fractional counts of publications.	Thomson Reuters.
15	Percentage of internationally co-authored scholarly publications from Swedish researchers in the period 1982–2015, in collaboration with researchers in the regions EU+2, North America, Asia, Oceania, Africa and Latin America.	EU+2 denotes the 28 EU countries, Switzerland and Norway. Full counts of publications, therefore, as one article may have been published in a partnership between researchers from more than one different region, the sum exceeds 100 per cent (an article with authors from, for example, four regions will be counted four times in the figure).	Thomson Reuters.
16	Number of international co-authored scholarly publications from Swedish researchers in collaboration with researchers from other countries.	Number of articles per annum is stated as an average value for the years 2011–2015. Full counts of publications.	Thomson Reuters.
17	International co-authored scholarly publications from Swedish researchers within 13 research areas in 2005 and 2015 as a percentage of the total number of Swedish publications within the respective area.	Research area: please refer to the methods section under Bibliometric analysis. Full counts of publications.	Thomson Reuters.

Figure	Indicator	Explanation	Source
18	Financial volume in the Swedish R&D system in 2013, distributed by funder and research performer.	Funder is stated on the top edge of the figure and performer on the bottom edge. The amounts are stated in SEK billions.	Statistics Sweden: Research and development in Sweden – an overview and international comparisons (Funding of R&D performed in Sweden).
19	Sweden's government R&D funding in the period 2005–2016 distributed by recipient: research funding agencies, government authorities and higher education institutions.	Amounts are stated in SEK millions and at constant prices for 2016.	Statistics Sweden: Government budget allocations for R&D (GBARD, SEK millions, distributed by recipient and year).
20	R&D revenues within the Swedish higher education sector in 2011 and 2013, distributed by source of funding.	Data for 2013. The figures for 2011 are stated in parentheses. Sources of funding: Direct government funding, Government agencies, Private non-profit organisations in Sweden, Companies, the EU incl. ERC, County Councils and Municipalities, Public research foundations, Higher education institutions, Other sources, Private non-profit organisations abroad.	Statistics Sweden: Research and development in the higher education sector (Revenue (Current cost) for R&D in the higher education sector by source of funds 2013).
21	Revenue (operating costs) for R&D in the Swedish higher education sector in the period 2001–2013, distributed by category of higher education institution.	Amounts are stated in SEK millions and at constant prices for 2013. HEI categories: Comprehensive universities, Specialised universities, New universities, University colleges, University colleges of fine arts, Other independent education providers.	Statistics Sweden: Research and development in the higher education sector (Current costs for R&D in higher education institutions, higher education institution and funding source).
22	Revenue (operating costs) for R&D in the Swedish higher education sector in 2011 and 2013, distributed by category of higher education institution and field of research.	HEI categories: Comprehensive universities, Specialised universities, New universities, University colleges, University colleges of fine arts, Other independent education providers. Fields of research: Medical and health sciences, Natural sciences, Engineering and technology, Social sciences, Humanities, Agricultural sciences.	Statistics Sweden: Research and development in the higher education sector (Current costs for R&D in higher education institutions, higher education institution and funding source).
23	Research and teaching staff and doctoral students in Swedish higher education in the period 2001–2015 by employment category.	Employment categories: Doctoral students, Senior lecturers, Lecturers, Professors, Other research and teaching staff without PhDs, Other research and teaching staff with PhDs, Postdoctoral positions, Career-development positions.	UKÄ, underlying data for the official higher education statistics.
24	Research and teaching staff in Swedish higher education in 2015, distributed by employment category and category of higher education institution.	Data for 2015. The figure states the proportion (left axis) and number (right axis) for the various categories.	UKÄ, underlying data for the official higher education statistics.
25	Gender distribution among those who have recently gained a PhD in Swedish higher education in 2005 and 2015.	Data for 2005 and 2015. Categories: Recently gained PhDs, Other research and teaching staff with PhDs, Postdoctoral positions, Career-development positions, Senior lecturers, Professors.	UKÄ, underlying data for the official higher education statistics and Statistics Sweden: Doctoral degrees in the years 1973–2015 by field of research and technology and gender.

