The Swedish Research Barometer 2021

The Swedish research system in international comparison

Swedish Research Council

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Foreword

The Research Barometer aims to give an overall description of Swedish research and development (R&D), and to highlight how Sweden compares internationally as a research nation. The description places particular focus on the research conducted within the Swedish higher education sector.

The strong point of the Research Barometer is that it gathers information from several statistics sources, while also reporting unique information about scientific publications and their citation impact. One of the new features of this year's report are statistics on open access to scientific publications. The development towards open access has accelerated over the last few years, both internationally and in Sweden, and this area is therefore becoming ever more important to monitor and analyse.

This year's report has been produced by a project group at the Swedish Research Council, consisting of Stina Gerdes Barriere, Karin Tegerstedt, Johan Fröberg and Gustav Hansson (project manager).

I hope that the Swedish Research Barometer 2021, like previous editions, will constitute an important source of information and statistics on the Swedish R&D system, and that the report will be used as the basis for discussion about the future of Swedish research.

Stockholm, 19 October 2021

Sven Stafström
Director General, Swedish Research Council

Summary

The Research Barometer aims to give an overall description of Swedish research and development (R&D), and to highlight how Sweden compares internationally as a research nation. The report focuses in particular on R&D in the Swedish higher education sector, and consists of three chapters: research funding, research personnel and scientific publication.

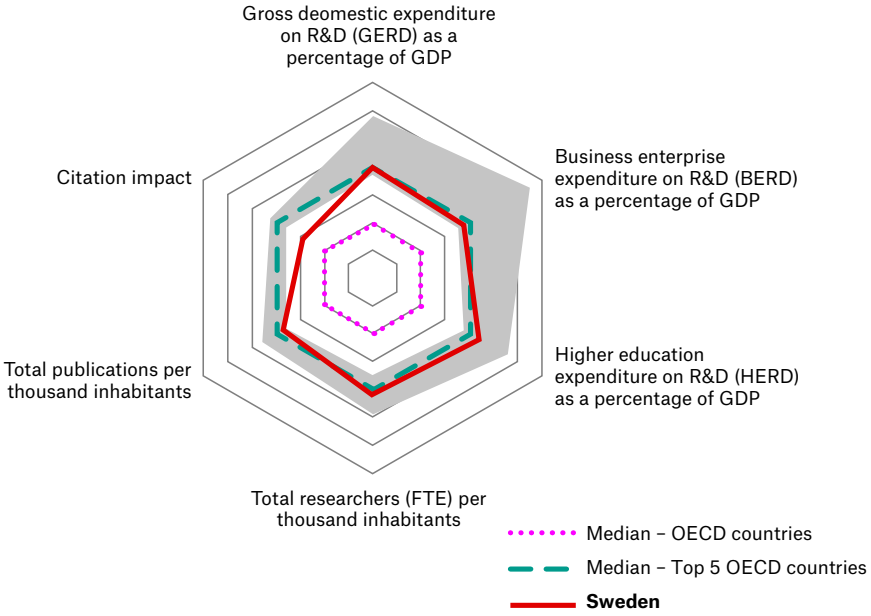

Figure 1. The Swedish research system in international comparison 2019.

Note: Sweden's position is shown in relation to the median value for all OECD countries, and the median value for the top five OECD countries. The figure also contains a grey area, which shows minimum and maximum values for the top five countries[1]. Source: OECD, Clarivate analytics, and UN.

1 The top countries are the five countries with the highest values for each indicator: Total expenditure on R&D as a percentage of GDP (Israel, South Korea, Sweden, Japan and Austria). Business sector expenditure on R&D as a percentage of GDP (Israel, South Korea, Japan, Sweden and USA). Higher education sector expenditure on R&D as a percentage of GDP (Denmark, Sweden, Norway, Austria and Finland). Number of researchers per thousand inhabitants (South Korea, Sweden, Denmark, Finland and Norway). Number of publications per thousand inhabitants (Denmark, Switzerland, Australia, Sweden and Norway). Proportion of frequently cited publications (Switzerland, United Kingdom, the Netherlands, USA and Australia). The indicators are for 2019, which means a drop-out of certain countries for certain indicators.

Swedish research in international comparison

Sweden has long been an internationally prominent research nation, with high R&D intensity and with a citation impact above the world average. The spider diagram in Figure 1 above provides a summarising description of the Swedish R&D system in international comparison. The figure shows six primary indicators from the report, and illustrates both the preconditions for R&D and also the performance of the R&D system. The figure shows Sweden's position (red line), both in relation to the median for all OECD countries (purple line), and also in relation to the median for the top five countries for each indicator (green line). The figure also shows the highest and lowest values for the top five countries (pale grey field).

Sweden is one of the top five countries in the OECD with the highest R&D expenditure as a percentage of GDP, both in total and for the business sector and the higher education sector separately. Sweden is also one of the five countries in the OECD with the highest percentage of researchers in relation to population size. This shows that Sweden has good preconditions for being a prominent research nation.

Sweden is also one of the five countries in the OECD that publishes the highest number of scientific publications in relation to population size. On the other hand, Sweden is not one of the top five countries in terms of citation impact (percentage of frequently cited publications). Here, Sweden is ranked as 13th in the world, with a citation impact above the world average.

This shows that, overall, Sweden is among the foremost countries in terms of preconditions for R&D and number of publications, but that we are not among the foremost in terms of scientific citations. This raises an important question for the Swedish R&D system: how can we have the best preconditions, but still not perform better in terms of impact of research?

Research funding

Total R&D expenditure in Sweden amounted to 171 billion SEK in 2019, which is an increase in relation to previous years. R&D expenditure as a percentage of GDP amounted to 3.4 per cent, and Sweden therefore exceeds the EU's goal of 3-per cent. At the same time, this is lower than the Swedish national goal within the Europe 2020 strategy, where the total R&D expenditure should amount to around 4 per cent of GDP in 2020.

The business sector is responsible for 72 per cent of R&D expenditure in Sweden. The higher education sector is responsible for 24 per cent, while the rest of the public sector is responsible for just under 5 per cent. The business sector's share of total R&D expenditure in Sweden corresponds to that of USA, Switzerland and the OECD as a whole. The R&D systems and business sectors in Finland, Denmark and Norway are structured differently, and the business sector's percentages of R&D expenditure there are smaller.

Around two thirds of the business sector's R&D expenditure consists of development activities. Despite this, the business sector's expenditure on basic and applied research amounted to as much as 28 billion SEK in 2019. This can be compared to the higher education sector, where R&D expenditure amounted to 40 billion SEK[2]. Higher education R&D is funded primarily by the public sector (around 30 billion SEK), private non-profit sector (around 6 billion SEK) and funds from abroad (around 3 billion SEK).

An important funding source for R&D in Sweden is the EU's framework programmes for research and innovation, Horizon 2020 and Horizon Europe. A new feature in this year's Research Barometer is new indicators for Sweden's participation in the framework programmes. Together, the indicators show that Swedish researchers' competitiveness is comparable to that of other researchers in the EU, but that in relation to the size of the Swedish R&D system, there is potential to increase the number of applications for funding, and thereby improve our chances of being awarded more funding.

Research personnel

Sweden is one of the top five countries in the OECD in terms of the number of researchers in relation to population size. The percentage of researchers in the population of Sweden is at roughly the same level as in Norway, Denmark and Finland.

A large proportion of researchers in Sweden work within the business sector. Sweden has a higher percentage of researchers in the business sector than the EU and OECD, but roughly an equal percentage as several comparable countries, such as Norway, Denmark, Finland and the Netherlands.

Over the last ten-year period, research and teaching personnel in the higher education sector have increased by around 6 000 persons to just under 40 000 persons in 2020. The number of employees has increased in practically all employment categories. The employment category that has seen the highest percentage increase is postdocs, while senior lecturers have seen the largest increase in number of persons.

A new feature in this year's Research Barometer is that, for different employment categories, we report the proportion of higher education personnel that have a doctoral degree from a higher education institution (HEI) other than that where they are employed. This is an interesting indicator to monitor, as the mobility of researchers and teachers is thought to make a positive contribution to the quality and originality of research. Statistics have shown that around half of the research and teaching personnel have a doctoral degree from an HEI other than that where they are employed, Swedish or foreign. Having a foreign doctoral degree is, however, much more common among postdocs, associate senior lecturers/research associates and researchers than among professors and senior lecturers.

2 ALF funding not included.

Scientific publication

One way of measuring the impact of research is to measure the number of scientific publications, and how often these are cited. There are, of course, many other ways for research to be recognised and have impact, but these are unfortunately more difficult to measure.

Sweden is one of the five countries in the OECD with the highest percentage of scientific publications in relation to population size. For example, Sweden produces more publications per inhabitant than Norway and Finland, but slightly fewer than Denmark and Switzerland.

A new feature in this year's Research Barometer is data on the percentage of open access publications. The percentage of open access publications is increasing more in Sweden than in both the EU and OECD. Between 2010 and 2019, the percentage of open access publications by Swedish authors has more than doubled.

In terms of citation impact, Sweden is above the world average, but not one of the top five countries in the OECD. The percentage of highly cited publications in Sweden is 11 per cent, which is higher than Norway and Finland for example, but lower than Denmark and the Netherlands.

In the Swedish higher education sector, it is primarily the broad-based established universities and the specialised universities that are responsible for the scientific production. The citation impact for these HEIs have long been above the world average. The new universities and university colleges are responsible for a smaller proportion of the scientific production, and do not in general have as high a citation impact. However, this varies between individual HEIs and over time, as the new universities and university colleges have individual periods with a citation impact above the world average.

Research funding

1. Research funding

This chapter contains a description of expenditure on and funding of R&D. The first section includes a description of the Swedish R&D system in international comparison, and the second section a description of R&D within the Swedish higher education sector.

1.1 Funding of the R&D system in international comparison

Expenditure on R&D

For several years, Sweden has invested considerable resources in research and development (R&D), both in relation to GDP and to our population size. A country's R&D expenditure measures the overall expenditure on R&D carried out within the country over a given period of time. R&D expenditure as a proportion of GDP or in relation to population size is a measure of R&D intensity. Figure 2 shows the R&D intensity for a selection of countries, and that there are great differences between the countries. For some countries, R&D expenditure as a proportion of GDP amounts to 4.5 per cent, while the proportions for the majority are around 1 or 2 per cent.

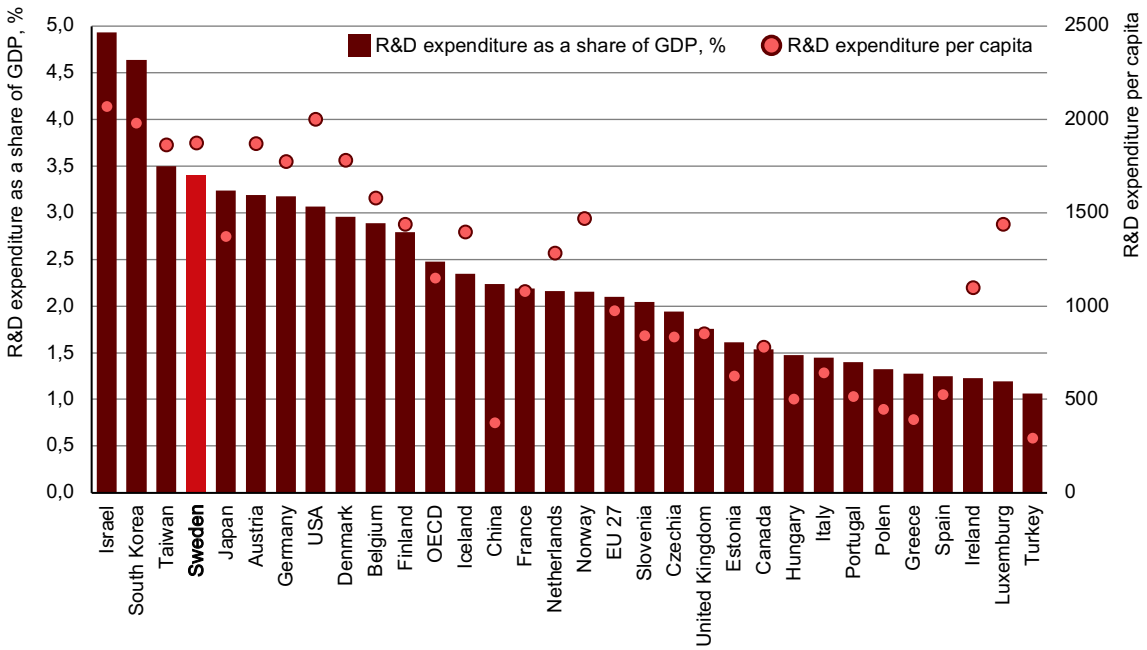

Figure 2. Gross domestic expenditure on R&D (GERD) as a proportion of GDP and R&D expenditure (PPP$) per capita 2019, for a selection of countries. Source: OECD.

Sweden's R&D expenditure as a proportion of GDP amounted to 3.4 per cent in 2019. This means that Sweden has high R&D intensity, and that it is higher than for the EU or OECD as whole, and also higher than for USA, Germany and the United Kingdom, for example.

The EU set a goal for private and public expenditure on R&D to amount to 3-per cent of GDP in 2010. The Swedish national goal for R&D expenditure within the framework for the Europe 2020 strategy is for R&D expenditure to amount to around 4 per cent of GDP in 2020.[3] Overall, this means that Sweden exceeds the EU's goal, while not achieving its own goal linked to the Europe 2020 strategy.

How is R&D defined?

To measure R&D expenditure and to ensure statistics are comparable between countries, the OECD has developed a definition for R&D: Research and development comprise creative work undertaken on a systematic basis in order to increase the stock of knowledge (including knowledge of man, culture and society) and the use of this knowledge to devise new applications.

R&D includes basic research, applied research and development activities. In order for an activity to be classified as R&D, it should be characterised by: (i) Novelty – the purpose of R&D is to create new knowledge and to find new applications for existing knowledge. (ii) Creativity – R&D is based on original concepts and hypotheses. (iii) Uncertainty – the outcome of R&D activities, including economic and personal resources, cannot be securely known in advance. (iv) Systematics – R&D is carried out systematically, and is planned and budgeted for. (v) Transferable and/or reproducible – R&D is intended to lead to results that can potentially be transferred and/or reproduced.[4]

The OECD's definition of R&D is generally accepted and used by Statistics Sweden among others for the statistics on R&D presented later on in this report.[5]

Figure 2 also shows R&D intensity in terms of R&D expenditure per capita. Countries with high R&D expenditure as a proportion of GDP also often have a high proportion of R&D expenditure per capita. Exceptions are, for example, population-heavy countries such as China, which has a lower proportion of R&D

3 Govt. Bill 2020/21:1 Utgiftsområde 16, p 250.
4 OECD (2015). 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.
5 Statistics Sweden (2020). Statistikens framställning – Forskning och utveckling i Sverige. UF0301 2020-10-19.

expenditure per capita than countries such as Luxembourg, even if R&D expenditure as a proportion of GDP is considerably higher for China than for Luxembourg. This shows that it can sometimes be difficult to compare R&D expenditure between countries, and that it is therefore important to consider both these measures together.

Development of R&D expenditure for a selection of countries

As the Research Barometer aims to describe the Swedish research system in international comparison, the selection of countries that Sweden is compared with is important. Figure 2 uses a selection of the countries in the OECD database with the highest R&D expenditure as a proportion of GDP. It is important to compare with a large number of countries in order to analyse patterns, and to give an overall picture. To describe how Sweden compares internationally, it may however often be more interesting to compare with individual countries, and with groups of countries with similar preconditions. In the Research Barometer, Sweden is therefore compared both with the comparison groups EU, OECD and the world, and also with a sample of individual countries that may be classified as "comparable countries", "large established research countries" and "fast-growing research countries" (see the fact box and method appendix for further information).

Figure 3 shows the development of Sweden's R&D expenditure as a proportion of GDP together with the selections of countries listed above. The top diagram in the figure shows Sweden and comparable countries for the period 2010–2019. Sweden has had high R&D intensity with little change over the entire ten-year period, remaining above 3 per cent for the entire time. Among the comparable countries, only Finland and Switzerland have had higher R&D intensity during some of the period.

For 2019, Sweden's R&D intensity was also higher than those of all large established research nations (see the middle diagram). In this comparison, Sweden and Japan have taken turns to have the highest R&D expenditure as a proportion of GDP during the ten-year period. The figure also shows that R&D intensity has increased in Germany and USA, which means that they are now approaching Sweden's level, while R&D intensity has remained more or less constant in France and the United Kingdom.

The bottom diagram shows that South Korea has increased strongly in R&D intensity, and is now above Sweden, while China is still far below. This diagram also shows the development of R&D intensity for the EU and OECD, which have on average been at a considerably lower level than Sweden over the ten-year period.

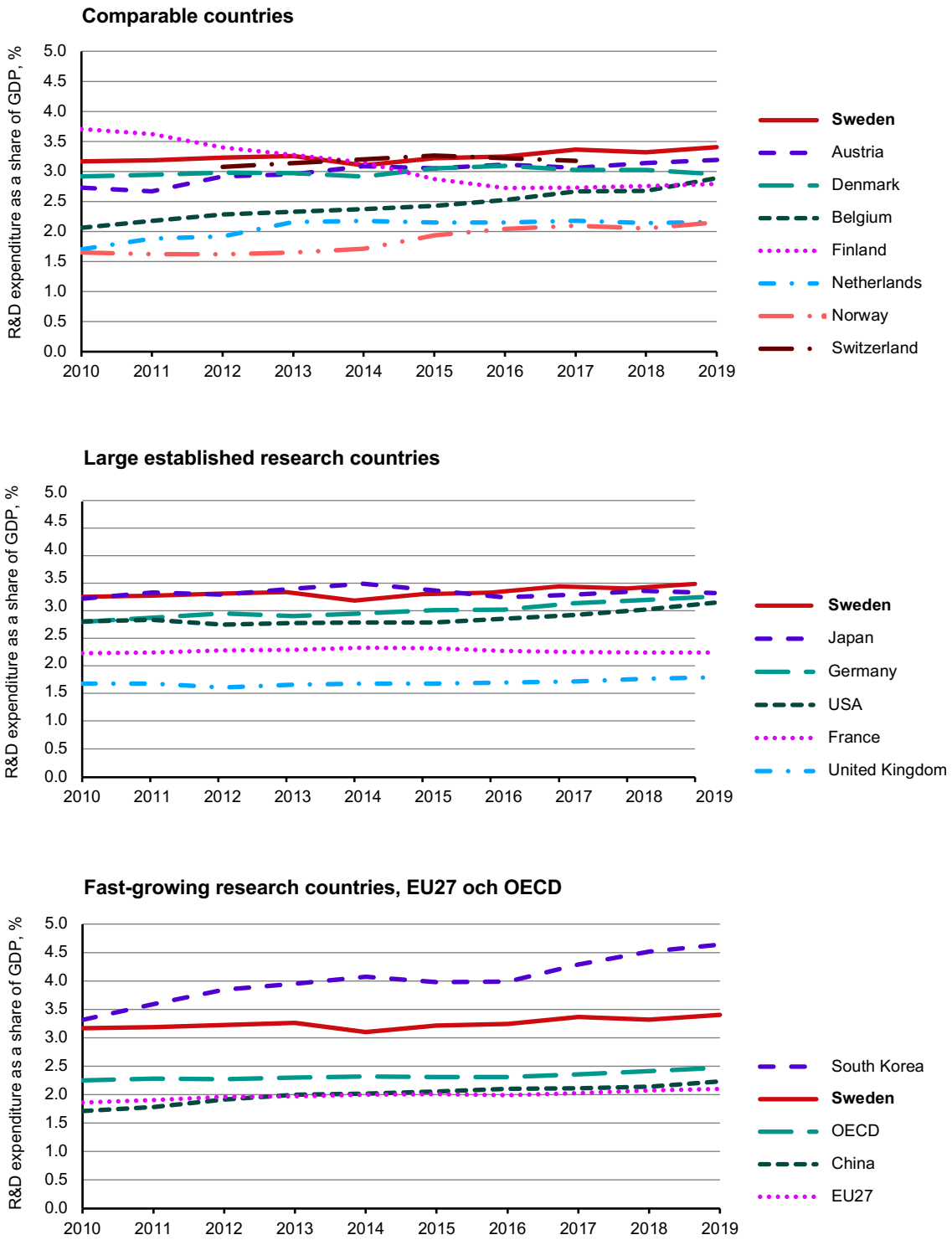

Figure 3. Gross domestic expenditure on R&D (GERD) as a proportion of GDP over time, for a selection of countries, EU27 and OECD

Note: Data for Switzerland is only available for 2012, 2015 and 2017. Source: OECD.

What selection of countries has been used?

The Research Barometer makes international comparisons with the following selection of countries:

- **Comparable countries:** Belgium, Denmark, Finland, Netherlands, Norway, Switzerland, and Austria.
- **Large established research countries:** France, Japan, United Kingdom, Germany, and USA
- **Fast-growing research countries:** China and South Korea
- **Comparison groups:** EU27, OECD and the world.

The comparable countries have preconditions for R&D that are similar to those that apply for Sweden, and are also similar in terms of number of publications in relation to population size and citation impact. The major established research countries are countries that are often perceived as central actors in international comparisons. In the fast-growing research countries, the R&D systems have expanded rapidly over the last ten-year period. The comparison groups EU and OECD are often used, but have also been chosen using available statistics as the starting point. Comparisons with "the world" are only made in relation to scientific publications.

Source of funding and performing sector

R&D expenditure can be described based on the sectors funding the R&D work (source of funding) and based on the sectors carrying out the R&D work (performing sector).

Figure 4 shows how R&D expenditure as a proportion of GDP has developed over time for Sweden and our selected comparison countries. For each year, it also shows how large a proportion has been funded by the government, business sector, foreign sources, higher education sector and private non-profit sector. This figure, like the previous one, shows that Sweden has high R&D intensity compared to other countries. It also shows that several countries have increased their R&D intensity, while Sweden has remained relatively constant.

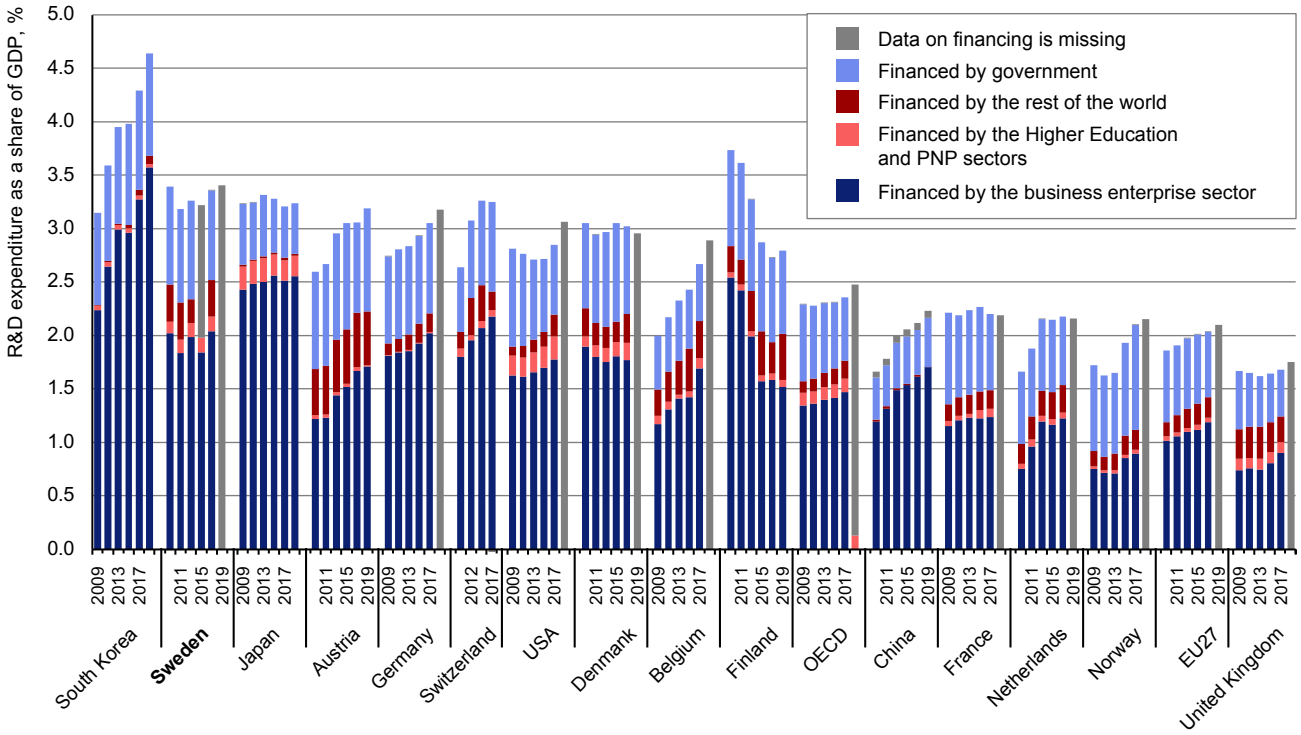

Figure 4. Gross domestic expenditure on R&D (GERD) as a proportion of GDP, divided up by source of funding, for 2009–2019 (every second year).

Note: Switzerland is included for the years 2008, 2012, 2015 and 2017. Source: OECD.

The proportion of R&D expenditure that is funded by the business sector in Sweden amounts to around 60 per cent. The business sector is responsible for a considerable proportion also in all other comparison countries. In several cases, funding from the business sector explains how R&D intensity has developed over time. For example, in South Korea, China, Austria and Belgium, the increase in R&D intensity is largely due to the increase in funding from business. The opposite applies for Finland, where R&D intensity has fallen sharply as a result of a reduction in funding from the business sector.

Figure 4 also shows that there are big differences between countries in terms of the distribution of funding from different sectors. The differences are also shown in Figure 5, which instead of showing funding as a proportion of GDP shows funding from different sectors as a proportion of total funding. The figure has been sorted on the basis of how much funding originates from government. While the proportion of funding from national government for Sweden amounts to 25 per cent, in Norway it is almost 50 per cent. For other countries, the proportion is 20 to 30 per cent, while in Japan it is as little as 14 per cent. Funding from the business sector lies between 40 and 80 per cent, and Sweden's proportion of 61 per cent is in parity with the median. Funding from abroad varies between 5 and 16 per cent, with some few exceptions. For Sweden, funding from abroad represents 10 per cent, which is comparable with the EU as a whole.

