Baltic Science Network

Connecting Through Science

Scientific Excellence: Joint Potentials in the Baltic Sea Region – an explorative study

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Project in brief

Baltic Science Network (BSN) serves as a forum for higher education, science and research cooperation in the Baltic Sea Region (BSR).

BSN is a policy network gathering relevant transnational, national and regional policy actors from the BSR countries. The Network is a springboard for targeted multilateral activities in the frame of research and innovation excellence, mobility of scientists and expanded participation. These joint activities are modelled with an overall aim to ensure that the BSR remains a hub of cutting-edge scientific solutions with the capacity to exploit the region´s full innovation and scientific potential. The activities are modelled as examples of best practice which form basis of the policy recommendations drafted by the Network.

The platform is tailored to provide advice on how to enhance a macro-regional dimension in higher education, science and research cooperation. Recommendations jointly formulated by the Network members address the European, national and regional policy-making levels.

BSN is a flagship of the EU Strategy for the Baltic Sea Region under the Policy Area Education, Research and Employability, as well as one of two cornerstones of the Science, Research and Innovation Agenda of the Council of the Baltic Sea States.

Disclaimer: This explorative study is based on input from stakeholders and BSN partners and does not necessarily reflect the views of all participating Member States and organisations.

Contents

List of abbreviations

BBMRI	Biobanking and BioMolecular resources Research Infrastructure
BONUS	Joint Baltic Sea Research and Development Programme
BSR	Baltic Sea Region
CBSS	Council of the Baltic Sea States
CH JPI	Cultural Heritage and Global Change
CLARIN	European Research Infrastructure for Language Resources and Technology
COST	European Cooperation in Science & Technology
DESY	German Electron Synchroton
EISCAT	European Incoherent Scatter Scientific Association
EMBL	European Molecular Biology Laboratory
ESFRI	The European Strategy Forum on Research Infrastructures
ERA	European Research Area
ERC	European Research Council
ERDF	European Regional Development Fund
ERIC	European Research Infrastructure Consortium
ESS	European Spallation Source
ESS ERIC	The European Social Survey European Research Infrastructure Consortium
ESS LT	The European Social Survey – Lithuania
ETPs	European Technology Platforms
EUSBSR	European Union Strategy for the Baltic Sea Region
EUSDR	European Union Strategy for the Danube Region
ECSEL JU	Electronic Components and Systems for European Leadership Joint Undertaking
FET	Future and Emerging Technologies
FP7	7th Framework Programme (EU Research Funding 2007–2013)
GDP	Gross Domestic Product
GEOMAR	Helmholtz Centre for Ocean Research Kiel
H2020	Horizon 2020 (EU Research and Innovation programme)
HAs	Horizontal Actions (within EUSBSR)
HALs	Horizontal Action Leaders (within EUSBSR)
HDHL	JPI Healthy Diet for a Healthy Life
HEIs	Higher Education Institutions
HELCOM	Baltic Marine Environment Protection Commission – Helsinki Commission
HH	Hamburg
ICT	Information and Communications Technology
JPI	Joint Programming Initiative
JPND	JPI Neurodegenerative Disease Research
JRC	European Commission's Joint Research Centre
JTI	Joint Technology Initiative
JU	Joint Undertaking
MWP	Mecklenburg-Western Pomerania

NB8	Nordic-Baltic Eight (regional cooperation format)
NCoEs	Nordic Centres of Excellence
NordForsk	Research funding organisation under the Nordic Council of Ministers
PA	Policy Area (within EUSBSR)
PAC	Policy Area Coordinator (within EUSBSR)
PPP	Purchasing Power Parity
PSF	Project Support facility
RAS	Russian Academy of Sciences
R&D	Research and Development
R&I	Research and Innovation
R&S	Research and Science
RI	Research Infrastructure
RIS3	Research and Innovation Strategies for Smart Specialisation
SF	Structural Funds
SH	Schleswig-Holstein
SMEs	Small and medium-sized enterprises
SSH	Social Sciences and Humanities
SSTD	Strategy for Scientific and Technological Development (of Russia)
UE	JPI Urban Europe
VASAB	Vision and Strategies Around the Baltic Sea
XFEL	X-Ray Free-Electron Laser

Introduction

The aim of this study is to identify starting points for the development of synergetic transnational science strategies in the Baltic Sea region (BSR).[1] Such starting points are coinciding areas of actual or potential scientific excellence, examples of research infrastructure of supra-regional significance and best practice already established in scientific cooperation, and existing research and innovation strategies of international organisations of several BSR countries.

The investigation has proceeded in two steps. First, it has mapped highlights of the science landscape in the BSR, based on an analysis of existing and potential fields of excellent research as well as major instances of transnational science cooperation and infrastructure. Second, it has investigated current research strategies and objectives at various political levels, thereby correlating the findings from the first step of the investigation with chosen paths of science policy in the region. The two steps combine different analytical approaches, namely an empirical examination of the status quo and a policy analysis of national and supranational research and innovation strategies.

Step 1: Analysis of the research landscape in the Baltic Sea region

Aims and objectives

The objective of this step has been to provide a comprehensive assessment of the current research landscape in the BSR and to identify (potential) areas of transnational scientific excellence. It thus requires a profound analysis of universities and research infrastructures with regard to current and potential, or especially promising areas of particular expertise, and with regard to starting points for transnational cooperation. This part of the study has focused on delivering results from the following activities:

- Mapping and correlating research foci and specialised expertise in the BSR countries;
- Specifying 4-5 particularly promising areas of transnational scientific excellence;
- Identifying best-practice examples and limitations of transnational cooperation in science;
- Mapping and comparing existing and planned research and innovation infrastructures[2] of supra-regional significance with the aim of estimating their potential for further transnational advancement;
- Analysing the involvement of BSR countries and their individual share within joint EU initiatives and programmes on research and technological innovation such as JPIs, JTIs, COST, EUREKA.

[1] The geographic scope of the study departs from the call for tender and the partnership structure of the Baltic Science Network (http://www.baltic-science.org/index.php/about/bsn-partners), including all coastal states of the Baltic Sea at the level of their respective governmental representation. This means that Germany is represented by the three federal states of Hamburg, Mecklenburg-Western Pomerania, and Schleswig-Holstein. In addition, Norway, with its participation in many Baltic Sea forums and close research cooperation with the EU and North-West Russia, is included in the study.

[2] The term "research infrastructures" will be used according to the definition at http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=what

When selecting areas of potential transnational scientific excellence, the basic criterion has been that each area must involve at least three BSR countries. The selection has been motivated by an overriding interest in including each country in at least one of the identified areas of scientific excellence. Moreover, we have also decided that areas of research excellence limited to countries from only one sub-region should be taken into account (e.g. in the case of clusters only involving Nordic countries, without significant potential in other parts of the region).

Defining "scientific excellence"

The core concept of the study has been that of scientific excellence. It is widely claimed in studies of higher education and science policy that the pursuit of excellence has always been at the heart of scientific exploration and investigations, but it was largely individual with a strong reference to self-motivation and professional accountability to the academic community.[3] It was less explicitly exposed on the organisational level as universities traditionally were depicted as communities of scholars enjoying high levels of autonomy. This is at odds with a new understanding of excellence in higher education and science. Excellence has become a political concept linked to an increasingly instrumental conception of the role of higher education and scientific research for society and economic development.

Given the above mentioned conceptual shifts, in this investigation we have continually reflected upon the term "scientific excellence" for appropriate operationalisation. Despite widespread reference to scientific excellence, there is no generally acknowledged definition. Over the last two decades, there has been a rapid increase in the use of the terms "scientific excellence" or "research excellence" in political and academic discourse.[4] The concept has become a point of reference for quality measurement such as that of university rankings or for investment in research infrastructure, as well as for the allocation of research funds in general.[5] As noted by Antonowicz and others, "the political concept of *excellence* has become a prevalent feature surrounding the 'Europe of Knowledge' discourse."[6] Eventually, as illustrated by Geschwind and Pinheiro in the case of the Nordic countries, the abstract idea of excellence became embodied in specific policy instruments pertaining to science policy.[7]

Decision makers in politics and administration, who need to base decisions on rational and transparent criteria, tend to agree that excellence in research should be measured in quantitative terms such as publication output and citation impact. However, academics warn that basing quality assessment primarily on bibliometric methods may be misleading.[8]

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[3] Clark, Burton (1995), *Places of inquiry: Research and advanced education in modern universities*. Berkeley: University of California Press.

[4] Sørensen, Mads P., Carter Bloch and Mitchell Young (2015), Excellence in the knowledge-based economy: from scientific to research excellence. *European Journal of Higher Education* 6 (3): 217-236.

[5] http://www.keepeek.com/Digital-Asset-Management/oecd/science-and-technology/promoting-research-excellence/chapter-1-research-excellence-initiatives-a-new-form-of-competitive-research-funding_9789264207462-4-en#page18

[6] Antonowicz, Dominik et al. (2017), The roads of 'excellence' in Central and Eastern Europe, *European Educational Research Journal*, 1-21.

[7] Geschwind, Lars and Rómulo M. Pinheiro (2017), Raising the summit or flattening the agora? The elitist turn in science policy in Northern Europe, *Journal of Baltic Studies*, 48:4, 513-528

[8] http://www.ae-info.org/attach/Acad_Main/Publications/Press_release/Walloe-on-Exellence.pdf

According to them, such quantification provides incentives for mainstream research and portioning out of insights over a large number of publications rather than a concise exploration of innovative scientific questions that involve risks and a major research effort before yielding presentable results.[9]

Despite such diverging views on what excellent research is, there is a common understanding that it is possible to use the concept heuristically and that experienced observers can identify excellence even without detailed criteria that determine it in advance. Consequently, independent peer review and external evaluation committees are the most frequently mentioned institutions suitable to determine and sustain scientific excellence,[10] whereas criteria overdetermined by numerical indicators are not recommended.[11]

For the purpose of this study we have adopted an inclusive understanding of scientific excellence, based on both bibliometric approximations and on subjective understandings present in the national science policy strategies. We found it both appropriate and necessary to include both methods in order to satisfy the varying approaches that may prevail within the countries and administrative levels examined.[12]

Methods and databases

Since objective and generally accepted criteria for recognising scientific excellence were not clearly defined in the heterogeneous environment of the BSR, our analysis approached the issue from a variety of perspectives. This involved the exploitation of databases, surveys, and other sources provided by public authorities at the national, regional, European, and international level as well as independent scientific studies. Expert interviews were used as a validity check and in order to acquire additional information.

The web application "Mapping Scientific Excellence" (www.excellencemapping.net) gave us a first approximation of the BSR science landscape both in terms of assessing quality levels and identifying areas of specialisation. The tool is linked to academic ranking lists (such as the Academic Ranking of World Universities[13]) and to spatial visualisation approaches.[14] It has therefore also provided a model for possible graphic representations of the results of the proposed study. The excellence mapping tool has been very helpful for a first approximation of investigation results in the heterogeneous environment of BSR science. However, individual countries are very unequally represented due to the methodological limitations of this database.

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[9] Sørensen/Bloch/Young (2015) and http://www.euroscientist.com/towards-research-excellence-rather-than-excellence-itself/

[10] http://ec.europa.eu/research/infrastructures/pdf/lts_report_062016_final.pdf#view=fitf&pagemode=none

[11] http://www.euroscientist.com/towards-research-excellence-rather-than-excellence-itself/

[12] Hardeman, Sjoerd, Vincent Van Roy, Daniel Vertesy (2013), An analysis of national research systems (I): A Composite Indicator for Scientific and Technological Research Excellence, *JRC Scientific and Policy Reports*, November 2013, http://publications.jrc.ec.europa.eu/repository/bitstream/JRC83723/lbna26093enn.pdf

[13] http://www.shanghairanking.com/

[14] Bornmann, Lutz, Moritz Stefaner, Felix de Moya Anegón, Rüdiger Mutz (2015). Ranking and mapping of universities and research-focused institutions worldwide: The third release of excellencemapping.net. COLLNET *Journal of Scientometrics and Information Management* 9 (1)

The data derived from excellencemapping.net database considers the publications of relatively large institutions when defining potential areas of cooperation in the BSR. While this may be representative for strong and large networks, there are several relatively small research groups in the region that are not represented despite their potential for excellence. For instance, in Estonia there are small research groups that have been cited extensively in recent years and that have proven to be excellent cooperation partners in Europe and worldwide.[15] However, the number of publications they produce does not reach the threshold of 500 set by excellencemapping.net database. Therefore, we are of the opinion that the full potential of the BSR is not taken into consideration when only this method is used for mapping. Furthermore, as the report constitutes the likely basis for future action plans (and possibly cooperation strategies) for the members of the Baltic Science Network, the excellencemapping.net results could potentially be interpreted in a way that would lead to further widening of the participation gap, eventually limiting the possibilities of smaller institutions, and against the overall interest of the network.

Therefore, additional mapping methods that would highlight the "small but strong" institutions and their potential in defining areas of collaboration were needed in the study. For reasons of aggregation and comparison, analytical tools provided by international organisations, primarily by the OECD and the EU, have been of particular value. The latter has issued various country profiles, which examine research and innovation performance. These studies include all EU member states and Norway. They point out areas of research specialisation and compare the countries' scientific and technological capacities in a global perspective.[16] Moreover, the EU provides data on research infrastructures that are funded by the European Commission.[17]

Another method of gaining knowledge about areas of research specialisation has been to study the European Strategy Forum on Research Infrastructures (ESFRI) roadmap of the EU and the related list of landmarks, which refers to projects that have been selected for scientific excellence.[18] The analysis of the involvement of BSR countries and their individual share within joint EU initiatives and programmes (JPIs, JTIs, COST, EUREKA) have been investigated to reveal research profiles and priorities and, thus, starting points for regional science cooperation.[19]

In addition to the documentation of research landscapes and quality assessment in academic publications and by international organisations, the study has to a large extent drawn on evaluation reports coming from the national science systems. The challenge here has been

[15] http://www.etag.ee/wp-content/uploads/2015/12/TA_teaduskogumik_ENG_veeb.pdf. As an example: based on the Thomson Reuters Web of Knowledge (TR WoK) Essential Science Indicators the Estonian National Institute of Chemical Physics and Biophysics (NICPB) is among the top 1% most cited research institutions in physics since May 1, 2013. See https://kbfi.ee/wp-content/uploads/2015/09/NICPB-Activity-Report-2011-2014.pdf.

[16] http://ec.europa.eu/research/innovation-union/index_en.cfm

[17] http://ec.europa.eu/research/infrastructures/index_en.cfm?pg=mapri

[18] http://www.esfri.eu/esfri_roadmap2016/roadmap-2016.php. ESFRI is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach. The competitive and open access to high quality Research Infrastructures supports and benchmarks the quality of the activities of European scientists, and attracts the best researchers from around the world.

[19] Information on research and innovation policies and performances for all EU member states as well as documentation of their participation in the EU's joint initiatives and programs is provided at https://rio.jrc.ec.europa.eu/en/country-analysis. 10 Joint Programming Initiatives (JPIs) have been launched to date, as indicated on http://ec.europa.eu/research/era/joint-programming-initiatives_en.htm.

that excellence may have been judged by distinct national criteria, which are not necessarily compatible with standards applied elsewhere. While this could potentially restrict the comparability of the findings, the analysis of national cases has provided basic insight into scientific areas of relative significance and potential for all BSR countries. In cases where the national perspective deviated radically from international standards, for the sake of correction and confirmation, other approaches were used in the study (such as university rankings and EU-documentation).

After having identified scientific fields and specialised expertise in individual BSR countries, we examined promising starting points for the development of joint areas of transnational scientific excellence. They have emerged from similar or complementary research areas within two or more countries, and they have often been based on already established cooperation agreements. This study has analysed and systematically categorized examples of best practices and of constraints for the development of transnational scientific relations.[20]

Step 2: Analysis of science, research, and innovation strategies

Aims and objectives

The aim of the second part of the study has been to provide a comparative analysis of the science, research and innovation strategies within the BSR at various political and policy levels. Together with the findings from the first part, the results should provide knowledge for improving political decision-makers' and policy makers' capacity to prepare well-founded transnational research strategies for the BSR countries. The levels at which we have investigated research and innovation strategies include:

- the European Union;
- the BSR, NB8 (i.e., the five Nordic countries and three Baltic States) and Nordic cooperation;
- the national level;
- the subnational level (North German federal states).

The comparative inquiry into strategic goals of science, research, and innovation policies within and across these various levels has been aimed at identifying similar and complementary objectives that might exist among a significant number of them.

Methods and databases

Similar to the pragmatic way in which the current study understands the concept of "excellence", the comparison of research policy strategies has also adopted a broad and inclusive approach. We have recognised it as a precondition for a meaningful comparison

[20] The Medicon Valley Alliance, which comprises both universities and private biotech companies from Denmark and Sweden, has served as an example. Established in 1997, its aim is to contribute to increasing intra-Øresund cooperation within the life science sector and thereby to create new research opportunities, which its members would not have been able to realise individually. Starting points for the development of transnational relations within the academic community of the BSR are furthermore provided by thematic academic networks such as Novaboda (agriculture), Nordtech (technology), and ScanBalt (biotechnology and bioeconomy). See Lindroos, Paula and Kazimierz Musiał (2014), Dimensions of educational and research co-operation in the Baltic Sea Region. *Political State of the Region Report 2014*. Published by Baltic Development Forum, Copenhagen, pp. 47-52.

of levels and spatial units that differ substantially in size, coherence and competencies. Generally, all policy documents that shed light on the strategic development of research areas and on measures designed to improve innovative capabilities within the BSR have been recognised as worthwhile for the analysis. Expert interviews have provided a validity check and additional information.

At the EU-level, we have directed special attention to research policies that are shaped as part of the promotion of the European Research Area (ERA) and its general objectives in fields such as medical, industrial, environmental, agricultural, and socioeconomic research.[21] These objectives are further specified in the EU Research and Innovation programme "Horizon 2020" (H2020).[22]

Another European policy instrument relevant for supporting research and innovation has been the EU's "Innovation Union" initiative. By setting up European Innovation Partnerships (EIPs) it focuses on research and development efforts in order to find solutions to societal challenges (such as ageing populations, agricultural sustainability, transition to smart cities, water, raw materials).[23]

The link between EU-wide goals for research cooperation and the macro-regional level is provided by the EU Strategy for the Baltic Sea Region (EUSBSR). Its three objectives (save the sea, increase prosperity, connect the region) have recently been specified by identifying challenges where the BSR countries "must cooperate" in the future.[24] The challenges are:

- Addressing climate change pressures;
- Effective civil protection systems;
- Blue growth;
- Clean and safe shipping, maritime safety and security;
- Safeguarding long-term cooperation in the BSR.

Although these are broad aims, intended to influence all fields of macro-regional cooperation, we have studied them with regard to providing orientation for future research priorities in the BSR. In addition to the EUSBSR, other region-wide cooperation frameworks such as VASAB (maritime spatial planning), HELCOM and BONUS (marine pollution; clean and safe shipping) have been helpful to identify joint research agendas.[25]

The group of the Nordic states, in some cases joined by the three Baltic States, has well-established cooperation in research and education policies. The study has therefore also examined the research priorities and innovation strategies promoted by NordForsk.[26] This organisation was established in 2005 by the Nordic Council of Ministers and comprises the national research councils and other research funders of the five Nordic countries.

[21] http://ec.europa.eu/research/era/joint-programming_en.htm
[22] https://ec.europa.eu/programmes/horizon2020/en/h2020-sections
[23] http://ec.europa.eu/research/innovation-union/index_en.cfm?pg=eip
[24] http://www.strategyforum2016.eu/media/reports/looking-towards-2030-report-33885447
[25] Cf. Lindroos/ Musiał (2014).
[26] https://www.nordforsk.org/en/about-nordforsk/purpose-and-priorities/strategy-2015-2018

While existing patterns of international cooperation in research policy and joint funding initiatives are particularly significant as starting points for BSR initiatives, national governments and, in Germany, the Federal States (*Länder*) hold the most powerful position in the field. Thus, a particular focus of the study has been on the examination of national research and innovation strategies. Careful and extensive investigation at the national level has been essential not only because ten countries are examined, but also because of their presumably different ways of adopting and implementing strategic research goals. As expected, they often vary, depending on factors such as the countries' size, characteristics of the political system and institutional setting. Therefore the analysis takes as points of departure research strategies developed by the national ministries and similar institutions such as the ministries of the German Federal States. Through the national lens provided by case studies, we have examined national ERA roadmaps, identifying joint or complementary objectives when possible.[27] Furthermore, OECD has been a source of profound reports on some of the BSR countries' profiles in science and innovation.[28] In the final stage, we have reviewed the strategies that exist at the various levels and compared them in a synoptic overview. This has enabled us to identify similar and complementary objectives both within and across the analysed levels.