Figure	Indicator	Explanation	Source
26	Number of women and men among the research and teaching staff in Swedish higher education in 2015, distributed by field of research and employment category.	<p>Data for 2015. The statistics concern individuals, i.e. not full-time equivalents.</p> <p>Fields of research: Natural sciences, Engineering and technology, Medical and health sciences, Agricultural sciences, Social sciences, Humanities.</p> <p>Employment categories: Other research and teaching staff with PhDs (incl. doctorates awarded abroad), Career-development positions, Postdoctoral positions, Senior lecturers, Professors.</p>	UKÄ, underlying data for the official higher education statistics.
27	Number of women and men among the research and teaching staff in Swedish higher education in 2015, distributed by year of PhD and employment category.	<p>Data for 2015. Men to the left of the centre line and women to the right.</p> <p>Employment categories: Professors, Senior lecturers, Career-development positions, Postdoctoral positions, Other research and teaching staff with PhDs, Lecturers with PhDs.</p>	Statistics Sweden (collated data from the higher education register).
28	Distribution of working time for men and women in the various employment categories of research and teaching staff in Swedish higher education in 2013.	<p>Data for 2013. The figure states the percentage (left axis) and number (right axis) of R&D annual full-time equivalents for the various categories. Aside from research and teaching staff, doctoral students and administrative staff with teaching and research duties are also included.</p> <p>The data concerns Research and teaching in Swedish higher education.</p>	Statistics Sweden: R&D annual full-time equivalents in higher education in accordance with a specific classification of employment categories.
29	Internal, domestic and international recruitment of employees by category of higher education institution in Swedish higher education in 2015.	<p>The percentage of employees in the various HEI categories in Sweden in 2015 who were recruited from the same institution, another Swedish institution or from abroad. The term “recruited from” means the institution that awarded their doctorate.</p> <p>HEI categories: Comprehensive universities, Specialised universities, New universities, University colleges.</p>	Statistics Sweden: (collated data from the higher education register).
30	Production of scholarly publication in Sweden in 2002 and 2014 in terms of total volume and increase in volume by category of higher education institution.	<p>Number of publication in 2002 and 2014 and yearly percental increase in the number of publications between 2002 and 2014.</p> <p>HEI categories: Comprehensive universities, Specialised universities, New universities, University colleges, University colleges of fine arts, Other independent education providers, Other.</p> <p>The increase in volume for university colleges of fine arts and other independent education providers is not reported because of its low volume. The category Other includes primarily companies, hospitals (not university hospitals) and government authorities outside of the higher education sector. Fractional counts of publications.</p>	Thomson Reuters.

Figure	Indicator	Explanation	Source
31	Citation impact (proportion of all the higher education institution's scholarly publications that are among the 10 per cent most highly cited in the world) by category of higher education institutions in the periods 2007–2009 and 2012–2014.	<p>The data concerns the periods 2007–2009 and 2012–2014. Proportion of all the country's scholarly publications that are among the 10 per cent most highly cited in the world.</p> <p>HEI categories: Comprehensive universities, New universities, University colleges, Other. The category Other includes primarily companies, hospitals (not university hospitals) and government authorities outside of the higher education sector. University colleges of fine arts and independent education providers are not reported due to the low publication volume (fewer than 50 per category over the course of both periods). Fractional counts of publications.</p>	Thomson Reuters.
32	Relative Specialisation Index (RSI) and citation impact of a selection of Swedish higher education institutions and for the 15 university colleges on an aggregated level in the periods 2007–2009 and 2012–2014.	<p>The arrows indicate the development from 2007-2009 to 2012-2014 for the circles whose position varied the most between the two periods. The horizontal axis shows the institution's Relative Specialisation Index (RSI). The vertical axis shows the proportion of the institution's scholarly publications that are among the 10 per cent most highly cited in the world within the various research areas. The area of a circle is proportional to that research area's share of each institution's total article volume. Only research areas in which each institution has at least 30 publications (10/year) are included in the figure. Fractional counts of publications.</p>	Thomson Reuters.
33	Relative Specialisation Index (RSI) for scholarly co-publications within 13 research areas, in comparison with the RSI for all Swedish publication and with the global average in each area.	<p>Research profile expressed as Relative Specialisation Index (RSI) for co-publications (in partnerships between authors from Swedish HEIs and other sectors of society). University hospitals are included in the HEI category. This is compared with the RSI for all Swedish publication and with the global average. Research areas: please refer to the methods section under Bibliometric analysis.</p> <p>Publication years: 2013-2015. Full counts of publications.</p>	Thomson Reuters.