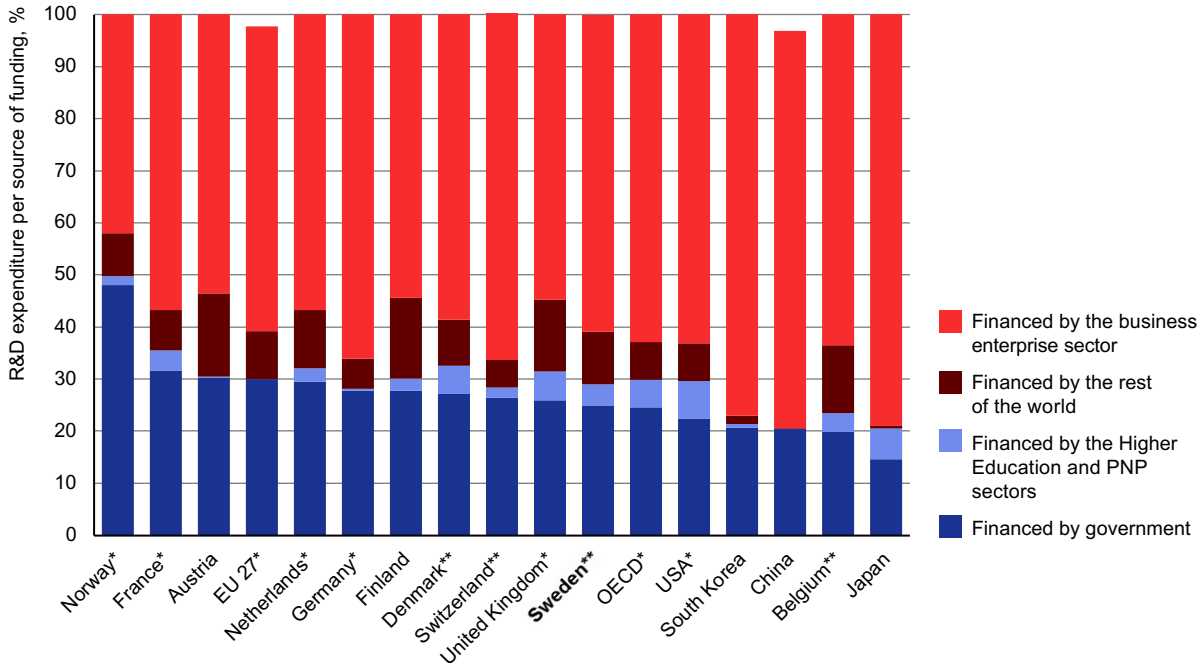

Figure 5. Gross domestic expenditure on R&D (GERD) divided up by source of funding, for 2019 or last available year.

Note: *Values for 2018, **Values for 2017. Values for some countries do not add up to 100%. Source: OECD.

Figure 6 shows R&D expenditure allocated to the performing sectors, that is, how large a proportion of research and development that has been performed by different sectors, sorted according to the higher education sector. Of Sweden's total expenditure for performing R&D, the business sector is responsible for 72-per cent, the higher education sector for 24 per cent, and other government sector for 5 per cent. The business sector is also the sector responsible for the highest proportion of R&D expenditure in our comparison countries. The business sector's share of R&D expenditure in Sweden is equal to that of the OECD as a whole, while it is smaller in Finland, Denmark and Norway, where it is responsible for 66, 63 and 53 per cent respectively.

Another interesting difference between countries is the proportion of R&D expenditure within other government sector. This sector's share of total R&D expenditure varies from 15 per cent in China to 1 per cent in Switzerland. For Sweden, this sector's share amounts to only 5 per cent, which is relatively little in international comparison. These differences reflect the fact that the R&D system is constructed differently in different countries.

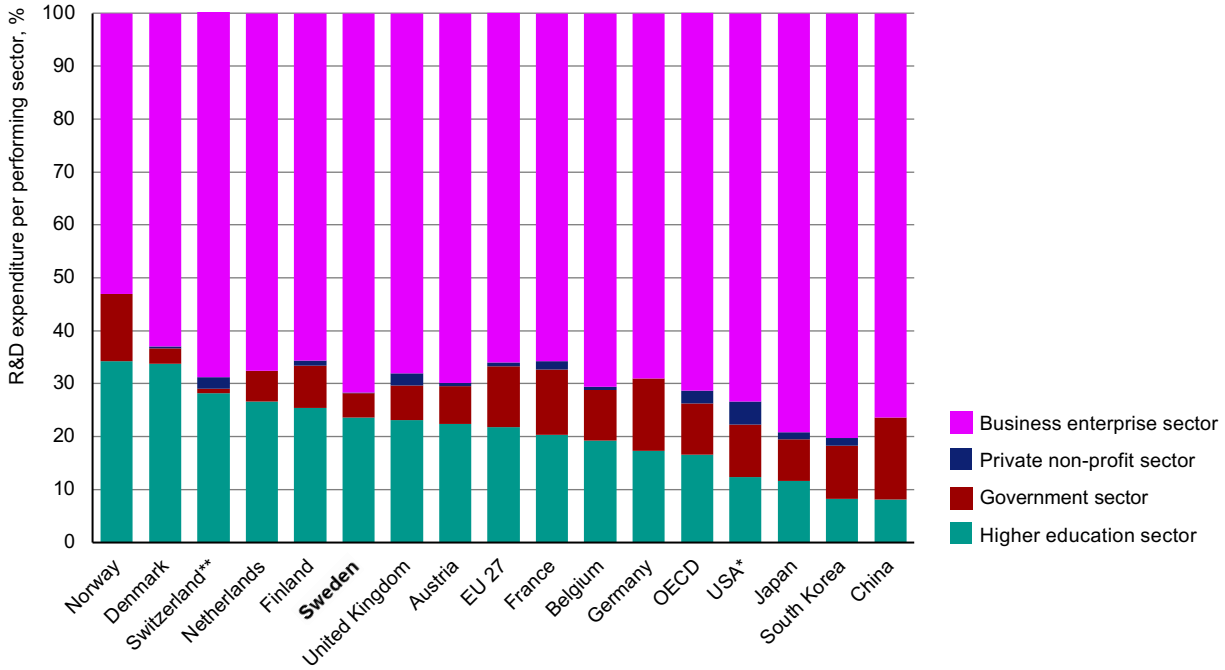

Figure 6. Gross domestic expenditure on R&D (GERD) divided up by performing sector, for 2019 or last available year.

Note: *Values for 2018, **Values for 2017. Source: OECD.

Sweden's participation in Horizon 2020

An important source of funding for Swedish research has been Horizon 2020, the EU's eighth framework programme for research and innovation for the years 2014–2020. Horizon 2020 has now been superseded by Horizon Europe, which is the EU's ninth framework programme, and applies for the years 2021–2027.

Horizon 2020 and Horizon Europe have similar structures, and consist of various pillars and programmes focused on scientific excellence, societal challenges and industrial leadership. Researchers at both higher education institutions and research organisations and in the business sector and government sector take part in the framework programme.[6]

Statistics for the participation by Sweden-based (hereafter called 'Swedish') researchers in Horizon 2020 are interesting to see, as they show how much R&D funding the framework programme has contributed to Swedish R&D, but also show how well Swedish researchers have done in the competition for R&D funding. How well Swedish researchers have done in the competition is, of course, dependent on how much they choose to participate. We therefore use three measures to describe and analyse Swedish participation: relative application rate, relative success, and success rate, see Figure 7.

6 For further information, see Vinnova (2020). Horisont 2020 – årsbok 2019. Vinnova rapport VR 2020:08, or https://www.vinnova.se/m/horisont-europa/ and https://ec.europa.eu/programmes/horizon2020/en

Relative application rate shows the number of applications in relation to the number of researchers in the R&D system. Figure 7 shows that Sweden has a lower relative application rate than both our selection of comparable countries and the EU as a whole.

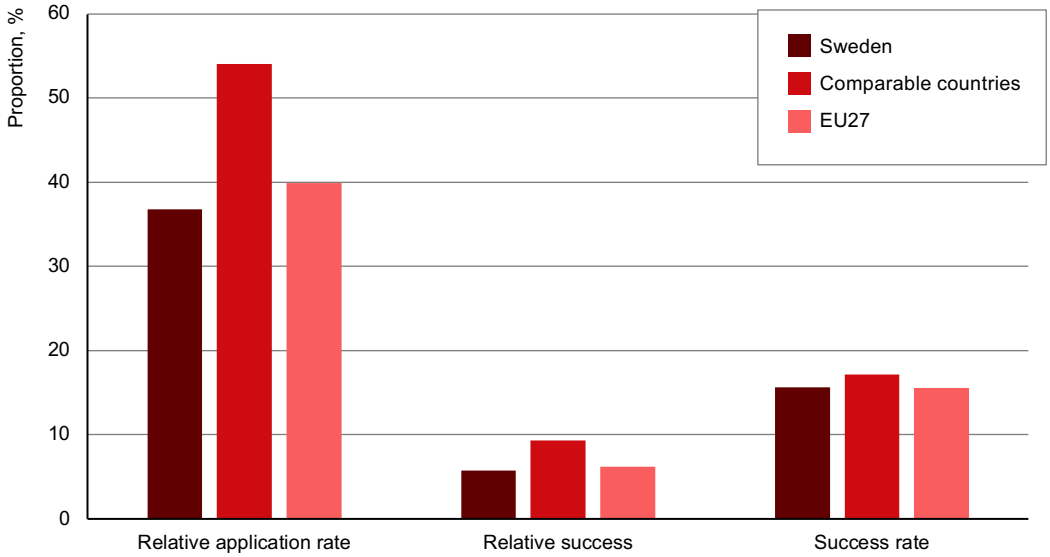

Figure 7. Indicators for Sweden's participation in Horizon 2020. Source: eCORDA and OECD.

Relative success shows the number of approved applications in relation to the number of researchers in the R&D system. Here too, Sweden has a value that is lower than comparable countries, and slightly lower than the EU, even if the differences are small. A low value for relative success compared to other countries indicates that Sweden underperforms when compared to what we should have the potential tos earn, considering the number of researchers in the Swedish R&D system. There is, of course, a connection with the relative application rate: if we do not apply for funding, then we cannot be successful. These two measures are also based on the assumption that the number of researchers in the R&D system is a good approximation for the potential number of applicants.

Success rate shows the number of approved (retained) applications in relation to the number of applications. The success rate therefore measures the competitiveness of Swedish researchers. The success rate for Sweden is in parity with the EU average, but slightly lower than for comparable countries. These three indicators show together that Sweden, in terms of the size of our R&D system, should theoretically expect a higher application rate and a higher proportion of funds awarded, while the competitiveness of Swedish researchers should be regarded as good, as the success rate is in parity with that of the EU as a whole.

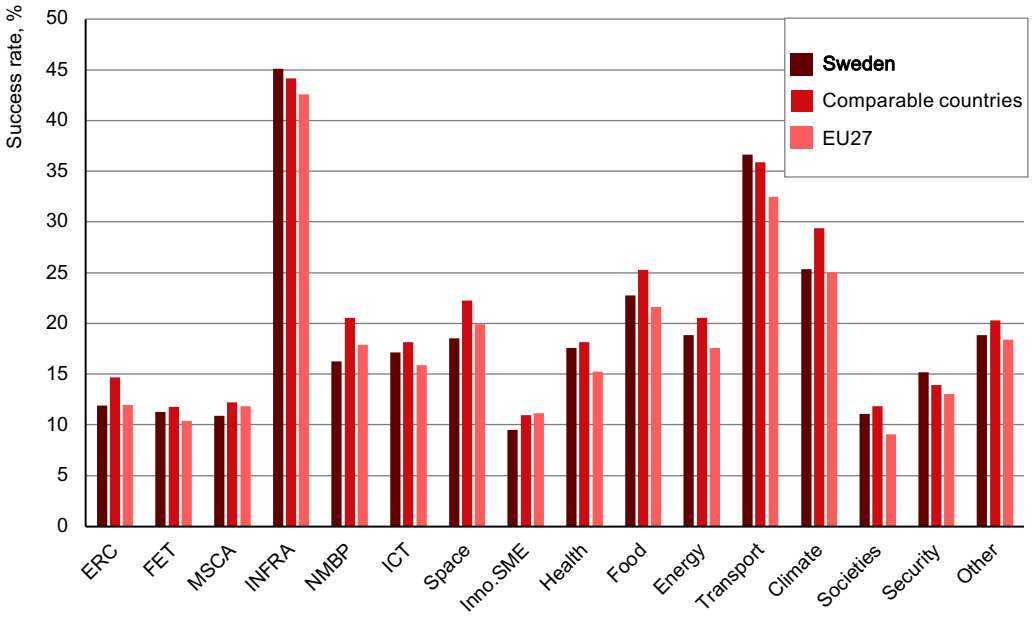

Figure 8. Success rate for the programme units in Horizon 2020, divided up into Sweden, comparable countries, and EU27. Source: eCORDA.[7]

Figure 8 above shows the success rate for the different programmes in Horizon 2020, and here Sweden is compared with the averages for comparable countries and with the EU as a whole. The figure shows that the success rate varies sharply depending on the programme. For example, the success rate for the EU is 43 per cent for Infrastructure (INFRA), but only 12 per cent for the European Research Council (ERC).

Sweden has a higher success rate than the EU for 12 out of 16 programmes, while only having a higher success rate than comparable countries do for 3 of the programmes (INFRA, Transport and Security). This shows, once again, that Swedish researchers do well in the competition compared with the EU, but that we are not as competitive as our comparable countries.

7 Pillar 1 – Scientific excellence: ERC (European Research Council), FET (Future and Existing Technology), MSCA (Marie Skłodowska-Curie Actions) and INFRA (European Research Infrastructure). Pillar 2 – Industrial leadership: NMBP (Nanotechnology, advanced materials, biotechnology, production and process technology), ICT (Information and communication technology), Space (Space) and Inno.SME (Innovation for small and medium-sized enterprises). Pillar 3 – Societal challenges: Health (Health, population development and wellbeing), Food (Food security, sustainable agriculture and forestry, marine and aquatic research, and bioeconomics), Energy (Clean, secure and efficient energy), Transport (Smart, green and integrated transport), Climate (Climate action, environment, resource efficiency, and raw materials), Societies (Europe in a changing world, Inclusive, innovative and reflective societies), Security (Secure societies). Programmes outside the main focuses: Other programmes (Swafs, Widening, and Euratom).

1.2 The R&D system in Sweden

This chapter describes the R&D system in Sweden, the sectors that carry out R&D, and the sources of funding.

Performers and sources of funding of R&D in Sweden

Figure 9 below shows the total R&D expenditure in Sweden in 2019, from the left based on the sectors funding the R&D (sources of funding), and from the right based on the sectors performing R&D (performers). The figure also shows the size of the payment streams between the sources of funding and the performers. The figure thereby gives an overall picture of the funding of the Swedish R&D system.

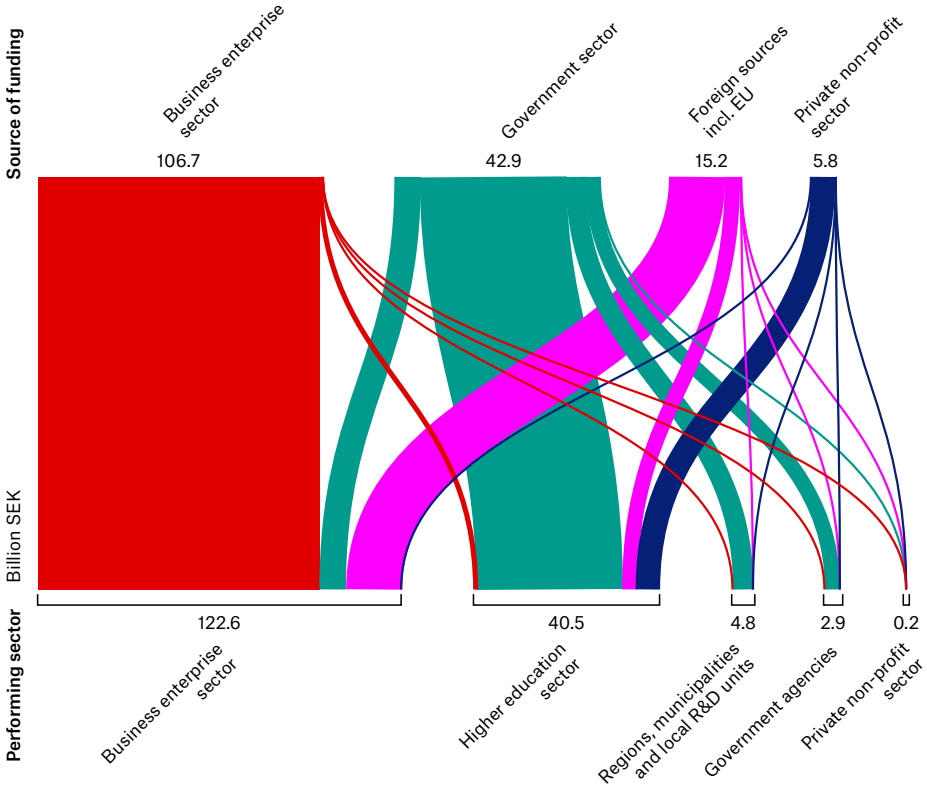

Figure 9. Gross domestic expenditure on R&D (GERD) in Sweden divided up into sources of funding and performers of R&D (billion SEK).

Note: The lines represent the size of the flows from sources of funding to performers of R&D. Due to limitations of the statistics, all R&D expenditures cannot be attributed to one source of funding; therefore, funded R&D in the figure is slightly smaller than performed R&D. The flows to the private non-profit sector as performer are estimated.[8] Source: Statistics Sweden, own calculations.

8 Statistics Sweden does not have data on sources of funding for the private non-profit sector. In the figure, these flows have therefore been estimated by dividing up the funding of the sector's R&D expenditure equally between the business sector, the government sector, sources abroad, and from the private non-profit sector.

Performers

Total expenditure on R&D carried out in Sweden amounted to 171.1 billion SEK for 2019, which is an increase on 2017 of 7.5 billion SEK (2019 constant prices). The business sector was by far the greatest performer of R&D in Sweden. This sector's share of total R&D expenditure amounted to 72 per cent. The higher education sector's share amounted to 24 per cent, while the share of municipalities, regions and R&D units amounted to 3 per cent, government agencies' share to 2 per cent, and private non-profit sector's to 0.1 per cent. (It should also be noted that in this figure, ALF funding is allocated to the regions).

R&D expenditure in the business sector increased by 5 per cent from 116.6 billion SEK to 122.7 billion SEK between 2017 and 2019 (constant prices). Of this, 6 per cent constituted basic research, 17 per cent applied research, and 77-per cent development activities. This means that the business sector's expenditure on performing basic and applied research amounted to 28.2 billion SEK in 2019. The proportion of research in the business sector's R&D has grown ever larger over the last few years.

R&D in the business sector is relatively concentrated into a few industries and companies. Ten companies are responsible for 50 per cent of the expenditure on R&D performed within the business sector, and just over 50 per cent of the business sector's R&D expenditure can be found within information and communication companies, and also in the transport vehicle industry, which includes ships, airplanes and military vehicles.[9]

What is included in R&D expenditure?

R&D expenditure is the total of operating costs for and investments in R&D performed in Sweden during a specific year.

Operating costs for R&D are made up from personnel costs (such as salary costs and payroll tax), premises costs (such as premises rental and maintenance), and other running costs (such as administration, consumables and computer programs).

Investments in R&D are made up from expenditure on assets and equipment. Investments are reported at acquisition value and, for the higher education sector, are divided up into investments in "buildings, land and property", and investments in "machines and equipment".

9 Statistics news from Statistics Sweden 2020-10-15 9.30: "Tio företag utför hälften av näringslivets FoU 2019" https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/forskning/forskning-och-utveckling-i-sverige/pong/statistiknyhet/forskning-och-utveckling-inom-foretagssektorn-2019/

Statistics Sweden's figures for this R&D expenditure are based on a survey, and are collected every second year.[10] R&D statistics differentiate between intramural R&D (performed) and extramural R&D (assignments for others to perform). The Research Barometer only reports the expenditure on intramural R&D. For the higher education sector, R&D revenues is used as an approximation of operating costs for R&D. The source of funding for the higher education sector is reported only for R&D revenues (operating costs).

R&D expenditure within the *higher education sector* amounted to 40.5 billion SEK in 2019. Figure 9 shows the ALF funding as paid to the regions, and not to the higher education sector, to avoid double-counting.[11] If the ALF funding is instead included, then R&D expenditure in the higher education sector amounted to 42.2 billion SEK. R&D expenditure in the higher education sector on basic research, applied research and development activities is not reported separately.

Government agencies excluding higher education institutions (HEIs) had R&D expenditure of 2.9 billion SEK, which amounts to 2.6 per cent of Sweden's overall R&D expenditure. Of this expenditure, 10 per cent was on basic research, 44 per cent on applied research, and 47 per cent on development activities.

Regions and municipalities (including local and regional R&D units) had R&D expenditure of 4.8 billion SEK, which is a decrease of 3.7 per cent since 2017. Of this expenditure, 5 per cent was on basic research, 85 per cent on applied research, and 11 per cent on development activities.

Private non-profit organisations had R&D expenditure of 0.2 billion SEK, which is an increase of 2.3 per cent since 2017. Private non-profit organisations consist mainly of various foundations and charitable organisations. (These figures are not available divided up per source of funding, and therefore we have assumed the expenditure was equal for each source of financing in figure 9.)

10 Statistics Sweden (2020). Statistikens framställning – Forskning och utveckling i Sverige. UF0301 2020-10-19., Statistics Sweden (2021). Forskning och utveckling i Sverige 2019., OECD (2015). 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.

11 ALF is the Swedish abbreviation of "Avtal om läkarutbildning och forskning", and is a national agreement between the government and seven regions relating to their participation in the training of physicians, clinical research and development of health and medical care. ALF funds are paid out by national government to the HEIs, and thereafter to the regions, and forms the government's compensation to the regions within the framework of the agreement. This means that the ALF funding can be found in the R&D statistics both for the higher education sector, and also for the regions, which must be accounted for when describing the total R&D expenditure for the R&D system. According to new rules set by Statistics Sweden, the ALF funding is accounted for by the regions when describing the whole R&D system.

Sources of funding

The largest source of funding of R&D in Sweden in 2019 was the business sector (106.7 billion SEK), followed by the government sector (42.9 billion SEK), foreign sources (15.1 billion SEK) and private non-profit organisations (5.8 billion SEK). (Careful readers will notice that the sum of the R&D funded is not as large as the expenditure on R&D carried out. This is because not all R&D expenditure can be allocated to a source of funding.)

The funding of the *business sector R&D* came mainly from the own sector (86-per cent) and from abroad (10 per cent). 80 per cent of the R&D funding of businesses consisted of in-house funding, that is, from the own company. If funding from companies in the same group in Sweden and abroad is included, then the in-house funding of the business sector amounts to 89 per cent.

Funding of R&D in the *higher education sector* came mainly from the government sector (76 per cent) and thereafter from the private non-profit sector (14 per cent), abroad (8 per cent) and the business sector (3 per cent).[12]

Government agencies received their R&D funding mainly from the government sector (92 per cent), and primarily in the form of direct government grants (1.3 billion SEK). *Regions and municipalities* also received their R&D funding mainly from the government sector (92 per cent), and primarily as in-house funding (2.0 billion SEK) and ALF funding (1.9 billion SEK).

Government budget allocations for R&D

As shown in figure 9, the government is a significant source of R&D funding in Sweden. Figure 10 shows the development of government budget allocations for R&D in the Government's budget for the period 2015–2021, divided up by purpose/socio-economic goal. The figure shows that government appropriations for R&D during the period increased from 36.9 to 42.7 billion SEK, using constant 2021 prices.

The largest increase in R&D appropriations during the period occurred between the years 2020 and 2021, when the R&D appropriations increased by 3.7 billion SEK. This increase was justified by the Government due both to competition between countries intensifying, as several countries are investing heavily in R&D, at the same time as the COVID-19 pandemic risks making it more difficult for private actors to invest in research.[13] The R&D appropriations make up 3.7 per cent of the total Government budget, and 0.8 per cent of GDP. The proportion of R&D funding in the Government budget has remained more or less unchanged since 2015, despite last year's increase.[14]

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12 The source of funding for the higher education sector is usually only reported for operating costs. The flows illustrated in the figure, however, estimate the overall R&D expenditure for the higher education sector (operating costs and investment costs).

13 Govt. Bill 2020/21:1 Utgiftsområde 16, p 261.

14 See Statistiknyhet from Statistics Sweden 2021-04-21 Ökade FoU-anslag till universitet och högskolor under 2021: https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/forskning/statliga-anslag-till-forskning-och-utveckling/pong/statistiknyhet/statliga-anslag-till-forskning-och-utveckling-2021/

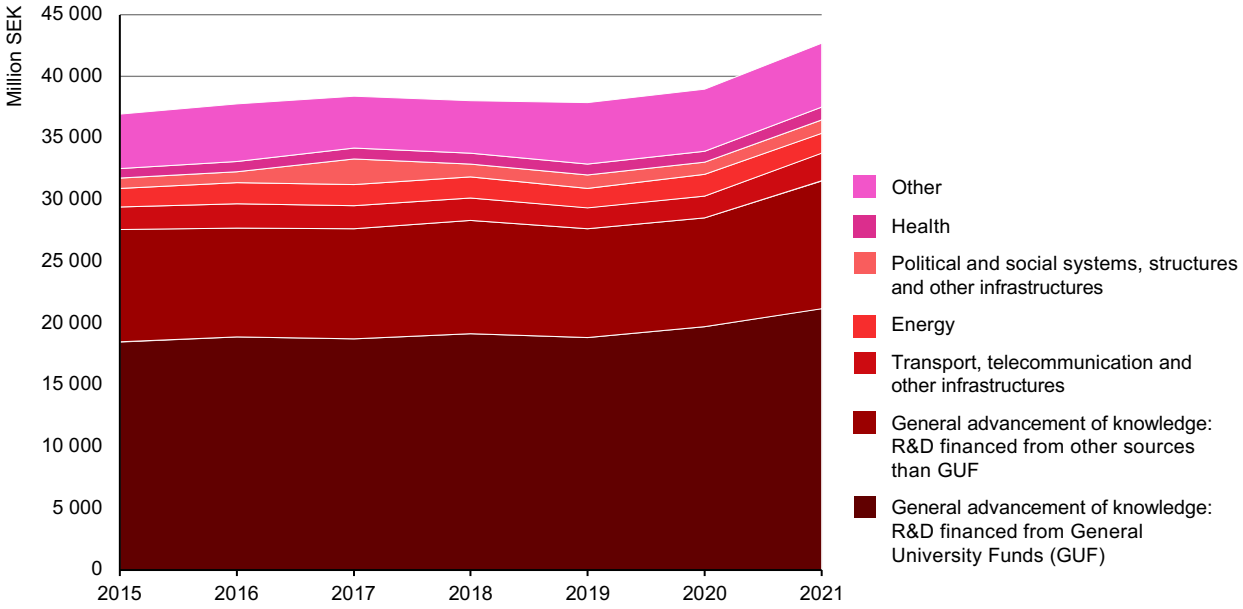

Figure 10. Government budget allocations for R&D during the period 2015–20219, divided up by purpose and goal (2021 prices, million SEK). Source: Statistics Sweden.