[27] See for instance the German ERA roadmap on
https://www.bmbf.de/files/Strategy_of_the_Federal_Government_on_the_European_Research_(ERA.pdf
[28] https://www.oecd.org/sti/; http://www.oecd.org/innovation/inno/oecdreviewsofinnovationpolicy.htm

1. National points of departure

In order to arrive at the areas of potential scientific excellence in the BSR, it is essential to consider the national points of departure with regard to science policy. National strategies for the development of science policy and the financial ability to support the most desirable developments must be recognised before defining some areas, disciplines or branches of science as potentially excellent at the regional level. Therefore a cursory look at the economic foundations of scientific cooperation in the BSR is provided, with a point of departure in the GDP figures and their relationship with R&D spending. It is believed that the ability to generate a common strategy for regional science policy in a number of fields will depend on a successful translation of the vested national interests in the scientific domain into transnational strategies, aiming at financial synergy and problem-based cooperation at the BSR level. Potential excellence in some disciplines, areas or branches of science in the BSR may be achieved if common social or natural challenges in the BSR are clearly defined and agreed upon, with the opportunities of joint research endeavours to meet these challenges duly ascertained. For this an optimal balance and maximal synergy among "policy-driven", "industry-driven", and "bottom-up science driven" interests of all the involved national and transnational stakeholders in the BSR is necessary.

Economic foundations of scientific cooperation in BSR

As indicated in the 2017 Baltic Science Network publication on *Participation in ERA and Baltic Sea RDI Initiatives and Activities*, BSR as a region has substantially increased its total R&D funding to almost EUR 37 billion in 2014, forming 11.4% of total EU expenditures. This growth has been driven by Sweden, Denmark and Germany, whereas in Finland R&D expenditure continued to increase during the crisis years, but reversed afterwards when both government and business investments started to decline. Poland and Lithuania have also increased their investments in R&D, but in Estonia and Latvia, similarly to Finland, there was a decline after the crisis followed by a small rise in Estonia in 2015. However, the highest pre-crisis investment levels in those countries have still not been achieved. In Latvia, while government spending has increased, it is caused by decreasing business expenditure; in Estonia, besides business investments also government investments into R&D have decreased more recently.[29]

The following tables and figures demonstrate that there is no simple and straightforward translation of real GDP growth in the BSR into scientific output or individual countries' expenditures on R&D.

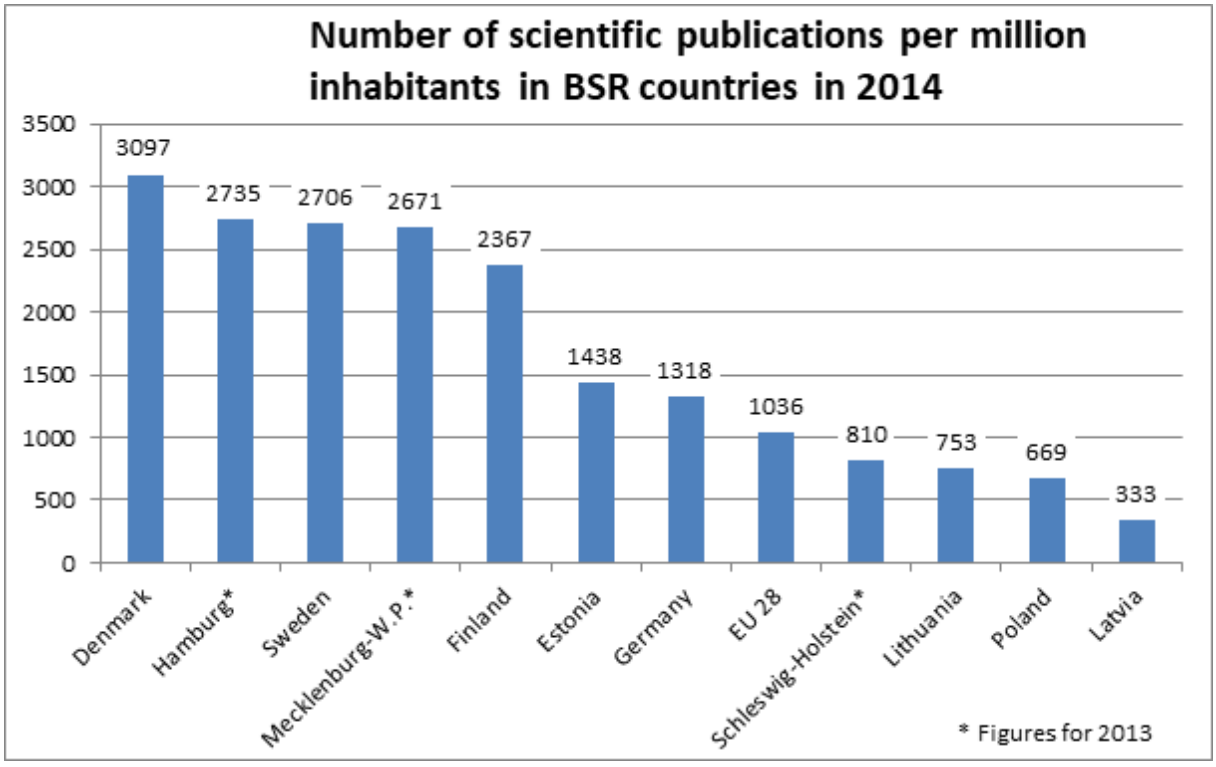
[29] Ukrainski, Kadri, Erkki Karo, Margit Kirs, Hanna Kanep (2017), Participation in ERA and Baltic Sea RDI Initiatives and Activities: Analysis and Policy Implications for Widening Participation of Strong and Moderate Innovators, Baltic Science Network, p.27.

Table 1. Real GDP growth in the Baltic Sea region

Real GDP growth, % y/y	2011	2012	2013	2014	2015	2016E	2017E
Baltic Sea Region	2.2	0.9	0.7	1.6	1.9	1.7	1.6
Denmark	1.2	-0.1	-0.2	1.3	1.2	1.0	1.5
Estonia	7.6	5.2	1.6	2.9	1.1	1.7	2.6
Finland	2.6	-1.4	-0.8	-0.7	0.5	1.0	0.8
Germany	2.0	0.4	0.3	1.6	1.7	1.7	1.4
Iceland	2.0	1.2	4.4	2.0	4.0	3.5	3.3
Latvia	6.2	4.0	3.0	2.4	2.7	2.2	2.8
Lithuania	6.0	3.8	3.5	3.0	1.6	2.6	3.0
Norway	1.0	2.7	1.0	2.2	1.6	0.7	1.5
Poland	3.8	1.6	1.3	3.3	3.6	2.8	3.5
Russia	3.2	3.5	1.3	0.7	-3.7	-1.0	1.1
Sweden	2.7	-0.3	1.2	2.3	4.1	3.3	1.7

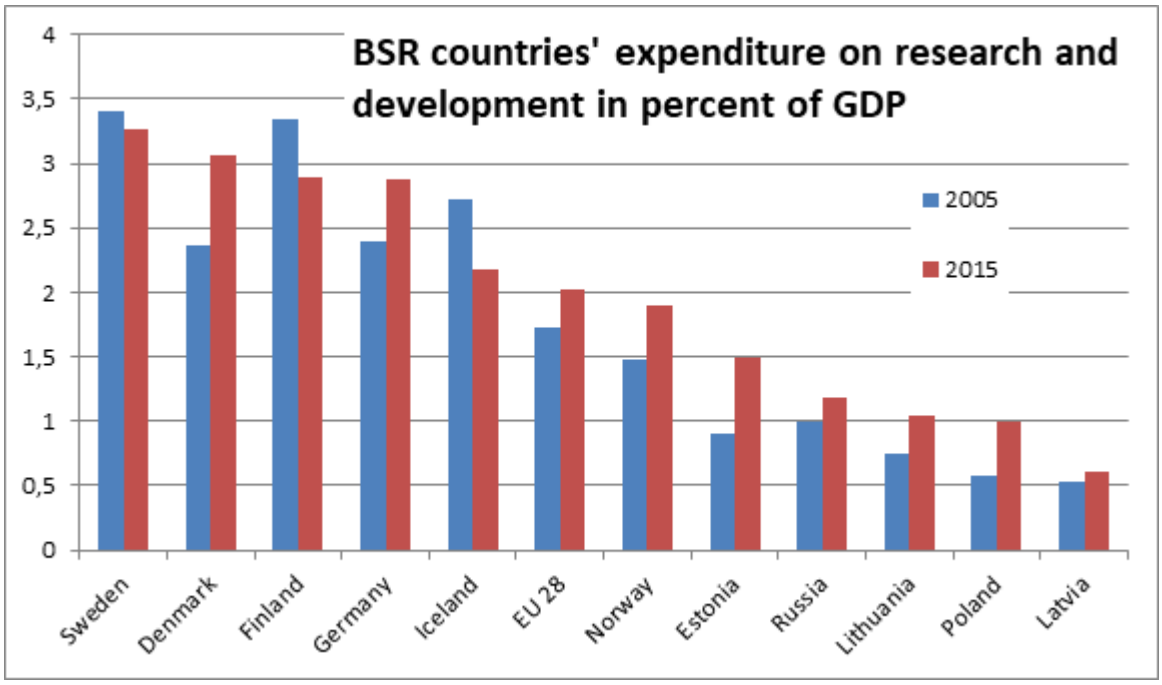
Source: BDF State of the Region Report 2016, p.44.

Figure 1. Number of scientific publications in BSR countries



Source: Own compilation, based on: Bundesbericht Forschung und Innovation 2016

Figure 2. Expenditure on research and development in the Baltic Sea region



Source: Own compilation, based on http://ec.europa.eu/eurostat/statistics-explained/index.php/R_%26_D_expenditure

The apparent disparity in expenditures on R&D and the strikingly different figures of scientific publications per million inhabitants in BSR countries show how diverse the points of departure are and why making comparisons and drawing conclusions for common science policy in the region must be seen as a great challenge. To meet this challenge, our analysis of potentiality of scientific excellence in the region starts with individual countries. In each country case we briefly demonstrate the systemic or ideational foundations of R&D policy measures, we take into account the official as well as subjective opinions of the decision makers and practitioners, we analyse currently evolving science policies and strategies, and we ascertain nationally defined political self-interest, limitations and potentiality for supporting scientific excellence at the transnational level.

Denmark

Short description of the country's R&D profile

Denmark has the third highest R&D intensity among EU Member States. It was the third country after Finland and Sweden, which has achieved the EU target of a public R&D investment level of 1% of GDP by 2011. Among EU member states, Denmark occupies the first place in terms of highly cited publications. 14,5% of total national scientific publications belong to the 10% most highly cited scientific publications in the world, which is one of the world's highest rates.[30]

[30] http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/countries/denmark.pdf

Assessing current research landscapes (subjective opinions from country studies)

The most important strengths of Danish research are within **medicine, biochemistry and genetics** as well as in energy, (and here especially in branches related to **renewable energy** sources and electricity transmission systems). In contrast, Danish research in ICT is of comparatively low importance.

Analysing science policies and strategies (country specific – their strategies and goals)

In June 2017 the Danish Ministry of Higher Education published the "RESEARCH2025-catalogue"[31], which contains a list of highly promising future research areas as seen by the private sector, ministries and other public institutions. It will serve as a source of inspiration when deciding about future strategic research investments by national funding organisations. According to the catalogue the suggested main fields of future Danish research are:

- **New technological opportunities** (special emphasis on digitalisation, new production technologies and materials, biomaterials, biotechnology);
- **Green growth** (special emphasis on energy, electricity transmission, wind power and other renewable energy sources, biofuels, transport and logistics, urban development and new construction technologies and materials, transition to circular economy);
- **Better health** (special emphasis on personalised medicine, biochemistry and genetics, people-oriented and technology-assisted health systems, the fight against global and local health threats, antibiotic resistance, prevention and healthy lifestyle);
- **People and society** (special emphasis on youth and education, effective public administration in a highly digitalized society, social conditions and cohesion, Denmark in a globalized world).

The "Research2025-catalogue" highlights the fact that the establishment of world leading research infrastructures in the field of structural sciences in close proximity to the Danish border (such as the European Spallation Source (ESS), MAX IV in Southern Sweden and the EUROPEAN X-Ray Free-Electron Laser (XFEL) in Hamburg/Schleswig-Holstein) will offer unique opportunities for Danish researchers and companies to achieve an internationally leading position in bio- and material technologies.

The "Danish Roadmap for the European Research Area 2016-2020"[32] emphasizes the broad consistency between Danish interests and European research strategies as manifested in the H2020 framework programme. Accordingly, the European focus on grand societal challenges such as food, health, energy, climate and the environment corresponds directly with the positions of strength of the Danish economy and Danish research institutions.

[31] http://ufm.dk/publikationer/2017/filer/forsk2025.pdf

[32] http://ufm.dk/publikationer/2015/dansk-roadmap-for-forskningsinfrastruktur

Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

As a small country Denmark relies heavily on an open economy and on the development of internationally competitive products. The Danish economy has thus specialised in the development of research intensive branches that build upon intensive knowledge exchange between academic researchers and companies. Due to the country's generally good economic situation, public spending on the research sector is rather generous. In addition, large companies contribute strongly to a particular orientation of Danish research towards medicine, biochemistry and biotechnology.

Country profile and standing in *www.excellencemapping.net*

The excellencemapping.net database reveals high quality values for Danish research institutions in almost all analysed scientific disciplines. The best results are achieved in **medicine, biochemistry and genetics, engineering, computer science and materials science**. In each of these disciplines about two or three Danish institutions belong to the global top 10%, while a few others still rank among the global top 25%. If seen from a BSR perspective the average value of the analysed Danish institutions is in most disciplines the highest or second highest as far as citation impact is concerned. At the same time the vast majority of institutions rank clearly above global average. The only exception with a slightly weaker evaluation is neuroscience.

Among the Danish research institutions that belong to the global top 10% very good results are achieved by the **University of Copenhagen** in engineering (ranked 9 out of global 1330) and in veterinary science (global rank 3 out of 53 by citation impact). In medicine as well as in biochemistry and genetics **Novo Nordisk A/S** and **Danish Cancer Society** are excellent, ranked 9 out of global 1676 in medicine and in first position in the BSR. In materials science **Aarhus University** is ranked first in the BSR and 7th out of 829 at global level.

Country participation in H2020 with other BSR countries

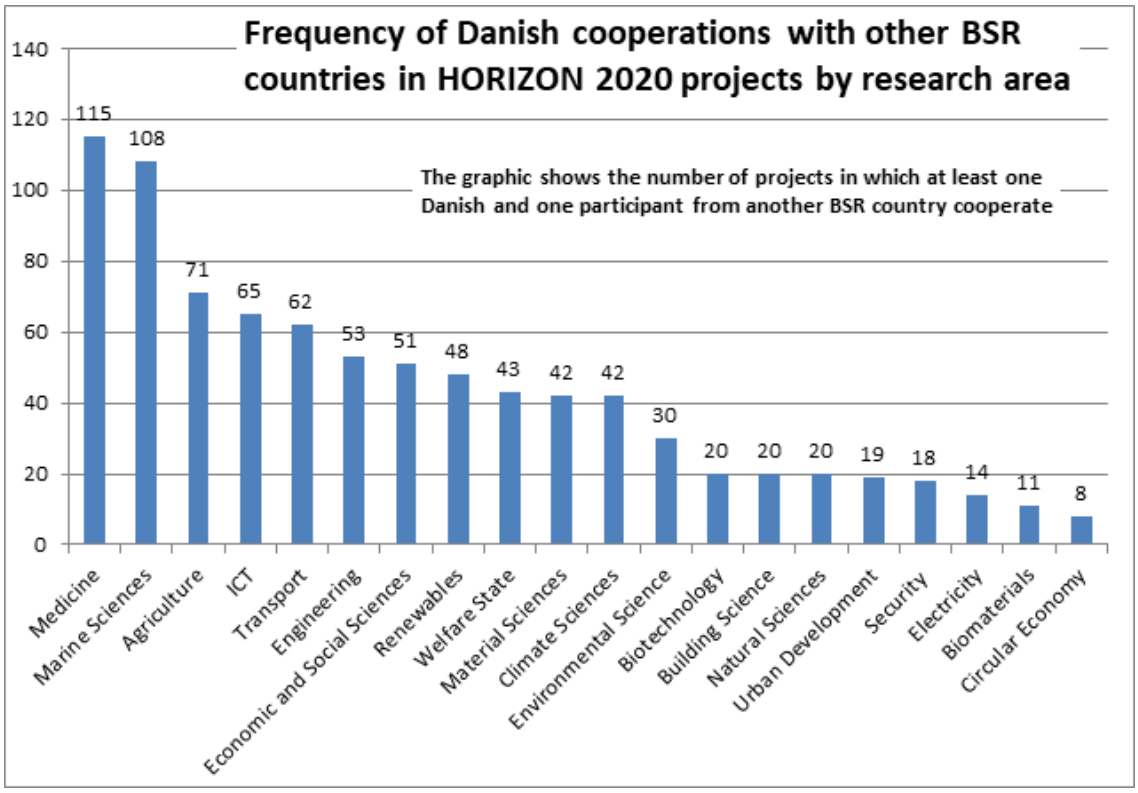
In absolute numbers Denmark is in second place after Sweden as far as frequency of joint participations with other BSR countries in H2020 projects is concerned. However, the relative importance of BSR cooperation in that context is not tangible. Only less than half of Danish H2020 projects involve partners from other BSR countries. Only in the case of Sweden is this share lower. In contrast, almost two thirds of H2020 projects with Norwegian participation involve partners from other BSR countries and in Latvia the share is even higher at 76%. Within H2020 Danish research institutions most frequently cooperate with partners from other Nordic countries, most of all with Sweden (365 partner institutions), Finland (257) and Norway (254). Poland (175) and the German BSR states rank in the mid-range, whereas the lowest levels of cooperation are recorded with project partners from Estonia (69), Latvia (53), Lithuania (50) and Iceland (42).[33]

For Denmark, by far the most important research areas, when cooperating with project partners from other BSR countries, are **medicine and marine sciences**. This applies both in absolute numbers as well as in comparison with other BSR countries. Furthermore, Denmark

[33] See Figure 15.

is in first place in the BSR as far as project participation rates related to **renewable energy** sources are concerned, as demonstrated in Figure 3.

Figure 3. Frequency of Danish H2020 cooperation with BSR countries (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Country participation in JPI/JTI, COST actions, EUREKA

The Danish total participation rate in JPI projects (73) is mid-range if seen from a BSR perspective; the number is less than half of the Swedish rate (153) and still lower than that of Norway (91) but slightly higher than the Finnish one (58). As for research areas, Danish research institutions are strongly engaged in JPIs that are related to **health and medicine** as well as to **agriculture, food and water**. Surprisingly and unlike its Nordic neighbours, Denmark has so far not participated in JPI "Oceans" projects.[34]

In contrast to the medium numbers of engagement in JPIs, Denmark shows very high participation rates in all JTI project categories. Particularly striking is the **high number (97) of JTI Fuel Cell and Hydrogen project participations**,[35] which exceeds by far those of any other BSR country. This can be attributed to the general importance of research on **renewable energy** sources in Denmark and in particular on **wind energy**. Denmark occupies second position among the BSR countries as far as project participations in the ECSEL JU and in the JTI Innovative Medicines Initiative are concerned.

Again, Danish participation rates in COST actions and EUREKA projects are at a medium level if compared to other Nordic and BSR countries. The vast majority of Danish EUREKA projects

[34] See Table 4.
[35] See Figure 23.

are related to **Medical technology, Biology and Biotechnology**. Within this field, among the BSR countries only the Swedish participation rate is higher. In contrast, Denmark shows comparatively low participation rates in EUREKA projects in the fields of Electronics and ICT as well as in Materials Technology and average participation rates in energy technology and agriculture.

Important research infrastructures of regional relevance

- Wind energy

Østerild National Test Centre, established 2012, is so far the only place in the world where the large wind turbines of the future – which are as high as the pylons of the Great Belt Bridge – can be tested. The research infrastructure is owned by the Danish government and managed by the Technical University of Denmark (DTU). With 210 employed researchers, **DTU Wind energy** department is the world's largest university knowledge centre for wind energy with the longest experience and the most measurements of wind turbines.[36]

- Materials science

In materials science Denmark is expected to benefit strongly from the large European research infrastructures in Sweden and Germany, which have been established in close proximity to the Danish border. Denmark is not only among the founding members of the **European Spallation Source** ERIC **(ESS)**, but is also the host of its **Data Management and Software Centre**, which is located in Copenhagen. For the analysis of nanoscale materials, the strongest group of electron microscopes in the world is located at the **Centre for Electron Nanoscopy** at the Technical University of Denmark in Copenhagen. The **Centre for Storage Ring Facilities (ISA)** in Aarhus supports research in fields like fundamental physics, materials science, molecular biology and laboratory astrophysics, using accelerators and storage rings.

- Electricity

PowerLabDK provides an experimental platform for electric power and energy. It includes flexible test laboratories, large-scale experimental facilities as well as a complete full-scale power distribution system on the Island of Bornholm. **SYSLAB** provides a flexible intelligent laboratory for research and testing of control concepts and strategies for power systems with distributed control and integration of decentralized production and consumption components.[37]

Estonia

Short description of the country's R&D profile

The Research and Innovation Policy Performance Report[38] mentions that public spending in research in Estonia has declined and has been partly counterbalanced by EU Structural Funds

[36] http://www.sebrochure.dk/DTU_Vindenergi_UK/MailView/

[37] www.powerlab.dk

[38] https://rio.jrc.ec.europa.eu/en/library/estonia-research-and-innovation-performance

but business spending in R&D has continued its downward trend (note that this is an interesting conflict, since Estonian research strategy seems to be heavily directed towards establishing strong connections between business and research). In fact the weak academia-business cooperation has been brought out by the report as one of the major challenges for Estonian research. The report also notes that Estonia has moved down the ranks from 'strong innovator' to 'moderate innovator', with few companies investing in R&D.