3.6 Glossary and abbreviations

Activity index (AI): Calculated for a specific country by dividing a country's proportion of publications in a certain research area by the proportion of the database as a whole that the area constitutes. Please also refer to Relative Specialisation Index.

Career-development position: A new personnel category in UKÄ's personnel statistics from 2012 that consists of the former categories research assistants (which included associate senior lecturers) and postdoctoral positions, which previously belonged to the category other research and teaching personnel.⁴³

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

Current prices: Current prices are actual prices from the time in question, as opposed to constant prices, which are corrected for variations in monetary value over time.

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

EU-15: The European Union's member states prior to the expansion by ten new countries on 1 May 2004: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom.

EU-28: The countries that were members of the European Union on 1 July 2013: Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden and the United Kingdom.

Field of research: Classification of Swedish R&D in accordance with the Swedish standard classification of fields of research (Swedish National Agency for Higher Education and Statistics Sweden, 2011). All R&D is classified at one, three or five-figure level. Fields of research (at one-figure level) are: Natural sciences, Engineering and technology, Medical and health sciences, Agricultural sciences, Social sciences and Humanities.

GERD: Gross domestic expenditure on research and development denotes the total domestic expenditure on R&D that is conducted within a country over the course of a certain period.

Gross Domestic Product (GDP): The value of all goods and services produced within a country's geographical borders.

ICT: Information and communications technology.

Indicator: A measurable phenomenon that shows or indicates the status of a larger system.

Operating costs: The operating costs are equivalent to revenue for R&D and are exclusive of write-downs and investments.

Publication volume: Number of scholarly publications for a specific period of time.

⁴³ Universitetskanslersämbetet. Personal vid universitet och högskolor 2012. Statistiskt meddelande 13/06/2013. [Swedish Higher Education Authority. Employees in Higher Education 2012.]

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). The RSI indicates whether a country publishes more or less than expected within a certain research area.

Researcher: In the international comparisons, the term researcher is used in accordance with the definition in the Frascati Manual (2015): Researchers are: "Professionals engaged in the conception or creation of new knowledge, products, processes, methods and systems, and in the management of the projects concerned." Being designated a researcher in accordance with the Frascati Manual does not require a person to have a doctorate and also includes doctoral students.

R&D - Research and development: A systematic effort to look for new knowledge or new ideas with or without a specific application in mind. This includes systematic efforts that utilise research results, scientific knowledge or new ideas in order to create new materials, goods, services, processes, systems and methods, or to achieve significant improvements to those that already exist. (Definition from Statistics Sweden).

Research and teaching staff: The term research and teaching staff is used in the section concerning higher education personnel in Sweden in accordance with UKÄ's definition. Please refer to the List of personnel categories, below.

Research area: The bibliometric analyses use 13 large area that are aggregated from the 250 subject areas in *Web of Science*. Please also refer to 3.4.1.

Research profile: A country's research profile is based on its "Relative Specialisation Index" (see below) and indicates the country's production of scholarly articles within various research areas.

Revenue for R&D: Please refer to operating costs.

Scholarly publication: In the bibliometric analysis in the Research Barometer, the publication types *Article* and *Review* are combined into a common document type referred to as scholarly publication. Accordingly, this does not include monographs or other types of scholarly publication. Please also refer to 3.4.1.

3.6.1 Organisations, companies and government authorities

Formas: The Research Council for the Environment, Agricultural sciences and Spatial planning

Forte: The Research Council for Health, Working life and Welfare

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

Statistics Sweden (SCB): Swedish government authority responsible for producing Sweden's official statistics

Thomson Reuters: company that publishes *Web of Science*, a publication database with a citation index.

UKÄ: The Swedish Higher Education Authority

UNESCO: United Nations Educational, Scientific and Cultural Organization

Vinnova: Sweden's innovation agency

3.6.2 List of categories of higher education institutions

For an overview of the HEIs in Sweden, and an explanation of the differences between the categories, see "Higher Education Institutions"

All companies, organisations, etc. that are not listed below are included in the category “Other”.