Most of the governmental R&D appropriations (74 per cent) are intended to promote general advancement of knowledge through funding of various scientific disciplines. These funds consist in part of governmental R&D appropriations financed from General University Funds (50 per cent) and in part of other funding (24 per cent) that is not aimed directly at HEIs, such as funding to the research councils. The aim of the remaining R&D appropriations (26 per cent) is to promote R&D for various specific purposes, such as energy, or transport and telecommunications.

Over the period, the R&D appropriations for specific purpose have increased the most in percentage terms, while the funding for the general advancement of knowledge has increased the most in money terms. If we look at the development over the last year, it is R&D appropriations for the general advancement of knowledge that have increased the most, both in percentage and money terms.

The specific purposes consist of twelve different categories. In the figure above, only four purposes have been reported separated, while the other eight are summarised in the category "Other".[15] Of these, the greatest increase in R&D grants in money terms during the period has been for "transport, telecommunications and other infrastructure", "Environment" and "Exploration and exploitation of the Earth" respectively.

15 These socio-economic purposes are: (1) Industrial production and technology, (2) Environment, (3) Defence, (4) Agriculture, (3) Exploration and exploitation of the Earth, (6) Exploration and exploration of space, (7) Education, (8) Culture, recreation, religion and mass media.

What is the cost of research infrastructure?

Research infrastructure is used for conducting experiments, making observations, storing data or analysing data, for example. Examples of research infrastructure include facilities, instruments, knowledge corpora and services, aimed at being used by researchers or groups of researchers in basic research or applied research within all areas of research.[16]

Examples of research infrastructure within different research areas are: biobanks and various measuring instruments within medicine and health; laboratories within physics, chemistry, materials sciences, engineering sciences and life sciences; telescopes and other measuring platforms within astronomy, environmental and geosciences; statistics and register data within social sciences; and reality laboratories and language databases within humanities. Research infrastructure can thus take many forms, and the description above is therefore not exhaustive.[17]

Costs for research infrastructure consists of costs for development and purchase, and also running costs, such as maintenance, premises rental and personnel costs. Taken together, this means that it is difficult to estimate the overall magnitude and therefore also the costs of research infrastructure.

The available statistics do not provide a full picture of the costs of research infrastructure. Statistics Sweden's figures for expenditure on R&D are divided up into operating costs and investments at acquisition cost. Within the higher education sector, the investment in machines and equipment amounted to 1.5 billion SEK for 2019, which is 3.6 per cent of the higher education sector's overall R&D expenditure. These figures thereby form part of the expenditure on research infrastructure, but do not include running costs, and therefore do not provide a complete picture. Statistics Sweden's figures for investments have been used, for example, to study changes over time, and as background documentation for a discussion of future needs for investment in research equipment.[18]

16 Govt. Bill 2016/17:50. Kunskap i samverkan – för samhällets utmaningar och stärkt konkurrenskraft, page 46.

17 For more information on different types of infrastructure, see Vetenskapsrådet (2018). Vetenskapsrådets guide till infrastrukturen 2018. Vetenskapsrådet, Stockholm.

18 Vetenskapsrådet (2010). En studie av investeringar i utrustning för forskning vid svenska universitet och högskolor, 1997–2007. Vetenskapsrådet, Stockholm.

1.3 R&D revenues in the higher education sector

Figure 11 below shows the higher education sector's R&D revenue for 2019, divided up by source of funding. The description in this figure differs slightly from Figure 9, as funding from abroad is only reported separately for the EU including ERC, while funding from the business sector and private non-profit section includes funding from both Sweden and abroad.

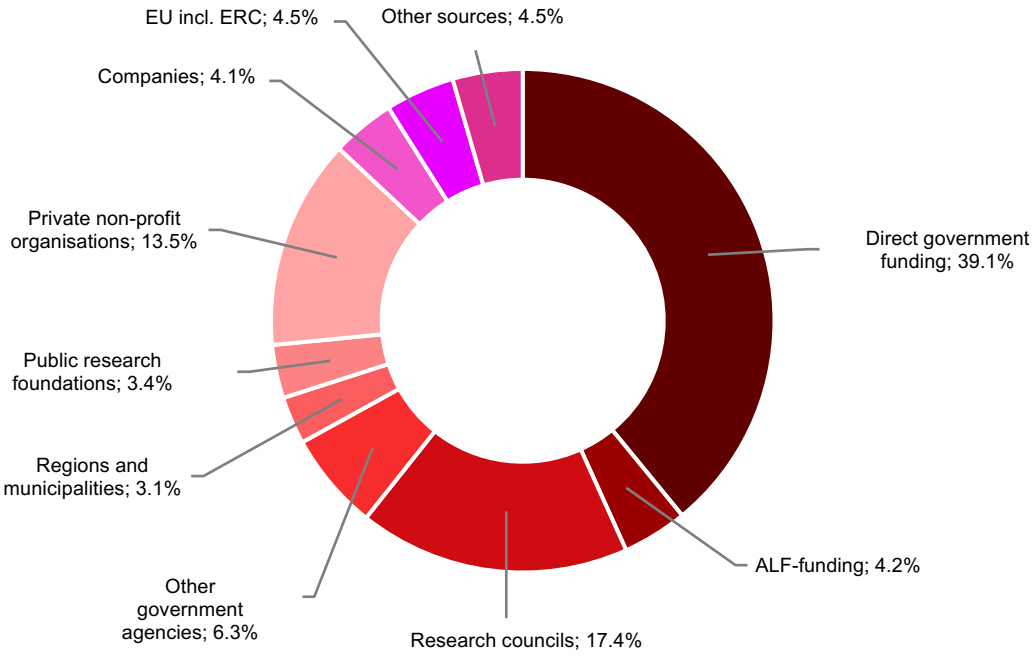

Figure 11. R&D revenues in the higher education sector 2019, by source of funding. Source: Statistics Sweden.

The higher education sector's largest source of funding for R&D in 2019 was direct government funding, that is to say block grants and other government appropriations paid direct by the government to higher education institutions (HEIs). Direct government funding amounted to 15.6 billion SEK, which is 39 per cent of the overall R&D revenues for the higher education sector.

The second largest source of funding for R&D was the governmental research councils (Swedish Research Council, Forte, Formas and Vinnova), which amounted to 6.9 billion SEK, or just over 17 per cent. The largest revenue source among these was the Swedish Research Council, which contributed 4.6 billion SEK, or 11 per cent.

The third largest source of funding was private non-profit organisations, which contributed 5.4 billion SEK, or 14 per cent of overall revenue. This groups consists of sources such as private foundations and trusts in Sweden and

abroad. The private non-profit organisations based in Sweden formed the majority, and were responsible for 4.7 billion SEK.

In total, the public sector was responsible for 73 per cent of R&D revenue, private non-profit for 14 per cent, the business sector for 4 per cent, and the EU for 4 per cent. Funding from other sources amounted to just over 4 per cent, and this includes items such as funding from other HEIs, as well as funding from foundations and trusts administered by the HEIs.

The higher education sector's R&D revenues over time

Figure 12 and figure 13 show the development of the higher education sector's R&D revenues over time. Most sources of funding have been relatively unchanged over time, measured as a proportion of the total R&D revenue. The proportion of overall R&D revenue represented by direct government funding has decreased slightly, from 41 per cent in 2013 to 39 per cent in 2019. At the same time, the proportion from private non-profit organisations has increased from 11 to 14 per cent.

If we look instead at the development in money terms for the years 2013–2019, R&D revenues has increased from nearly all sources of funding (see figure 13). In total, the higher education sector's R&D revenue increased by 3.7 billion SEK during the period (at constant prices). It is primarily R&D revenue from private non-profit organisations that has increased, by 1.6 billion SEK, while direct government funding increased by 0.9 billion SEK and funding from the research councils increased by 0.6 billion SEK. The largest percentage increase is from private non-profit organisations and government research foundations, which increased their funding of R&D at HEIs by 41 per cent and 25 per cent respectively. At the same time, funding from business, regions and municipalities reduced slightly.

If we look at the development between 2017 and 2019, R&D revenue from most funding sources increased. Here too, private non-profit organisations are responsible for the largest increase in money terms. Figure 12 and figure 13 show an interesting interaction. Direct government funding have increased in money terms, but remained relatively unchanged as a proportion of the total R&D revenue. The fact that the proportion has remained unchanged is, of course, explained by the other sources of funding changing over time. It therefore becomes misleading to discuss the size of the direct government funding and other sources of funding, if only the share of the overall funding is taken into account.

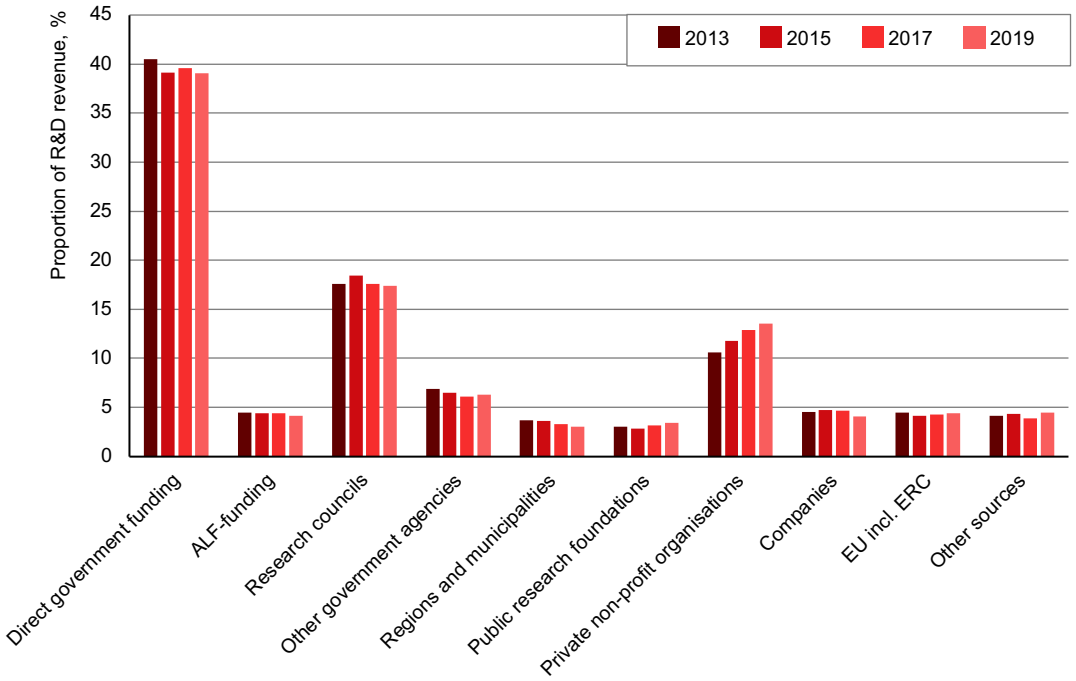

Figure 12. Development of higher education sector's R&D revenue by source of funding (proportion of overall R&D revenue). Source: Statistics Sweden.

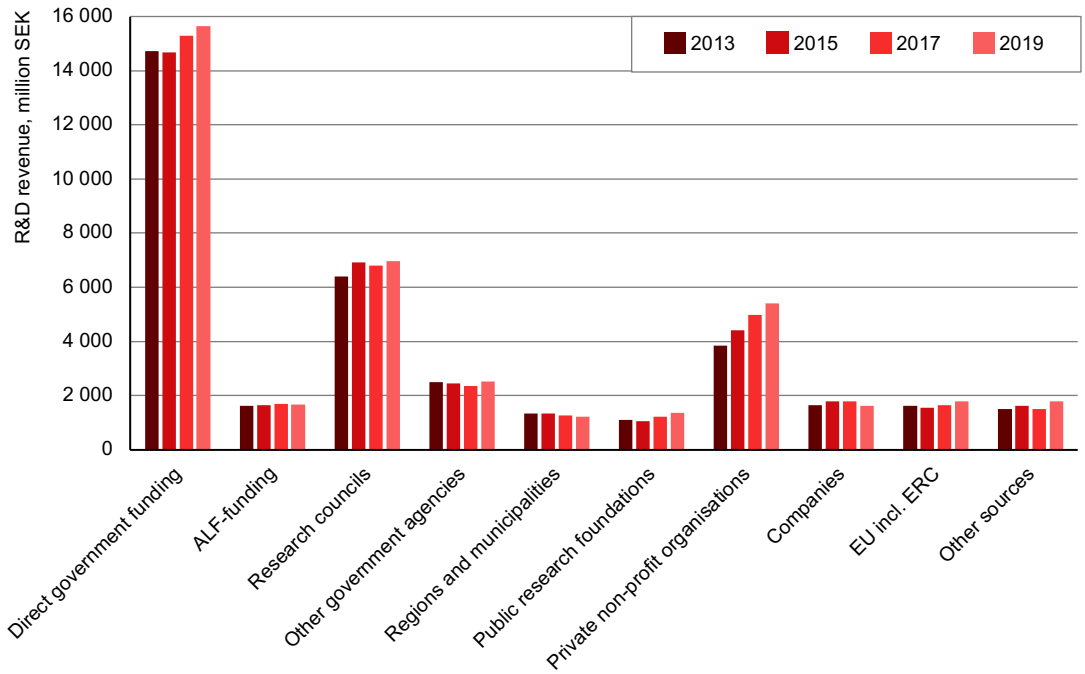

Figure 13. Development of higher education sector's R&D revenue by source of funding (million SEK, constant 2019 prices). Source: Statistics Sweden.

R&D revenues divided up by HEI category

Figure 14 shows how the R&D revenue has developed per HEI category, which provides an overall picture of where in the higher education sector R&D is carried out (see fact box for further information about division into HEI categories).

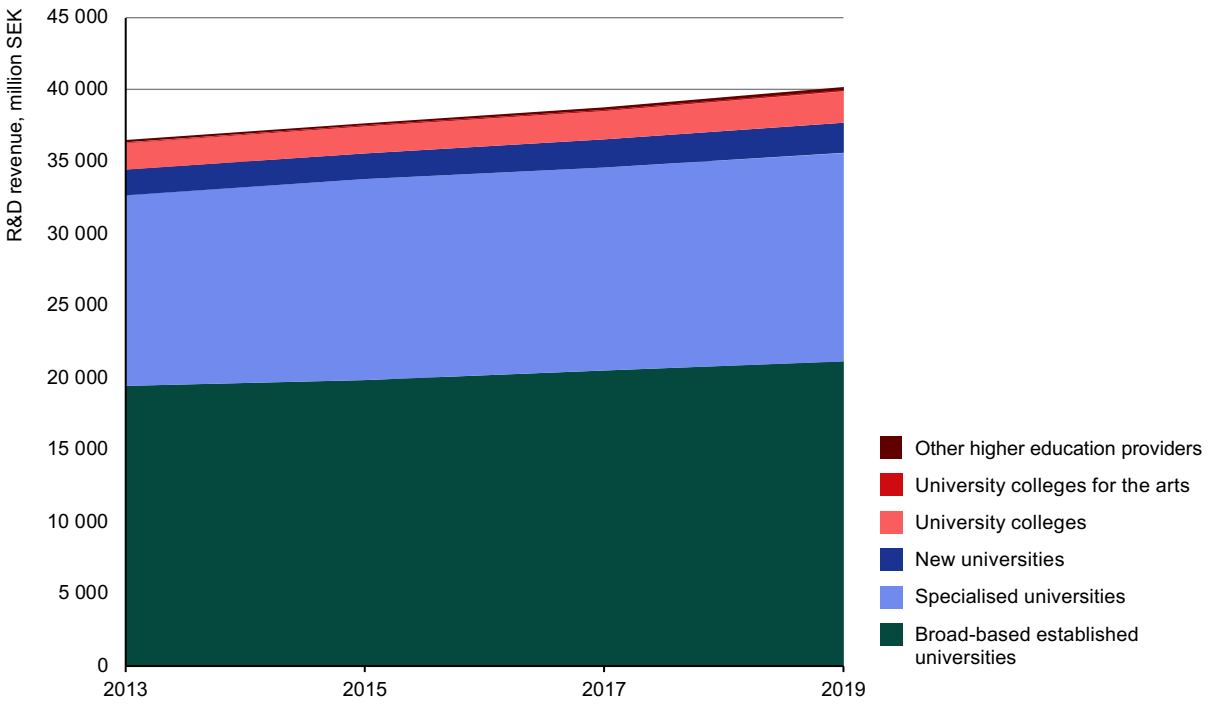

Figure 14. Development of higher education sector's R&D revenue, divided up by HEI category (million SEK, constant 2019 prices). Source: Statistics Sweden.

The higher education sector's R&D revenue primarily goes to the broad-based established universities and the specialised universities. The broad-based universities received 53 per cent of the R&D revenue in 2019, while the specialised universities received 36 per cent. At the same time, new universities and university colleges received 5 per cent each, and university colleges for the arts and other private higher education providers together received just under 1 per cent of the overall R&D revenue.

There are also large differences between individual HEIs within each HEI category. R&D revenue among the broad-based established universities ranges from 2.1 billion SEK to 5.3 billion SEK, while R&D revenue among the new universities ranges from 367 million SEK to 517 million SEK. An HEI in the new universities group therefore received R&D revenue of 421 million SEK on average, while a university college received 167 million SEK on average.

The higher education sector's R&D revenue has increased from 36.5 billion SEK in 2013 to 40.2 billion SEK in 2019 (constant prices).[19] All HEI categories have seen an increase in their R&D revenue during this period. The broad-based established universities and specialised universities saw the largest increase in absolute terms (1.7 billion SEK and 1.2 billion SEK respectively). The largest percentage increase, however, was for university colleges for the arts, where R&D revenue increased by 70 per cent. Most of this increase occurred between 2017 and 2019, when R&D revenue increased from 86 million SEK to 121 million SEK.

What are the different HEI categories?

The higher education institutions (HEIs) have been divided up into different HEI categories An HEI category aims to represent a group of HEIs that share similar characteristics. This does not mean that there cannot also be considerable differences within an HEI category. HEIs are included in the report if the official statistics contains data about R&D expenditure and/or research and teaching personnel.

- **Broad-based established universities:**[20] University of Gothenburg, Linköping University, Lund University, Stockholm University, Umeå University, and Uppsala University.
- **Specialised universities:** Chalmers University of Technology, Stockholm School of Economics, Karolinska Institutet[21], KTH Royal Institute of Technology, Luleå University of Technology, and the Swedish University of Agricultural Sciences.
- **New universities:** Karlstad University, Linnaeus University, Malmö University, Mid Sweden University, and Örebro University[22].

19 R&D expenditure consists of operating costs and investment costs. The operating costs for the higher education sector are the same as R&D revenue. This means that the higher education sector's R&D revenues amounted to 40.2 billion SEK in 2019. The higher education sector's R&D expenditure (including ALF funds) amounted to 42.2 billion SEK, while the higher education sector's R&D expenditure (excluding ALF funds) amounted to 40.5 billion SEK.

20 For indicators relating to publications and citations, this also includes the university hospitals' data for the University of Gothenburg (Sahlgrenska University Hospital), Linköping University (Linköping University Hospital), Lund University (Skåne University Hospital), Umeå University (Norrlands University Hospital), and Uppsala University (Uppsala University Hospital).

21 For indicators relating to publications and citations, this also includes Karolinska University Hospital.

22 For indicators relating to publications and citations, this also includes Örebro University Hospital.

- **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, University West, Mälardalen University, and Södertörn University.
- **University colleges for the arts:** University of Arts, Crafts and Design, Royal Institute of Art, Royal College of Music, and Stockholm University of the Arts.
- **Other private higher education providers:** Beckmans College of Design, University College Stockholm, Erica Foundation, Ersta Sköndal Bräcke University College, Gammelkroppa School of Forestry, Högskolan Evidens, Institute of Space Physics, Johannelund School of Theology, The Newman Institute University College, Swedish Red Cross University College, Högskolan SAPU, Sophiahemmet University, Stockholm University College of Music Education, Swedish Institute for CBT & Schema Therapy, and Örebro School of Theology.

Figure 15 shows the development of the higher education sector's R&D revenue divided up by HEI category and field of research. The figure shows that there are large differences in R&D revenue between different fields of research, and that these differences have remained over time.

Medicine and health sciences was the research field that received the largest R&D revenue, followed by natural sciences, engineering sciences, social sciences, humanities and arts, as well as agricultural and veterinary sciences. Of the higher education sector's overall R&D revenue for 2019, 33 per cent went to medicine and health, 24 per cent to natural sciences, 16 per cent to engineering and technology, 14 per cent to social sciences, 7 per cent to humanities and the arts, and 6 per cent to agricultural and veterinary sciences.

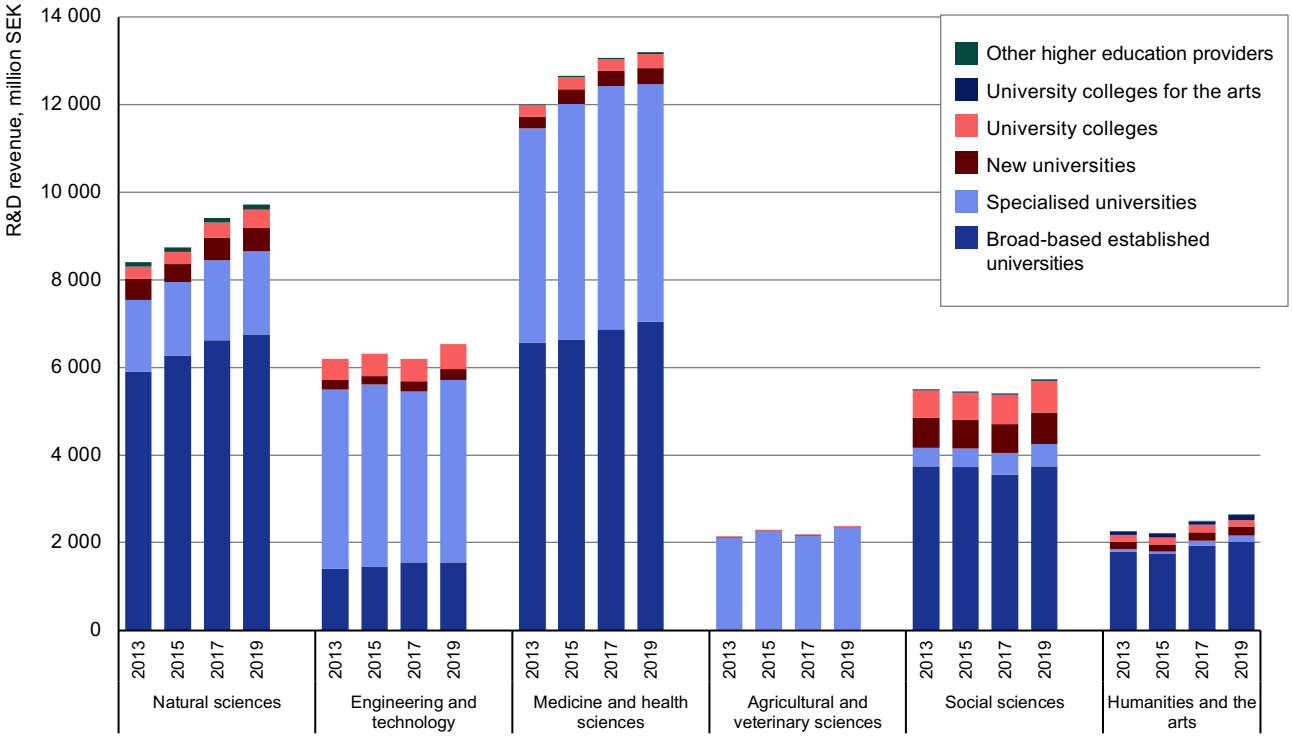

Figure 15. Development of higher education sector's R&D revenue, divided up by field of research and development (FORD) and HEI category (million SEK, constant 2019 prices). Source: Statistics Sweden.

Between 2013 and 2019, the greatest increase in R&D revenue was in natural sciences and medicine and health sciences, where the revenue increased by 1.3 billion SEK and 1.2 billion SEK respectively. The greatest percentage increase was in the humanities and the arts, however, which went from 2.3 billion in 2013 to 2.6 billion in 2019, an increase of 17 per cent. During the latter part of this period, from 2017 to 2019, R&D revenue also increased for all fields or research. R&D revenue increased the most for agricultural and veterinary sciences (an increase of 9 per cent). Medicine and health sciences, which has the largest R&D revenue, increased the least (1 per cent).

Figure 15 also provides an overall picture of what field of research is conducted within the different HEI categories. The broad-based established universities receive a slightly higher proportion of R&D revenue for natural sciences, medicine and health sciences, and social sciences than for other fields of research. As we have seen, the broad-based established universities receive 53 per cent of the higher education sector's total R&D revenue, and they are also the ones that carry out the most R&D in all research fields, apart from engineering sciences and agricultural sciences. In the humanities and the arts, for example, 77 per cent of the R&D revenue is paid to the broad-based established universities.

The specialised universities carry out R&D mainly within medicine and health, engineering sciences, agricultural sciences, and natural sciences. 98 per cent of the R&D revenue in medicine and health for this HEI category was paid to Karolinska Institutet, while 99 per cent of the R&D revenue in agricultural sciences and veterinary medicine was paid to the Swedish University of Agricultural Sciences.

The specialised universities carry out R&D in social sciences and humanities to a lesser extent. In money terms, however, the R&D revenue in social sciences and humanities at the specialised universities is approximately of the same magnitude as at the university colleges.