The report also claims that the quality of the science base is improving (warranted by the number of scientific publications that are highly cited). The same can be said about scientific collaboration, however the report also mentions that increase in this area might have at least partly to do with the overall increase in international co-authorships.

The report also mentions that the Estonian research and innovation system needs more researchers and engineers. This however, is difficult to achieve if investment into science is decreasing. The reason for the difficulties in cooperation between business and science in Estonia might stem from the fact that most enterprises in Estonia are small to medium size and hence are not interested in investing in high-tech developments. As the Research and Innovation Policy Performance report mentions, the Estonian industrial sector is largely driven by basic subcontracting manufacturing. Hence in order to shift to high-tech, the Estonian economy would need restructuring, diversification and a transition to higher value added outputs.

The report has also highlighted as weaknesses the medium quality of the higher education system and the non-absorption of highly-skilled graduates in firms. It says that even though Estonia has improved its performance in public-private cooperation, it still faces the challenge of increasing the excellence and internationalization of its research institutions.

The report also brings out six areas of scientific and technological strength for Estonia: **food, agriculture and fisheries, energy, environment, ICT, nanosciences and nanotechnologies, and biotechnology**. Furthermore, according to the citation impact ranking, Estonia has been extremely successful in areas such as **biochemistry and genetics** as well as **agricultural and biological sciences** (see Figure 31). Medicine, although slightly less cited than two other areas, has however had most publications in the best journals.

Assessing current research landscapes (subjective opinions from country studies)

Estonia seems to want to develop its research by increasing cooperation between the private market and research institutions. This, as has been seen, has also been mentioned as one of the greatest weaknesses for the Estonian research landscape. The question then remains, taking into consideration the specifics of the Estonian economy, is this strategy feasible? The fact that Estonia currently has huge number of small enterprises poses a considerable problem when trying to encourage cooperation between research institutions and business. The country has also realized its need for specialization and has been investing more heavily in certain areas of science such as ICT. The prioritized areas are defined by the R&D profile. Several applied programmes have been announced to support the prioritized areas, such as NUTIKAS (Applied research in smart specialization growth areas). Furthermore, participation in large scale European projects such as JPI and JTI is decided by either the Estonian Research

Council or the corresponding ministry taking into consideration the areas of smart specialisation.

Furthermore, there is a certain structural problem within Estonian science funding – namely, one has to wait two years after completing a doctorate in Estonia before being eligible to apply for an individual research grant. However, the funds are available for applying for post-doctorates abroad or for Estonian scientists that have completed their education elsewhere and want to return to Estonia.[39] This is intended to encourage Estonian scientists to work abroad, however it can have an unintended consequence of some scientists never returning after completing their post-doctorate abroad.

There have also been significant changes in Estonian research funding structure in recent years. As a result of reforms, competitive funding instruments and funding process were also rearranged. ESF grants were transformed to personal research grants. Targeted funding of research topics was transformed to institutional research grants (highly competitive grants with some elements of institutional support). Furthermore, the Science Competence Council – the decision-making body for targeted funding – was transformed into the Evaluation Committee, which evaluates applications for personal and institutional funding submitted to the Estonian Research Council, and upon the request of the Research Council carries out other duties. In 2014, a working group formulated recommendations to change the current funding model and increase the share of baseline funding to 50% in order to provide more stability for operational expenses.[40]

It should also be noted that a big share of funding in Estonian research comes from EU Structural Funds and hence European research policy has an important impact on Estonian science and its development.[41]

Analysing science policies and strategies (country specific – their strategies and goals)

Estonian research strategy states that its aim is to enhance cooperation with enterprises and authorities. Such cooperation is also assumed to help in marketing Estonia international as a high tech country. Cooperation with enterprises and authorities is seen as especially necessary in terms of handling increasing data volumes. Three areas especially have been prioritized: **ICT, health technologies and services** and **more effective use of resources**. Since 2008-2009, research and private sector partnerships and interactions are supported by the Estonian government through three main channels: the Competence Centre Programme, the Cluster Development Programme and the Innovation voucher grant. Additionally, in August 2015, new activities were launched to support innovation in the areas of smart specialisation either in innovative enterprises or through the utilisation of research products in Estonian companies. EU Structural Funds of EUR 26.6 million were allocated to these activities – and 15 million will be added as co-funding of private enterprises. International cooperation in the form of European research initiatives and international research infrastructures is used to cope with potential problems, especially when it comes to funding. In terms of prioritized areas, the

[39] http://www.etag.ee/wp-content/uploads/2017/03/PUT_JD_taotlemise-juhend-2017.pdf

[40] Cf. http://ec.europa.eu/research/era/pdf/era_progress_report2016/country_fiches/era-ee.pdf

[41] https://energiatalgud.ee/img_auth.php/8/89/Koppel%2C_A._Rakendusuuringud_Eestis._Koht_meie_teaduskorralduses_ja_tulevik._2015.pdf

significant research centres in health technologies and services are located in the University of Tartu, in the National Institute of Health Development and in hospitals (North Estonia Medical Centre and Tartu University Hospital). In terms of the second prioritized field – the more effective use of resources – the centres are located largely in the University of Tartu and in Tallinn University of Technology. In ICT the relevant centres are located in Tallinn Technical University, the University of Tartu and in IT College (which is a part of the Technical University).

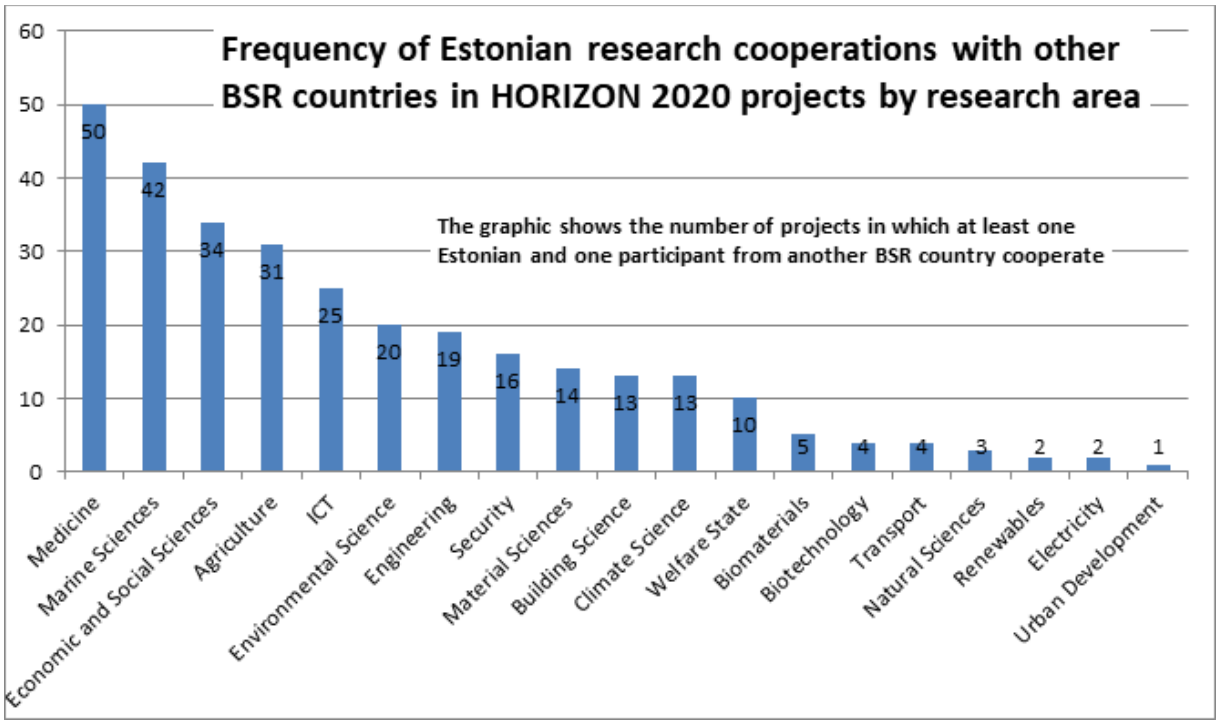
Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

Estonia has focused heavily on making research market-oriented. Hence research areas which can potentially be useful for the knowledge economy are supported. Many researchers in humanities and social sciences are therefore trying to cooperate with the sciences in order to secure themselves funding. A good example of such cooperation is the *Centre of Estonian Language Resources* – an infrastructure which enables all researchers to access language resources and technologies. Partners include the Institute of Computer Science at the University of Tartu, the Institute of Cybernetics at Tallinn University of Technology and the Institute of Estonian Language. With respect to the humanities, research related to culture and language seems to be considered worthy of funding.

As can be seen from the graph on the next page, in the framework of H2020 projects, Estonia has a high level of cooperation with other BSR countries in **medicine and marine sciences**. In terms of medicine there is a standing cooperation between Karolinska Institutet in Sweden and the University of Tartu, which already has a long record of common applications under multiple international calls. Hence this can be seen as one of the more established cooperations. There is also cooperation between Södertörn University and the National Institute of Health Development. In terms of marine research a good example of cooperation is *SeaDataCloud* – further developing the pan-European infrastructure for marine and ocean data management, including virtually all BSR countries.

Based on the graph, even though there is some cooperation in ICT, it is not one of the most popular areas of cooperation with other BSR countries. Note that ICT is one of the highly prioritized areas of research. However, a lot of international cooperation in ICT is conducted with either the UK or the US.

Figure 4. Frequency of Estonian H2020 cooperation with BSR countries (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

More effective use of resources, if we include under this heading projects focusing on energy politics, appear to involve many BSR countries simultaneously. For instance, the project BRILLIANT (*Baltic Region Initiative for Long Lasting Innovative Nuclear Technologies*) includes Poland, Lithuania, Sweden, Latvia and Estonia. Energy politics and energy saving are an important focus in multiple BSR projects and can be seen as one of the fields in which transnational cooperation is most developed.

Country participation in JPI/JTI, COST actions, EUREKA

Estonia participates in 7 out of 10 Joint Programming Initiatives (JPIs), but to varying degrees: the country is participating fully in three JPIs, is an associated member in one JPI and an observer in three others. It also participates in three Joint Technology Initiatives as well as Knowledge and Innovation Communities. The different ministries involved have allocated EUR 2.21 million in total to transnational cooperation in 2015. Additionally, the Estonian Research Council is funding regional initiatives with Baltic and Nordic countries through the Nordplus Framework Programme.[42] Estonia has also participated actively in EP7 call, having 20 projects funded. The projects which have been funded vary in terms of their specialisation, ranging from biodiversity to material science. Under H2020, multiple projects from different calls have also been funded.

Participation in JTI's has not been popular in recent years. In previous years Estonia received funding for four projects, two under the initiative for "Innovative Medicines" and two for "JTI Fuel Cells and Hydrogen". Two Innovative Medicines projects called "European Medical Information Framework" (2013) and "New models for preclinical evaluation of drug efficacy in

[42] http://ec.europa.eu/research/era/pdf/era_progress_report2016/country_fiches/era-ee.pdf

common solid tumours" (2011), both located at the University of Tartu, received funding. Two companies have received funding from the Fuel Cells and Hydrogen Joint Undertaking.

Estonia is participating in Joint Baltic Sea Research and Development Programme BONUS and European Metrology Programme for Innovation and Research (EMPIR).

Participation in EUREKA and Eurostars funding schemes, as can be seen in Figure 63, is relatively low when compared to other BSR countries.

Even though Estonia is not leading any COST projects, it is actively participating in many of them. The most popular areas here are: Individuals, Societies, Cultures and Health, where Estonia is a participant in 50 actions and in 78 CA cost actions. Examples of projects include: *Children's Welfare*, *Cyberbullying*, *Advancing Marine Conservation in European and contiguous seas* and *Understanding and Combating African Swine Fever in Europe*. From Figure 61 we can also see that participation in COST calls increased in the period from 2013 to 2015.

Important research infrastructures of regional relevance

The idea of the National Roadmap to research infrastructures in Estonia was to support smart specialisation. Hence the centres supported are mainly technical in nature. However, the supported projects vary in terms of area of specialisation, so there is no significant sign of support for only the areas which were mentioned as high priority in the Research strategy (ICT, health technologies and services and more effective use of resources). For instance, the National Roadmap supports participation in several big physics schemes such as the European Spallation Source and Estonian Beamline MAX-IV at the Synchrotron Radiation Source. However, one of the tendencies that can be observed in projects is, as mentioned earlier, cooperation between humanities and sciences on multiple occasions. This seems to be the direction social scientists are increasingly taking in Estonia. This also appears to be logical, considering that the aim has been to support smart specialisation and the overall goal has been to increase the impact of research on and cooperation with state authorities and enterprises. It should be noted that whereas the National Roadmap is not a funding scheme, several initiatives, mainly of an applied nature, have been announced following the identification of prioritized areas (such as RITA, a programme aiming to increase the role of the state in the strategic managing of research and the capabilities of R&D institutions in carrying out socially relevant research).

Most relevant developments for BSR cooperation in the future

One of the developments which has not been mentioned so far is Estonia's participation in NordForsk, which supports societal research, cyber security and social media studies. Estonia has also actively applied for EEA and Norway Grants to support its research. Furthermore, the programme "Nordic Spaces" announced by Riksbanken in Sweden had a positive effect on humanities in Estonia and several projects were supported through this.

In terms of active cooperation, Estonia has had successful cooperation between Aalto University and the Universities of Jyväskylä and Tartu in meteorology; in physics between the University of Tartu and Lund University; in medicine between Karolinska Institutet and the University of Tartu. All interviewed experts stressed the importance of cooperation with

other BSR states on multiple levels, through EU Structural Funds, but also through more local funds such as NordForsk or Nordic Spaces. According to the experts there is also a problem when applying for EU Structural Funds, where EU13 countries are discredited easily and therefore cooperation with EU15 countries, and especially with the Nordic countries, is regarded to be of the utmost importance.[43] Cooperation with other EU13 countries is seen as less significant due to funding reasons, but also due to the stereotypes that are attached to the state of their research (underdeveloped, old-school etc).

Finland

Short description of the country's R&D profile

Although Finnish R&D intensity has in recent years significantly decreased from 3.55% in 2012 to 2.9% in 2015, it is still among the highest rates of all EU countries. Moreover, Finland's innovation output indicator is the fifth highest in the EU – after Germany, Sweden, Ireland and Luxemburg. Central clusters of research and innovation include **ICT, environment, materials, energy, security, food and agriculture**.[44] However, in spite of the country's high R&D intensity, high-tech goods make a relatively low contribution to the Finnish trade balance. This is partly due to the structure of the export industry, which is focused on machinery and paper products. In addition, the decline of Nokia has led to a decrease in business R&D expenditures that previously were dominated by the company. These structural conditions stand at the centre of Finnish research and innovation policies, which focus almost solely on the potential for commercialisation of research and converting research into a tool of economic growth.

Assessing current research landscapes (subjective opinions from country studies)

There is no direct government steering of research areas in Finland. Steering takes place through competition for funding. The main source of research funding in Finland is direct funding from the Ministry of Education and Culture to the universities, where it is allocated to research according to the university's own policy. As of 2015, this direct funding amounted to EUR 820 million (56% of all funding). It is therefore important to realize the limits any research policy faces: the amount of research funding that is under governmental control is very limited given the broader funding situation.

Since 2010 Finland has been undergoing a major reform aimed at greater financial autonomy of the universities and greater concentration of research institutes by reorganising and discontinuing small research units. The Academy of Finland has a small budget to support universities in this reorganisation. In addition, a new **Strategic Research Fund** is available for the government to promote research in politically designated strategic areas. It provides funding for 3 to 6 years. Recent **thematic programmes include**:

- Utilisation of **disruptive technologies** and changing institutions (2015);

[43] Disparities between the core EU-15 countries and the EU-13 countries has been well documented, for instance, in: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/collaboration-and-networks-eu13-participation-international-science

[44] http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/countries/finland.pdf

- A **climate-neutral and resource-scarce society** (2015);
- **Equality** and its promotion (2015);
- Knowledge, know-how and changing **working life** (2016);
- **Health** and changing lifestyles (2016);
- Overall **security** in a global environment (2016);
- Dynamics of **urbanisation** (2016);
- Changing citizenship – **society** in a state of global flux (2017);
- Reform or wither – **resources** and solutions (2018).

In the national ERA roadmap, Finland sets the goal to "streamline" the profiling of universities – which has met much opposition from the universities – and to increase cooperation between the state's research institutions (e.g. Technical Research Centre of Finland, Institute for Economic Research, Institute of Meteorology, Natural Resources Institute Finland, National Institute for Health and Welfare). Areas that have emerged as policy priorities include: **bioeconomy, clean tech, digital economy, health, immaterial value.** Furthermore, **ICT** and **Arctic knowledge** have been mentioned as carrying potential for the Finnish economy.[45]

Analysing science policies and strategies (country specific – their strategies and goals)

Finland shows scientific specialisation within the following areas: automobiles, food, agriculture and fisheries, construction technology, ICT, environment and socio-economic sciences. These areas are not always the same as those classified as "revealed technology advantage" since the latter are measured in number of patents (which in Finland are high in security, ICT and other technology). A central challenge to the Finnish knowledge-based economy – the main concern of current research and innovation policy – is the transition from the Nokia-dominated electronics industry and paper industry to a more varied knowledge-based economy. Cooperation between the research community and private business is placed at the core of this transition in government research and innovation policy. Areas of rising R&D intensity include metals, environment, energy and construction. Given the generally shared idea of knowledge-based economy as a current mode of production, research and innovation policy have been harnessed as major tools for recovery from the economic crisis that hit Finland in 2008-2009 (RIO Country Report 2016).[46] This has given especially government research policy a certain economic slant that the research community or the funding agencies do not always fully share.

Country profile and standing in *www.excellencemapping.net*

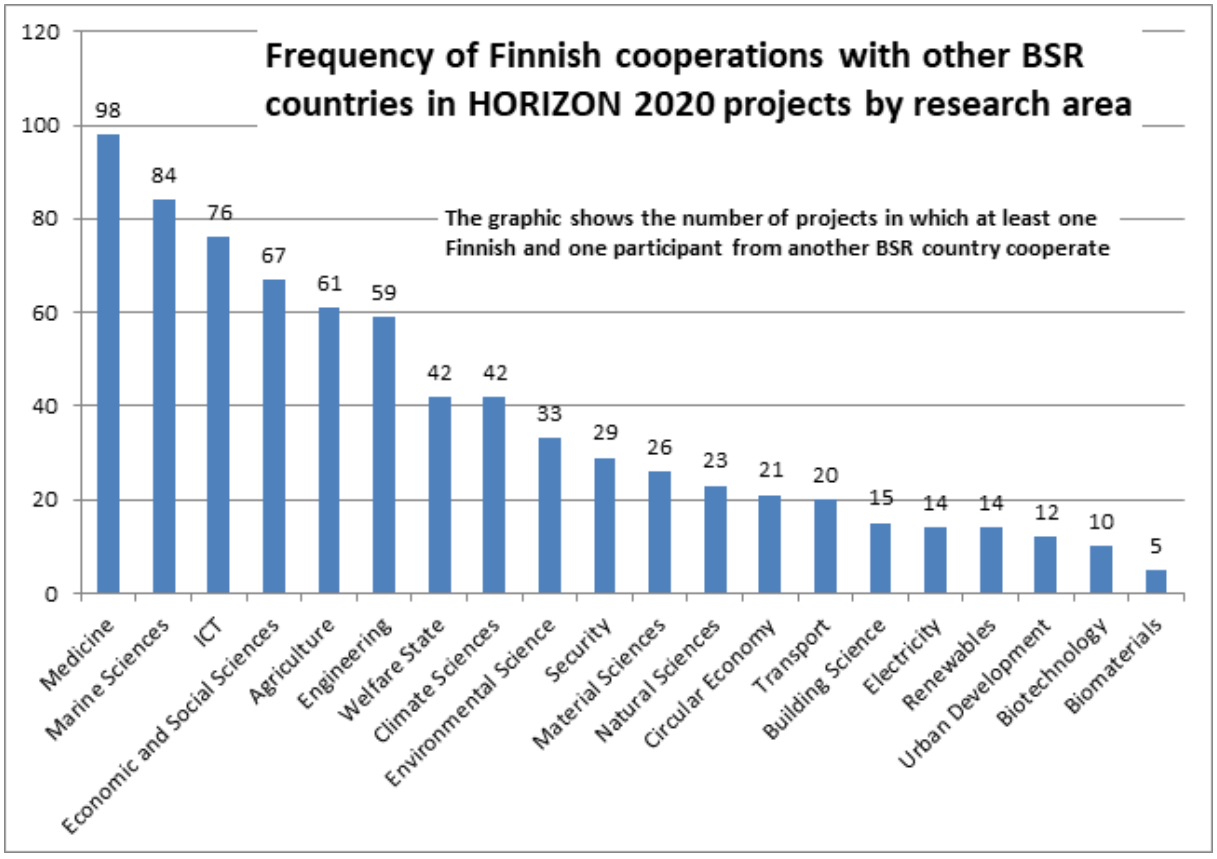
The excellencemapping.net database ranks most Finnish research institutes above global average and in a medium position if compared with the other Nordic countries. Finland occupies the first place of all BSR countries in **medicine**. All 15 analysed Finnish medical institutes range within the global top 25% as far as publication rates in world leading journals are concerned and five of them even achieve a position within the global top 10%.