Comprehensive 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
KTH Royal Institute of Technology
Luleå University of Technology
Swedish University of Agricultural Sciences

New universities

Karlstad University
Linnaeus University (merger of Växjö University and the University of Kalmar on 1 January 2010)
Mid Sweden University (Mid Sweden University College prior to 1 January 2005)
Örebro University

University colleges

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

University colleges focused on fine, applied and performing arts

Beckmans College of Design
School of Dance and Circus (Stockholm University of the Arts from 1 January 2014)
Konstfack
Royal Institute of Art
Royal College of Music in Stockholm
University College of Opera (Stockholm University of the Arts from 1 January 2014)
Stockholm Academy of Dramatic Arts (Stockholm University of the Arts from 1 January 2014)

Other independent education providers

The Erica Foundation
Ersta Sköndal University College
Gammelkroppa School of Forestry
Evidens University College
Johannelund School of Theology
The Red Cross University College
The Newman Institute
Scandinavia's Academy for Psychotherapy Development
Sophiahemmet University
University College of Music Education in Stockholm
The Swedish Institute for CBT & Schema Therapy
Stockholm School of Theology
Örebro School of Theology

University hospitals – these are considered part of their respective university

Uppsala University Hospital
Karolinska University Hospital (Stockholm)
Linköping University Hospital
University Hospital of Umeå
Sahlgrenska University Hospital (Gothenburg)
Skåne University Hospital (Lund) (merger of the university hospitals in Lund and Malmö on 1 January 2010)
Örebro University Hospital

3.6.3 Employment categories

Table 2. List of employment categories with explanations⁴⁴

Category	Definition/explanation	Comment
Lecturer	Employment category. Denotes positions organised under the employment category "Lecturer".	In the personnel statistics, the positions adjunct lecturer and university lecturer are included.
Other research and teaching staff:	The employment category for personnel with teaching and/or research duties that do not belong to any of the other employment categories that include research and teaching staff.	This includes, for example, the positions researcher, research engineer and research assistant. This also includes technical and administrative personnel with research or teaching duties, as well as visiting lecturers and part-time fixed-term teachers. Other research and teaching staff is sometimes split up on the basis of whether or not the person has a PhD or not.
Research and teaching staff	Collective term for the employment categories professor, senior lecturer, career-development position, lecturer and other research and teaching staff.	
Researchers	Please refer to Other research and teaching staff.	The Frascati Manual's definition of researcher is used in the international comparisons.

⁴⁴ Based on data from: Universitetskanslersämbetet. Grundläggande begrepp vid redovisning av officiell statistik inom högskolesektorn. June 2015. [The Swedish Higher Education Authority. Fundamental terms in the reporting of official statistics in the higher education sector.]

Category	Definition/explanation	Comment
Senior lecturer	Employment category. Denotes positions organised under the employment category "Senior lecturer".	Teaching positions are regulated in the Higher Education Ordinance. Requires a PhD or equivalent. Other qualification requirements apply to artistic activities. In the personnel statistics, the positions docent, associate professor and adjunct senior lecturer, among others, are also included in the category senior lecturer.
Career-development position	Employment category. This includes postdoctoral research fellows and associate senior lecturers. In some cases postdoctoral positions are included in this employment category.	Teaching positions are regulated in the Higher Education Ordinance. Requires a PhD or equivalent. Postdoctoral positions are consistently reported separately in the Research Barometer.
Postdoctoral position	Temporary appointment to a postdoctoral position in accordance with an agreement between the social partners that was signed in 2008. ⁴⁵ Previously included in Other research and teaching personnel.	Postdoctoral positions are consistently reported separately in the Research Barometer.
Professor	Employment category. Denotes positions organised under the employment category "Professor".	Teaching positions are regulated in the Higher Education Ordinance. Employment as a professor is the foremost teaching position. Professors also includes, among others, the employment categories visiting professor and adjunct professor.

⁴⁵ <https://www.arbetsgivarverket.se/globalassets/avtal-skrifter/centralaavtal/avtal.pdf>

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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/forskningsbarometern2016). There, the reader can filter and visualise the data themselves in interactive graphs.

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The Swedish Research Council has a leading role in developing Swedish research of the highest scientific quality, thereby contributing to the development of society. Besides research funding, the agency advises the government on research-related issues and participates actively in the discussions to create understanding of the long-term benefits of research.