The new universities and university colleges are carrying out R&D within all fields of research. The new universities receive their largest R&D revenues in social sciences, natural sciences, and medicine and health, while the university colleges receive their largest R&D revenues in social sciences, engineering sciences, and natural sciences.

Research personnel

2. Research personnel

This chapter describes the research and teaching personnel in the R&D system. The first section includes a description of the Swedish R&D system in international comparison, while the second section gives an in-depth picture of the Swedish higher education sector.

2.1 The R&D system's personnel in international comparison

Proportion of researchers in the population

Figure 16 below shows the number of researchers (full time equivalents, FTE) as a proportion of the population in our selection of countries. The figure shows researchers in all sectors of society according to the definition in the Frascati Manual (see fact box). Where data divided by gender is available, this is also shown. This is a new indicator since the Research Barometer 2019, when the indicator 'proportion of researchers (headcount) of the population' was used.

The highest proportion of researchers (FTE) in the population is found in South Korea. This country has also experienced a large increase over the period. Sweden, Denmark, Finland and Norway are also characterised by a high proportion of researchers in the population. These countries came immediately after South Korea among our comparison countries. The proportion of researchers in the population has increased for nearly all countries in our selection.

How are researchers defined in the statistics?

In the Frascati Manual, R&D personnel are divided up into researchers and other R&D personnel, where researchers are defined as professionals engaged in the creation of new knowledge with the help of advanced knowledge and skills. Although these skills may have been acquired through research education, a research degree is not a necessary criterion.[23]

The figure also shows the proportions of women and men who are researchers. Here, the availability of data is less good for certain countries and years, and the indicator is therefore only presented when data is available. The proportion of women among researchers in Sweden is around 27 per cent, which is about the same proportion as in France. The proportion of women is slightly higher in Denmark, but considerably lower in Austria and Germany.

23 OECD (2015). 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.

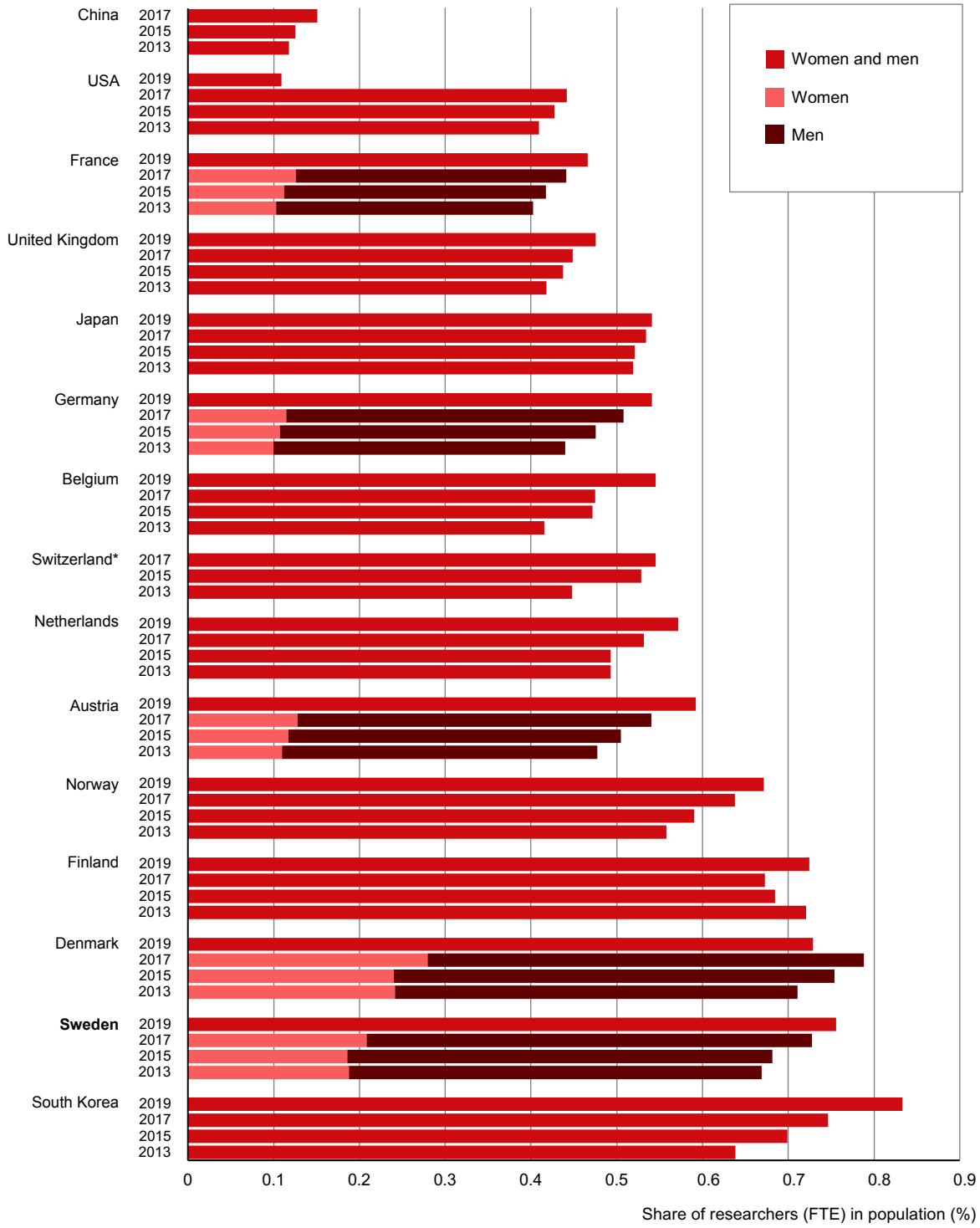

Figure 16. Proportion of the population who are researchers (full time equivalents), over time and divided up into women and men for a selection of countries, latest available years.

Note: Switzerland is included for the years 2012, 2015 and 2017. Source: OECD R&D Statistics.

Figure 17 shows the relationship between R&D expenditure as a proportion of GDP and the number of researchers per thousand inhabitants, for our selection of countries. The sizes of the circles illustrate the magnitude of R&D expenditure in relation to the countries in the figure. The figure shows that the proportion of researchers in the population is related positively with R&D expenditure as a proportion of GDP. The figure also shows that, in our selection of countries, only South Korea has a higher proportion of researchers in its population, and a higher proportion of R&D expenditure in relation to GDP than Sweden.

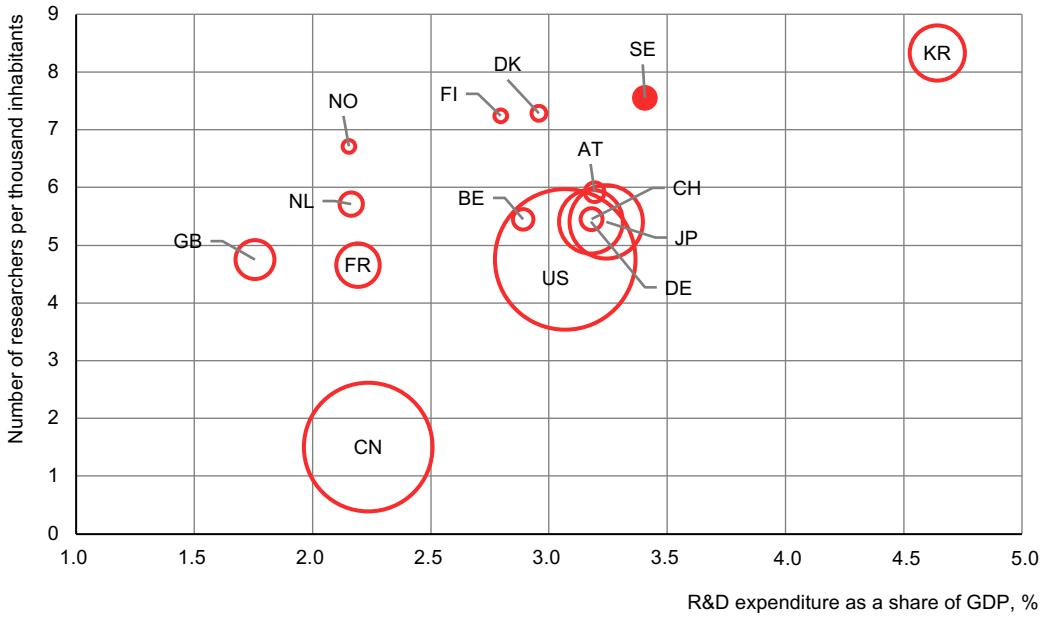

Figure 17. Gross domestic expenditure on R&D (GERD) as a proportion of GDP, in relation to the number of researchers (FTE) per thousand inhabitants, and proportion of R&D expenditure in relation to all countries in the figure (size of circles), 2019.

Note: The key to the country codes can be found in the method appendix. For USA, data on number of researchers refer to 2018. For Switzerland, data refer to 2017. Source: OECD.

Proportion of researchers in different sectors

Figure 18 shows how researchers are distributed between the business sector, government sector and higher education sector. In South Korea and Japan, by far the largest number of researchers are active in the business sector. The United Kingdom and Norway have the lowest proportion of researchers active in the business sector. The higher education sector employs the highest proportion of researchers in the United Kingdom and Switzerland. A high proportion of researchers in the government sector can be found in countries where research is done at governmental research institutes, such as Norway, China and Germany. The changes since the last Research Barometer are fairly small.

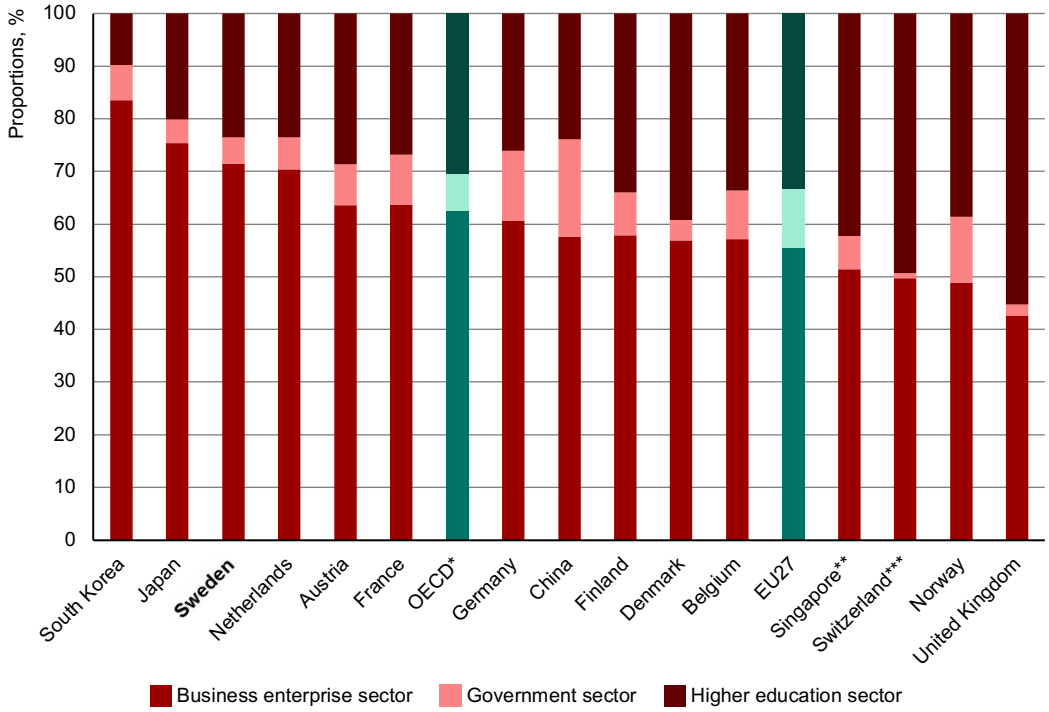

Figure18. Distribution of researchers (full time equivalents) between the business enterprise sector, higher education sector, and other government sector, 2019.

Note: *2016, **2018, ***2017. Source: OECD.

The proportion of researchers in Sweden active in the business sector is 71 per cent. Sweden thereby has a higher proportion of researchers in the business sector than the EU and OECD as a whole, as do most countries in our selection. The high proportion of researchers in the business sector in South Korea, Japan and Sweden reflects the great R&D resources invested in this sector in these countries. Figure 18 shows that South Korea, Sweden and Japan spends the highest proportion of GDP on R&D in the business sector.

2.2 Higher education sector in Sweden

Research and teaching personnel, and doctoral students

The number of higher education personnel has increased by around 6 000 persons over the last ten-year period, and in 2020 amounted to just under 40 000 persons. This corresponds to just over 32 000 work year equivalents (full-time equivalents). The increase has been greatest in agricultural and veterinary sciences, followed by medicine and health sciences. In the humanities and social sciences, personnel numbers have only increased slightly.

Figure 19 shows how the various personnel categories at HEIs with teaching and research tasks and doctoral student employees have developed over the last ten-year period.

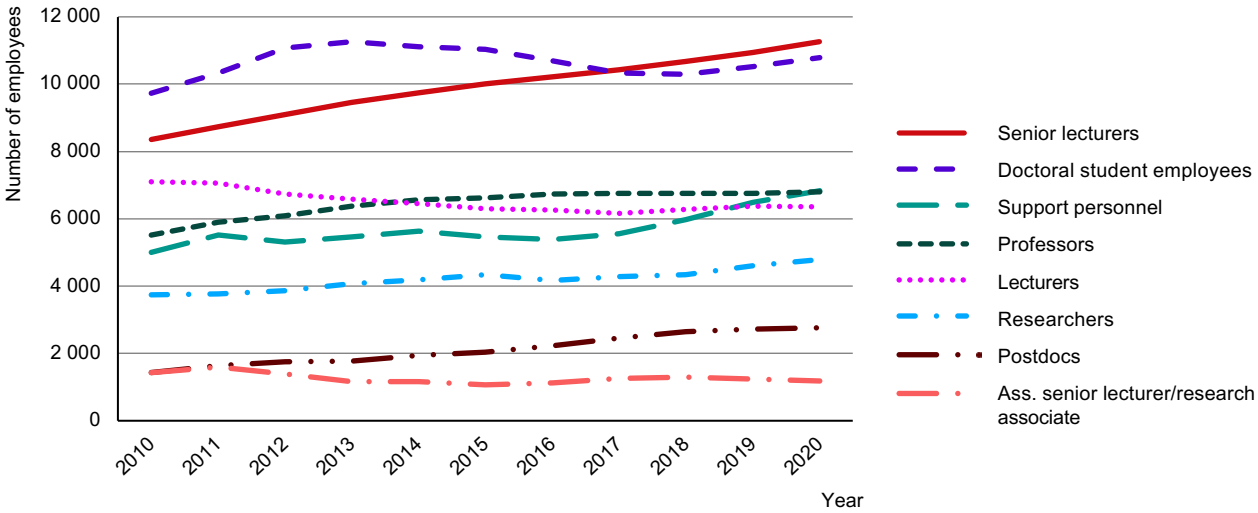

Figure 19. Development of research and teaching personnel as well as doctoral student employees (headcount) during the period 2010–2020. Source: Swedish Higher Education Authority.

The figure shows that the number of employees in the higher education sector has increased in practically all employment categories. Only the categories 'lecturer' and 'associate senior lecturer/research associate' have decreased.

The employment category that has seen the highest percentage increase is 'postdoc'. The employment category 'postdoc' was introduced in 2008, and increased greatly over the first ten years, to then slow down in the last few years. Instead, researcher employment has increased. The employment category 'senior lecturer' is the one that has increased most in terms of number of persons. The number of support personnel, researcher employees and professors has also increased over the period. However, it can be established that the increase in the number of professors in the last few years has been marginal. On the other hand, the number of support personnel has increased considerably, by around 1 500 persons between 2016 and 2020.

The number of doctoral student employees continues to increase, after an earlier reduction. In total, there were just over 17 000 active doctoral students in 2020, of which 11 000 had doctoral student employment. Other earing formats were employment as physician, other employment within or outside higher education, company doctoral student, or subsistence on grants.

Around 37 per cent of the doctoral students were foreign. Foreign doctoral students are persons from other countries who have been admitted to and carry on education at research level in Sweden. They have either been granted a residence permit for studies for less than two years before the doctoral studies

began, or were born abroad and immigrated less than two years before the doctoral studies began (according to Swedish Higher Education Authority's definition). Foreign doctoral students were most common in natural sciences and engineering sciences, where more than half of both the female and male doctoral students came from another country to study at research level.

The largest number of R&D personnel work in medicine and health sciences, followed by social sciences, and thereafter natural sciences. These areas employ approximately the same number of researchers and teachers with doctoral degrees. Agricultural and veterinary sciences is the smallest subject area, in terms of personnel numbers, followed by humanities and the arts, and thereafter engineering sciences.

The employment categories also vary between fields of research. Researcher employments (researchers) varies greatly, from forming almost half of all employees with doctoral degrees in agricultural sciences, to less than ten per cent in social sciences and humanities. In medicine and health sciences, researchers constitute around 25 per cent of all employees with a doctoral degree, in natural sciences around 20 per cent, and in engineering sciences around 15 per cent. The largest number of postdocs are found in medicine and health sciences, and in natural sciences. The increase in the number of postdocs was largest in engineering sciences, however, where numbers have more than quadrupled since 2010.

Research associates and associate senior lecturers form a small proportion of the R&D personnel in all research fields, but the highest proportion can be found in medicine and health sciences, in natural sciences, and in engineering sciences. The proportion of senior lecturers vary greatly between subject areas, and in social sciences and humanities they make up more than 60 per cent of the R&D personnel with doctoral degrees. The lowest proportion of senior lecturers is found in agricultural sciences, where they only make up around 20 per cent, followed by medicine and health sciences (just under 30 per cent), natural sciences (just over 30 per cent) and engineering sciences (around 40 per cent). The proportion of professors also varies, and is highest (around 25 per cent) in medicine and health sciences and engineering sciences, and lowest in agricultural sciences (less than 20 per cent), followed by social sciences (around 20 per cent) and humanities and the arts (just over 20 per cent).

Research and teaching personnel in higher education

Employment in higher education is regulated in the Swedish higher education ordinance, (Högskoleförordningen 1993:100), through agreements between the parties on the labour market or, if otherwise is not stated, in the Swedish employment protection act (Lagen om anställningsskydd 1982:80).

Employment categories regulated in Högskoleförordningen:

- **Professor:** *(Sw. professor.)* Teaching employment; there is also adjunct professor, visiting professor and combined employment with a healthcare principal.
- **Senior lecturer:** *(Sw. lektor.)* Teaching employment; there is also combined employment with a healthcare principal.
- **Associate senior lecturer:** *(Sw. biträdande lektor.)* Four-year career development employment as teacher, with the right to a review for consideration of permanent employment as senior lecturer. Can be achieved within five years of doctoral degree award. Has been subject to several changes, and was previously designated as 'research associate', and then had no right to a review for consideration of permanent employment.
- **Postdoc:** *(Sw. postdoktor.)* Two-year employment, regulated via an agreement between the parties on the labour market. Can be achieved within two years of doctoral degree award.
- **Doctoral student:** *(Sw. doktorandanställd.)* Employment for doctoral students to complete third-cycle education. Not all registered research students are employed as doctoral students. Doctoral student employees are not included in the statistics for teaching and research personnel in higher education.

In addition, there are further employment categories:

- **Other research and teaching personnel with doctoral degrees:** Designated as researcher employments (researchers) in the Research Barometer.
- **Other research and teaching personnel without doctoral degrees:** Designated as 'support personnel' in the Research Barometer.
- **Lecturer:** (*Sw. adjunkt.*) Teachers with or without doctoral degree.

Research and teaching personnel per higher education institution group

Sweden's higher education sector consists of around 40 higher education institutions (HEIs) of varying sizes, varying research field specialisations, and with large variations in the proportions between time spent in research and teaching. In the Research Barometer, the HEIs are divided up into six main groups: broad-based established universities, specialised universities, new universities, university colleges, university colleges for the arts, and other private higher education providers (see the fact box in Section 1.3 for which HEIs are included in the different groups).

Figure 20 shows the composition of the teaching personnel, including employment categories that do not normally require a doctoral degree, such as support personnel and lecturers. The figure also shows the total number of employees that make up the research and teaching personnel in the different HEI groups. In the statistics, doctoral student employees are not included in the research and teaching personnel, and are therefore not included in the figure.

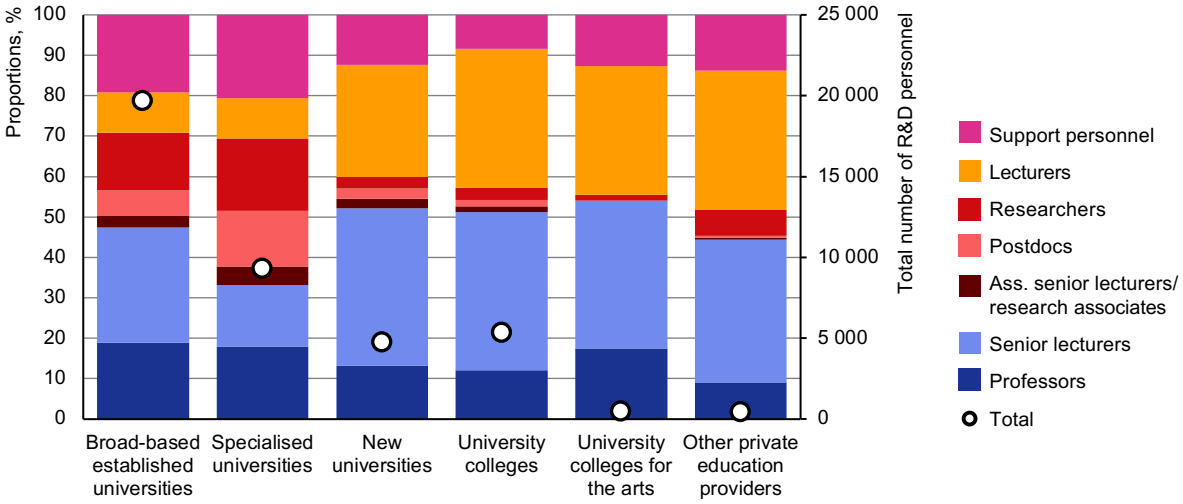

Figure 20. Research and teaching personnel at Swedish HEIs, divided by different HEI groups, year 2020.

Note: The left axis shows the relative distribution between employment categories (bars) and the right axis the number of employees (circles). Source: Swedish Higher Education Authority.

The figure shows that the largest number of research and teaching personnel are employed at the broad-based established universities, followed by the specialised universities, the university colleges and the new universities. At the broad-based established universities, the research and teaching personnel amounted to just under 20 000 persons. At the new universities, the corresponding figure is just under 5 000 persons.

At the broad-based established universities and the specialised universities, around 70 per cent of the personnel are in employment categories that normally require a doctoral degree (that is, professor, senior lecturer, career development positions such as research associate and associate senior lecturer, postdoc and researchers). The corresponding figure at the new universities and higher education colleges is slightly lower, around 60 per cent.

The highest proportion of professors can be found at the broad-based established universities, and at the specialised universities and university colleges for the arts. The highest proportion of senior lecturers is at the new universities and university colleges, while the proportion of postdocs, researchers and associate senior lecturers/research associates is highest at the

broad-based established universities and the specialised universities. Lecturers form a high proportion of the research and teaching personnel at the new universities, university colleges and at the university colleges for the arts, as well as at private education providers.

Women and men in the HEI sector

The Swedish Riksdag has decided that there shall be a goal for gender distribution among newly recruited professors. The Government has set a goal that, by 2030, 50 per cent of all newly recruited professors shall be women.

Figure 21 shows how the proportions of women and men at different career stages have developed over the last ten-year period. The proportion of women and men has remained within the interval of 40–60 per cent for all career stages except professors. The proportion of women among professors increased to 30 per cent by 2020, from having been just over 20 per cent in 2010.

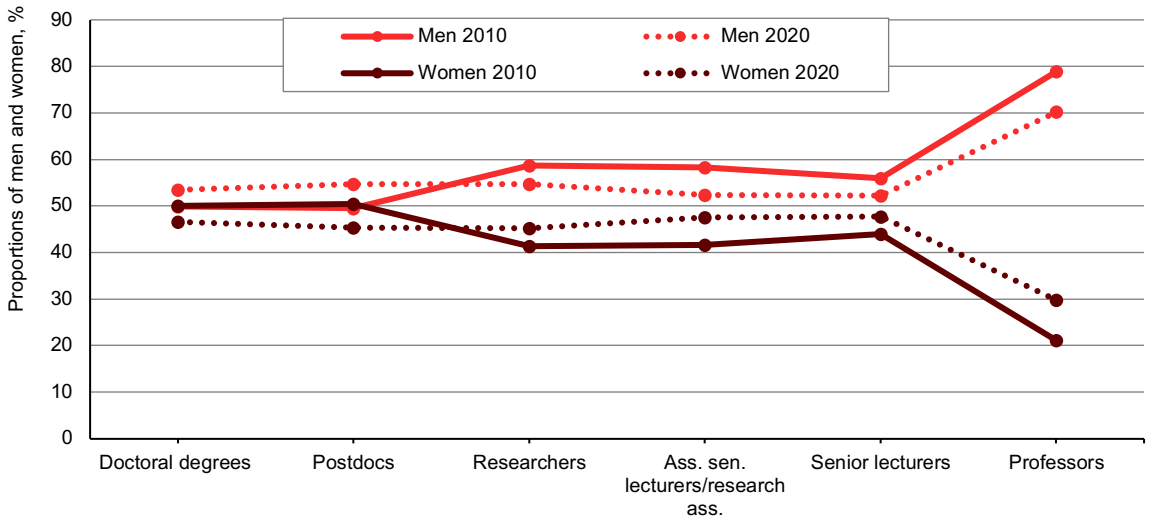

Figure 21. Proportions of women and men among different employment categories, as well as newly awarded doctoral degree holders, 2010 and 2020. Source: Swedish Higher Education Authority.

The report "How gender-equal is higher education?" from the Swedish Research Council discusses possible explanations to why the proportion of women among professors is so low.[24] A partial explanation is that the group that hold professorships is dominated by persons with a doctoral degree that is more than twenty years old; a time when the proportion of women was considerably lower. At the same time, it can be established that the increase in the proportion of women should have been greater, as the proportion of women in the group of doctoral degree holders that professors are recruited from is higher. One of the

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explanations for these observations is that women are often active in research fields that have a low proportion of professors. These are fields that are often characterised by a lot of teaching and little access to research time, which makes it more difficult for researchers and teachers in these fields to gain merit for higher positions.