[45] Prime Minister's Office Finland, *Finland´s Strategy for the Arctic Region 2013*, http://vnk.fi/documents/10616/334509/Arktinen+strategia+2013+en.pdf/6b6fb723-40ec-4c17-b286-5b5910fbecf4, p.13, confirmed by The Government's strategy session 26.9.2016 *Government policy regarding the priorities in the updated Arctic strategy*.

[46] https://rio.jrc.ec.europa.eu/en/library/rio-country-report-finland-2016

Other research areas, which show very high rankings, are **biochemistry and genetics** as well as **engineering, physics and computer science**. By contrast, Finnish results in materials science and environmental science range mostly below global average.

Figure 5. Frequency of Finnish H2020 cooperation with BSR countries (2014–2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Country participation in H2020 with other BSR countries

Finland participates in H2020 projects at a level that is comparable with that of the other Nordic countries. In slightly more than half of the projects (53%) Finland participates jointly with at least one partner from another BSR country. In most cases these partners are from Sweden, followed by Denmark, Norway, Poland, Estonia and the German BSR. As regards research areas, most of the Finnish projects are related to **medicine** and **marine science**, which is a pattern similar to the other BSR countries. However, in contrast to them, Finland has a comparatively high share of project participations related to **ICT** and **engineering** (second highest of all BSR countries after Sweden).

Country participation in JPI/JTI, COST actions, EUREKA

The total number of Finnish participations in JPI projects (58) is significantly lower than in the other Nordic countries (for instance Sweden: 148) but higher than in Poland (38) and the German BSR (16). As in the other BSR countries, most participations are related to **Agriculture, Food and Climate Change**. However, in contrast to other BSR countries, Finland also shows relatively high participation rates in projects related to the JPI **Urban Europe**.

Unlike in JPIs, Finnish engagement in JTIs is more intensive if seen in a Nordic – or especially BSR-wide – context. This is true in particular for the **Bio-based Industries** and **ECSEL (Electronic Components and Systems for European Leadership) Joint Undertakings**. In both cases Finland occupies the first place in the BSR in terms of both numbers of participating organisations per country and of country participations, clearly ahead of Sweden and Denmark respectively. Finland has in 2016 also received the highest funding (1.9 million Euro) from the ECSEL JU budget of all BSR countries, slightly ahead of Sweden (1.8 million Euro). Finnish participation rates in the JTI Fuel Cell and Hydrogen and the JTI Innovative Medicines Initiative are however in line with the Nordic average.

In contrast to all other BSR countries, the share of Finnish participation in COST has slightly decreased in recent years (from 80% in 2011 to 74% in 2015) and is now lower than that of all other Nordic countries (except Iceland). However, the absolute amount of COST project funding transferred to Finland in 2015 was at the same level as in Sweden (EUR 0.9 million) and even exceeded the level of funding transferred to Denmark (EUR 0.7 million) and Norway (EUR 0.6 million).

The total number of Finnish EUREKA and Eurostars project participations between 2008 and 2017 (341) is lower than in all other Nordic states (except Iceland) but higher than in Poland (253). As to technological areas, Finland has of all BSR countries had the highest share of project participations related to **Electronics and ICT** and the lowest share related to energy technology, whereas participation within all other areas is similar to the levels in other BSR countries.

Important research infrastructures of regional relevance

There are 31 national RIs and two planned RIs included in "Finland's strategy and roadmap for research infrastructures 2014-2020."[47] The roadmap is based on previous international evaluation.

Table 2. RIs included in the Finnish national roadmap for research infrastructures

Research Area	in operation	in preparation	in planning
Art and Humanities / Social Sciences	3	3	1
Environmental Sciences	1	–	4
Bio and Health Sciences	7	1	3
Materials science and Analytics	–	–	2
Natural Science and Technology	1	–	3
E-infrastructures and Mathematics	1	–	1

Source: Own compilation

[47] http://www.aka.fi/globalassets/awanhat/documents/tiekartta/tutkimusinfrastruktuurien_strategia_ja_tiekartta_2014_20.pdf

The purpose of the roadmap is to oversee the development (inclusion of new infrastructures and upgrading of those already in existence) of RIs in Finland during the coming 10 to 15 years. Out of the 50 ESFRI RIs, Finland participates in 25 and in 19 cases the national centre participating in the ESFRI RI is also included as one of the 33 nationally major RIs. Most operative RIs are in Bio and Health Sciences and in Arts and humanities and social sciences. The break-up of RIs included in the national roadmap in Finland is stated on the previous page.

Within these categories important RIs of regional relevance are:

- Art and humanities / social sciences

The database **Finnish Microdata Access Services (FMAS)** (in operation since 2015) handles personal data collected by Finnish state offices. The FMAS RI is designed to make the use of personal register data more accessible to research purposes. In a comparative sense, the Finnish state registers of personal data are, together with other Nordic countries, unique and make the use of big data more appealing to social sciences.

A research infrastructure not directly mentioned in the roadmap, but which is worthy of note is the collection of the **Slavica library** from the 19th and early 20th centuries. From 1809 until 1917 Finland was part of tsarist Russia and the Finnish National Library received a copy of every publication produced in tsarist Russia.

- Environmental sciences

ESFRI's **EISCAT_3D** ISR-Radarsystem (in preparation since 2016; start of operation scheduled for 2018) is a RI to study the atmosphere in the northern polar area. This RI is unique in the world. It is planned to be operational for the coming 30 years. ESFRI's **Finnish National Initiative of the European Plate Observing System (FIN-EPOS)** (in preparation since 2015; start of operation scheduled for 2020) is a RI designed to sense data (seismic, geodetic, magnetic) of the European continent. In October 2015, the European Commission established a pan-European greenhouse gas monitoring organisation, **Integrated Carbon Observation System (ICOS-ERIC)**. The organisation consists of national networks of measuring stations, central facilities specialising in various fields and the head office in Finland.

- Bio- and health sciences

ESFRI's **Biobanking and Biomolecular Resources Research Infrastructure (BBMRI)** (in preparation since 2011-2018; start of operation scheduled for 2018) will function as a biobank and the national BIOCENTER biobank. ESFRI's **European Infrastructure of Open Screening Platforms for Chemical Biology (OPENSCREEN)** (in operation since 2016) is a RI for high-capacity screening in chemical biology. ESFRI's **European Infrastructure for Phenotyping and Archiving of Model Mammalian Genomes (INFRAFRONTIER)** (in operation since 2013) is a RI for genetically modified mice analysis.

- E-infrastructures and mathematics

Finnish IT Center for Science (CSC) (in operation) is one of Northern Europe's largest supercomputing centres and a partner in several ESFRI projects. **FGCI – Finnish Grid and Cloud Infrastructure**. The aim of this RI is to build a coherent grid and cloud infrastructure in Finland. The RI has been under construction since 2014 and the start of operations is scheduled for 2019.

German BSR

Short description of the country's R&D profile

The German BSR states (Hamburg, Mecklenburg-Western Pomerania and Schleswig-Holstein) present a multifaceted scientific landscape with particular strengths in the areas of marine science, climate science, structural research, biochemistry and medicine. The three federal states host 41 universities and other institutions of higher education as well as a large number of non-university research facilities, including six Max Planck Institutes and 12 Leibniz Institutes. In addition, particular crystallisation points for research are the two huge Helmholtz research centres (DESY[48] and GEOMAR[49]), and – since 2017 – the European XFEL.

In recent years, R&D investments have increased systematically in the German BSR states. However, Hamburg (2.33%), Mecklenburg-Western Pomerania (1.91%) and Schleswig-Holstein (1.55% of GDP in 2014) still have levels below the German average (2.94% in 2016),[50] which is raised in particular by southern federal states such as Baden-Württemberg (4.91%) and Bavaria (3.17% in 2014).[51]

One explanation for this gap is the automobile sector's dominant position in the German economy, which comprises nearly one-third of total German business R&D investment. The automobile sector is however concentrated in the southern and central parts of the country and has no production sites in the German BSR states. R&D investments in other business sectors and even in high-tech areas such as pharmaceuticals and ICT are generally relatively low in Germany.[52] These structural characteristics of German industry are also reflected by large discrepancies in terms of patent applications, which are significantly higher in Southern Germany than in the German BSR states.[53]

Assessing current research landscapes (subjective opinions from country studies)

The most obvious scientific strengths of the German BSR states are **marine science (including maritime technologies), climate science, structural research and materials science, biochemistry and medicine, with specialisations in infection research, immunology and neuroscience**. In these areas a wide range of unique, world leading research facilities exist. The high level of expertise is also reflected by the frequency of related project participations with European partners. The potential for solid development is additionally underpinned by the

[48] German Electron Synchroton
[49] Helmholtz Centre for Ocean Research Kiel
[50] http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_20&plugin=1
[51] http://www.gwk-bonn.de/fileadmin/Papers/GWK-Heft-51-Strategie-Europa-2020.pdf
[52] http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/countries/germany.pdf
[53] Bundesbericht Forschung und Innovation 2016, Ergänzungsband I

commitment of German science policies to continue to concentrate efforts and investments in order to expand these research areas.

In contrast, the German BSR states' profile in research areas such as ICT, social sciences, genetics, engineering and, apart from Hamburg, also in renewable energies, is rather low. One explanation is the absence of large companies related to these sectors in the German BSR. To give one example: despite the dominant position of wind energy for electricity supply in Schleswig-Holstein, most of the related R&D takes place in Southern Germany, where the large companies from the electrical sector, in this case Siemens, have based their research facilities.

Analysing science policies and strategies (country specific – their strategies and goals)

Federal level

In 2016 the federal government presented the following research areas as strategic objectives of specialisation for future German research policies:[54]

- **Digitalisation** and development of key technologies such as **communication, electronics and materials**;
- **Sustainability** with special emphasis on bioeconomy, climate, ecology, resource efficiency, energy and sustainable agriculture;
- **Health, medicine and nutrition**;
- **Mobility**;
- **Security**, especially civil- and cyber-security and defenceb
- Basic research in **natural sciences**;
- **Social and economic sciences**, including innovations for **demographic change**.

Moreover, in 2015 the federal government started a National Roadmap-process aimed at the establishment of new complex research infrastructures, each with an investment volume of at least EUR 50 million (EUR 20 million in social sciences and humanities). The adoption of the National Roadmap, which will contain a list of envisaged projects, is expected in 2018.

In order to strengthen Germany's position as a leading industrial and exporting nation the federal government's **"High-Tech Strategy"**[55] (adopted in 2014) calls for a concentration on digital economy and society, sustainable economy and energy, innovative workplace, healthy living, intelligent mobility and civil security as priority areas for research and innovation.

Furthermore, the Federal Government and the *Länder* together have launched the following science "pacts" – the **Initiative for Excellence** and the **Higher Education Pact** (both targeted at universities) and the **Pact for Research and Innovation** (targeted at non-university research institutes) – to enhance the performance and capabilities of the German science system. Each of these science pacts is worth several billion Euros.

[54] Bundesbericht Forschung und Innovation. Forschungs- und innovationspolitische Ziele und Maßnahmen.
[55] https://www.hightech-strategie.de/de/The-new-High-Tech-Strategy-390.php

The long-term goals of German research policies at the federal level are supplemented by research strategies developed by the individual German federal states.

Federal state level

Hamburg

Generally, the most important research focuses of **Hamburg** are **structural research, climate research, infection research, research on manuscript cultures and neuroscience**.[56] Moreover, the city-state has in 2014 adopted a specific "Baltic Sea Strategy for Hamburg as a centre of science".[57] The strategy highlights in particular the unique potentials which emerge from the density of world leading infrastructures in **structural research, systems biology** and **infection research** in the BSR and calls for a further widening and deepening of cooperation in these disciplines on the basis of already well-established scientific relations with the Öresund Region and with Hamburg's partner city St. Petersburg. In order to generally enhance scientific relations with BSR countries, Hamburg has since 2013 devoted a special funding line to support networking between the city's research institutions and partner institutions in the BSR. The goal is to enable the emerging partnerships to jointly develop research projects and to apply for funding at EU and other international levels.[58] Likewise, in 2014 Hamburg adopted a regional innovation strategy which identifies among others **aviation, life sciences, logistics, renewable energies and maritime technologies** as the city's fields of scientific, economic and technological expertise and calls for further efforts in order to strengthen these areas.[59]

Mecklenburg-Western Pomerania

The government of **Mecklenburg-Western Pomerania** has announced its ambition to further strengthen those research areas that already have a strong basis within the federal state, in particular **plasma physics** and related applied technologies such as **biotechnology, ICT, maritime technologies** as well as **agriculture**.[60] In addition, the government has developed a regional innovation strategy, which points out promising fields for scientific and technological development, including **life sciences, engineering, ICT, nutrition, energy and climate** as well as **mobility**.[61]

[56] Bundesbericht Forschung und Innovation 2018

[57] https://www.buergerschaft-hh.de/ParlDok/dokument/43528/stellungnahme-des-senats-zu-dem-ersuchen-der-b%C3%BCrgerschaft-vom-14-m%C3%A4rz-2012-%E2%80%9Ehochschulkooperation-im-ostseeraum-%E2%80%93-bestandsaufnahme-der-wissenschaftlichen.pdf

[58] http://www.hamburg.de/contentblob/4370852/cb86c5d82bdcf14bb322b75ead3b1594/data/ausschreibung-foerdermassnahme-internationale-forschungskooperation-2017.pdf

[59] http://www.hamburg.de/contentblob/4612440/f4fbf213d2c3e9136e83337595f52821/data/regionale-innovationsstrategie-hamburg.pdf

[60] Bundesbericht Forschung und Innovation 2016. Forschungs- und Innovationspolitische Ziele und Maßnahmen, p. 342.

[61] http://www.regierung-mv.de/Landesregierung/wm/Technologie/Technologiepolitische-Schwerpunkte/?id=9591&processor=veroeff

Schleswig-Holstein

Schleswig-Holstein adopted a regional innovation strategy[62] in 2014 and another development strategy "Schleswig-Holstein 2030"[63] in 2017. Both emphasize the federal state's unique strengths and development opportunities within **marine research, maritime technologies, life sciences, renewable energies and nutrition**. In addition, they emphasize the role of key technologies such as **ICT, nanotechnologies, materials science, environmental technologies and biotechnology** as drivers for innovation within these branches.

Country profile and standing in *www.excellencemapping.net*

According to the excellencemapping.net database most of the analysed research institutes in the German BSR states range above global average regarding both citation impact and number of publications in world leading journals. However, the share of institutes that belong to the global top 25% is relatively low if for instance compared to the Nordic countries. Only in one case does a BSR German research institute, namely **University Medical Center Schleswig-Holstein**, rank among the global top 10%, regarding its citation impact in biochemistry and genetics. The latter research discipline generally, together with medicine, achieves the best results within the German BSR states' rankings, followed by agriculture and physics.

In contrast, most of the analysed research institutes in computer science, immunology and microbiology as well as in engineering occupy positions below the global average. Only in one field of research is an institute from the German BSR ranked number one in a BSR wide comparison, namely the University of Hamburg in neuroscience, with regard to both citation impact and number of publications in world leading journals. There are only small differences as to the composition of analysed disciplines between the three German BSR states. However, in terms of quality Schleswig-Holstein achieves slightly better results than Hamburg, whereas the analysed institutes in Mecklenburg-Western Pomerania generally achieve weaker results.

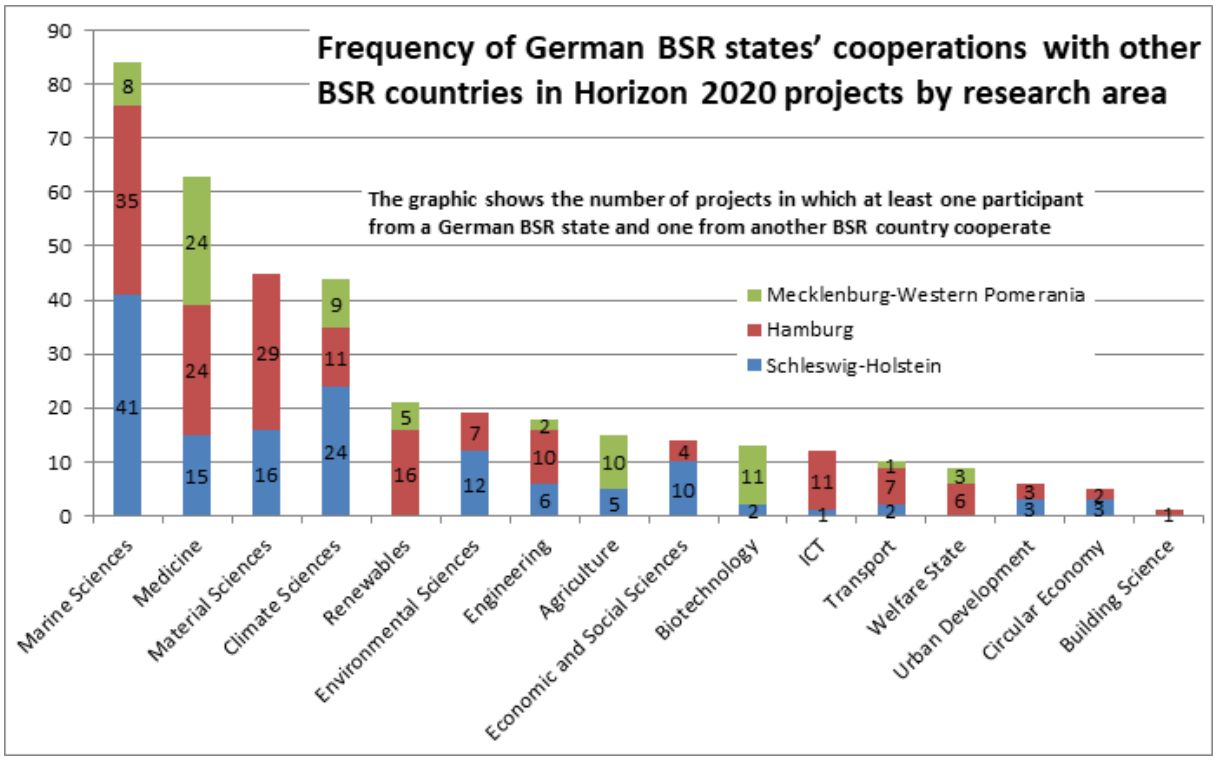
Country participation in H2020 with other BSR countries

The number of H2020 projects in which German BSR states cooperate with other BSR countries is lower than in the case of the Nordic states and Poland but higher than in the Baltic States. The individual numbers for Hamburg (166) and Schleswig-Holstein (140) are significantly higher than for Mecklenburg-Western Pomerania (73). Most frequently the three German states participate in these projects with partners from Sweden, Denmark, Norway and Finland (in that order) and least often with partners from Lithuania and Iceland.

[62] https://www.schleswig-holstein.de/DE/Fachinhalte/F/foerderprogramme/MWAVT/Downloads/regionale_innovationsstrategieNEU.pdf?__blob=publicationFile&v=3

[63] http://www.schleswig-holstein.de/DE/Schwerpunkte/Landesentwicklungsstrategie/Downloads/downloads/landesentwicklungsstrategie.pdf?__blob=publicationFile&v=6

Figure 6. Frequency of German BSR states' H2020 cooperation with BSR countries (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

In **Schleswig-Holstein** (41) and **Hamburg** (35) the majority of H2020 projects that are carried out jointly with partners from other BSR countries are related to **marine science**, whereas in **Mecklenburg-Western Pomerania** the majority are related to **medicine** (24). Other notable results are the relatively high numbers of projects with participation from Hamburg related to materials science (29) and to renewable energies (16), from Schleswig-Holstein related to climate science (24) and from Mecklenburg-Western Pomerania to biotechnology (11). Within the BSR and if counted together, the **German BSR states** show the second highest number of project participations related to **materials science** (45) after Sweden (79) and to **climate science** (44) after Norway (50). In contrast, German BSR states show the second lowest participation rate, after Iceland (4), in projects related to agriculture (15). The total number of BSR German project participations related to ICT (12) is also remarkably low. In this scientific field, the BSR German states together rank only in 7th place within the BSR, quite a way behind Estonia (25) and just ahead of Latvia (11).

Country participation in JPI/JTI, COST actions, EUREKA

The number of German BSR participations in JPI projects is remarkably low. If counted together, the three German states only show participations in 16 cases: SH (9), MWP (6), HH (1), in contrast with the rest of Germany (244). German BSR participations are far below the numbers recorded for the Nordic states, for instance Sweden (148) and Poland (38). Only the Baltic countries have lower participation rates (3 each). The German BSR states are, if at all, mostly engaged in the JPI Agriculture, Food and Climate and to a minor extent in JPIs related to Oceans/Water and Health.