Figure 22 shows how professors and senior lecturers in the HEI sector are distributed by gender and year of doctoral degree award in five-year intervals.

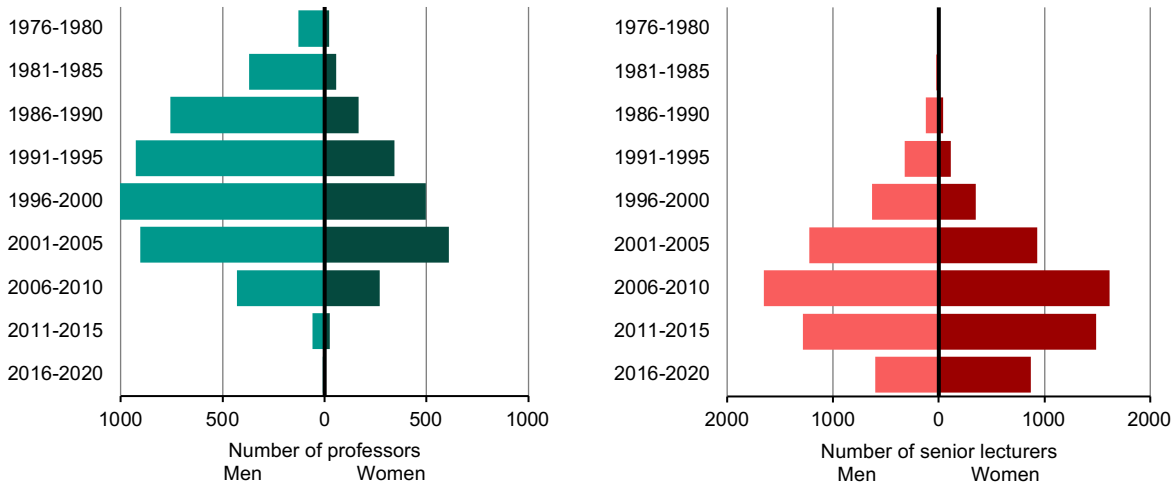

Figure 22. Number of professors and senior lecturers distributed by year of doctoral degree award and gender, 2020.

Note: See the method appendix for further information. Source: Statistics Sweden, own calculations.

The figure shows that men who are professors more often have an older doctoral degree than women who are professors. The gender distribution among professors is uneven for all five-year intervals for year of doctoral degree award. In only one is the distribution almost even, 2001–2005, where women make up 40 per cent and men 60 per cent of all professors.

The majority of the professors, but not all, have been employed as senior lecturers before becoming professors.[25] Among senior lecturers, there are around the same number of women as men. Here too, men as a group are older in career terms than the women. Among those who received their doctoral degrees in 2011 and onwards, women outnumber men slightly.

To create further understanding of the gender distribution among higher education research and teaching personnel with doctoral degrees, Figure shows how men and women are distributed across the different fields of research, employment categories and doctoral degree award years.

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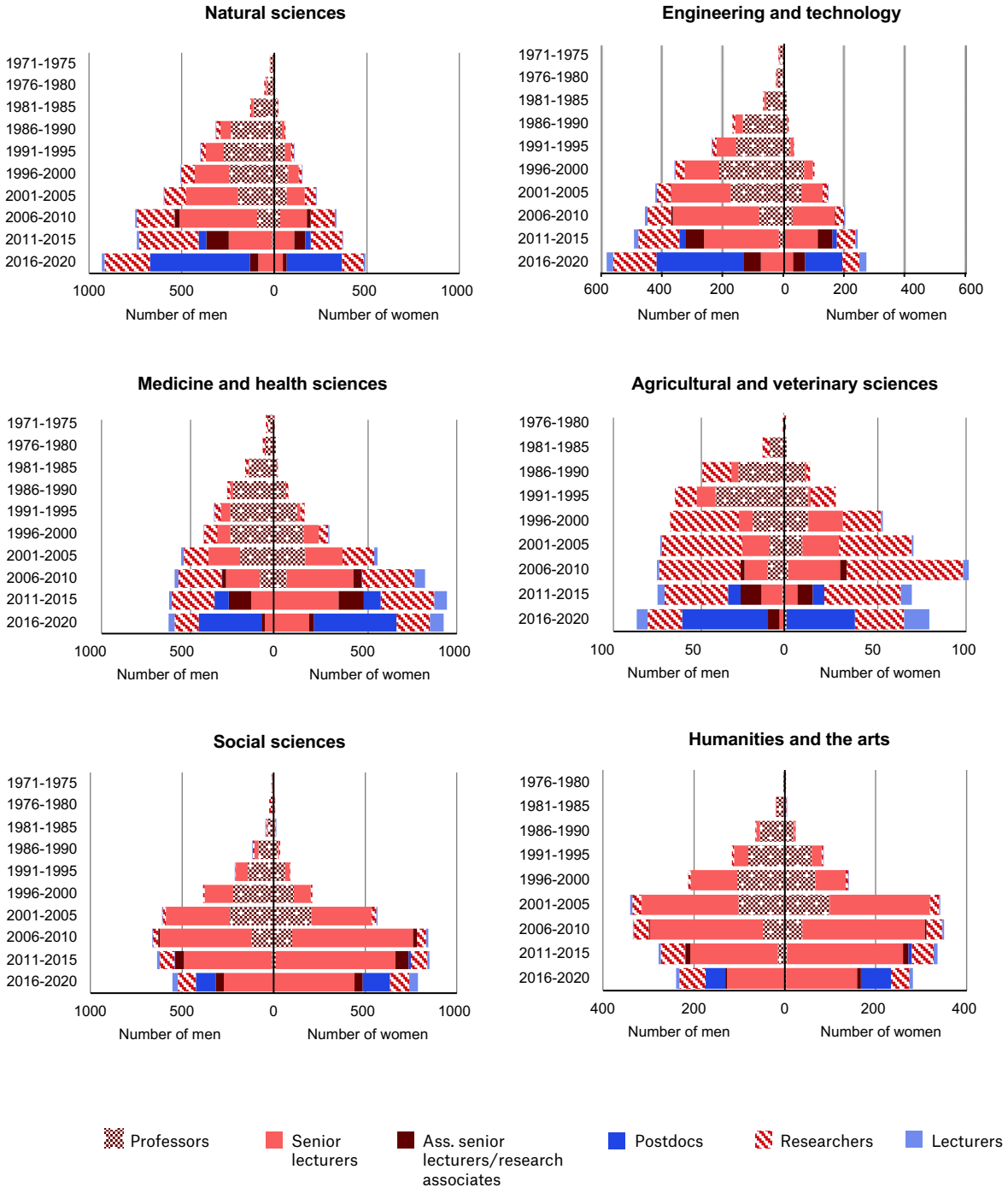


Figure 23. Research and teaching personnel with doctoral degrees, according to doctoral degree award year, employment category, and gender. For different fields of research, 2020.

Note: See the method appendix for further information. Source: Statistics Sweden, own calculations.

The research and teaching personnel with doctoral degrees is not evenly distributed across the various career ages. In natural sciences and engineering sciences, the diagrams are clearly pyramid-shaped, with the largest number of employees in the youngest career age interval. Postdoc is the dominant employment form for these junior researchers. Postdoc is also a common employment form for junior researchers in medicine and health sciences. The high proportion of personnel in these subject areas with relatively low career ages may depend on a number of factors, such as personnel numbers in these subject areas having increased. Furthermore, a relatively high proportion of the postdocs have a foreign doctoral degree, and many of these will continue on to other countries after completing the postdoc period.

In social sciences and in humanities and the arts, the diagrams do not have such a clear pyramid shape. Instead, these fields, most researchers and teachers have doctoral degrees from 2006 to 2010. This is probably due both to the fact that these areas have not expanded as strongly over the last few years, and also that international mobility – measured as a proportion of the personnel with a foreign doctoral degree – is lower than in other fields of research. The number of postdocs is considerably lower among junior researchers and teachers in these subject areas. Instead, senior lecturer is a common employment form, even at low career age (years after being awarded a doctoral degree). This also reflects the fact that teaching forms a proportionally larger part of the activities within social sciences and humanities than within the other research fields.

The figure also shows that the overall gender distribution varies greatly between the different research fields. In natural and engineering sciences, men form the majority in all career ages, even if the proportion of women is higher among those who have a more recent doctoral degree. In other research fields, the gender distribution is even overall. However, there are differences depending on career age. Men are in the majority in the older career age bands, while women are in the majority in the younger career age bands. In medicine and health sciences, women make up more than 60 per cent of all employees with a doctoral degree from 2011 or later. This indicates that, with time, women will form the majority in humanities, social sciences, and medicine and health sciences, provided the current development continues.

Agricultural and veterinary sciences differ from the other fields of research, both because the number of employees is considerably smaller than in the other fields, and also because the number of employees is relatively equally distributed across the different career age groups. Agricultural and veterinary sciences do, however, show a similar pattern to the other subject areas, in that men form the majority in the older career age groups, and then switches so that women form the majority in the younger career age groups.

Use of working hours

On average, research and teaching personnel in higher education spend 47 per cent of their working hours on R&D, just over 23 per cent on teaching at first and second cycle level, 2 per cent on teaching at third cycle level, and the rest of the time on other work, such as administration, various expert and representative assignments, etc. Figure 24 shows how the tasks are distributed for women and men in different employment categories, as well as the total number of R&D work year equivalents carried out by personnel in these categories.

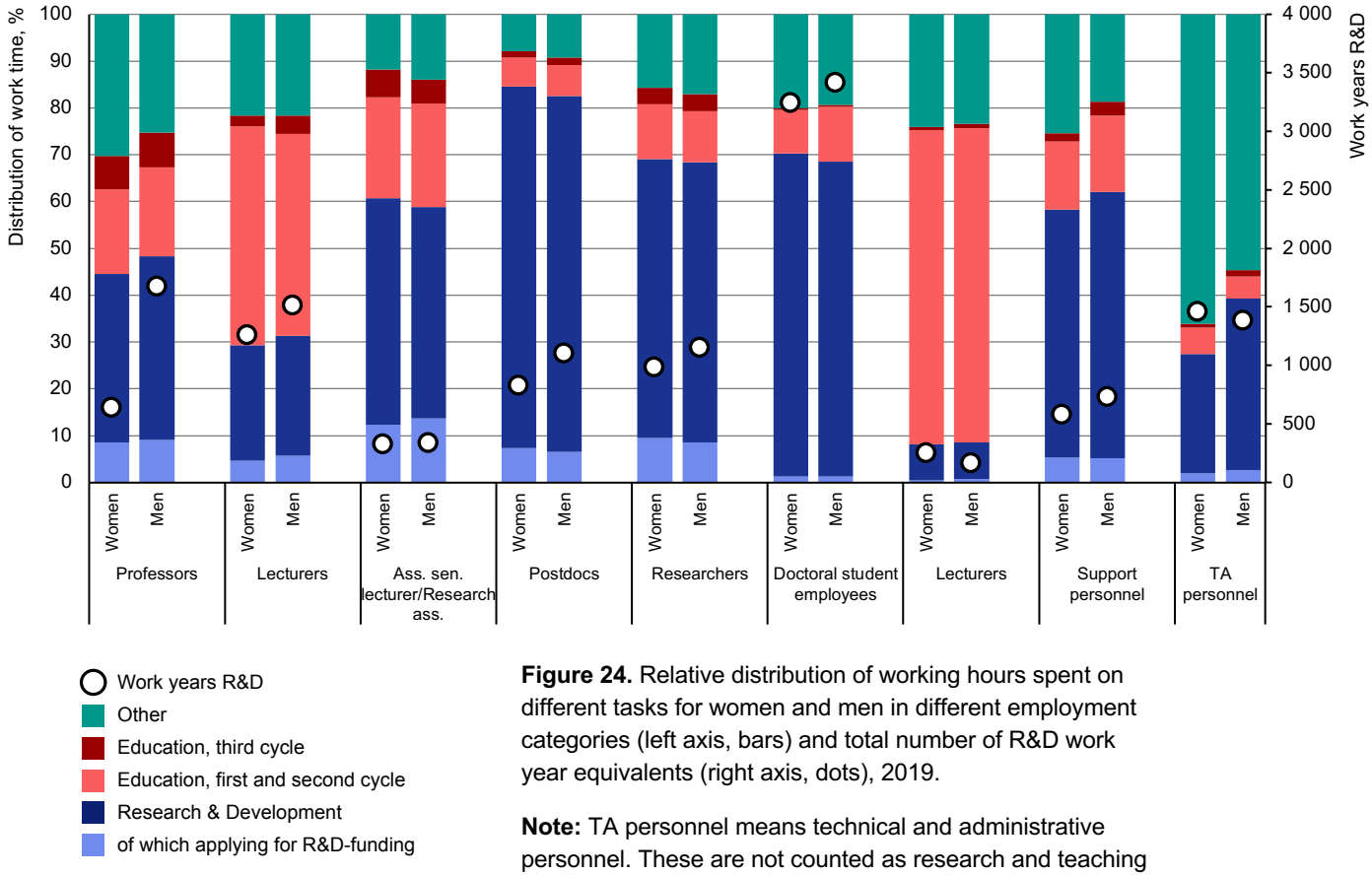


Figure 24. Relative distribution of working hours spent on different tasks for women and men in different employment categories (left axis, bars) and total number of R&D work year equivalents (right axis, dots), 2019.

Note: TA personnel means technical and administrative personnel. These are not counted as research and teaching personnel, and are therefore not included in the other figures relating to personnel in this section. The total working time spent on R&D consists of "R&D" and "of which applying for R&D funding". Source: Statistics Sweden.

The figure shows that postdocs spend the highest proportion of their working hours on research, more than 80 per cent, followed by doctoral students and researchers. Lecturers and senior lecturers spend the highest proportion of their working hours on teaching. The distribution of working hours on different work

tasks is the same for women and men within the employment categories, and approximately the same number of R&D work year equivalents are carried out by women as by men in all employment categories apart from professors, where more than twice as many R&D work year equivalents are carried out by men as by women.

Research and teaching personnel also spend time on applying for R&D funding. Associate senior lecturers/research associates invest the highest proportion of their working hours, around 13 per cent, while professors on average spend around 9 per cent of their working hours on this task.

Internal, national and international recruitment

A lot of research is carried out in international collaboration. By collaborating with researchers from other environments, knowledge and experiences can be woven together, and in this way contribute to improving the quality of the research. It is therefore seemed beneficial that a certain proportion of researchers and teachers leave their own higher education institution (HEI) after obtaining their doctorates, and gain experience from other research environments for a short or longer time.

Figure 25 shows the proportion of research and teaching personnel in higher education whose doctoral degree is from the same HEI as the one they are employed by (same HEI), and the proportion whose doctoral degree is from another HEI.

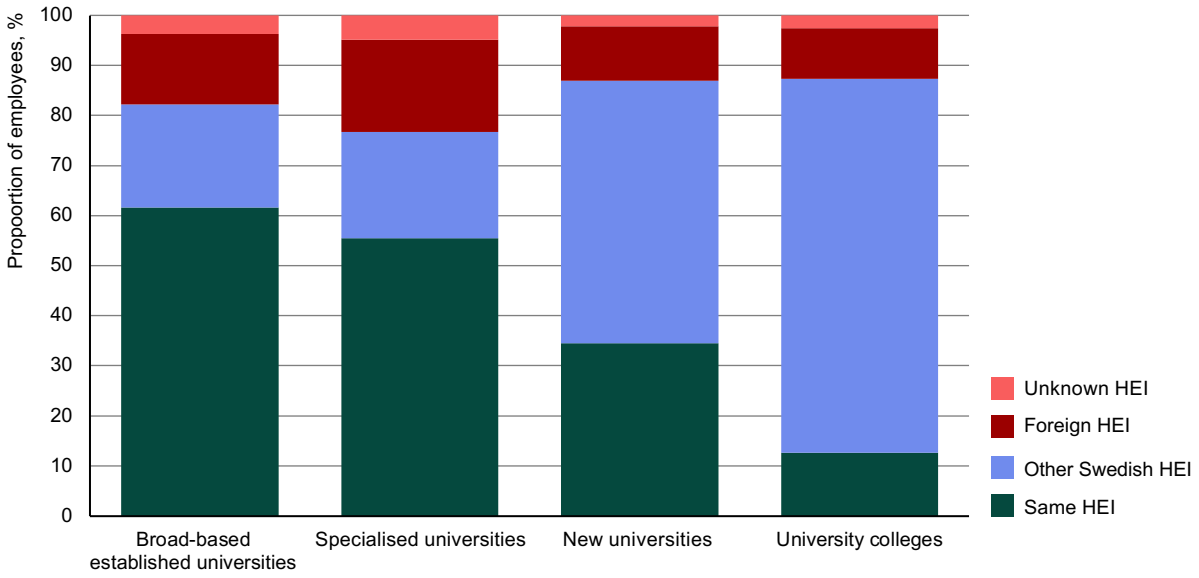


Figure 25. Proportion of higher education personnel with doctoral degrees from the same, another Swedish, or a foreign higher education institution (HEI), per HEI category, 2020. Source: Statistics Sweden.

The figure shows that the highest proportion with a doctoral degree from the same HEI, 62 per cent, is at the broad-based established universities. At the specialised universities, the corresponding proportion is 56 per cent, while at the new universities it is 35 per cent, and only 13 per cent at the university colleges. This is as expected, as the new universities and university colleges do not award as many doctoral degrees, and not within the breadth of research fields that they need to recruit from.

Recruitment of doctoral degree holders from foreign HEIs is highest at the specialised universities, where 23 per cent of the research and teaching personnel have a doctoral degree from another country or an unknown HEI.[26]

The figure below shows the proportion of research and teaching personnel in higher education whose doctoral degree is from the same HEI as the one they are employed by, and the proportion whose doctoral degree is from another HEI, divided up by employment category.

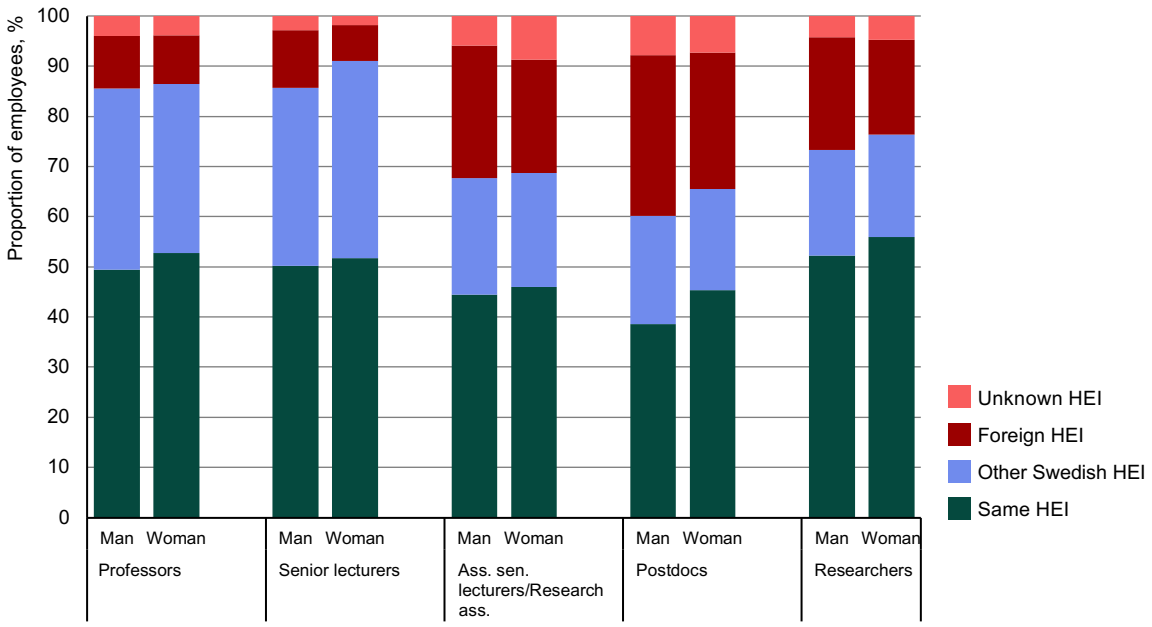


Figure 26. Proportion of higher education personnel with doctoral degrees from the same, another Swedish, or a foreign higher education institution (HEI), per HEI category and gender, 2020. Source: Statistics Sweden.

For the employment categories researchers, senior lecturers, and professors, just over half have a doctoral degree from the same HEI. Professors and senior lecturers are most likely to have been recruited from other Swedish HEIs, at 30–40 per cent, while this is not as common for the other employment categories.

26 Persons with doctoral degrees from an unknown HEI are primarily assumed to have a foreign doctoral degree, and are therefore included in this group.

Around 80 per cent of the research and teaching personnel are therefore recruited from a Swedish HEI, while just under 20 per cent are recruited from a foreign or unknown HEI. (Doctoral degrees from unknown HEIs are probably largely doctoral degrees from a foreign HEI.) Having a foreign doctoral degree is more common among postdocs, associate senior lecturers/research associates and researchers. Among postdocs, 40 per cent of men and 34 per cent of women have doctoral degrees from a foreign or unknown HEI. Among associate senior lecturers/research associates, 32 per cent of women and men have doctoral degrees from a foreign or unknown HEI. Only 14 per cent of professors and 12 per cent of senior lecturers have doctoral degrees from a foreign or unknown HEI.

Scientific publication

3. Scientific publication

This chapter contains a description of scientific publications and their citation impact. The first section describes Swedish scientific publications in international comparison, and the second section describes the Swedish higher education institutions' publications.

3.1 Scientific publications in international comparison

Scientific publication

Figure 27 shows the development of the number of scientific publications, for different continents and for different research areas. The overall number of scientific publications has increased significantly since the early 2000s. Since 2009, the number of publications has increased sharply across all continents, although Asia stands out with the greatest increase in both relative and absolute numbers. From 2009 to 2019, the volume of publications in Asia increased by 139 per cent, which can be compared to publications in Europe and North America, which increased by 30 and 20 per cent respectively over the same period.

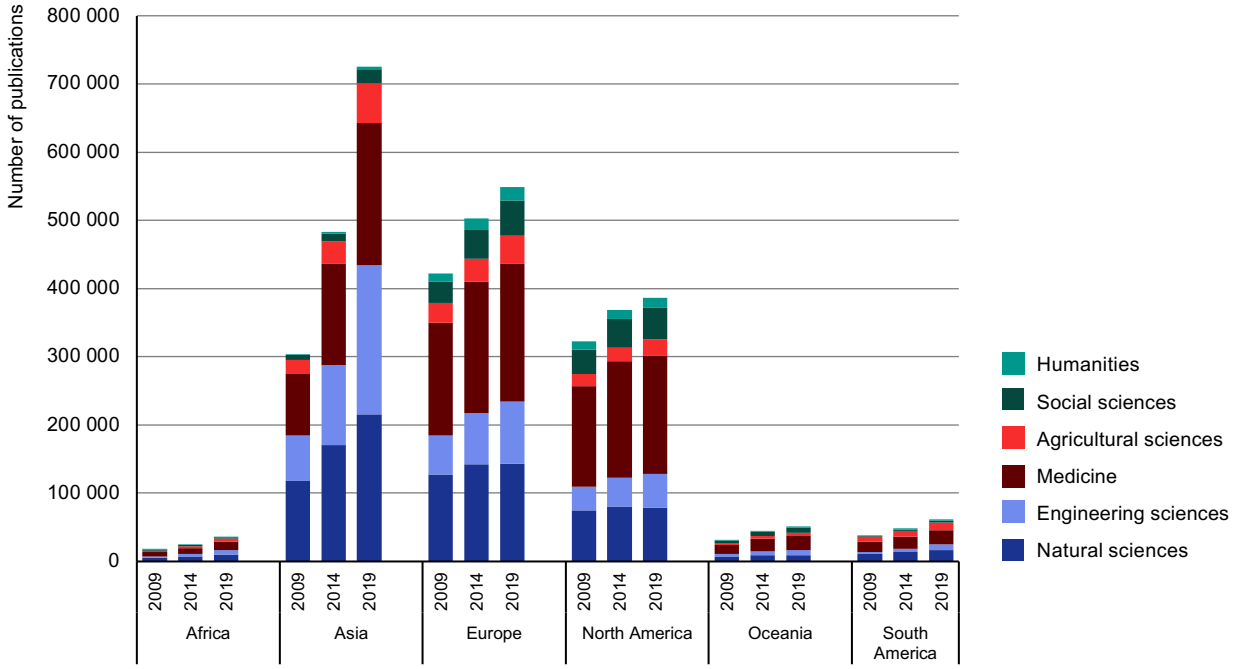


Figure 27. Number of publications per continent, year, and research area. Source: Clarivate Analytics.

Asia, Europe and North America produce around 90 per cent of the total number of scientific publications. Asia was largest in agronomy, natural sciences and engineering sciences in 2019, and has caught up with Europe and North America in medicine. Europe and North America were considerably larger, however, in social sciences and humanities.

When divided up into different research areas, it can be seen that, out of the total number of publications in 2019, medicine represents 35 per cent, natural sciences 26 per cent, and engineering sciences 21 per cent. Social sciences and humanities together represent only 10 per cent, but here it is important to point out that these research areas have poor coverage in the publication database (see the fact box).

How is the number of publications calculated?

The publication statistics are based on data from the Swedish Research Council's publication database, the contents of which correspond to the international publication database Web of Science. The publication database covers around 18 000 international scientific journals. These periodicals are classified into one or several of around 250 subjects, and the individual publications receive the periodical's subject classification. In the Research Barometer, these 250 subjects have been aggregated into two classifications, one with 6 research areas and one with 16 research areas.

The degree of coverage varies between different research areas in the publication database. The coverage is very good for medicine and natural sciences, but considerably weaker for humanities and parts of social sciences. The reason for this is that researchers in humanities and social sciences publish a lot in books and national periodicals, which are not included in the publication database. As the calculations in the Research Barometer are based on the publications included in the publication database, the reliability of the bibliometric indicators varies between research areas.

Publications are identified in the database according to/by author addresses. Unless otherwise is stated, the Research Barometer uses fractional calculation of the number of publications. In fractional calculation, authors A and B are awarded half a publication each, and the author total ends up the same as the actual number of publications. See the method appendix for further description.

Open access to publications

In recent years, the development towards open access has speeded up, due to, among other factors, various national and international initiatives. Open access to publications means that they are made available in digital format, without any

cost to the reader.[27] In both Sweden and the EU, work is in progress to speed up the transition to an open science system. The national guidelines state that scientific publications that are a result of research financed by public funds shall be immediately openly accessible starting from 2021.[28] Open access to publications can be organised in various ways, and the fact box below describes four generally accepted categories.