German BSR states' participations in JTI projects are also generally low. However, there are clear differences between the three states. Whereas Schleswig-Holstein and Mecklenburg-Western Pomerania only participate to a very limited extend in JTIs, Hamburg shows – at least in some of them – participation rates that are to some extent comparable to those of the Nordic states and in projects related to the JTIs ECSEL JU and Medicine even higher than those of Poland. As to participations in COST and EUREKA actions, figures that single out the exact rates for the German BSR states are hardly available. Germany in total participates in 99% of all COST actions, of which 3% can be attributed to Hamburg and 2% to Schleswig-Holstein and Mecklenburg-Western Pomerania each.

Important research infrastructures of regional relevance

- Marine sciences

The **GEOMAR – Helmholtz Centre for Ocean Research Kiel** operates a fleet of ocean **research vessels**, among others the "Alkor" (main operating areas are the Baltic Sea and North Sea) and the "Poseidon" (North Atlantic Ocean, Mediterranean Sea), both are even well-suited for the deployment of the three-ton submersible "JAGO", the only one of its kind in Germany. Rostock is the home port of several research vessels operated by the **Leibniz Institute for Baltic Sea Research at Warnemünde,** including Germany's second most modern research vessel "Maria S. Merian" (intended also for Arctic research) and "Elisabeth Mann Borgese", which primarily operates in the Baltic Sea. The **University of Hamburg** hosts the **German Research Fleet Coordination Centre**, which coordinates several of Germany's most important research vessels**.** Hamburg is also home port to the "Meteor", which is mainly used in the Atlantic Ocean and is able to operate 50 days at sea without having to call at a port. The Hamburg based **Federal Maritime and Hydrographic Agency (BSH)** operates several research, survey and wreck search vessels.

Other important marine research infrastructures include the **Coastal Observing System for Northern and Arctic Seas (COSYNA)** operated by the **Helmholtz-Zentrum Geesthacht Centre for Materials and Coastal Research**. The **Fraunhofer Institution for Marine Biotechnology and Cell Technology** in Lübeck maintains the **"Cryo-Brehm"**, one of the biggest archives for cell cultures from vertebrates worldwide. The **Hamburg Ship Model Basin (HSVA)** provides research and experimental facilities to the maritime industry such as a ship model basin, a hydrodynamics and cavitation tunnel and a unique ice tank. Research facilities at the **Federal Waterways Engineering and Research Institute (BAW)** in Hamburg include a peripheral channel with a total volume of approx. 360 m^3, a ship handling simulator and a Shallow Water Ship Basin.

- Structural research / materials science

The **Deutsches Elektronen-Synchroton (DESY)** in Hamburg is one of the world's leading accelerator centres. The large-scale facilities at DESY enable researchers to explore the microcosm in all its variety, from the interactions of tiny elementary particles and the behaviour of new types of nanomaterials to biomolecular processes that are essential to life. RIs at DESY include **PETRA III**, the world's best storage ring for generating X-ray radiation, **FLASH**, the world's only free-electron laser in the soft X-ray range, **REGAE**, a novel

source of relativistic electron beams and the **European XFEL** which is expected to set a new world record by generating the most intensive X-ray flashes in history. The Hamburg based **Max Planck Institute for the Structure and Dynamics of Matter (MPSD)** investigates dynamical phenomena within matter down to the elementary timescales of atomic and electronic motions, at the femtosecond or attosecond timescale. Since 2012 **Hamburg University** has received funding within the German Excellence Initiative for the **Hamburg Centre for Ultrafast Imaging (CUI)**, which observes the movement of atoms in real time.
The **Helmholtz-Zentrum Geesthacht** provides a unique worldwide infrastructure for complementary research with photons and neutrons. Instruments using synchrotron radiation are operated at the outstation at DESY in Hamburg and instruments using neutrons are located at the outstation at the FRM II in Garching near Munich.

- Physics

The **Wendelstein 7-X** at the **Greifswald branch of Max Planck Institute for Plasma Physics (IPP)** is the world's largest fusion device of the stellarator type. Its objective is to investigate the suitability of this type for a power plant. It will test an optimised magnetic field for confining the plasma, which will be produced by a system of 50 non-planar and superconducting magnet coils, this being the technical core piece of the device.
The **Leibniz Institute for Plasma Science and Technology (INP Greifswald)** is the largest non-university institute in the field of low temperature plasmas, their fundamentals and technical applications in Europe. At present plasmas for materials, energy, environment and health are the focus of interest.
The **Leibniz-Institute of Atmospheric Physics (IAP)** at Rostock University, which is a major partner of the **ALOMAR observatory** in northern Norway, carries out continuous observations of dynamical and thermal parameters of the troposphere and lower stratosphere as well as the mesosphere and lower thermosphere.

- Climate science

The **German Climate Computing Center (DKRZ)** in Hamburg provides high performance computing platforms as well as sophisticated high capacity data management for climate science. The work on a new supercomputer for climate analysis and simulation began in 2015. The DKRZ also hosts the **World Data Center for Climate (WDCC)**, which collects, stores and disseminates Earth System data with a focus on climate simulation data and climate related data products. The Hamburg based **Max Planck Institute for Meteorology** together with **Hamburg University** and other non-university research facilities constitute the **Climate Research Excellence Cluster (CliSAP)**. The **Climate Service Center Germany (GERICS)** in Hamburg functions as a think tank for climate services. It offers advisory services and decision-relevant information in order to support government, administration and business in their efforts to adapt to climate change.

- Medicine and health

A unique concentration of expertise and infrastructure for **research on infectious diseases** can be found in the Hamburg metropolitan region. As well as the **universities** of **Lübeck**

and **Hamburg**, there are the **Leibniz Institute Research Center Borstel**, the **Heinrich Pette Institute for Experimental Virology** and the **Bernhard Nocht Institute for Tropical Medicine**. They include the **National Reference Centres for tuberculosis and all tropical pathogens, biosafety level 3 and 4 laboratories and insectaries** and a spectrum of **bio-imaging facilities**. The **Centre for structural systems biology (CSSB)**, located on the DESY campus in Hamburg, facilitates joint research of 10 north German research institutions with a special focus on infections. State-of-the-art electron microscopy instruments will be available to CSSB partners. Moreover, the establishment of core facilities including high-throughput crystallisation (HTX), Protein Characterisation (PC), advanced light and fluorescence microscopy (ALFM) and Protein Production (PP) is currently in progress.
The **Hamburg City Health Study**, the world's largest local health study, covers 45,000 Hamburg residents and since 2015 has been carried out at the **University Medical Center Hamburg-Eppendorf (UKE)**.

- Veterinary and farm animal biology

The Friedrich-Loeffler-Institut **(FLI) Federal Research Institute for Animal Health** on the Island of Riems carries out research in infectology, molecular virology and cell biology. It is equipped with laboratories for pathology, experimental animal husbandry and bacteriology and for the generation of monoclonal antibodies. Furthermore, a biobank operates a virus collection and a collection of cell lines in veterinary medicine. The **Leibniz Institute for Farm Animal Biology** in Dummerstorf carries out research on animal-related aspects of sustainable farm husbandry in six disciplinary institutes (Genetics and Biometry, Genome Biology, Reproductive Biology, Behavioural Biology, Muscle Biology and Growth, Nutritional Physiology).

- Economics and social sciences

The **Leibniz Information Centre for Economics (ZBW)**, which is located in Kiel and Hamburg, is the world's largest research infrastructure for economic literature, online as well as offline. It used to be a department of the **Kiel Institute for the World Economy (ifw)** from which it was formally separated in 2007.
The **Max Planck Institute for Demographic Research (MPIDR)** in Rostock is one of the leading demographic research centres in the world. The institute operates several databases, among others the Human Mortality Database, the Human Fertility Database and the International Database on Longevity.

Most relevant developments for BSR cooperation in the future

In order to intensify research cooperation and to better exploit the unique research infrastructures in material science and structural biology in Northern Germany and Sweden, and in particular along the Hamburg-Lund axis, in 2010 both countries founded the **Röntgen-Ångström-Cluster (RÅC)**. The strategic goal is to establish a European Centre of Excellence within structural research in Northern Europe, which may become a role model for research-

intensive regions at a global scale with regard to joint procurement of funds and programming.[64]

The **HafenCity University Hamburg** has in its 2013 adopted internationalisation strategy set a **regional focus on the BSR**. The stated reasons are close cultural and historical ties in the region as well as similar challenges such as urban sustainable development and planning, demographic change or transformation of port areas. In order to intensify research cooperation, the HafenCity University in 2015 established an annual summer academy where ca. 70 researchers from the partner universities of the BSR meet to conduct research in interdisciplinary teams.

The **Centre for Baltic and Scandinavian Archaeology (ZBSA)** in Schleswig was founded in September 2008. It is the only non-university institute in the Federal Republic of Germany that concentrates on transregional archaeology over the ages in the North Sea and Baltic regions and Scandinavia. Research projects are mainly carried out in close cooperation with partner institutions in Scandinavia, the Baltic countries, Poland and Russia.

Latvia

Short description of the country's R&D profile

Having begun in 2014 structural reforms in the science system aimed at increasing its competitiveness, and having set a limited number of research specialisations in its Smart Specialisation Strategy (RIS3), Latvia has yet to see significant results of its recent policy measures. Despite some improvement, in 2016 Latvia remained in the group of "moderate innovators", with the medium- and high-tech sectors of its economy in 2011-2015 shown to comprise 11.4% of the total (more than three times lower than EU average).[65] The data for 2015 shows that some system aspects even declined from 2012: the national R&I intensity again returned to 0.62% (the target being 1.5%), and the level of business expenditure on R&D had decreased by 35%.[66] There was a slight increase of doctoral degree holders working in research, however the failure to attract foreign talent continued. Current inputs in the system are targeting infrastructure (31% of SF investment), human resources (64%) and institutional capacity building (5%), including strategic specialisation of research institutions.

Assessing current research landscapes (subjective opinions from country studies)

Research in Latvia is characterized by an increasing concentration of infrastructures and human capital, with only some thematic areas predominantly developed outside of the capital (e.g. water ecology, radio astronomy).[67]

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[64] https://www.buergerschaft-hh.de/ParlDok/dokument/43528/stellungnahme-des-senats-zu-dem-ersuchen-der-b%C3%BCrgerschaft-vom-14-m%C3%A4rz-2012-%E2%80%9Ehochschulkooperation-im-ostseeraum-%E2%80%93-bestandsaufnahme-der-wissenschaftlichen.pdf

[65] European Commission, European Innovation Scoreboard, Latvia's profile available at http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_lv

[66] Central Statistical Bureau (2016) *Research Statistics for 2015* (in Latvian), available at http://www.csb.gov.lv/sites/default/files/nr_36_petniecibas_statistika_16_00_lv.pdf

[67] Ministry of Education and Science (2016) Par pētniecības un inovācijas infrastruktūras un

The following research foci appear to show both the potential for excellence and strong international links: **structural sciences, bioeconomy** (e.g. renewable energy, forest science, sustainable agriculture), **cultural heritage** (e.g. modern forms of tradition), **climate research, health and medicine** (e.g. biomedical technologies, pharmacology), **welfare society** (e.g. migration, social memory, urban developments) and **marine studies** (e.g. e-navigation, marine monitoring). There is also long-standing work on selected aspects of ICT (e.g digital language tools) and space research.

Analysing science policies and strategies (country specific – their strategies and goals)

Science policies and strategies are geared towards increasing institutional capacity and competitiveness and in the new SF programming period – increased linkages between research, higher education and knowledge transfer infrastructures. The policy logic explicitly links science with its contribution to economy.

Five research specialisation areas are identified in the current version of the Smart Specialisation Strategy (RIS3): **bioeconomy, bio-medicine and medical technologies, advanced materials, technologies and engineering systems, smart energy and ICT**. In addition, the key priority areas of RIS address the issues of regional development, the innovation ecosystem and social innovation, and modern education as horizontal issues. RIS3, especially its research specialisation areas, is a major driving force in funding allocation for science.

Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

The specialisations defined in RIS3 are primarily linked to their potential to promote economic transformation; science is expected to be both excellent according to one-size-fit-all criteria, and to further desirable economic outcomes. Thus, some disciplines (most notably social sciences and humanities) are *de facto* left to their own devices to overcome the imbalance caused by prior policy measures and the dominant development models. Despite that, some SSH research institutions are capable of excellence and collaboration, as evidenced by H2020 projects (see later), and a Latvian research institution becoming the leading partner of Nordic-Baltic Tradition Archive Project.[68]

Furthermore, the potential for excellence in Latvia has been influenced by two human resource-related conditions: a lack of coherent staff development policies[69] (resulting in brain drain), and the critically low stipends at doctoral student level (necessitating outside

pētnieciskās darbības koncentrācijas teritoriālo kartējumu (Report on the Territorial Mapping of Research Institutions snd Infrastructures – in Latvian), available at http://www.izm.gov.lv/images/zinatne/kart%C4%93jums/IZMzino_120416_ZIkartejums.pdf

[68] The Network of Nordic-Baltic Tradition Archives (Nordic Culture Point) ,(NBTA), first established at the end of 2014, introduced productive links among similar institutions in the Nordic and Baltic countries. – http://lulfmi.lv/Nordic-Baltic-Mobility-Programme

[69] OECD (2016), *Education in Latvia*, Reviews of National Policies for Education, OECD Publishing, Paris, p.277, http://dx.doi.org/10.1787/9789264250628-en

employment, impeding the attraction of foreign talent).[70] National reforms[71] and research institutions have recently started to address the former condition, and the latter may be somewhat mitigated by the recently initiated support for post-doctoral research. While the critically low level of state budget financing for science in Latvia is often cited as a major obstacle to the development of science, the use of existing funds (including Structural Funds and international research project funding) to support excellence has been less than optimal, as evidenced by recent corrections: the introduction of changes in Structural Funds' proposal evaluation criteria, the introduction of performance funding, and the attention given by the Ministry of Education and Science and World Bank experts to internal governance systems of HEIs and research institutions.

Meanwhile researchers continue to be underpaid and overloaded with teaching – the underpayment at an individual institution resulting from complex calculations regarding the number of students, state funding for the specific discipline and level of study, and faculty-level reallocation of available funding for various needs. Overall, an academic hour is more poorly paid than an hour of teaching at an elementary school. Since the number of contact hours within one academic programme is limited, academic staff juggle several academic, project and administrative jobs (working part-time at each institution). Remuneration levels are higher for those with access to participation in (more lucrative) international research projects.

Country profile and standing in *www.excellencemapping.net*

The above resource reflects excellence of publications as measured against global criteria (the data is for 2009-2013). Latvia's research appears to be of low excellence in all areas mapped, with several of Latvia's FP7 and H2020 project areas not reflected at all (e.g. health and medical research). The usefulness of this data for decision-making appears limited, as an analysis of Latvia's research presence and BSR cooperation aspects shows a broader set of successful thematic areas, and participant institutions.

In the context of H2020 cooperation the top areas for Latvia-BSR cooperation are **medicine** (e.g. VACTRAIN: Twinning on DNA-based cancer vaccines, with partners in Sweden and Poland;[72] Northern Dimension Antibiotic Resistance studies NoDars) and **agriculture**, which can be viewed as part of the bioeconomy thematic area, together with the **circular economy**, some biomaterials and renewables (e.g. ERIFORE – Research Infrastructure for Circular Forest Bioeconomy,[73] Finland, Germany, Norway, Sweden, Latvia cooperating). There is also notable cooperation on **governance issues** and in the social sciences. This is followed by marine research (e.g. *SeaDataCloud* – Further developing the pan-

[70] Sursock A. (2016) *Latvian doctoral studies and promotion system*, World Bank consultancy report, available at http://www.izm.gov.lv/images/izglitiba_augst/Pasaules_Banka/Latvian_doctoral_studies_and_promotion_system.pdf

[71] The 2016 Cabinet regulation on the remuneration of pedagogic work, including Annex 3 on higher education, stipulating the workload and the planned gradual increase of minimal rates, available at https://likumi.lv/ta/id/283667-pedagogu-darba-samaksas-noteikumi; the 2013 Cabinet regulation on the state funding of research institutions, available at https://likumi.lv/doc.php?id=262508.

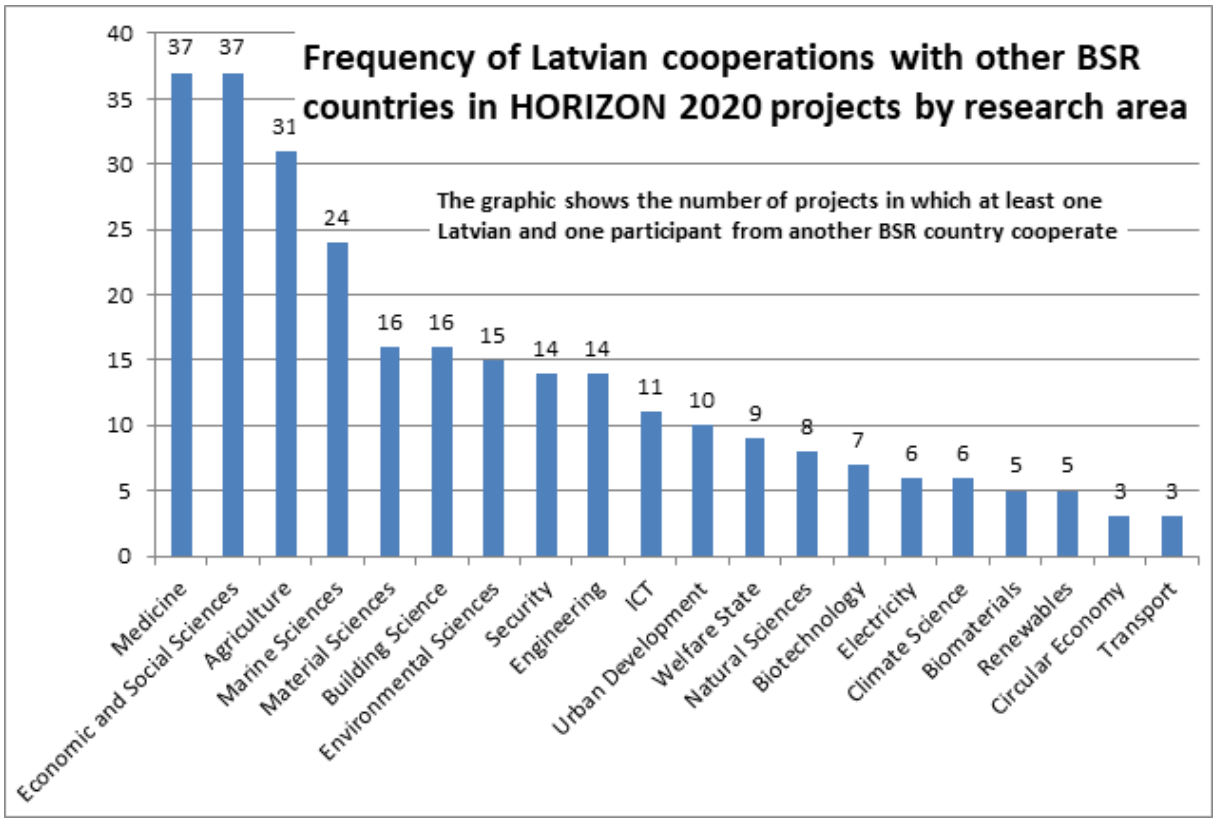
[72] http://cordis.europa.eu/project/rcn/199979_en.html

[73] http://cordis.europa.eu/project/rcn/200673_en.html

European infrastructure for marine and ocean data management,[74] including virtually all BSR countries), and combined urban development and **welfare state** (e.g. YMOBILITY – Youth mobility: maximising opportunities for individuals, labour markets and regions in Europe; Germany, Latvia, Sweden as partners[75]).

Country participation in H2020 with other BSR countries

Figure 7. Frequency of Latvian H2020 cooperation with BSR countries (2014–2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

The next group (by the number of proposals) is formed by **structural science** (CAMART 2 – (Teaming)[76] with KTH Royal Institute of Technology and Acreo Swedish ICT as partners), building science and environmental sciences. Excellence and cooperation is evident in ICT and energy-related projects – electricity and some of the renewables (e.g. BRILLIANT – Baltic Region Initiative for Long Lasting Innovative Nuclear Technologies,[77] with Poland, Estonia, Lithuania, Sweden, Latvia).

Altogether, the H2020 cooperation snapshot confirms the areas identified as potentialities for BSR excellence and collaboration.

[74] https://www.seadatanet.org/About-us/SeaDataCloud
[75] http://cordis.europa.eu/project/rcn/194588_en.html
[76] http://cordis.europa.eu/project/rcn/196942_en.html
[77] http://cordis.europa.eu/project/rcn/196918_en.html

Country participation in JPI/JTI, COST actions, EUREKA

Latvia participates (data for June 2017) in 4 JPI as an observer (JPND, HDHL, CH, Water, UE). However, the National Roadmap states that there is expertise in all thematic areas. Selection of JPIs for full participation is pending.

Analysis of Latvia's participation in COST action committees confirms the active international involvement of Latvia's researchers. About one third of all participation is in medicine and biomedical technologies, closely followed by bioeconomy, with considerable presence in structural science actions and ICT. These are followed by a range of actions to do with welfare state. A number of areas appear to be taken up to a lesser degree (marine research, transport, energy), although there still are several COST actions with Latvian researchers on board.