Categories for open access to publications

- **Gold:** Publication in an openly accessible periodical, where it immediately becomes openly accessible.
- **Hybrid:** Publication in a traditional subscription-based periodical, made immediately openly accessible via a fee paid by the author.
- **Green:** Publication in a traditional subscription-based periodical, made openly accessible by the author by placing a post-print copy of a peer-reviewed publication in a digital archive, known as a 'repository'. This type of open access is also known as 'parallel publication' or 'self-archiving'. Green publication usually involves an embargo, which means that publication in an open archive may only be done after a certain delay.
- **Bronze:** Publication published with open access, but with limitations, relating to licences for use, for example. Bronze is not usually regarded as full open access publication, and in the Research Barometer they have therefore not been included in the category 'fully open access publications'.

27 Read more on the Swedish National Library's website: https://www.kb.se/samverkan-och-utveckling/oppen-tillgang-och-bibsamkonsortiet/oppen-tillgang.html
28 Govt. Bill 2020/21:60, page 101.

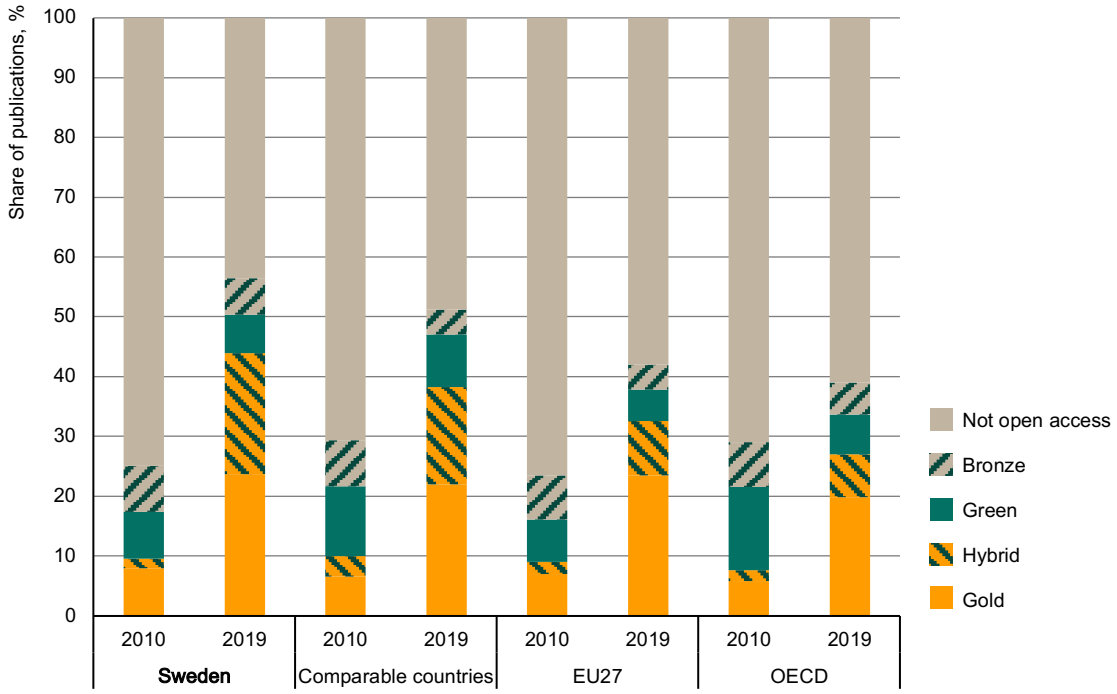


Figure 28. Proportion of open access publications in Sweden, comparable countries, EU27 and OECD, for the years 2010 and 2019.

Note: Gold, hybrid, green and bronze constitute different classifications of openly accessible publications, see the fact box. Source: Clarivate Analytics.

The diagram shows that the proportion of Swedish publications that are openly accessible in some way (excluding bronze) has more than doubled between 2010 and 2019. A similar, but slightly slower, development has occurred in the three comparison groups shown in the diagram. For our sample of comparable countries (see the fact box in Section 1.1), the proportions of openly accessible publications are almost as large as for Sweden, at 47 per cent and 50 per cent respectively. For the EU and OECD, slightly lower proportions apply, 38 per cent and 34 per cent respectively. In all cases, the proportions consisting of hybrid publications (that is, openly accessible because a fee has been paid) have increased the most between 2010 and 2019. For Sweden, these made up almost as large a proportion as publications in the gold category.

Citation impact

The number of publications a country publishes is strongly correlated to the number of inhabitants in the country. Instead of expressing publication volume in absolute terms, it can also be expressed relative to the number of inhabitants, which can also be seen as a form of productivity measure. Figure 29 compares the number of publications per 1 000 inhabitants with the proportion of highly cited publications (where 10 per cent is the world

average). The sizes of the circles illustrate the countries' relative publication volumes. The countries selected are the OECD countries, Singapore and China, and the years are 2017–2019.

During the period 2017–2019, Denmark (DK) published the largest number of publications per inhabitant, closely followed by Switzerland (CH). Australia (AU) takes the third place, and Sweden follows thereafter as the fourth most productive country. Major research countries, such as USA (US), China (CN) and United Kingdom (GB), which produce lost in absolute terms, do less well in such a comparison, while small countries, such as the Nordic countries, Netherlands (NL) and Singapore (SG) have larger production in relative terms.

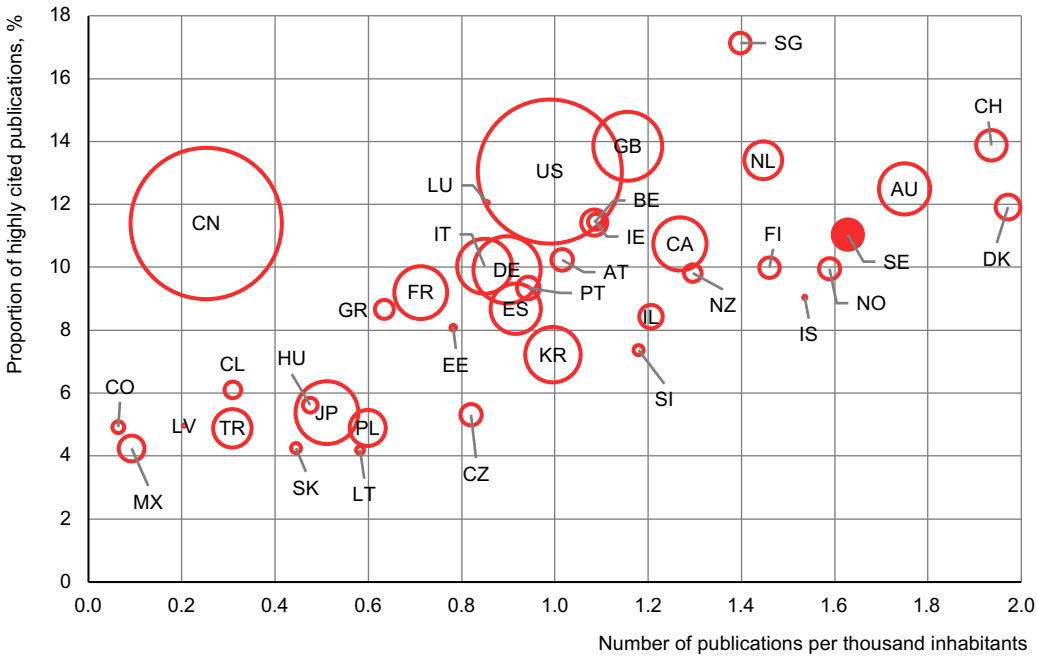


Figure 29. Number of publications per 1 000 inhabitants in relation to the proportion of highly cited publications, and the countries' relative publication volume (sizes of circles), for OECD, Singapore and China, 2017–2019.

Note: The key to the country codes can be found in the appendix. Source: Clarivate Analytics and UN.

In addition to the number of publications per inhabitant, Figure 29 also shows the different countries' proportion of highly cited publications. Countries at the top right are countries with large publication volumes per capita that also have a large citation impact.

How is the proportion of highly cited publications calculated?

The Research Barometer uses the *proportion* of highly cited publications as a measure of citation impact that, contrary to the citation average, is not significantly impacted on by one-off extremely highly cited publications. This measure shows how large a proportion of a continent's, a country's or an organisation's publication volume is in the 10 per cent most cited publications in the world. The global average for this indicator is 10 per cent.

All figures are field-standardised. This means that a highly cited publication is among the 10 per cent most cited scientific publications published *within the same subject* in one specific year. The proportion of publications among the 10 per cent most highly cited is then calculated by dividing the sum of all publication fractions that are among the 10 per cent most cited by the sum of all publication fractions.

The number of citations is counted during a three-year window, which means that the citations are counted as from the year the publication is published and for two years afterwards. Self-citations are excluded. For further details, please see the method appendix.

Figure 30 shows the citation impact during three time periods for Sweden and our selection of countries. The figures in brackets shows each country's placing in terms of highly cited publications among all the countries during the period 2017–2019. Singapore has the highest citation impact, with 17 per cent of its publications among the 10 per cent most highly cited publications. Thereafter follows Switzerland, United Kingdom, Netherlands and USA, with 13–14 per cent of their publication volumes among the 10 per cent most highly cited. Places six to eight are held by Australia, Qatar and Luxembourg (not included in the figure). Qatar and Luxembourg both produce very small numbers of scientific publications, however.

Sweden's proportion of highly cited publications is around 11 per cent for all three periods, and is ranked in 13th place in the world by this measure. Sweden is therefore ranked after Denmark (which has almost 12 per cent), but before the other Nordic countries.

China and Singapore stand out with a large increase in the citation impact during the periods investigated. China has increased its citation impact by 43 per cent, and Singapore its by 33 per cent over a ten-year period. During the same period, USA, Denmark and Japan have seen a negative development of their citation impacts.

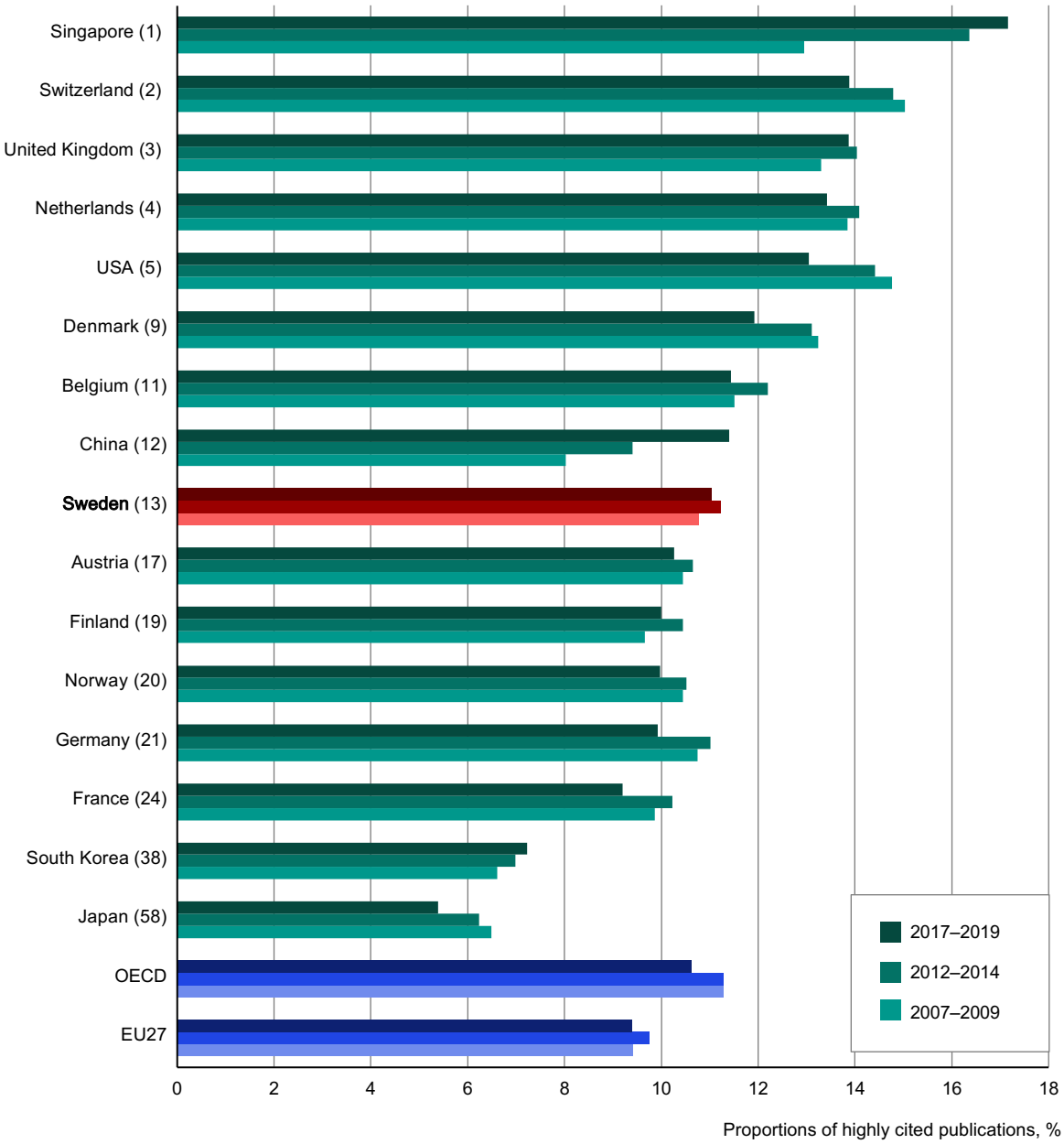


Figure 30. Development of the proportion of highly cited publications for a selection of countries, and the countries' world rankings.

Note: The proportion of highly cited publications is calculated for a three-year period. The figure in brackets shows the country's ranking for 2017–2019. Only countries with more than 300 publications per year are included. Source: Clarivate Analytics.

Figure 31 shows the higher education sector's R&D expenditure as a proportion of GDP, in relation to the proportion of highly cited publications. To take into account the time displacement that exists between research being conducted and

being published, the citation impact is calculated for the period 2017–2019 and the proportion of R&D expenditure for the period 2015–2017. The figure shows that the higher education sector's R&D expenditure in relation to GDP is about the same in Switzerland (CH) and in SE (SWE), but that Switzerland has considerably higher citation impact. The figure also shows that countries such as Singapore (SG), USA (US), United Kingdom (GB), Netherlands (NL) and Australia (AU) all have higher citation impacts than Sweden, while all having lower R&D expenditure in the higher education sector in relation to GDP. The differences in citation impact can therefore not simply be explained by the amount of resources invested in R&D, but probably has more complicated explanations to do with factors such as the organisation and function of the research systems. One such factor is, for example, the size of the higher education sector in relation to the business and institute sectors.

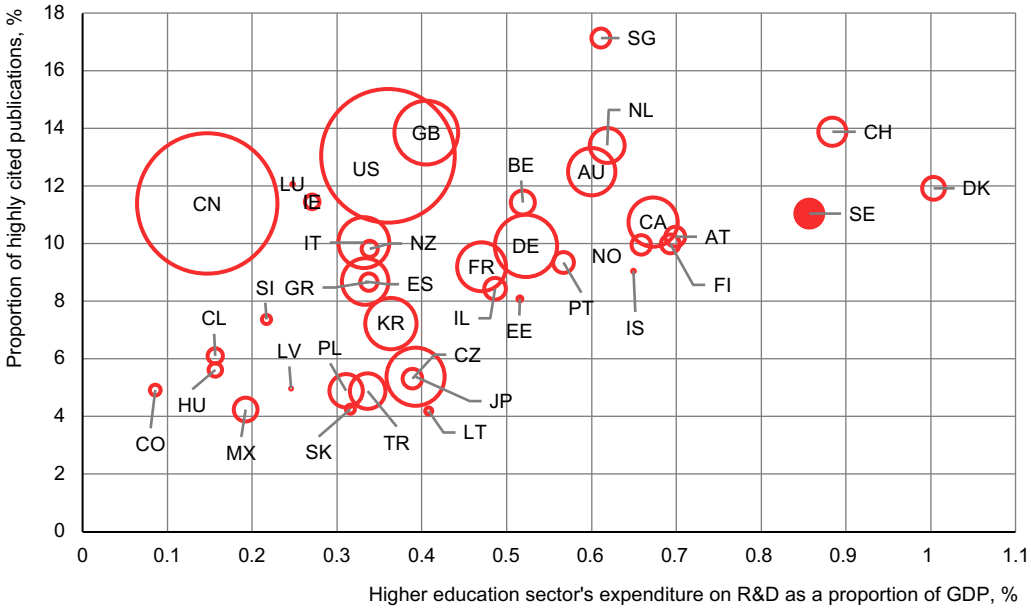


Figure 31. Higher education sector's expenditure on R&D (HERD) as a proportion of GDP 2015–2017, in relation to the proportion of highly cited publications 2017–2019, and the countries' relative scientific production (circle size). Source: Clarivate Analytics and OECD.

Citation impact for different research areas

Figure 32 shows the citation impact for Sweden, EU, and the world, divided up into 16 different research areas. Sweden is above or just under the world average for the majority of research areas. Agronomy and biology, the research areas where Sweden has the greatest impact, are also the research areas where the EU has its greatest citation impact. Sweden is also above the world average in humanities, geosciences, physics, biomedicine, and clinical medicine. Sweden is below the world average, however, in four research areas: health sciences, mathematics, materials science, and computer and information sciences.

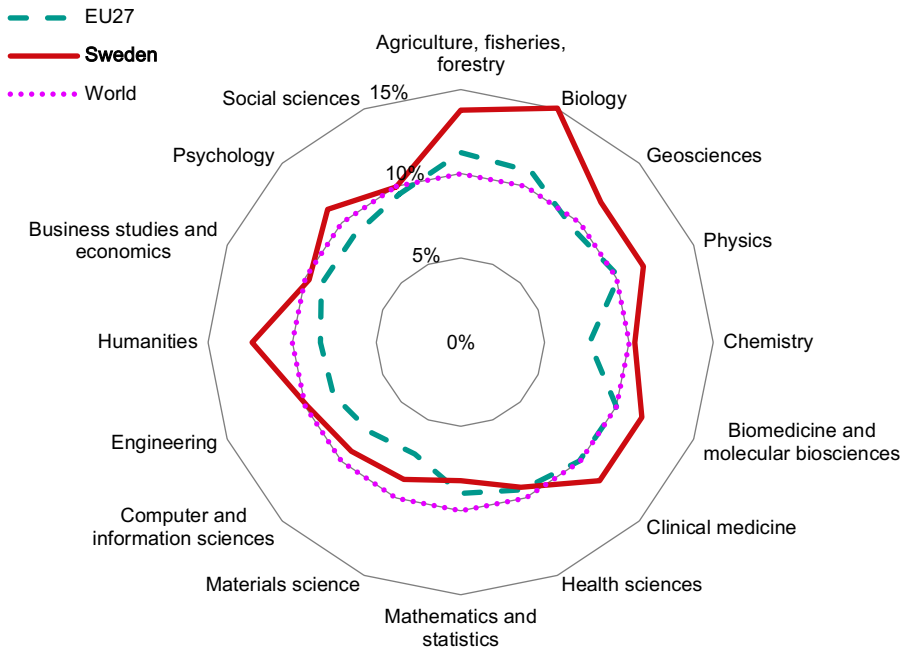


Figure 32. Proportion of highly cited publications within different research areas, for Sweden, EU27, and the world, 2017–2019. Source: Clarivate Analytics.

Different countries' research profiles

Figure 33 shows the citation impact and research specialisation in different research areas, defined as 'research profile', for Sweden, USA and China. The circles represent different research areas, and their size is proportional to the country's volume of publications. This shows how specialised the countries are in different research areas, that is, the proportion published in different research areas compared to the world average. If a research area is to the right in the figure, above zero, it means that the country in question has published a larger proportion than the world average in this research area. If a research area is to the left in the figure, below zero, one the other hand, the country has published a smaller proportion than the world average in the research area. Furthermore, if a research area is in the upper half of the figure, above 10 per cent, the citation impact is higher than the world average in that area, while if a research area is below 10 per cent, then the citation impact is lower than the world average.

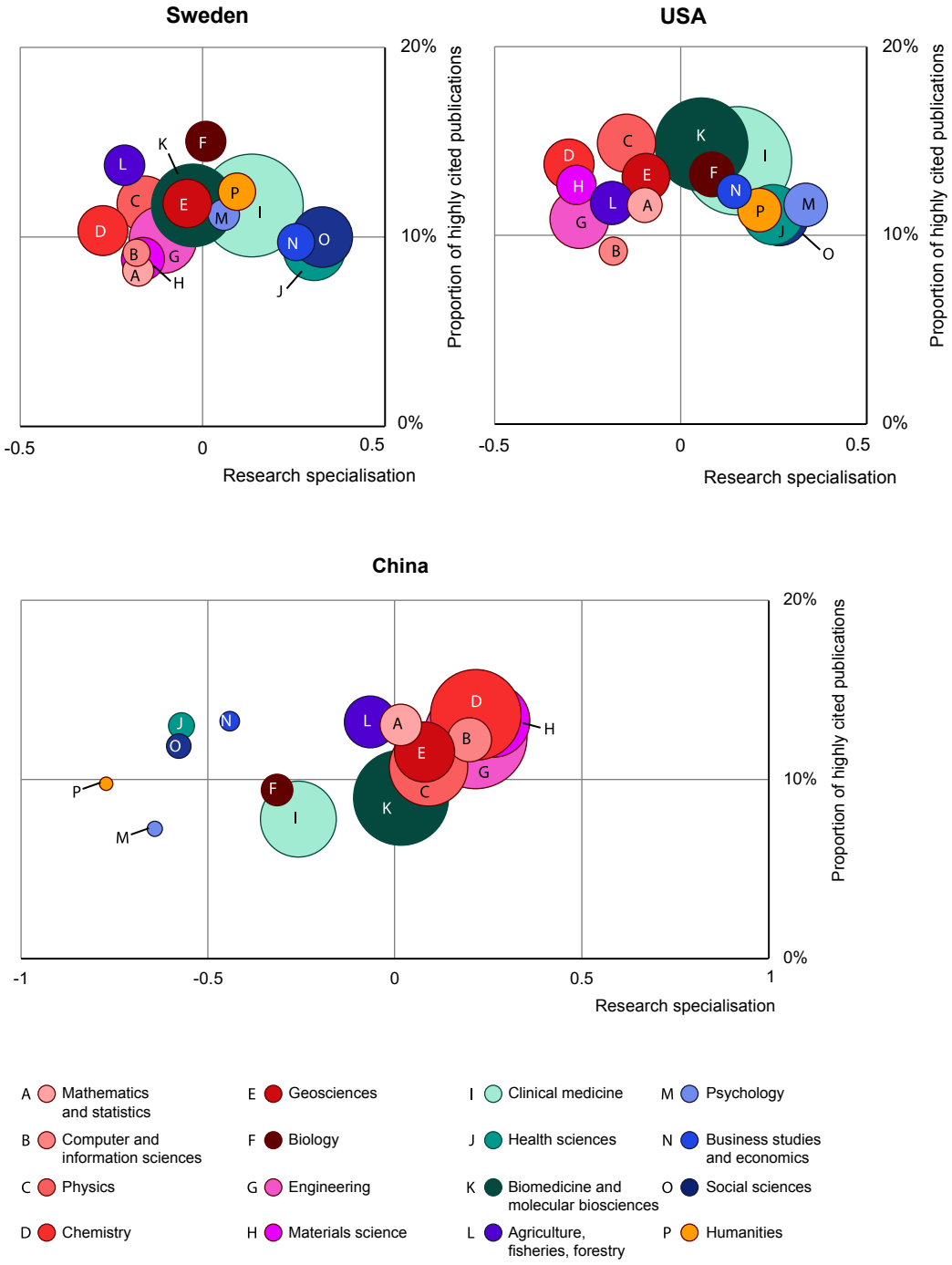


Figure 33. Research profile (research specialisation and citation impact) for Sweden, USA and China.

Note: The size of each circle is proportional to the research area's share of the country's overall production. Publications published 2017–2019. Source: Clarivate Analytics.

The research areas with the highest citation impact in Sweden are agronomy and biology, which we also saw in Figure 32. On the other hand, Sweden produces a smaller proportion of publications in agronomy than the world average. Compared to the rest of the world, Sweden produces a larger proportion of publications in business studies and economics, health sciences, and social sciences, while the citation impact for these research areas are below the world average. At the same time, Sweden is above the world average in terms of both citation impact and research specialisation in the area where Sweden produces the largest number of publications: clinical medicine.

For USA, the citation impact for all research areas, except computer and information sciences, is above the global average of 10 per cent. USA produces, in relative terms, more publications than the rest of the world in humanities, health sciences, psychology and social sciences, but fewer than the rest of the world in materials science, chemistry and engineering. Like in Sweden, clinical medicine is the area in which USA produces the highest number of publications.

China produces a larger proportion than the world average, particularly in materials science, chemistry and engineering sciences, where it is also above the world average in terms of citation impact. It also produces a smaller proportion than the world average in psychology and humanities, where it is also below the world average in terms of citation impact. China's largest scientific production is in engineering sciences.

3.2 Higher education sector in Sweden

Scientific publication

Figure 34 shows the number of scientific publications for different higher education institution categories for the years 2007–2009 and 2017–2019. It is the broad-based established universities and the specialised universities that produce the most publications. In 2017–2019, the broad-based established universities produced half of the published publications in Sweden, while the specialised universities produced almost one third. The new universities produced 5 per cent, and the university colleges 4 per cent of the total Swedish production. The organisations classified as 'other', such as businesses, research institutes and government agencies, produced 11 per cent of the overall number of publications.

During the period, the university colleges and new universities have seen the largest increase in the number of scientific publications. Over the ten-year period, the volume produced by university colleges has more than doubled, and the volume by the new universities has increased by 70 per cent. During the same period, the broad-based established universities and the specialist universities increased by 31 and 33 per cent respectively.

University colleges for the arts and the private providers of education have very few scientific publications included in the publication database Web of Science. This is assumed to be because their focus is on teaching, and also because the university colleges for the arts publish their research results via channels other than those included in the database.