Important research infrastructures of regional relevance

Latvia has confirmed its support for 8 ESFRI roadmap infrastructures (five consortia – BBMRI, CLARIN, ESS, EARTRIS and JIVE), as well as three infrastructure platforms – EU-OPENSCREEN, INSTRUCT and MIRRI.

These correspond to the following potential areas of BSR excellence: structural science, health and medicine, marine research, bioeconomy, welfare society, with two areas – ICT and radio astronomy – being outside identified BSR synergies.

Most relevant developments for BSR cooperation in the future

Latvia has been involved in several major long-term policy collaboration initiatives which will continue, namely HELCOM and EU Northern Dimension (esp. in the area of health, climate, energy, and transport). All the Baltic States participate or plan to participate in the BBMRI, CLARIN and ESS infrastructures. Latvian decisions to participate in JPI initiatives will further promote BSR cooperation, as the two most likely candidates are the BSR-relevant Water Protection and Urban Development. Overall, the links to BSR are strong and developing.

Lithuania

Short description of the country's R&D profile

Lithuania's R&D can be classified as a medium-knowledge-capacity system with a strong role being played by services and low knowledge-intensive services. Currently, Lithuania ranks 16th in the 2017 European Innovation Scoreboard as a Moderate Innovator, and is one of the leading EU countries according to increase in innovation performance. Its main scientific and technological strengths include transport other than automobiles and aeronautics, construction and construction technologies, energy, food, agriculture and fisheries, and the environment. In 2007–2013 huge investments were made in developing RIs, by creating specialised scientific valleys, which replaced the outdated research infrastructure. There are currently 5 integrated science, studies and business centres (valleys) in Lithuania:

- Saulėtekis – life and materials science, laser, light and nano technologies, semiconductor physics, electronics, and civil engineering;

- Santara – biotechnologies, biopharmacy, molecular medicine and innovative medical technologies, ecosystems, safe environment research and computer science;
- Santaka – chemistry and biopharmacy, mechatronics, energy and environmental engineering, information and telecommunication technologies;
- Nemunas – agricultural sciences, forestry and food processing technologies;
- Maritime Valley – marine studies and marine industries.

And while most of the problems regarding Lithuania's R&D are still to be addressed, there are certain positive signs. First of all, there are several new instruments that demonstrate efforts for better coordination, such as "Joint science-business projects" and "Intellect LT. Joint science-business projects". Also, the adoption of the smart specialisation strategy has helped to concentrate research efforts thematically. However, due to negative demographic tendencies and the insufficient quality of higher education, human resources shortages in R&D remain a serious problem. Another structural challenge is lack of private investment in R&D – although there are a few existing R&D based innovators, diversification of existing sectors and transition to new knowledge based activities is necessary in order to boost Lithuanian business R&D. Finally, the existing Lithuanian R&D infrastructures for commercialisation and technology transfer have the potential to be better exploited.

Assessing current research landscapes (subjective opinions from country studies)

The recently defined Lithuanian R&I priorities for smart specialisation identify 6 broader priority areas, namely: **energy and sustainable environment, health technologies and biotechnologies, agro-innovation and food technologies, new processes, materials and technologies, transport, logistics and ICT, and creative society**. Correspondingly, there are 5 active national research programmes in Lithuania: "Towards future technologies (2016-2021)", "Welfare society (2015-2020)", "Sustainability of agro-, forest and water ecosystems (2015-2021)", "Healthy ageing (2015-2021)" and "Modernity in Lithuania (2017-2022)". As the titles themselves suggest, these programmes are aimed at facilitating technological progress, fostering the development of a welfare society, accelerating the country's modernisation and solving various ecological and demographical problems.

Analysing science policies and strategies (country specific – their strategies and goals)

The main strengths of Lithuania's R&D system include the considerable size of its public research sector and a steady supply of new graduates. And while public R&D intensity is no longer far from the EU average (Lithuania: 0.66%; EU: 0.74%), it remains very limited in the business sector, due to the low share of medium-tech and high-tech industries, low numbers of knowledge-intensive start-ups and the low rate of entrepreneurship. However, it has to be noted that the overall share of innovative firms is steadily increasing. The success stories include Kaunas University of Technology Startup Space, which constitutes the first scientific start-up centre in the country, and Vilnius Tech Park, currently one of the most state-of-the-art working environments in the Baltic States. It must be noted that the allocation to R&D from the national budget has declined significantly since 2007. In other words, public R&D funding in Lithuania has become excessively dependent on the Structural Funds and private investors are not keen enough to invest in R&D. This might change with

the implementation of the new Business Financing Fund, which consists of three instruments: "Technoinvest" (EUR 17.6m), "Entrepreneurship fund" (EUR 103.28m), and "Investment fund" (EUR 58.72m). Managed by INVEGA, a government funded institution supporting investment and business guarantees, the Fund will provide loans, guarantees, venture capital and interest rate compensation for new and existing businesses.

Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

When ascertaining political self-interest, limitations and potentiality for supporting scientific excellence it has to be noted that Lithuania's R&I system remains highly fragmented. Lithuania's science base is insufficiently competitive and is not well connected to European networks. Though Lithuania boasts the highest enterprises' birth rate among those EU Member States for which data is available, their survival rate, unfortunately, has been one of the lowest. There are various joint initiatives that are being implemented to promote business and science collaboration. One of the noteworthy examples is the Open Access to Science and Research (MITAP) project, which was implemented to facilitate technology transfer in Open Access Centres with the aim of strengthening the international competitiveness of Lithuanian researchers. Unfortunately, potential synergies are not achieved due to research being carried out in different institutions with little collaboration, resulting sometimes in overlapping and duplications in research. Due to negative demographic tendencies (an ageing society and mass emigration, which includes brain drain), the labour force in Lithuania is shrinking – and this naturally means a smaller supply of workforce irrespective of its skills. Although some steps have been taken to increase the internationalisation of Lithuania's R&D system (such as revisions of the Law on the Legal Situation of Foreigners and the adoption of "Startup Visas"), the immigration of skilled specialists and start-ups is by no means as effective as expected.

Country profile and standing in www.excellencemapping.net

According to excellencemapping.net database, the most promising Lithuanian science fields for transnational cooperation are as follows: **engineering, materials science, medicine, physics and astronomy, chemistry, and mathematics**. As for the institutional framework, Vilnius University, the Lithuanian University of Health Sciences, Kaunas University of Technology, and Vilnius Gediminas Technical University are the main hubs of scientific excellence in Lithuania.

Country participation in H2020 with other BSR countries

Lithuanian H2020 cooperation with other BSR countries is most fruitful in the **transport** (57 projects), administration (33 projects), marine sciences (27 projects), engineering (25 projects), welfare state (18 projects), agriculture (17 projects) and materials science (14 projects) research areas. Apparently, Lithuania's participation in H2020 and the potential areas of transnational scientific excellence in BSR are well aligned, matching 4 areas out of 7 (marine sciences, welfare state, agriculture and materials science).

Figure 8. Frequency of Lithuanian H2020 cooperation with BSR countries (2014-2017)

Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Country participation in JPI/JTI, COST actions, EUREKA

The level of transnational co-operation in joint activities with the EU is still rather low in Lithuania, since Lithuania has joined only 3 JPIs so far. However, the involvement of Lithuanian institutions in the activities of COST has been steadily increasing, with as many as 45 new COST activities per year. As for EUREKA projects, Lithuania mostly engaged in collaborations with Germany, Sweden, Poland and Finland among the BSR countries during the last two years (2015-2016). And even though there is a lack of policy coordination with neighbouring countries – a "Baltic Bonus" scheme, which has been created in order to promote cooperation between the three Baltic States (Lithuania, Latvia and Estonia), has to be mentioned. Additionally, several programmes are being implemented to foster international co-operation, including InoConnect LT, which aims to foster international partnerships and networking through supporting participation in international R&D initiatives in the EU, as well as SmartInvest LT and SmartInvest LT+, which aim to attract foreign direct investments in R&D.

Important research infrastructures of regional relevance

The Lithuanian Roadmap for Research Infrastructures 2015 has specified the following open access research infrastructures (RIs) that need to be developed and modernised in order to join ESFRI:

- Social sciences and humanities

E-lingua (CLARIN-LT) – Electronic Resources of the Lithuanian Language; ESS LT – European Social Survey; LiDA – Lithuanian Data Archive for Humanities and Social Sciences; HUMRE – Research Infrastructure for Human Well-Being and Development; PITI Aruodai – Heritage and History Research Infrastructure Aruodai.

- Biomedical sciences

AEROINFRA – National Aerobiological Research Infrastructure; MEDWAN – Biomedicine Data Warehousing, Standardization and Analysis Research Infrastructure; REIA – Research Infrastructure of Experimental Animals; CossyBio – Centre for Computational, Structural and Systems Biology; INECOM – Infrastructure for Ecological Metabolomics; Consortium Biobank-LT – National Networks of Biobanks.

- Natural sciences and technologies

INOCHEMAS – Centre of Innovative Chemistry; LitGrid-HPC – Lithuanian Grid Infrastructure for High-Performance Computing; Mechatronika – Research Infrastructure of Mechatronics; MNAAPC – Micro-, Nanotechnology and Analysis Open Access Centre; MAO – Molėtai Astronomical Observatory; Laser RI – High-Intensity and Broad Spectral Range Ultrashort Pulse Laser Research Infrastructure of National and International Access; PTC – Centre for Semiconductor Technologies; SPECTROVERSUM – Centre for Spectroscopic Characterization of Materials and Electronic / Molecular Processes; AChePha – Centre for Applied Chemistry and Biopharmaceutical Research; ULTRATEST – Ultrasonic Non-Destructive Testing, Measurement and Diagnostics Centre.

- Agriculture sciences

AGBC – Centre for Plant Genetics and Biotechnologies.

According to a March 2016 international expert assessment of R&D and innovation infrastructure available in Lithuanian research, only **Laser RI and CossyBio managed to achieve maximum scores**, which leads one to assume that most of these RIs remain underdeveloped to this day.

As of 2017, Lithuanian RIs participate in and/or closely cooperate with CLARIN ERIC (Common Language Resources and Technology Infrastructure), ESS ERIC (European Social Survey), CESSDA (Consortium of European Social Science Data Archives), EMBO/EMBC, DARIAH ERIC (European digital research infrastructure for the Arts and Humanities), SHARE ERIC (European Research Infrastructure Consortium for the Survey of Health, Ageing and Retirement in Europe), BBMRI ERIC (Biobanks and Biomolecular Resources Research Infrastructure Consortium), EATRIS ERIC (European Advanced Translational Research Infrastructure in Medicine European Research Infrastructure Consortium), ELIXIR, INFRA-FRONTIER, INSTRUCT, ELI and PRACE. In 2018, substantial investments will be made to join and closely cooperate with ELI (Extreme light infrastructure), EMBL (European Molecular Biology Laboratory), INSTRUCT (pan-European research infrastructure in structural biology), MAX IV

(Swedish national laboratory providing X-rays for research), BBMRI-ERIC (Biobanking and biomolecular resources research infrastructure – European Research Infrastructure Consortium), EGI (advanced computing for research), WEAVE (next-generation spectroscopy facility for the William Herschel telescope), thus helping Lithuanian R&D become even more immersed in international research infrastructures.

Most relevant developments for BSR cooperation in the future

A number of Lithuanian RIs appear to be success stories, and thus might be crucial to strengthening BSR cooperation in the future. These examples include: the Joint Baltic Sea Research and Development Programme BONUS, which seeks to develop strong cooperation across the region and consolidate joint research efforts on a macro-regional level in order to respond to situations in the Baltic Sea ecosystem; the Joint Programming Initiative Healthy and Productive Seas and Oceans (JPI OCEANS), which aims at ensuring the good environmental status of the seas, optimizing the response to climate change and mitigating human impacts on the marine environment; the JPI for Cultural Heritage and Global Change: A New Challenge for Europe, an initiative that aspires to promote the safeguarding of cultural heritage in its broadest meaning.

Norway

Short description of the country's R&D profile

The level of R&D intensity, which was 1.93% in 2015, is slightly below the EU average (2.03).[78] However, this can be explained to a large extent by the fact that the country's GDP *per capita* is the second highest in Europe. Consequently, Norway still has one of the highest spending levels on R&D *per capita* if compared to other EU countries. Mostly due to its special industrial structure, the level of Norwegian business R&D (0.87%) was much lower than the EU average (1.31%) in 2012. Moreover, the levels of patenting and of business innovation among SMEs are also lower than in comparable countries like for instance Denmark and Sweden.

Assessing current research landscapes (subjective opinions from country studies)

Since the mid-1990s Norwegian research has seen a significant rise in scientific impact, which now is above European average if measured by the proportion of highly cited publications. The greatest strengths of Norwegian research can be found in the areas: **marine research, climate and energy**. In these sectors the country occupies a unique position in Europe in terms of the high number of research institutes and infrastructures, their quality and degree of specialisation. Other research areas, which range high above global average are **medicine, agriculture and food**.

[78] The indicator provided is R&D as a percentage of GDP; http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_20&plugin=1

Analysing science policies and strategies (country specific – their strategies and goals)

The Norwegian government's "Long-term plan for research and higher education 2015-2024"[79] stakes out a course for national policies for research and higher education. The plan has the overarching objectives of enhancing competitiveness and innovation, tackling major societal challenges and developing research communities of outstanding quality. It also sets the following six long-term priority areas:

- **Seas and oceans**;
- **Climate, environment and clean energy**;
- **Public sector renewal**, better and more effective **welfare, health and care services**;
- **Enabling technologies**;
- Innovative and adaptable industry;
- World-leading academic groups.

The "Strategy for the Research Council of Norway 2015-2020"[80] provides orientation for Norway's main research and innovation agency's implementation of the national research priorities. In particular, the following scientific fields and grand challenges are envisaged in the strategy for further development:

- **Climate, the environment and environmental friendly energy**;
- Resource-based industries, particularly based on **marine industries**;
- **Schools, education and learning**;
- **Health, care and welfare**, with special emphasis on **labour force** participation and the rising proportion of the **elderly in society**;
- Finding solutions to **global challenges**;
- **Governance and distribution** challenges;
- Basic research within **ICT**.

Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

Norway performs well in terms of the number of scientific articles per thousand inhabitants, only surpassed by Switzerland, Denmark, Australia and Sweden. The total number of articles has increased by 69% from 2006-2014. Among comparable European countries only Denmark has a higher growth rate (77%) in the same period. On the other hand, natural benchmark countries such as Denmark, the Netherlands and Switzerland are still ahead of Norway in terms of traditional quality measures, such as share of the top 10% most cited publications and share of public-private co-publications. Other quality measures and evaluations give a similar

[79] Meld. St. 7 (2014-2015), https://www.regjeringen.no/en/dokumenter/meld.-st.-7-2014-2015/id2005541/ Other research related strategies are the "Norwegian Strategy for research and innovation cooperation with the EU: Horizon 2020 and ERA", https://www.regjeringen.no/en/search/id86008/?term=eu+strategy and the "National Strategy for Biotechnology 2011-2020 and the National Strategy for Biotechnology 2011-2020", https://www.regjeringen.no/globalassets/upload/kd/vedlegg/forskning/national_strategy_for_biotechnology_2011-2020.pdf

[80] http://www.forskningsradet.no/en/Main_strategy_of_the_Research_Council/1185261825635

picture of Norwegian research as highly productive, but more average in terms of its ability to develop cutting edge research.

After a strong and steady increase in the number of awarded doctorate degrees in recent decades, the number seems to have stabilized around 1500 for the last two years. A significant contribution to the recent increase has been that more women are gaining doctorates. From a gender perspective, 2014 was a milestone as this was the first year when the majority of degrees (51%) were awarded to women.

Attracting foreign research talents to Norwegian R&D institutions has been a declared priority in Norwegian R&D policies. While persons with non-Norwegian citizenship accounted for less than 10% of doctoral degrees at the start of the 1990s, the proportion of foreigners has now risen to more than a third. It also appears that Norway is among the countries which receive most foreigners with higher education. The integration and exploitation of this additional labour force is both a challenge and a great opportunity for Norway.[81]

Country profile and standing in *www.excellencemapping.net*

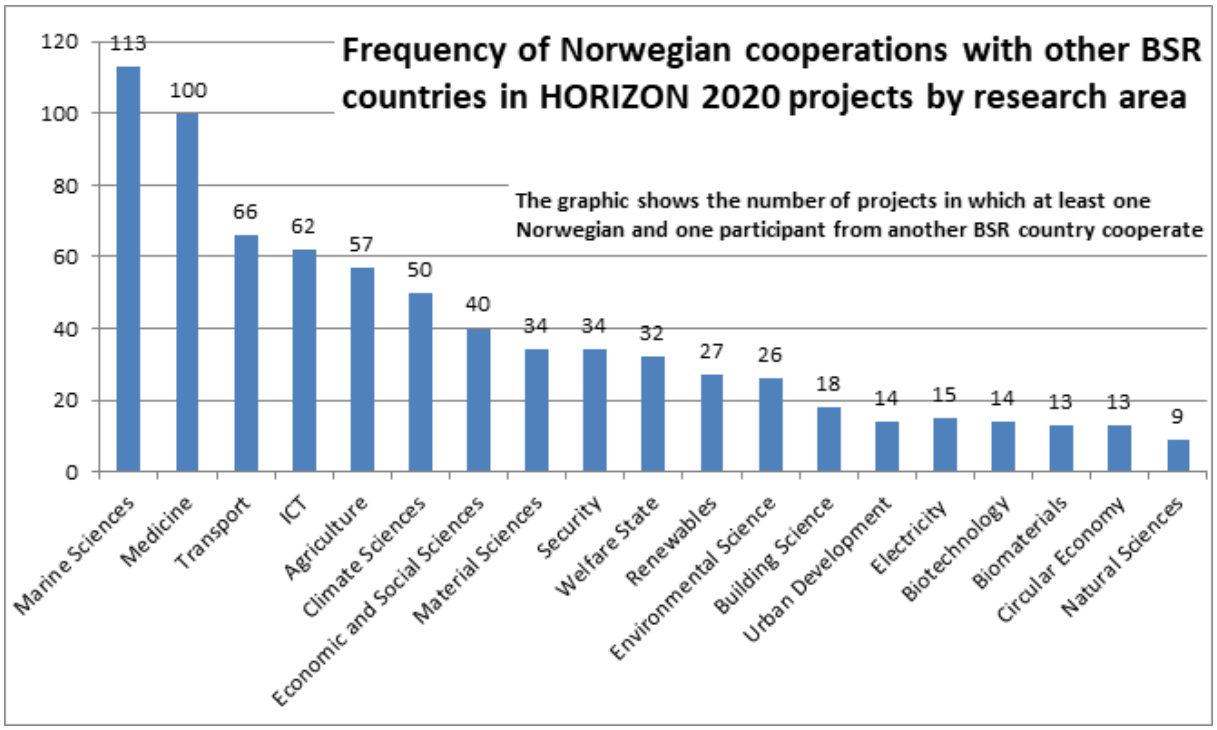
The excellencemapping.net database shows good quality indicators for Norwegian research institutions in most research disciplines and thus an overall position which is in line with the Nordic average, although most indicators are slightly weaker than those of Denmark and Sweden. The best results are achieved in **medicine**, where all analysed research institutions rank above global average in terms of both citation impact and publication rates in world leading journals. Moreover, when applying the latter criteria, 9 out of a total of 13 analysed Norwegian institutions even belong to the global top 25% in medicine. Other research areas with very good results are: **biochemistry and genetics, engineering, agriculture and computer science**. In contrast, a few research areas rank slightly below global average. These include neuroscience, immunology and microbiology and materials science. The **University of Bergen** is among the global top 10% in physics and astronomy (both in terms of citation impact and publication in world leading journals) and – regarding the latter criteria – also in computer science, where the university also occupies the first position within the BSR.

Country participation in H2020 with other BSR countries

The absolute number of participations in transnational H2020 projects is lower in Norway than in the other Nordic states but higher than in Poland and in the German BSR states. In contrast to Denmark and Sweden, Norway cooperates in most of these projects (61%) with partners from other BSR countries and here most frequently with Denmark, Sweden, Finland, Poland and the German BSR states (in that order). A clear majority of these projects is related to **marine science** (113) which is the highest number of all BSR countries, followed by Denmark (108). Likewise, Norway is more often than any other BSR country engaged in projects related to **climate science** (50) and occupies second place (27) after Denmark (48) regarding the number of projects related to **renewable energy**.

[81] European Commission (2015), RIO Country Report Norway 2015, https://rio.jrc.ec.europa.eu/en/country-analysis/Norway/country-report

Figure 9. Frequency of Norwegian H2020 cooperation with BSR countries (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Country participation in JPI/JTI, COST actions, EUREKA

Norway occupies second place among all BSR countries regarding the number of participations in JPI projects (90) and thus ranks between Sweden (148) and Denmark (74). As in the case of all other BSR countries most of the projects with Norwegian participation are related to the JPI **Agriculture, Food and Climate Change**. However, in contrast to them, among the BSR countries, **Norway shows by far the highest participation rates in the Oceans (15) and Climate (12) JPIs**, which corresponds with the above mentioned research specialisations of Norwegian H2020 projects. As for the other JPIs, Norway occupies a medium position if seen from an overall BSR perspective.

Norwegian participation rates in projects related to the JTIs ECSEL JU, Bio-based Industries JU and Innovative Medicines Initiative are slightly lower than those of the other Nordic countries but higher than the Polish rates. Only 2% of the funding allocated to BSR countries in the context of the JTI medicine is received by Norway, which differs hugely from 50% in the case of Sweden. In contrast, Norway is in second position in the BSR regarding the JTI **Fuel Cell and Hydrogen** with 49 project participations after Denmark (97).

In recent years Norway has significantly raised the share of participations in COST actions from 70% in 2011 to 81% in 2015 and ranges now more or less at the same level as the other Nordic states. However, the intensity of short term researcher mobility in the context of COST actions is still very low in Norway. In 2014/15 the country recorded only 77 incoming and 47 outgoing researchers, which is just half as much as for instance in the case of Finland (147 and 114 respectively). Overall participation rates in EUREKA projects are again quite high in Norway andare at Nordic level only surpassed by Sweden. Projects with Norwegian participation are

most frequently carried out in the technological areas **Electronics and ICT** as well as in **Medical technology, Biology and Biotechnology**.

Important research infrastructures of regional relevance

- Earth observation/geoscience/climate

NORSAR, with its head office located near Oslo, operates some of the world's most advanced monitoring installations for observing earthquakes and nuclear explosions. Field installations are located in different parts of the Norwegian mainland and on the Svalbard and Jan Mayen islands. The observatories of the **Norwegian Institute for Air Research (NILU)** in Norway, the Arctic and in Antarctica collect data on air pollutants, climate gases and climate forcing agents.

- Marine research

The **Institute of Marine Research** is Norway's largest centre of marine science with a staff of almost 750. The institute has research stations throughout the country and is equipped with a large fleet of vessels, which are at sea for a total of 1600 days a year. **Nofima** (Tromsø) is one of the largest European research institutes in the fields of fisheries, aquaculture and food research. **VESO Vikan** is an aquatic research facility, which is equipped with a wet lab with separate isolates and holding tanks from 4 to 13 000 litres. It carries out tests for the fisheries sector such as vaccine and feeding trials and trials to evaluate genetic resistance to viruses, bacteria and sea lice. Following a merger between several special institutions completed in January 2017, **SINTEF Ocean** carries out research in marine technology and biomarine research. Among a broad range of laboratories, many of them world leaders in their field, are also the world's largest ocean basin laboratory, located in Trondheim and the fisheries technology laboratories in Hirtshals, Denmark.

- Energy

SINTEF Energy Research covers among others hydropower, wind energy, system integration of renewable energy and gas technology. **VIVA** provides research infrastructure related to wind power production. Leading research facilities in the field of Hydropower are provided by the **Norwegian Hydropower Centre (NVKS)** in Trondheim. In the period 2017 – 2024 the activities within NVKS will be carried out in "HydroCen – the Norwegian Research Centre for Hydropower Technology".[82] Moreover, the **Waterpower Laboratory** at NTNU ENERGY in Trondheim provides research facilities that are unique in Europe and have played a leading role in the development of global hydropower. At the **European Carbon Dioxide Capture and Storage Laboratory Infrastructure (ECCSEL)** in Trondheim research is carried out in the field of carbon capture and storage. It was granted the legal status of an ERIC by the European Commission in June 2017.

[82] https://www.ntnu.edu/nvks

- Social sciences

The **Consortium of European Social Science Data Archives (CESSDA)** was granted the legal status of an ERIC by the European Commission in June 2017. It is hosted by Norway and has its statutory seat in Bergen. The **Norwegian Centre for Research Data (NSD)** provides information about human society at the levels of individuals, regions, private and public institutions as well as the political system.

Most relevant developments for BSR cooperation in the future

An often-underestimated source of initiating projects with a potential for scientific excellence in the BSR is deployed under the **EEA Grants - Norway Grants**.[83] In the BSR they encourage bilateral cooperation and project partnerships between Poland, Lithuania, Latvia and Estonia with entities from Iceland, Liechtenstein and Norway. The projects stipulate collaboration in some domains, which for instance in the case of Poland are: increasing **energy efficiency**, promoting **green innovation** in cooperation with Norwegian enterprises, improving **environmental monitoring** and protecting **biodiversity**, improving access to **public health services**, increasing research cooperation between Norway and Poland and contributing to a more efficient **judicial system**.

Poland

Short description of the country's R&D profile

The R&D profile on Poland is fragmented due to systemic foundations based on three different sets of organisations:

1. Universities and colleges (public and private, teaching and research);
2. Institutes of the Polish Academy of Sciences (research only, mostly basic studies);
3. Research institutes (research and development).

Their activities in the domain of R&D are supported by three funding agencies: the National Science Centre (NCN) (funding basic research only), the National Centre for Research and Development (NCBiR)[84] (funding applied projects) and the Foundation for Polish Science (FNP) (government-independent foundation supporting top quality research). A brand new development is the establishing of the Polish National Agency for Academic Exchange (NAWA, *Narodowa Agencja Wymiany Akademickiej*) with the mission of driving state activities in the broad process of internationalisation (mobility & exchange programmes, internationalisation of HEI and research institutions, promotion of Polish science and higher education, popularisation of Polish language teaching).

Assessing current research landscapes (subjective opinions from country studies)

In the years 2007-2013 major reforms took place in the Polish research and innovation landscape, significantly supported by European Structural and Investment Funds (ESIF) for the

[83] http://eeagrants.org/

[84] The biggest unit of this kind in Central and Eastern Europe (in terms of budget and number of the financed and implemented R&D projects).

2007-2013 and 2014-2020 perspectives. In 2013 a high-level strategic document *Strategy for the Innovation and Efficiency of the Economy* (SIEG, *Strategia Innowacyjności i Efektywności Gospodarki*) was adopted by the government, thereby paving the way for specific thematic areas of *National Smart Specialisations* (KIS, *Krajowe Inteligentne Specjalizacje*) adopted for the years 2014-2020.[85] At the same time investments in large research infrastructure were to be linked to the contents of the *Polish Roadmap for Research Infrastructure* (PMDIB, *Polska Mapa Drogowa Infrastruktury Badawczej*).[86] These planning documents were defined through bottom-up processes, with large-scale foresight projects,[87] calls for submission and consultations with stakeholders.

Analysing science policies and strategies (country specific – their strategies and goals)

Political interest in developing science policy and making use of scientific research as key for innovation and growth has been increasing in Poland over the years. Currently the most influential document where the political interest in science can be witnessed is *Strategy for Responsible Development* (SOR, *Strategia Odpowiedzialnego Rozwoju*) that builds on the accomplishments of several earlier policy and analytical documents, including in the area of operationalising smart specialisation, whether this refers to designing government funded programmes or prioritising certain sectors of the economy with a view to achieving long-term social and economic goals.[88]

In the *Strategy for Responsible Development* the current government endorses five strengths of Polish development, i.e. reindustrialisation; development of innovative companies; capital for development; foreign expansion; social and regional development. NIS3/RIS3 are included as enablers for reindustrialisation in order to identify national and regional market-related niches and competitive advantages for global markets. The 20 national smart specialisations are defined within the following branches: **healthy society; agri-food, timber and environmental sectors; sustainable energy; natural resources and waste management; innovative technologies and industrial processes**.

The Polish government undertook several attempts to establish centres of excellence across higher education and the research sector. All but one failed to earn wider political support and academic acceptance. Inspired by the idea of centres of excellence implemented in Germany, the Polish government made two calls for *National centres of excellence in research* (KNOW)

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[85] The catalogue of the specialisations on the KIS list is regularly updated (last time: 01.01.2018).

[86] MNiSW (2014), *Lista przedsięwzięć umieszczonych na Polskiej Mapie Drogowej Infrastruktury Badawczej*. Ministry of Science and Higher Education, Warsaw. PMDIB was established in 2011 and updated in 2014. At present it includes 53 projects, among which 30 are national projects and 23 are international ones, while 20 are already in their implementation phase. The purpose of the Roadmap is to guide the development of future research infrastructure initiatives of a national and international scale in a long-term perspective. At the same time, it corresponds to the European approach of linking national research strategies with the European ones under the auspices of ESFRI. There is also a clear link between being included in the Roadmap and having a possibility to apply for the EU Structural Funds under new financial perspective 2014-2020.

[87] For instance *Industry Technology Foresight – InSight 2030*, prepared in 2012.
https://rio.jrc.ec.europa.eu/en/file/8090/download?token=yGaOHLVk

[88] SOR was announced by the Ministry of Development in 2016. It was based on the *Polish Roadmap for Research Infrastructures, National Research Programme*, and the results of foresight projects.

in 2012 and 2014 but selected only five (2012) and six (2014) respectively.[89] Each of them received an extra block grant funding of PLN 50 million for a period of 5 years (PLN 10 million per year). The programme was eventually suspended in 2016 and is unlikely to be continued due to upcoming reforms. A programme funded from ERDF (Smart Growth Operational Programme) and implemented by the non-governmental Foundation for Polish Science is worthy of mention in this context. Their competition for *International Research Agendas* (IRA) with a total budget of EUR 126 million aims at establishing innovative centres of scientific excellence led by outstanding researchers and set up either as separate institutions or within already functioning Polish academic institutions in partnership with a strategic foreign research partner unit. Until 10/2017 only three such prestigious projects have been established in the area of physics and in biomedical sciences: the Research Foundation **MagTop** (International Centre for Interfacing Magnetism and Superconductivity with Topological Matter)[90] and the centre **ReMedy** (new solutions in civilisational disease diagnostics and therapy)[91] in Warsaw as well the **ICCVS** – International Centre for Cancer Vaccine Science at the University of Gdansk[92] – so far the only IRA led by foreign scientists in Poland.

Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

Notwithstanding the above mentioned ambitious strategies and frameworks to employ scientific research as a driver for economic development, a number of problems and challenges may have a negative effect on supporting scientific excellence. The most serious problem concerns the economic foundations, with a systemic underfunding of research institutions and researchers. Poland has a relatively low level of research funding (one of the lowest in the EU) which goes hand in hand with comparatively low salaries for academic teachers and researchers. This induces brain drain for the most talented researchers who migrate or consider migration to research centres in Germany, the United Kingdom, Scandinavia or the United States, where their research output is valued 3 to 4 times more even if adjusted by the purchasing power parity (PPP).

One of the major obstacles hampering the capacity for transnational cooperation is the Polish internal cycle of scientific communication that covers approximately 2.5k Polish language journals. Absorbing a significant part of research outcomes, they have failed to be recognized by the international community and exercise no influence on building new knowledge that is transnational by nature. With the exception of academics from some disciplines (for instance life sciences), many Polish researchers, having no internationally recognized research record, ultimately find themselves to be unattractive partners for collaborative projects. Under growing pressure to publish results in the most prestigious journals, academics tend to

[89] A list of nominated National Centres of Excellence in Research can be found on http://www.nauka.gov.pl/projekty-i-inicjatywy/krajowe-naukowe-osrodki-wiodace.html

[90] http://www.magtop.ifpan.edu.pl/

[91] http://irap.fnp.org.pl/winning-projects/professor-agnieszka-chacinska-and-professor-magda-konarska

[92] http://www.iccvs.ug.edu.pl/, and http://irap.fnp.org.pl/winning-projects/professor-theodore-hupp-and-professor-robin-fahraeus

seek to network with those who can increase their chances when applying for joint grants as well as make their research results more internationally visible.[93]

A further problem hampering Polish science is bureaucracy, with project leaders often being burdened with internal and external procedural and administrative regulations. Over-complicated procedures (e.g. public procurement) very often slow down research or make it impossible for researchers to excel in their projects. However, it must also be underlined that the quality of governance in Polish public administration has been improving quickly, with science policy possibly being one of beneficiaries of this change.[94]

These changes notwithstanding, the governance of public universities still rests upon the idea of "a community of scholars" and in practice is more about 'who gets what' than organizational steering. Universities are focused on internal politics rather than on building bridges with the world outside, resulting in university governing bodies often finding it hard to implement organizational reforms. Similar problems – although on a smaller scale – face the Polish Academy of Sciences, which would require a more managerial model of steering in order to concentrate on attaining scientific excellence in an international context.

Polish scientific institutions have specific problems regarding their participation in EU programmes. The problems are: (a) own contributions (Polish institutions do not have funds to cover this), (b) low rewards (due to low salaries, some Polish researchers are not interested in additional work in projects without extra pay), (c) low overheads (Polish institutions are not enthusiastic to carry out projects which are usually logistically complicated), (d) Value Added Tax (VAT) problems (if VAT is not deductible, Polish institutions do not have funds to cover VAT expenses).

Country profile and standing in *www.excellencemapping.net*

Poland's profile and standing on the excellencemapping.net database do not compare favourably with other bigger countries in the region, neither when best journal rate nor the citation impact are taken into account. Only in the field of **computer science and engineering** is there strong Polish representation, with the Polish Academy of Sciences ranking high in the global top 10% of best journal rate, and a few Polish institutions are counted among the top global 50%. In **physics and astronomy** the National Centre for Nuclear Research belongs to the group of global top 25% of institutions with citation impact whereas there are a number of other Polish institutions present on the list of the world's most influential publications. Yet another branch of science which scores relatively well is **materials science** where in the best journal rate Jagiellonian University ranks among the global top 50%, while the University of Warsaw, the Polish Academy of Sciences and the Adam Mickiewicz University are represented in the group below global average. In all other categories taken into account by excellencemapping.net database, Polish institutions for the most part belong to the group of far below global average (75%–100%), or are not enumerated at all.

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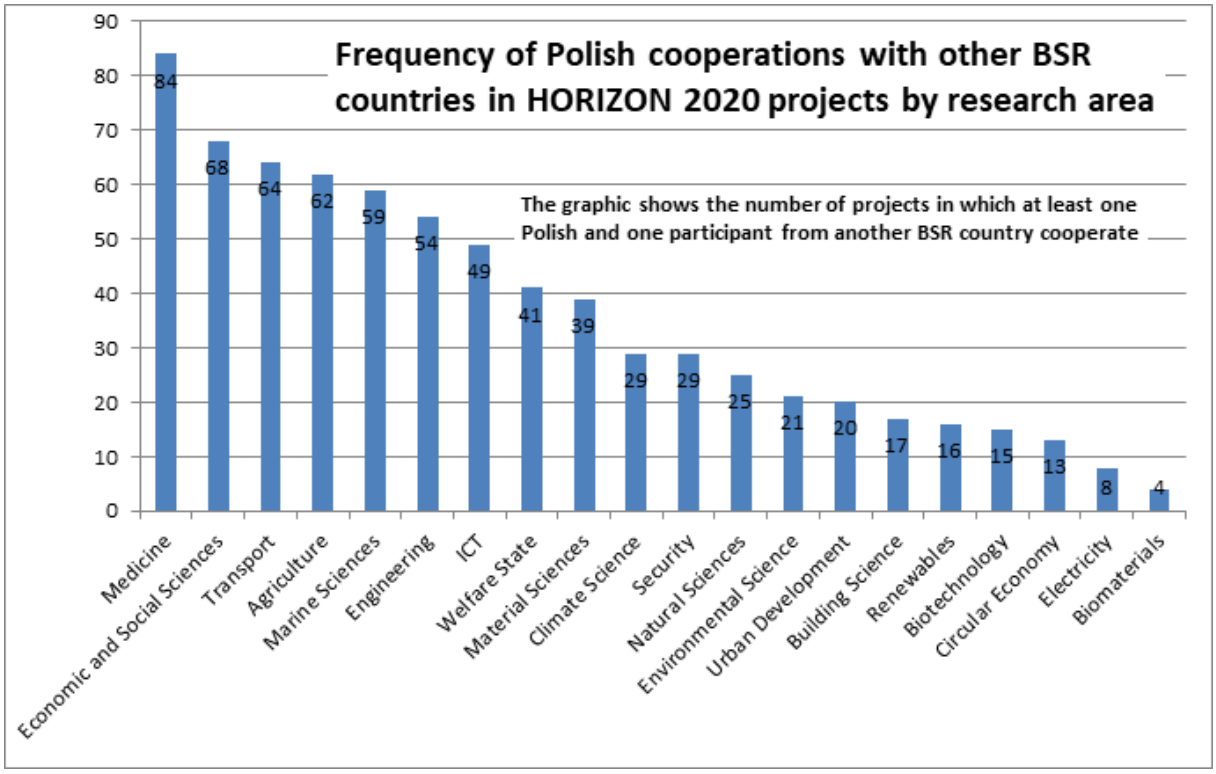
[93] Cf. European Commission (2017), *Peer Review of Poland's Higher Education and Science System*, https://rio.jrc.ec.europa.eu/en/library/peer-review-poland%E2%80%99s-higher-education-and-science-system

[94] Klincewicz, Krzysztof (2015), *Stairway to Excellence. Country Report: POLAND*, European Commission Joint Research Centre, pp. 6–13. https://ec.europa.eu/jrc/en/publication/stairway-excellence-country-report-poland.

Poland's participation in the H2020 project involving other BSR countries is most notable in **medicine** (87 projects), disciplines related to **economic and social sciences** (68 projects), **transport** (62 projects), **agriculture** (62 projects) **engineering** (59 projects) and **ICT** (49 projects).

Figure 10. Frequency of Polish H2020 cooperation with BSR countries (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Country participation in JPI/JTI, COST actions, EUREKA

Poland chairs the following European Cooperation in Science and Technology (COST) actions:

- CA CA15127 – Resilient communication services protecting end-user applications from disaster-based failures (RECODIS);
- CA CA15209 – European Network on NMR Relaxometry;
- CMST TD0802 – Dendrimers in Biomedical Applications;
- CMST CM1101 – Colloidal Aspects of Nanoscience for Innovative Processes and Materials;
- ESSEM 726 – Long term changes and climatology of UV radiation over Europe;
- ICT IC1406 – High-Performance Modelling and Simulation for Big Data Applications (cHiPSet);
- MPNS MP0702 – Towards Functional Sub-Wavelength Photonic Structures;
- TUD C8 – Best practice in sustainable urban infrastructure.

As of 2015 Poland was also involved in over three hundred COST actions, with Polish participants offering greatest expertise in biological sciences, health sciences, computer and information sciences and electrical engineering.[95]

Important research infrastructures of regional relevance

The database ESFRI.EU reveals a number of Polish infrastructures of regional relevance. In the domain of environmental and marine sciences **The Institute of Meteorology and Water Management – National Research Institute** (IMGW-PIB) in Warsaw contributes to SeaDataNet II: Pan-European infrastructure for ocean and marine data management, and the **Institute of Hydroengineering PAS** (IBW PAN) in Gdańsk contributed towards a joint European research infrastructure network for coastal observatories. In physical sciences and astronomy, the radio telescopes of the **Nicolaus Copernicus University in Toruń** contribute to advanced radio astronomy in Europe. In energy related research **Wrocław University of Science and Technology** offers biomass research facilities. In biology the **University of Warsaw** offers *s*tructural biology facilities. In computer sciences **Poznań University of Technology** has excelled in visualisation facilities together with **The Institute of Bioorganic Chemistry of the Polish Academy of Sciences** (IBCH PAS). **The Poznań University of Life Sciences** provides infrastructure for the integrated non-CO2 Greenhouse gas Observation System.

Most relevant developments for BSR scientific cooperation in the future

Poland's possible contribution to enhancing potential for scientific excellence in the BSR relies on both the declared priorities in science policy and on already existing research infrastructures. Current priorities link RIS3 with Poland's *Strategy for Responsible Development*, with a maximum concentration of resources in branches where Poland can be competitive, such as: 1) sustainable energy production, 2) agri-food, timber and environmental sectors, 3) healthy society, 4) natural resources and waste management, 5) innovative technologies and industrial processes.[96]

In terms of infrastructure, **PIONIER – Polish Optical Internet** – a nationwide broadband optical network for e-science,[97] represents a base for R&D in the area of information technology and telecommunications, computing sciences (grids, etc.), applications and services for the Information Society. Built entirely from KBN (Committee for Scientific Research) funds, it currently connects 21 Academic Network Centres of Metropolitan Area Networks (MAN) and 5 of the HPC (High Performance Computing) Centres using their own fibre optic connections. PIONIER is Europe's first national academic network that uses its own dark fibre optics and DWDM 10GE transmission. Major user groups are found in most areas relevant to eScience, including chemistry, engineering, physics, biology, computer science, mechanics, astrophysics, mathematics, meteorology, and high energy physics.

[95] COST 2017, Country fact sheets – Poland. http://www.cost.eu/module/download/58026 and http://www.cost.eu/about_cost/cost_member_states?countrycode=PL

[96] These branches and areas of cooperation relate to national smart specialisations and are here enumerated in the order of potential relevance for BSR collaboration, determined during interviews in the Polish Ministry of Science and Higher Education.

[97] http://www.pionier.net.pl/online/en/projects/69/PIONIER_Network.html

An important element of the PIONIER network are its existing, direct cross-border fibres (CBFs) to its BSR neighbours, for example Germany in Słubice (DFN network), Gubin and Kołbaskowo, and Lithuania in Ogrodniki. Using these CBFs it is possible to provide cost effective and quick access to major European Internet Exchange Points (IXPs) and connect with National Research and Education Networks (NRENs) in Europe.