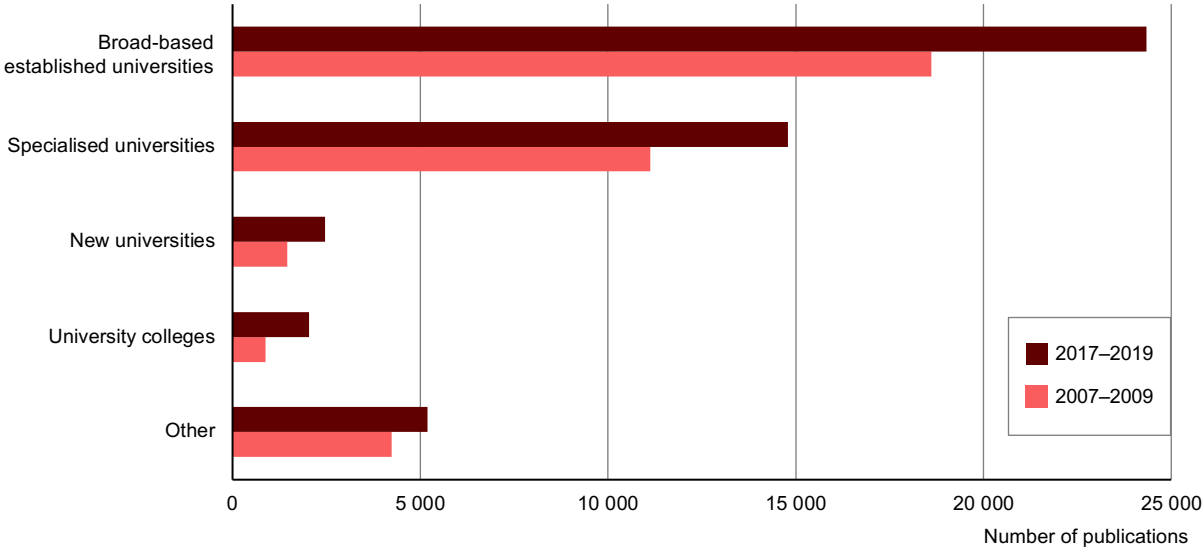


Figure 34. Number of scientific publications for different higher education institution categories including other organisations, 2007–2009, and 2017–2019.

Note: The category 'Others' includes mainly businesses, research institutes, hospitals (not university hospitals) and public agencies outside the higher education sector. University colleges for the arts and private providers of education are not shown due to having too small a number of publications. Source: Clarivate Analytics.

Co-publications with researchers in other countries

International collaboration within R&D is important, as international collaboration is assumed to raise the quality of the research and to strengthen the country's competitiveness and attraction. One way of measuring international research collaboration is to measure the proportion of Swedish publications that are co-authored with researchers from other countries.

The proportion of publications that are international co-publications has increased steadily in Sweden over a long period. In 2000, the proportion of international co-publications was around 43 per cent, and by 2019 it had risen to 71 per cent. It is, in particular, the proportion with many collaborating countries that has increased. The proportion with one collaborating country has remained constant across the period at 33 per cent, while the proportion with more collaboration countries has increased from 14 to 40 per cent. Figure 35 shows Swedish researchers' international co-publications divided up by different continents.

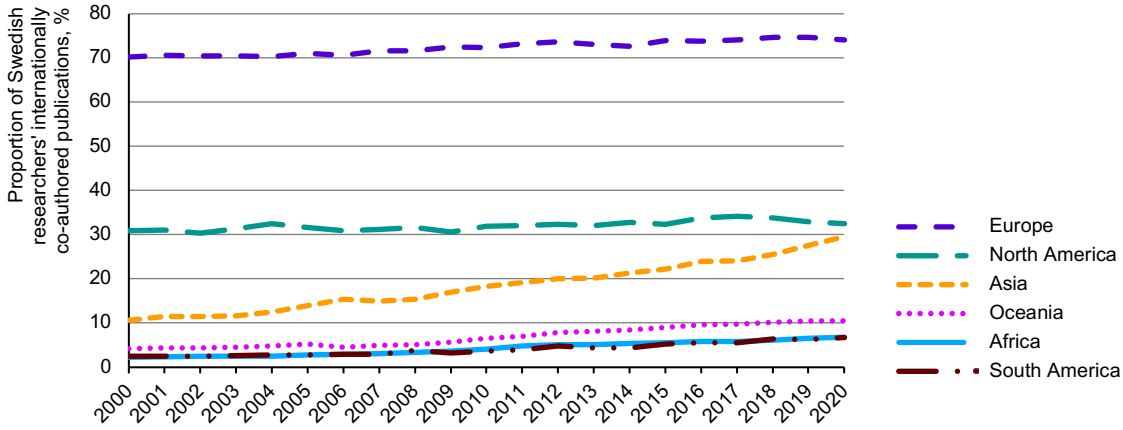


Figure 35. Development of the proportion of internationally co-authored publications by Swedish researchers, in terms of the location of the collaborating researchers.

Note: The publications are in full counts, which means that the sum of all co-publications is greater than 100 per cent. Source: Clarivate Analytics.

Co-publications with researchers in Europe and North America have remained stable, around just over 70 per cent and at 30 per cent over the last 20 years. The most marked increase is in co-publications with Asia, which increased from 11 to 30 per cent between 2000 and 2020. Collaboration with Africa, Oceania and South America is very limited in absolute terms, but has increased strongly in relative terms over the period.

Figure 36 shows the countries that Swedish researchers collaborate with the most, stated as the number of internationally co-authored scientific publications per year and collaborating country.

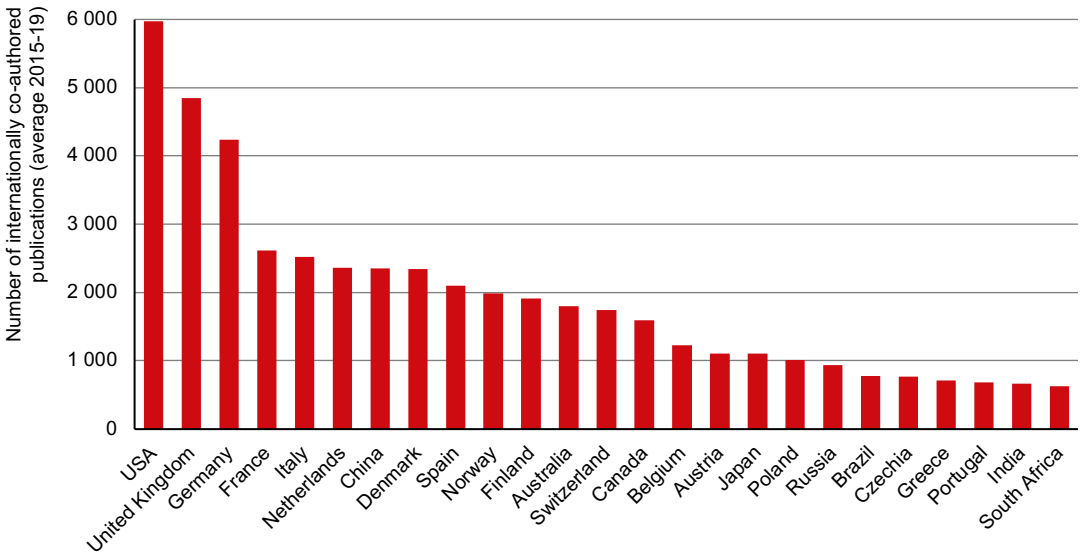


Figure 36. Number of internationally co-authored publications for Swedish researchers per collaboration country (number of publications in full counts, average for 2015–2019). Source: Clarivate Analytics.

Swedish researchers have mostly collaborated with researchers active in the USA. During the period 2015–2019, an average of 6 000 publications per year had at least one author from both Sweden and USA. This corresponds to around 30 per cent of all Swedish international co-publications. Swedish researchers also collaborate a lot with researchers in the United Kingdom and in Germany. Denmark is the Nordic country that Sweden collaborates with the most. Sweden collaborates with China to roughly the same extent as it collaborates with Norway and Finland.

Figure 37 shows the international co-publication within different research areas for Swedish researchers during 2010 and 2019 respectively.

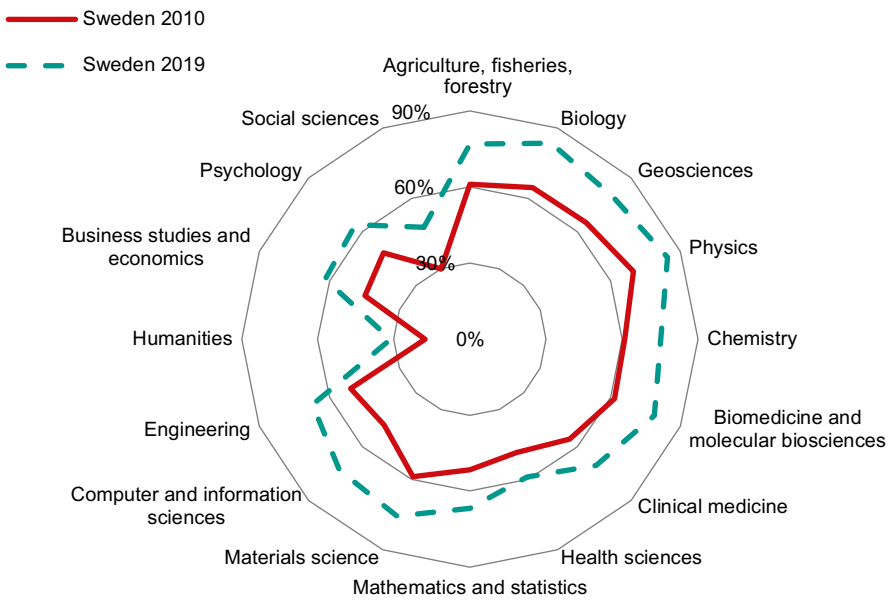


Figure 37. Swedish researchers' international co-publications as a proportion of the overall number of publications, for different research areas in 2010 and 2019. Source: Clarivate Analytics.

The figure shows that co-publication increased over the ten-year period in all research areas. However, there is great variation in international co-publication intensity between the different research areas. Co-publication occurs most frequently in biology, physics, and biomedicine. Publication traditions and access to joint infrastructures, are assumed to be two of the causes explaining the differences between research areas in the level of collaboration. In physics, major international infrastructures, such as the particle physics laboratory CERN, are also assumed to have contributed to international co-publication becoming even more common.

Humanities and social sciences are the research areas where Swedish researchers have the smallest proportion of co-publications with international

researchers. computer and information science and biology are the research areas that have seen the greatest increase in the proportion of co-publications during the period.

Citation impact

Figure 38 shows the citation impact for different higher education institution categories for 2007–2009 and 2017–2019. Broad-based established universities and specialist universities are both above the world average, while new universities and university colleges are below the world average. The new universities have, however, increased their citation impact the most over the ten-year period, from 7 per cent to 9 per cent of their publications among the 10 per cent most highly cited publications.

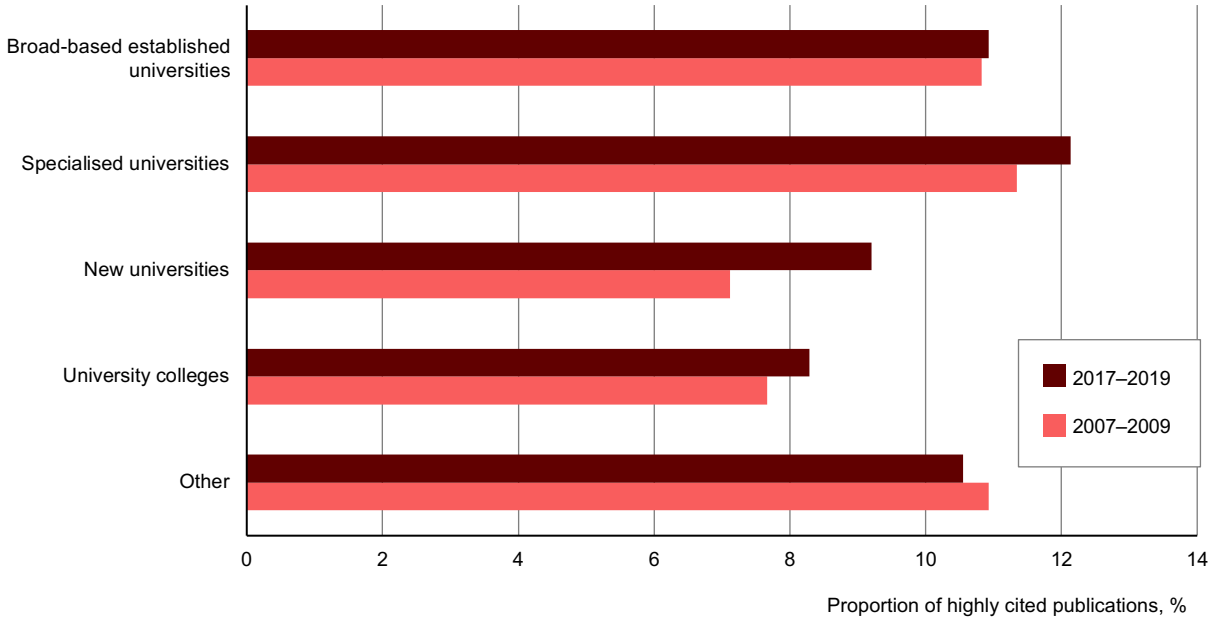


Figure 38. Development of the proportion of highly cited publications for different higher education institution categories, 2007–2009 and 2017–2019.

Note: The category 'Others' includes mainly businesses, research institutes, hospitals (not university hospitals) and public agencies outside the higher education sector. University colleges for the arts and private providers of education are not shown due to having too small a number of publications. Source: Clarivate Analytics.

Figure 39 shows the number of publications (points) and citation impact (bars) for different higher education institutions (HEIs) during the same time periods as in figure 38. The HEIs are sorted according to the largest number of publications during 2017–2019, and only HEIs with at least 100 publications during the period are shown in the figure. The world average of 10 per cent is illustrated with a horizontal line in the figure.

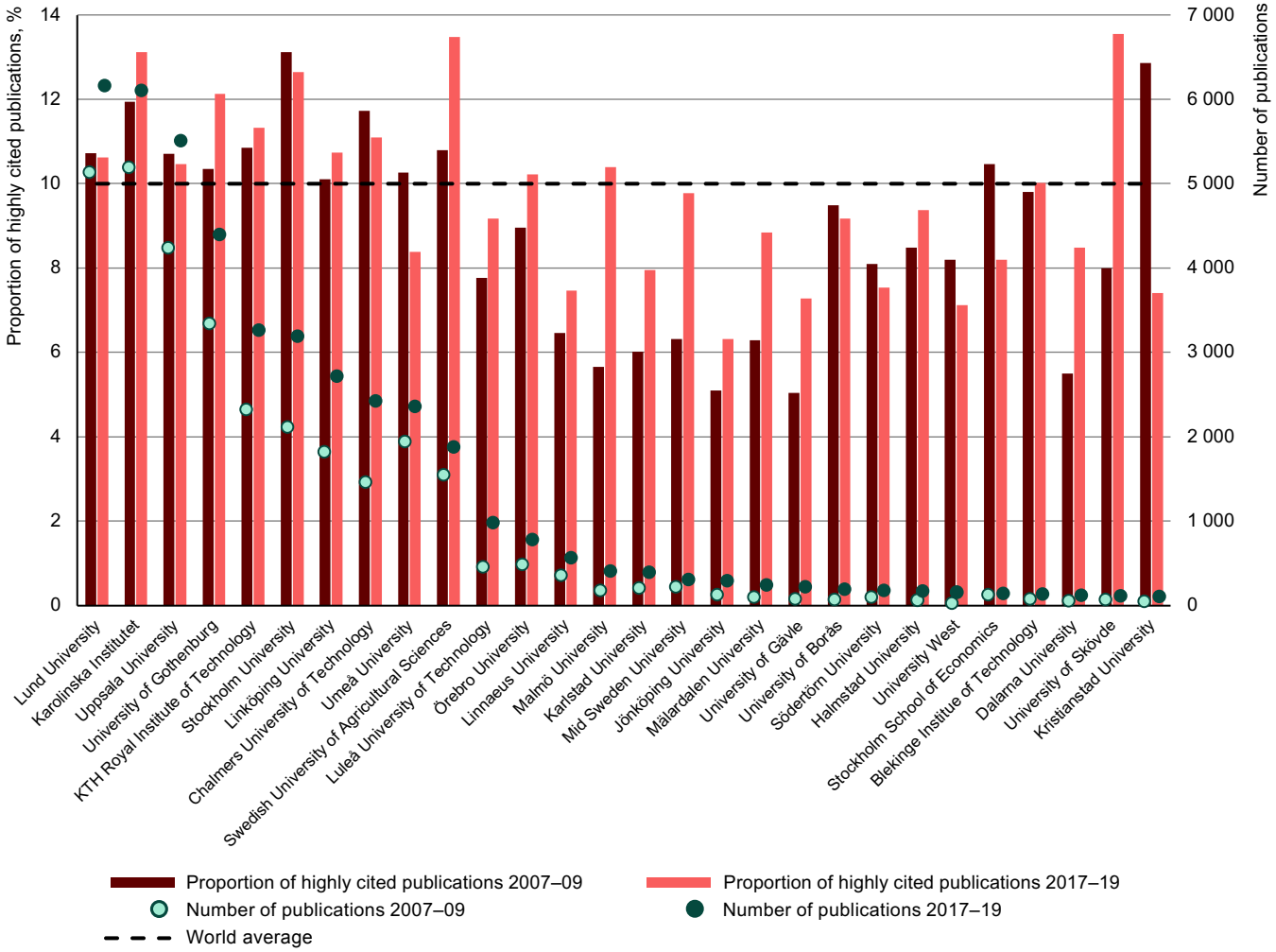


Figure 39. Development of the number of publications and proportion of highly cited publications for different higher education institutions, 2007–2009 and 2017–2019. Source: Clarivate Analytics.

The University of Skövde, the Swedish University of Agricultural Sciences, Karolinska Institutet and Stockholm University are among the HEIs with the highest citation impact during the period 2017–2019. They all had around 13 per cent of their publications among the 10 per cent most highly cited, and are therefore far above the world average. The University of Skövde increased its citation impact the most during the ten-year period, while Kristianstad University decreased the most. At the same time, both these university colleges have limited publication volumes, which means a much greater uncertainty in the results, as single years can produce large effects.

Higher education institutions' research profiles

Figure 40 shows the research profiles of different higher education institutions (HEIs) for 16 research areas, and is based on the HEIs' publications over a five-year period (2015–2019). Only research areas with at least 30 publications during the period are shown in the figure. If a research area is to the right in the figure (where research specialisation is above zero), it means that the HEI in question has published a larger proportion than the world average in this research area. If a research area is in the upper half of the figure, the research area has a higher citation impact than the world average, and vice versa. The size of each circle is proportional to each research area's share of the overall publication volume of the HEI in question.

Figure 40 shows that there is no obvious link between research specialisation and citation impact. The HEIs with a high citation impact overall often have a high impact in several research areas.

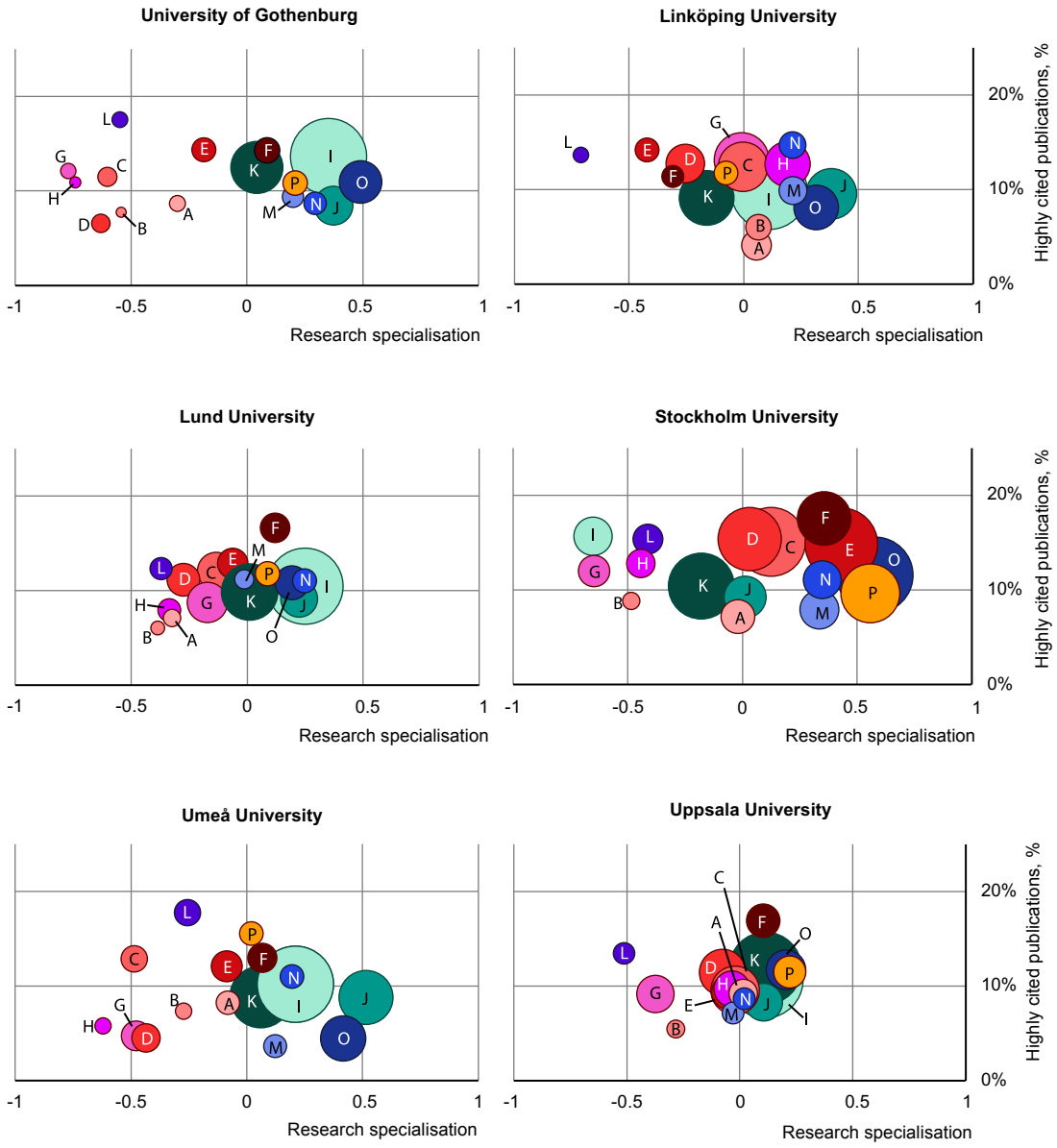
The broad-based established universities have publications in all 16 research areas, but show a wide range in their specialisation. Stockholm University and University of Gothenburg, which do not have engineering faculties, have a low proportion of publications within the technology subjects; engineering science and materials science, while they are big within social sciences. the other broad-based established universities, for which publications at each university hospital have been included, have their largest proportion of publications within clinical medicine or health sciences.

Among the broad-based established universities, Stockholm University is the HEI with the greatest range in its research specialisation, but it is also the HEI with the largest number of research areas with a citation impact above the world average. Lund University and Uppsala University have the smallest range in their research specialisations, and are around zero (world average) in most research areas.

The specialised universities are, as expected, much more specialised than other HEIs. For example, publications from the Stockholm School of Economics are almost exclusively in business studies and economics. The Swedish University of Agricultural Sciences publishes the largest volume in agronomy and biology, while the engineering universities the Royal Institute of Technology (KTH), Chalmers University of Technology and Luleå University of Technology, produce the most in engineering. Karolinska Institutet has a considerably higher proportion of publications in clinical medicine and health sciences than the world average.

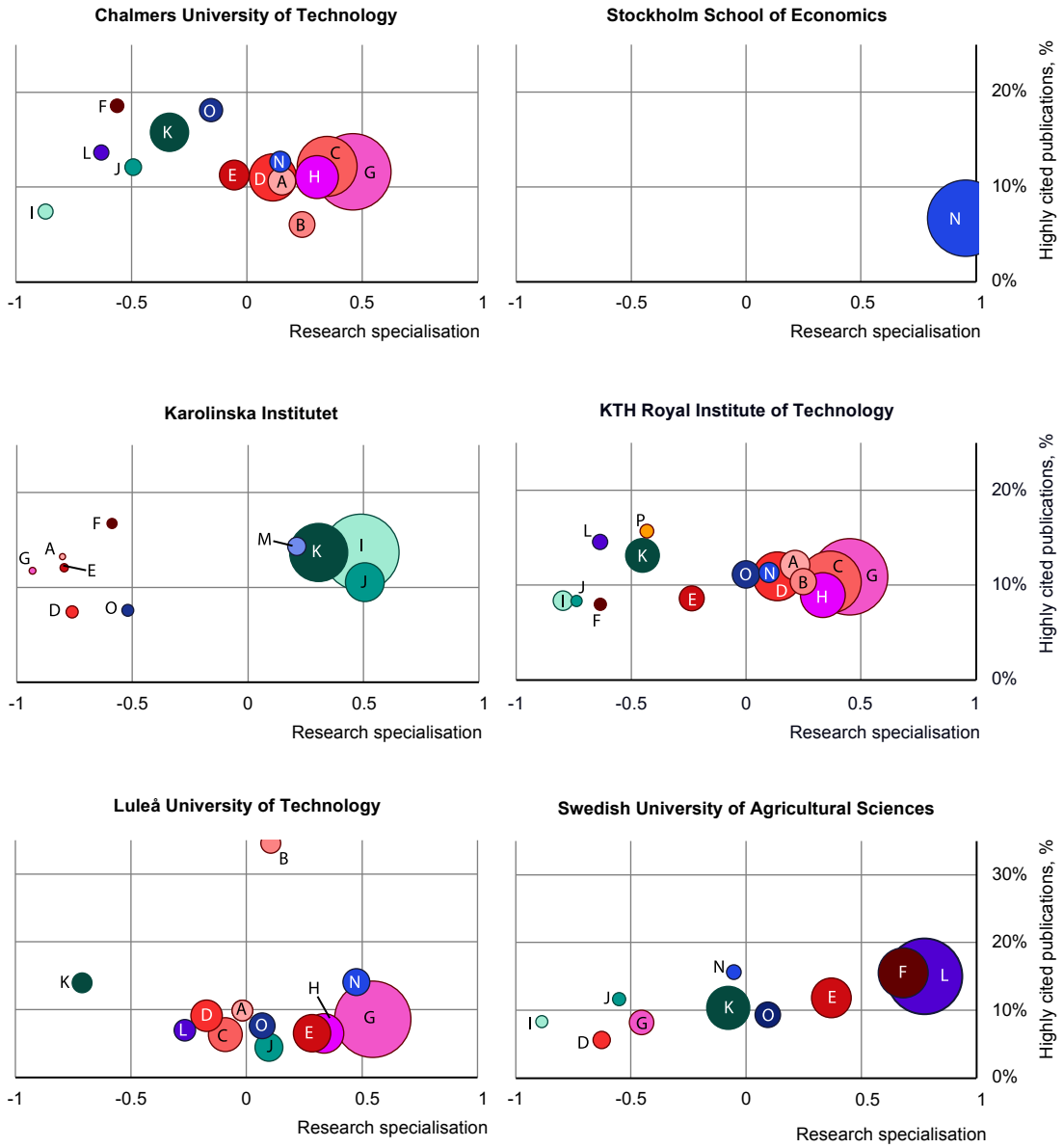
The new universities, with the exception of the Linnaeus University, only have a few research areas where they produced more than 30 publications during the period. A common denominator for the new universities and university colleges is that all have research specialisations above zero for social sciences and health sciences.

Broad-based established universities



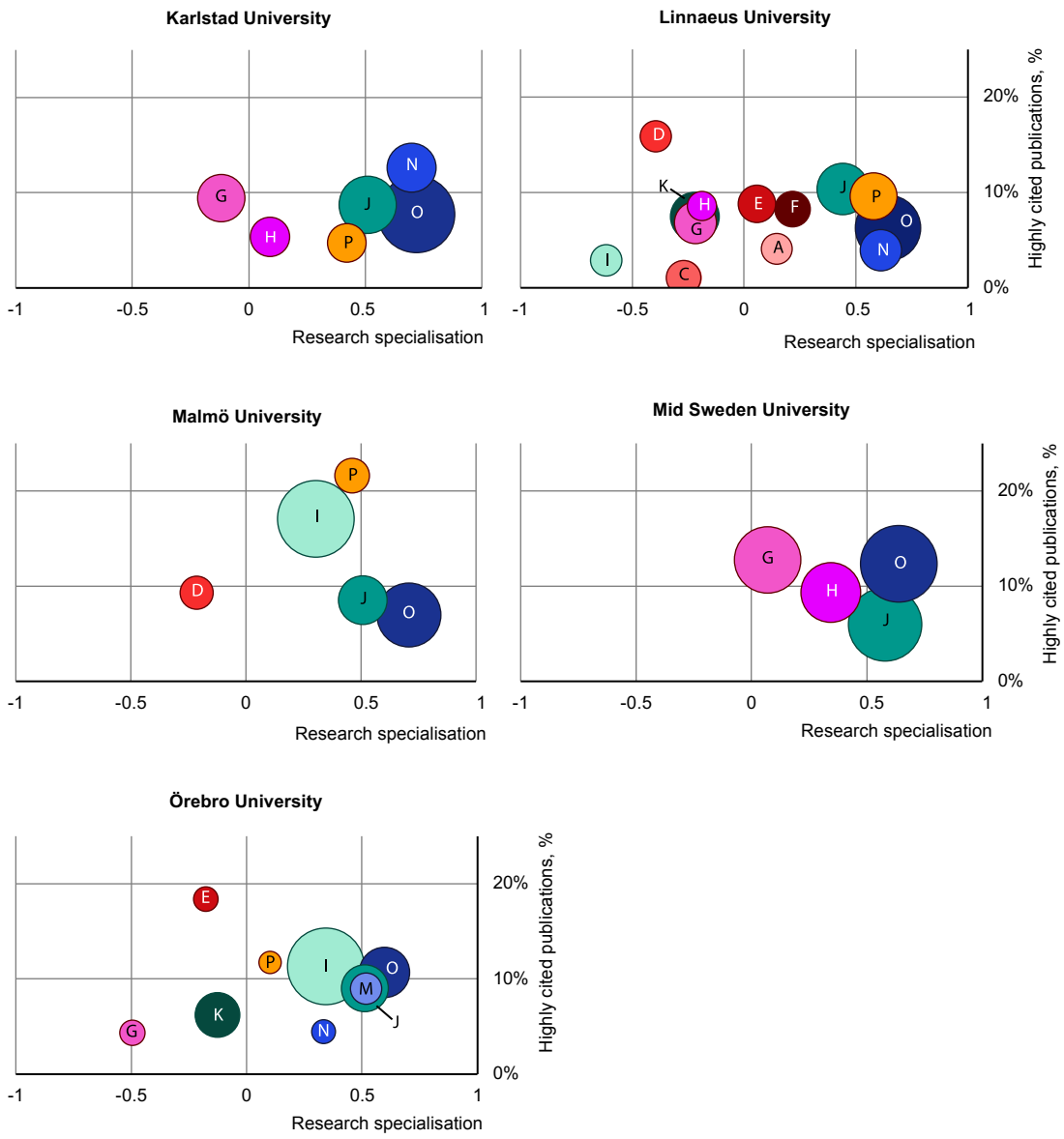
A Mathematics and statistics
B Computer and information sciences
C Physics
D Chemistry
E Geosciences
F Biology
G Engineering
H Materials science
I Clinical medicine
J Health sciences
K Biomedicine and molecular biosciences
L Agriculture, fisheries, forestry
M Psychology
N Business studies and economics
O Social sciences
P Humanities

Specialised universities



A Mathematics and statistics
B Computer and information sciences
C Physics
D Chemistry
E Geosciences
F Biology
G Engineering
H Materials science
I Clinical medicine
J Health sciences
K Biomedicine and molecular biosciences
L Agriculture, fisheries, forestry
M Psychology
N Business studies and economics
O Social sciences
P Humanities

New universities



A Mathematics and statistics
B Computer and information sciences
C Physics
D Chemistry
E Geosciences
F Biology
G Engineering
H Materials science
I Clinical medicine
J Health sciences
K Biomedicine and molecular biosciences
L Agriculture, fisheries, forestry
M Psychology
N Business studies and economics
O Social sciences
P Humanities

University colleges

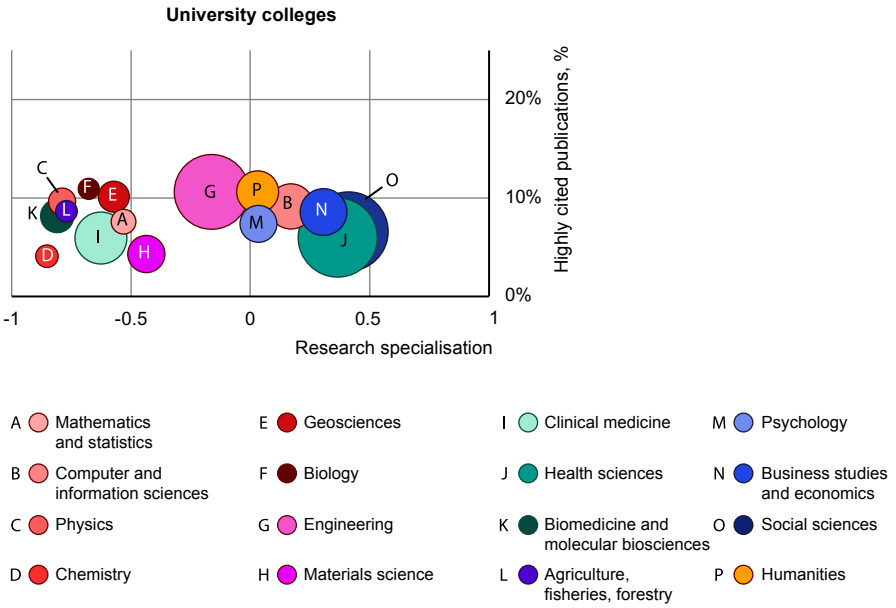


Figure 40. Research profile (research specialisation and citation impact) for Swedish higher education institutions.

Note: The size of each circle is proportional to the research area's share of the HEI's overall production. Only research areas where the HEI published at least 30 publications during 2015–2019 are included in the figure. Source: Clarivate Analytics.

References

Govt. bill 2016/17:50. Kunskap i samverkan – för samhällets utmaningar och stärkt konkurrenskraft.

Govt. bill 2020/21:1 Utgiftsområde 16.

Högskoleförordningen (1993:100)

Lagen om anställningsskydd (1982:80).

OECD (2015). 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.

Statistics Sweden (2020). Statistikens framställning – Forskning och utveckling i Sverige. UF0301 2020-10-19.

Statistics Sweden (2021). Forskning och utveckling i Sverige 2019.

Statistisknyhet från SCB 2020-10-15. ”Tio företag utför hälften av näringslivets FoU 2019” https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/forskning/forskning-och-utveckling-i-sverige/pong/statistiknyhet/forskning-och-utveckling-inom-foretagssektorn-2019/

Statistiknyhet från SCB 2021-04-21 Ökade FoU-anslag till universitet och högskolor under 2021: https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/forskning/statliga-anslag-till-forskning-och-utveckling/pong/statistiknyhet/statliga-anslag-till-forskning-och-utveckling-2021/

Statistiknyhet från SCB 2020-10-29. Forskning och utveckling ökar i Sverige. https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/forskning/forskning-och-utveckling-i-sverige/pong/statistiknyhet/forskning-och-utveckling-i-sverige-2019/

UKÄ (2016). Standard för svensk indelning av forskningsämnen 2011.

Vetenskapsrådet (2014). Riktlinjer för användning av bibliometri vid Vetenskapsrådet. 2014-12-15. Dnr 113-2014-7357.

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

Vetenskapsrådet (2018). Vetenskapsrådets guide till infrastrukturen 2018. VR1809.

Vetenskapsrådet (2019). Forskningsbarometern 2019 – Svensk forskning i internationell jämförelse. VR1915

Vetenskapsrådet (2010). En studie av investeringar i utrustning för forskning vid svenska universitet och högskolor, 1997–2007.

Vetenskapsrådet (2021). How gender-equal is higher education? Women's and men's preconditions for conducting research VR2106

Vinnova – Sweden's Innovation Agency (2020). Horisont 2020 – årsbok 2019. Vinnova rapport. VR 2020:08.

Appendix: Method and data

The purpose and focus of the Swedish Research Barometer

The Research Barometer aims to describe the status and development of Swedish research and development (R&D). The Research Barometer therefore includes an international comparison of the Swedish R&D system, but has particular focus on the Swedish higher education sector. By reporting statistics from several different sources, the report can provide a comprehensive picture of the Swedish R&D system. The strong point of the Research Barometer is that it gathers together information from several statistics sources, while also reporting unique information about scientific publications and their citation impact. This also means that the report is slightly more detailed with regard to information on citation impact and publications.

As the Research Barometer is a recurrent report, the choice of indicators and figures is largely repeated year by year, and the description focuses on development in recent years. The report takes a primarily descriptive approach.

International comparisons

As the Research Barometer aims to describe the Swedish R&D system and make international comparisons, the selection of countries and groups of countries to compare Sweden with is of central importance. International comparison of the R&D of different countries is not simple, as there are differences in factors such as organisation structure and funding model.

To provide a nuanced and fair picture of how Sweden compares as a research nation with other countries, Sweden is compared both with three different selections of countries, and also with general comparison groups (EU27, OECD and the world). The different groups of countries used are:

- **Comparable countries:** Belgium, Denmark, Finland, Netherlands, Norway, Switzerland, and Austria
- **Large established research countries:** France, Japan, United Kingdom, Germany, and USA
- **Fast-growing research countries:** China and South Korea
- **Comparison groups:** EU27, OECD and the world.

Comparable countries to Sweden are countries where the preconditions for research and development are similar to those that apply for Sweden. These countries are also comparable to Sweden in terms of citation impact and number of publications in relation to population size. The major established research countries are countries that are often perceived as central actors. The fast-

growing research countries are countries whose R&D systems have expanded rapidly over the last ten-year period.

As the Research Barometer also aims to describe how Sweden compares internationally, Sweden is also compared with the following groups of countries: EU, also referred to as 'EU27' (the EU's 27 member states), OECD (member countries of the OECD), OECD including Singapore and China, and the world as a whole. These comparison groups have been selected as they constitute interesting and often used comparison groups, but also because of limitations in the statistics available.

For statistics on R&D expenditure and number of researchers, the report is limited to the statistics available in the OECD's database Main Science and Technology Indicators. The OECD database relates primarily to the member countries of the OECD, but also includes statistics for a few other countries, and also totals for the EU. In some figures, the comparison group 'OECD including China and Singapore' has been used, as China is part of the group 'fast-growing research countries', and as Singapore is the country with the highest citation impact in the world. The comparison group 'the world' is only used in descriptions of number of publications and of citation impact, and is based on the countries included in the Swedish Research Council's publication database.

Data sources

Funding and personnel statistics in the international comparisons were taken from the OECD database Main Science and Technology Indicators (OECD MSTI version March 2021). The statistics are based on individual countries' reporting to the OECD. The figures based on data from the OECD do not always include data for all years. This therefore means that data for individual countries and years are sometimes lacking, and have therefore not been presented in the report either. For a number of figures, data from the nearest available year have been used instead, which is then shown in the figure and in the figure text.

Data on Sweden's participation in Horizon 2020 are taken from eCORDA and OECD. Applications and approved applications ("eligible" and "retained applications") are sourced from eCORDA (18 May 2021). Number of researchers (full-time equivalents) refers to 2019 (excl. Switzerland med figures for 2017) and are sourced from OECD MSTI. 'Number of researchers' refers to the entire R&D system, that is the higher education sector, business sector, and government sector.

Figures for R&D expenditure for the higher education sector in Sweden are taken from Statistics Sweden (SCB). The R&D statistics are updated every two years, and the latest available figures are from 2019. R&D expenditure that includes comparisons over time have been calculated at constant prices using the

GDP deflator[29], which in turn is based on data from the National Institute of Economic Research[30].

Data on number of publications, citation impact and international co-publication are based on the Swedish Research Council's publication database. The database is based on data from Clarivate Analytics and the contents correspond to that of Web of Science (WoS) as of March 2021.

Classification into fields of research and research areas

The Research Barometer uses a total of three classifications of research fields and areas. For data on R&D expenditure and R&D personnel within the higher education sector in Sweden, we use "Forskningsämnesområden" from the "Standard för svensk indelning av forskningsämnen", produced by the Swedish Higher Education Authority and Statistics Sweden.[31] The classification is based on the OECD classification Fields of Research and Development (FORD), and "Forskningsämnesområde" are thus referred to as "Field of research" in the English translation of the Swedish Research Barometer.

For data on number of publications and citation impact, we use "research area", which is based on the classification of scientific periodicals used in the Swedish Research Council's publications database. The classification of research areas is available for 6 research areas, and also for 16 research areas. As these three classifications are based on differing data, they are not entirely comparable, and in the report have therefore been called "fields of research" and "research areas".

Bibliometric analysis

This section summarises how the bibliometric indicators have been calculated and used in the Research Barometer. For a more detailed description of how bibliometrics are used at the Swedish Research Council, please see "Riktlinjer för användning av bibliometri vid Vetenskapsrådet" and "The bibliometric database at the Swedish Research Council – contents, methods and indicators"[32].

29 The GDP deflator is calculated as GDP in constant prices in relation to GDP in current prices.
30 Prognosdatabasen, December 2020.
31 UKÄ (2016). Standard för svensk indelning av forskningsämnen 2011.
32 Vetenskapsrådet (2014). Riktlinjer för användning av bibliometri vid Vetenskapsrådet. 2014-12-15. Dnr 113-2014-7357., Vetenskapsrådet (2015). The bibliometric database at the Swedish Research Council – contents, methods and indicators 2015, 2015-09-18. Dnr 113-2010-6148.

The Swedish Research Council's database for bibliometrics

The Swedish Research Council's database for bibliometrics is based on data from Clarivate Analytics and the contents correspond to that of Web of Science (WoS).[33] The Swedish Research Council's publications database covers around 18 000 international scientific periodicals. These periodicals are classified by Clarivate Analytics into one or several of around 250 subject classifications, and the individual publications receive the periodical's subject classification. In the Research Barometer, the 250 subjects have been aggregated into two classifications, one with 6 research areas and one with 16 research areas.[34] The Swedish Research Council reclassifies the periodicals classified by WoS as Other/Multi-disciplinary. Following reclassification of multi-disciplinary periodicals, very few publications remain in this category, and these have been excluded from the statistics in the Research Barometer.

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

The publications database's coverage of different research areas varies. Research areas such as biomedicine, chemistry and clinical medicine have a high rate of coverage in the database, while humanities has a very low rate of coverage. Social sciences, business studies and economics as well as computer science also have a relatively low rate of coverage. Researchers in these research areas publish a lot via channels that are not included in the Web of Science. As the Research Barometer's calculations of the number of publications and citation impact are based on the publications included in the publication database, the certainty of the figures in the report varies from one research area to another.

Publication volume and fractioning

One challenge of counting the number of publications is that a publication can have authors from different countries. The sum of the number of publications from the different countries is then larger than the total number of publications. The same challenge arises in comparisons that include the number of publications within different research areas, as a publication may be classified as belonging to several research classifications. This means that the sum of the

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33 The Swedish Research Council buys raw data from Clarivate Analytics and the contents correspond largely to the contents of Web of Science. When Web of Science is stated, this means the Swedish Research Council's database (consisting of the following products: Science Citation Index Expanded®, Social Science Citation Index® and Arts and Humanities Citation Index®. These products have been compiled by Clarivate Analytics®, Philadelphia, Pennsylvania, USA© Copyright Clarivate Analytics® 2021. All rights reserved.)

34 Agriculture, fisheries, forestry; biology; geosciences; physics; chemistry; biomedicine and molecular biosciences; clinical medicine; health sciences; mathematics and statistics; materials science; computer and information sciences; engineering; humanities, business studies and economics, psychology and social sciences.

number of publications within the individual research areas is larger than the total number of publications.

The number of publications can therefore be calculated using fractioned counting. In fractioned counting, authors A and B are instead award half a publication each, and the author total ends up the same as the actual number of publications. If the publication is also given several subjects, it is fractioned further. Unless otherwise is stated, the Research Barometer uses fractioned counting.

Sweden-based researchers' (Swedish) publications are identified in the database according to the organisation the author has stated as belonging to in the publication.

Proportion of highly cited publications

The *proportion* of highly cited scientific publications is a measure of citation impact that, contrary to the citation average, is not significantly impacted on by one-off extremely highly cited publications. To study the impact of publications, the Research Barometer therefore uses an indicator that states how large a proportion of a country's or an HEI's publications is among the 10 per cent most cited scientific publications in the world.

All figures are also *field-standardised*. This means that a highly cited article is among the 10 per cent most cited scientific publications published *in the same subject* in one specific year. The proportion of publications among the 10 per cent most highly cited is then calculated by dividing the sum of all publication fractions that are among the 10 per cent most cited by the sum of all publication fractions for the country.

The number of citations is counted during a three-year window, which means that the citations are counted as from the year the publication is published and for two years afterwards. Self-citations are excluded.

Scientific publication with open access

Information on whether a publication is an open access publication, is part of Clarivate's data, which forms the basis for the Swedish Research Council's publication database. Through collaboration with Our Research, Clarivate is using the service Unpaywall to update the information on open access. Each publication in the database may be openly accessible in several categories. In the Research Barometer, *one* category has been given to each publication, in the following priority order: Gold, hybrid, green, or bronze. The information on open access is that which was available from Clarivate at the most recent update of the publications database in March 2021.

Research specialisation

To relate the research specialisation of a country's (or an organisation's) publications, a measure of research specialisation is used: relative specialisation

index (RSI). 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 for a specific country is calculated by dividing the percentage of publications it has within a specific research by the percentage that the research constitutes in the publication database as a whole. If 50 per cent of Sweden's publications were classified as physics, while the corresponding figure for the whole of the database is 25 per cent, then Sweden's activity index for physics will be 2. In this example, Sweden therefore has double the amount of physics compared to the database. The activity index is an unsymmetrical measure that can assume values between 0 and infinity. To make the figures easier to compare, we use RSI instead, which is calculated as follows:

$$RSI = (AI - 1)/(AI + 1).$$

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

Country codes

Table 1. Country codes

AT = Austria	FI = Finland	LV = Latvia
AU = Australia	FR = France	MX = Mexico
BE = Belgium	GB = United Kingdom	NL = Netherlands
CA = Canada	GR = Greece	NO = Norway
CH = Switzerland	HU = Hungary	NZ = New Zealand
CL = Chile	IE = Ireland	PL = Poland
CN = China	IL = Israel	PT = Portugal
CO = Colombia	IS = Iceland	SE = Sweden
CZ = Czechia	IT = Italy	SG = Singapore
DE = Germany	JP = Japan	SI = Slovenia
DK = Denmark	KR = South Korea	SK = Slovakia
EE = Estonia	LT = Lithuania	TR = Turkey
ES = Spain	LU = Luxembourg	US = USA

Source: ISO 3166-1 alpha-2

Explanations of abbreviations and concepts

Clarivate Analytics: The company that publishes Web of Science, a publication database with citation indices. When Clarivate Analytics is referenced in figures and running text, this refers to the Swedish Research Council's database for bibliometrics, which is based on basic data from Web of Science.

Comparable countries: A classification of countries used in the Research Barometer to represent countries comparable to Sweden in terms of prerequisites for R&D, and that are also comparable in terms of number of publications in relation to population and citation impact. Consists of: Belgium, Denmark, Finland, Netherlands, Norway, Switzerland, and Austria.

Constant prices: Constant prices are prices from a specific (fixed) time period. Constant prices express the real value, which is the value at the price of another period. Constant prices are obtained by deflating current prices to a base year. Studying the development over time of R&D expenditure at constant prices therefore means that the development can be studied based on the same price level across the period, and therefore without any impact of changes in prices. The Research Barometer uses the GDP deflator.

Current prices: R&D expenditure at current prices means that R&D expenditure is expressed at the actual price level for the time in question. Expenditure at current prices is used to describe and compare expenditure at a specific point in time. To describe the development of expenditure over time, expenditure at constant prices is used instead, which means that the price level does not vary over time. See also Constant prices.

eCORDA: Data source on participation in the EU's framework programme for research and innovation (external COmmon Research DAta warehouse).

EU and EU27: The countries that are currently part of the European Union (27 countries): Belgium, Bulgaria, Cyprus, Denmark, Estonia, Finland, France, Greece, Ireland, Italy, Croatia, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Czechia, Germany, Hungary and Austria.

Fast-growing research countries: A classification of countries used in the Research Barometer to represent countries that have had rapid expansion of their research systems over the last ten-year period. Consists of China and South Korea.

Fields of research and development (FORD): Classification of Swedish R&D according to the Standard för svensk indelning av forskningsämnen.[35] All R&D is

35 UKÄ (2016). Standard för svensk indelning av forskningsämnen 2011.

classified at one-, three- and five-digit level. Fields of research (at one-digit level) are: Natural sciences, Technology, Medicine and health sciences, Agricultural and veterinary sciences, Social sciences, and Humanities and the arts.

Frascati Manual: OECD's guidelines for statistics on R&D.[36]

Gross domestic product (GDP): The value of all goods and services produced in a country during a given period.

Large established research countries: A classification of countries used in the Research Barometer to describe countries that are often perceived as central actors in international comparisons and are characterised by large publication volumes and high citation impact. Consists of: France, Japan, United Kingdom, Germany, and USA.

OECD: Organisation for Economic Cooperation and Development As from 25-May 2021, the OECD has 38 member countries, as Costa Rica became a member then. As the Research Barometer uses information from March 2021, the statistics relating to OECD refer to 37 member countries.

OECD MSTI. OECD Main Science and Technology Indicators. Source of statistics.

Proportion of highly cited publications: States the proportion of a country's or organisation's publications that are among the 10 per cent most cited scientific publications in the world (in the Swedish Research Council's publication database).

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

Purchasing power-adjusted values: Purchasing power adjustment is a way of taking into account price differences in different countries, and thereby expressing factors such as R&D expenditure or GDP based on the country's purchasing power. In simple terms, purchasing power adjustment takes into account that 100 SEK buys you different amounts in different countries, due to differences in the countries' price levels for various goods and services. Also: Purchasing Power Parity - PPP.

PPP$: Purchasing power-adjusted US dollars (USD). Purchasing Power Parity. See Purchasing power-adjusted values.

36 OECD (2015). 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.

Relative success: Number of approved applications in Horizon 2020 in relation to the number of researchers in the Swedish R&D system.

Relative number of applications: Number of applications in Horizon 2020 in relation to the number of researchers in the Swedish R&D system.

R&D (Research and development activities): Defined in the Frascati Manual as: "creative work and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to devise new applications of available knowledge."[37] R&D includes basic research, applied research and experimental development. See also the fact box in the report.

R&D intensity: R&D expenditure as a proportion of GDP or in relation to heads of population.

R&D system: Refers to all actors in a country funding and/or conducting R&D, that is to say the business sector, higher education sector, other government sector and private non-profit sector.

R&D expenditure: Gross domestic expenditure on R&D (GERD). Consists of running costs and investment expenditure. See also the fact box in the report.

R&D work year equivalent: The R&D work year equivalent is the work carried out by one full-time employee during one year. A full-time employee who spends half their time on R&D has carried out 0.5 R&D work year equivalents.

Research area: Classification of different research areas used in the description of scientific publication and citations. The research areas are based on the classification of scientific periodicals in the Swedish Research Council's publication database.

Researcher: The Frascati Manual definition is: "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."[38] Researchers can be found in the higher education sector, business enterprise sector, and elsewhere in society.

SCB: Statistics Sweden (*Sw. Statistiska centralbyrån*).

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37 OECD (2015). 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, page 44.

38 OECD (2015). 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, page 162.

Success rate: The number of approved applications in relation to the number of applications. The concept is used in the description of Sweden's participation in Horizon 2020.

UKÄ: Swedish Higher Education Authority (*Sw. Universitetskanslerämbetet*).

The Swedish Research Barometer provides an overall description of research and development (R&D) in Sweden, and highlights how Sweden compares internationally as a research nation. In addition, the Swedish Research Barometer places particular focus on the research conducted within the higher education sector in Sweden.

The report consists of three chapters:

- Research funding
- Research personnel
- Scientific publication

The Swedish Research Council publish the Swedish Research Barometer every two years. This is the fourth report.

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