With respect to research infrastructures in the BSR, Poland's participation (ca. EUR 30 million) in the consortium developing European XFEL in Hamburg demonstrates a commitment to support basic science and its practical applications, e.g. in materials science, biology and medicine. The Polish **National Centre for Nuclear Research** (NCBJ) is a shareholder in this initiative developing the world's most powerful laser for X-ray light, together with a number of BSR partners (Germany, Russia, Sweden and Denmark) and with other European institutions.

Regarding climate change research and building joint polar research efforts towards monitoring and disseminating data and knowledge about the impact of arctic regions on mid-latitudes, Poland has been contributing to the ESFRI list project **SIOS – Svalbard Integrated Arctic Earth Observing System** with estimated costs ca. EUR 86 million with operation EUR 2-3 million per year, and to EU-PolarNet. In both of them the **Institute of Geophysics of the Polish Academy of Science** (IGF PAN) plays one of the most prominent roles.

While many research centres that have potential for scientific excellence in Poland are located in central or southern parts of the country, due to its functional proximity to other Baltic Sea region neighbours, the northernmost region of Poland, Pomorskie Voivodship, may be the most relevant for BSR scientific cooperation in the future. The region has efficiently framed four smart specialisations where it may achieve excellence and be competitive on a global scale. They are: 1) **off-shore, port and logistics technologies, 2) interactive technologies in an information-saturated environment, 3) co-effective technologies in the generation, transmission, distribution and consumption of energy and fuels, and in construction, 4) medical technologies in the area of civilisation and ageing-associated diseases.** These specialisations rely on local research bases and on transnational scientific relations with large research and innovation infrastructures in other BSR countries in such domains as oceanography and blue biotechnology, life & environmental sciences and pollution research.[98]

Within the previously mentioned EEA and Norway grants, Norway is the largest donor. In the years 2004-2021 Norway will allocate almost EUR 1 billion to projects in and with Poland. There is a potential for these contributions and partnerships to translate into sustainable frameworks supporting scientific excellence. The most likely confluence of Polish strengths and Norwegian interests is in the domains of **climate change** and **polar research**, as well as

[98] Apart from the Gdansk University of Technology, the Maritime Academy in Gdynia and the Medical University of Gdansk (MUG), the University of Gdansk (UG) belongs to the core research institutions in this region. UG is an active member of ScanBalt in life sciences and bioeconomy (www.scanbalt.org) and has been nominated as the Polish partner in the Baltic Science Network. According to its leadership UG has reached a level of excellence in the international context in: **quantum physics** (ERC grants), **chemistry**, **biotechnology** (FP7-REGPOT funded MOBI4Health Centre and recently - the previously mentioned International Centre for Cancer Vaccine Science funded by a large grant from EU Structural Funds), and **oceanography** (the state-of-the-art research vessel, international grants, national grants).

energy efficiency and **green innovation** that are also mentioned among strategic directions pursued in the *Strategy for Responsible Development.*

Russia (Northwest)

Short description of the country's R&D profile

The report on Research and Innovation Performance in the EU (from 2014) does not have a section dedicated to Russia. In VASAB Russia is participating in the development of comparative statistics, and Russia is a partner for "HA Neighbours". Northwest Russia is a part of the country with a well-developed structure for research and innovation. In particular, the city of St. Petersburg is the second city (after Moscow) according to the number and ratings of universities, research institutions and libraries; it is one of the largest scientific and educational centres of Russia in which is concentrated over 10% of scientific potential and 14% of all researches of the country. There are more than 300 research institutions including 49 RAS (Russian Academy of Sciences) institutes, 190 other research organizations, 12 scientific centres and 78 universities.

The Strategy for social and economic development of Northwest Russia till 2020 (adopted in 2011) declares the modernization and innovative development of basic sectors of the economy to be a priority.

Assessing current research landscapes (subjective opinions from country studies)

Russia, and St. Petersburg in particular, has a well-developed infrastructure of research centres and libraries. St. Petersburg University occupies second place among Russian universities in the international ratings.[99] It is followed by the Higher School of Economics (which has a branch in St. Petersburg) and St. Petersburg State Polytechnic University. The region has also the Arctic Federal University (since 2010) and the Baltic Federal University (Kaliningrad), however their impact on the development of the research landscape is still not very significant. Often other educational institutions have a stronger record in science and innovation, for instance the St. Petersburg Institute of Technology and Design and the University of Telecommunication. Special attention is paid to projects focused on import substitution and high-tech projects. The most intensive high-tech industrial development is based on the cluster system when science, education and industry are concentrated in one technological area. St. Petersburg hosts 25 different clusters e.g. the PharmaCluster and the ITCluster, both of which were included in Governmental List of innovative local clusters on 28.08.2012.

Analysing science policies and strategies (country specific – their strategies and goals)

The National strategy includes the creation of the Public Office for Scientific Communities, and cooperation between investors and entrepreneurs for products of high technological standards. The legal framework includes:

- Decree no.599 (2012) of the President of the Russian Federation "On measures for the realisation of state politics in the sphere of education and science": elaboration of the

[99] https://ria.ru/abitura_world/20160905/1475901019.html

plan for raising the competitiveness of the leading universities before the end of 2020. It aims to guarantee that at least 5 Russian universities will be among the 100 best universities in the world by 2020 (but the impact of this strategy has still not been very great);

- The Strategy for Innovative development of Russia till 2020 (2011): international cooperation in the sphere of innovation, growth of state expenditure for innovations and use of private finances (venture foundations);
- The Federal targeted programme of the Ministry of Education and Science of the Russian Federation for scientific-technical development (2014-2020): transition to **ecological and resource saving production of energy**; high **medical technologies**; highly **productive and ecologically clean agriculture**;[100]
- The Strategy for scientific-technological development of the Russian Federation (2016): independence of scientific development of Russia and its ability to compete with other countries.[101]

St. Petersburg Scientific Centre of the Russian Academy of Science (St. Petersburg SC RAS) plays a key policymaking role in the region. The SC runs and supports fundamental research in the sphere of natural science, technical science, social sciences, humanities, etc. The Centre coordinates cross-disciplinary research in the region. The SC is responsible for international relations of the RAS institutions.

The SC RAS Cross-disciplinary council (led by academician Zhores Alferov, Nobel Prize in Physics) consists of seven Joint scientific councils: physics and mathematical studies, energy, material science, IT and telecommunications, ecology and recourses, biology and medicine and social sciences and humanities. The role of the Cross-disciplinary council is to coordinate key fundamental and applied research projects in NW Russia.

Ascertaining political self-interest, limitations and potentiality for supporting scientific excellence

Russia is interested in global cooperation in research and innovation, but, in the context of anti-Westernism and EU sanctions is looking for partners in Asia. These may have negative impact on researcher mobility or science cooperation in the BSR. The „New Silk Road" (transport communications) from China to Europe should be developed through the BSR - new incentives for development of regional infrastructure.

With respect to scientific and technological strengths based on thematic priorities of the EU Framework Programmes for Research and Technological Development, where the country shows scientific and technological specialisations, Russia is the most successful international cooperation partner country in terms of the total number of participations in the programme, the total amount of EU financial contribution received, and the number of collaborative actions

[100] http://www.fcpir.ru/

[101] http://static.kremlin.ru/media/acts/files/0001201612010007.pdf

launched. EU researchers successfully participate in Russia's Federal Targeted Programmes (FTPs), such as the FTP "R&D in Priority Fields of the S&T Complex of Russia (2007-2013)".[102]

Table 3. Country profile and standing in www.excellencemapping.net

Subject	Citation impact %	Best Journal Rate %
Biochemistry, genetics and molecular biology	SP U 4,7	SP U 26
Chemistry	SP U 3,3	SP U 34,4
Earth and Planetary Science	SPt U 8,9	SP U 35,2
Engineering	SP U 11,6 SP Tech 7,5	SP U 25,2 SP Tech 6,5
Materials Science	SP U 5,6	SP U 35,5
Mathematics	SP U 7,4	SP U 17,9
Physics and Astronomy	SP U 8,7 SP Tech 5,8	SP U 35 SP Tech 15

Source: Own calculation, based on: www.excellencemapping.net

Country participation in H2020 with other BSR countries

In 2003, the EU and Russia agreed to reinforce their cooperation in R&D towards the creation of a "**Common Space in Research and Education, including Cultural Matters**" in the framework of the EU-Russia Partnership and Cooperation Agreement. The **EU-Russia Partnership for Modernization** (2010) aims to tackle global economic and societal challenges. EU-Russia S&T cooperation is coordinated by the **Joint S&T Cooperation Committee**.

Country participation in JPI/JTI, COST actions, EUREKA

Russia has been a member of EUREKA since 1993 and takes part in COST.

Most relevant developments for BSR cooperation in the future

The Centre for Strategic Research "North-West", the Federal Agency for Scientific Organizations and the Russian Science Foundation have jointly launched a long-term cooperation project on forecasting the development of science topics.

The aim of the project is to identify the most promising areas of current research and science topics for immediate investment to ensure maximum effect. The following directions have been selected as the pilot areas for foresight research:

- Biomedicine

The St. Petersburg Institute of Technology and Design produces chirurgic materials. The Kurchatov institute, St. Petersburg pursues interdisciplinary convergent research in nano-, bio-, information, cognitive and socio-humanistic science and technology.

- Nutritional science; the fight against infectious diseases

[102] http://ec.europa.eu/research/iscp/index.cfm?lg=en&pg=russia

The work is based on the Disruptive Foresight method developed by the Centre for Strategic Research "North-West". The report covers the period from 2016 to 2040. The project includes round tables, questionnaires and foresight sessions with experts from different relevant fields. Leading researchers who take part identify the challenges, megatrends and breakthroughs that set the foundation for the approach. The advantages of the approach are openness and priority of dialogue. The project is being carried out within the framework of the Strategy for Scientific and Technological Development (SSTD) of Russia until 2035, approved by the Decree of the President of the Russian Federation No. 642 of 1st December, 2016 and recognizes the importance of challenges as the basis for decision-making and formation of priorities in science. Also, the selected research areas are in conformity with aims set out in SSTD.[103]

There are numerous research projects of St. Petersburg RC RAS and North-Western universities with Finnish and German colleagues. They include:

- The Kurchatov Institute's cooperation with German accelerators GSI and FAIR in Darmstadt, DESY in Hamburg, IKP in Juelich in the sphere of High Energy Physics. A new heavy ion accelerator facility will be open in Darmstadt in 2019.
- TOPCONS is a Finnish-Russian co-operation project that will develop innovative spatial tools for regional planning and long-term development of the sea areas. These will help society when striving for the sustainable consolidation of human activities and the protection of the marine environment. The objective of the project is to create methodology and tools to aid in forecasting and mapping the locations of the most diverse and sensitive under-water landscapes, and in the light of this knowledge, to execute the planning of ecosystem-based management. TOPCONS is co-ordinated by the Finnish Kotka Maritime Research Centre. Other Finnish partners are University of Helsinki, Finnish Environment Institute, Geological Survey of Finland, Metsähallitus and Finnish Game and Fisheries Research. The partners in Russia are A.P. Karpinsky Russian Geological Research Institute, Russian Academy of Science and Russian State Hydrometeorological University.

Sweden

Short description of the country's R&D profile

Despite a slight decrease in recent years from 3.31% in 2013 to 3.26% in 2015, Sweden still has the highest R&D share of GDP among all EU and BSR countries.[104] Moreover, business enterprise R&D intensity in Sweden is among the highest in Europe with a share of 2.23% in 2015, which corresponds to slightly above two thirds of total R&D investments in the country.[105] Sweden shows high scientific and technological specialisation in the automobile

[103] http://www.csr-nw.ru/en/projects/ongoing_projects/scientific-foresight/
[104] http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&language=en&pcode=t2020_20&plugin=1
[105] https://rio.jrc.ec.europa.eu/en/country-analysis/Sweden/country-report

and construction sectors as well as in health, energy, environmental research, security, transport and ICT.[106]

One of the challenges in national research policies is however the fact that Swedish innovation output is lower than expected if compared to the large volume of R&D investment. Moreover, Sweden's good R&D position is vulnerable due to its heavy dependence on a few large multinational companies. Several of them have been subject to acquisitions by foreign firms, which is a development that contributes to a delocalisation of strategic R&D investments. Swedish innovation policies therefore focus on an incremental industrial restructuring with the aims of reducing dependence on a few large actors, supporting growth in high-tech firms and improving framework conditions for SMEs.[107]

Assessing current research landscapes (subjective opinions from country studies)

Sweden shows a comparatively large (by population), well-funded and well-established academic landscape and can boast excellence in nearly all fields of research. Geographically, the greatest centre of scientific excellence is Stockholm, hosting not just Stockholm University, Karolinska Institute and the Royal Institute of Technology (KTH), but also in commuting distance of the universities of Uppsala, Linköping and Örebro. Further concentrations of academic excellence are to be found in Skåne (Lund, Skåne University Hospital, also within commuting distance of Copenhagen) and Gothenburg (university and Chalmers Institute of Technology).

The most important fields of excellence are in **medicine and life sciences**, which both have a broad base and a well-established and excellent academic production. The same goes for **materials science**, where a lot of research is carried out in the business-related research sector as well, for instance in RISE, the recently merged Research Institutes of Sweden AB. Physics, astronomy and geosciences have a somewhat narrower base in Sweden, but are excellent where they dominate. A world-renowned physics institute is the Oskar Klein Centre for Cosmoparticle Physics, based at Stockholm University.

Analysing science policies and strategies (country specific – their strategies and goals)

In 2016 the Swedish government set strategic aims related to science policies in its new ten-year research programme.[108] The topics have been sketched in rough terms and referred to the relevant research councils for further refinements, since the concept of a ten-year programme is rather novel. The following research areas have been ascribed high potential for further development:

- **Climate** (research on/mitigation of and adaptation to climate change);
- Building **sustainable communities** (with special emphasis on ecological and socioeconomic sustainability, security, inclusion, architecture, cultural environments and democracy);
- **Social housing and accessibility**;

[106] http://ec.europa.eu/research/innovation-union/pdf/state-of-the-union/2014/countries/sweden.pdf
[107] https://rio.jrc.ec.europa.eu/en/library/rio-country-report-sweden-2016
[108] http://www.regeringen.se/4adad0/contentassets/72faaf7629a845af9b30fde1ef6b5067/kunskap-i-samverkan--for-samhallets-utmaningar-och-starkt-konkurrenskraft-prop.-20161750.pdf

- **Migration and integration**;
- **Antibiotic resistance**;
- **Applied welfare** (with special emphasis on social services and intervention, mental health issues, macro- and micro-economic effects of work related health issues, reduction of sick leave, work-life balance, gender balance, discrimination and inclusion in the work environment, competency supply and education) and generally a better integration of theory and practice as well as the development of new research methods and techniques;
- **Digitalisation** (hi-tech production, 5G-technology, cyber security);
- **Space research**.

To coordinate research investments, the Swedish government has created five Strategic Innovation Areas: **mobility and transport, smart cities, circular and bio-based economy, medicine and health, online industry and materials**, which can be viewed as further clarifying statements on the country´s strategic orientation.

Country profile and standing in *www.excellencemapping.net*

Sweden shows – in most cases only surpassed by Denmark – the second highest ranking positions of all BSR countries in the majority of research areas analysed in the excellencemapping.net database. In all research areas most of the Swedish institutes perform above global average, the only exceptions being neuroscience, earth and planetary science and immunology. The best results are achieved in: **medicine, materials science, engineering, chemistry, biochemistry and genetics, physics and astronomy, chemistry, agriculture and social sciences**.

Several Swedish research institutes occupy top positions both at BSR and global level. Measured by "publication rate in world leading journals" the following Swedish institutes rank in first position in the BSR: **Karolinska Institute** in agriculture and biology (globally 4th of 729), psychology and in social sciences, **Lund University** in chemical engineering, energy, immunology and humanities, Stockholm University in environmental sciences, chemistry as well as in earth and planetary sciences and the **Oskar Klein Centre for Cosmoparticle Physics** in physics and astronomy (globally 6th of 1131). If measured by "citation impact" the following Swedish institutes rank in first position in the BSR: **Umeå University** in agriculture and biology, **Chalmers University of Technology** in chemical engineering, **Stockholm University** in chemistry and in environmental science, **Uppsala University** in computer science, Karolinska Institute in nursing, the Oskar Klein Centre for Cosmoparticle Physics in physics and astronomy (globally 4th of 1131) and Karolinska Institute in psychology.

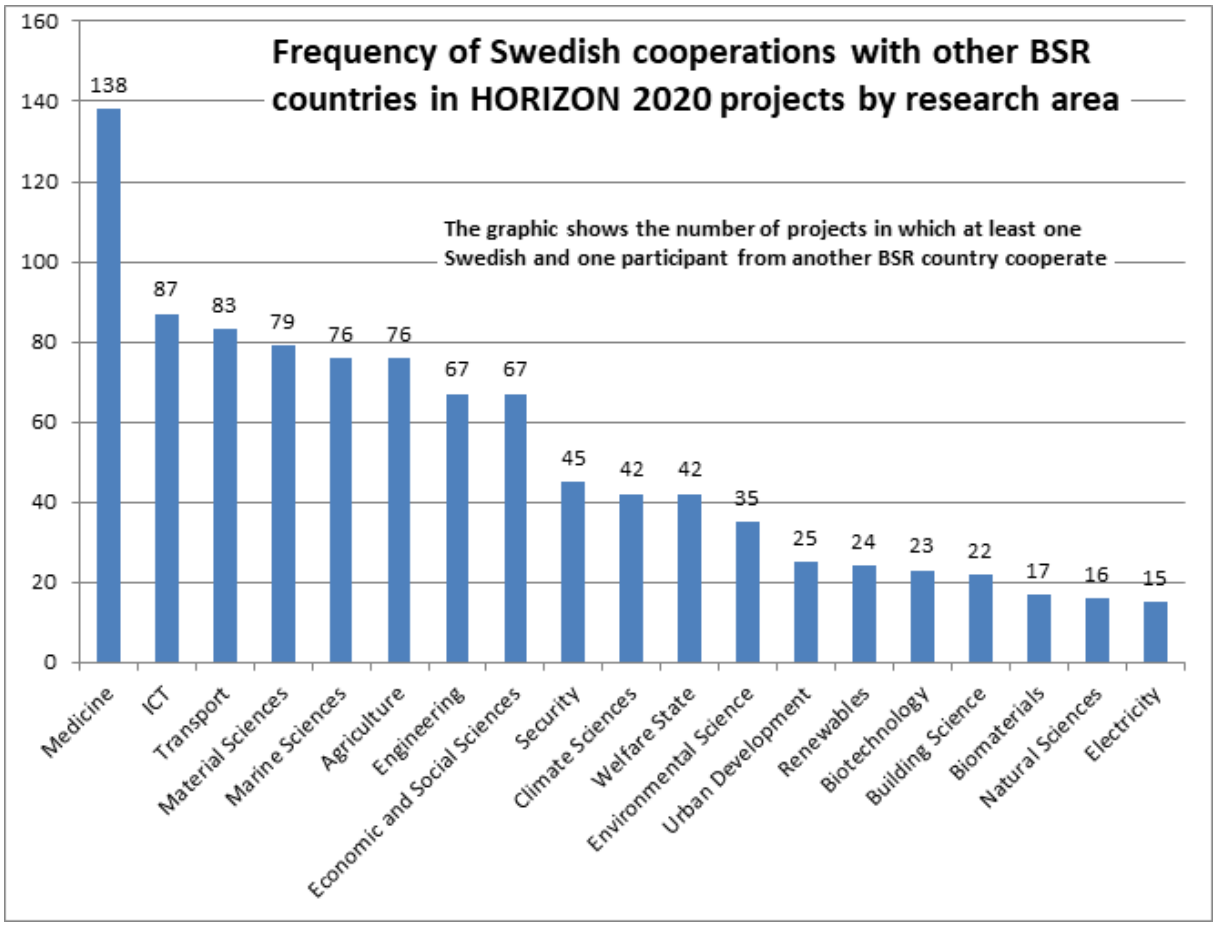
Country participation in H2020 with other BSR countries

In absolute numbers Sweden shows the highest rate of joint H2020 project participations with partners from other BSR countries (514). However, the relative share is the lowest of all BSR countries, since this number only corresponds to 46% of all Swedish participations in international H2020 projects, whereas in most of these cases (54%) no project partners from other BSR countries are involved. The share of BSR involvement is among others significantly higher in Finland (53%), Norway (61%) and Latvia (76%). Within the BSR Sweden cooperates in

most cases with partners from Denmark, Finland, Norway, Poland and the German BSR (in that order).

Similar to most countries in the BSR, it is in the field of **medicine** that Sweden has the highest level of cooperation in H2020 projects (128). However, unlike most countries in the BSR, Sweden's second highest number (87) of H2020 project cooperations is related to **ICT**. The number of joint projects with other BSR countries related to **materials science** (79) is also the highest in the region, far ahead of Denmark (42), which here ranks in second position.

Figure 11. Frequency of Swedish H2020 cooperation with BSR countries (2014–2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Country participation in JPI/JTI, COST actions, EUREKA

Sweden shows by far the highest number of JPI project participations (148) of all BSR countries, clearly ahead of Norway (90) which follows second. Unlike all other BSR countries, the largest share is on projects related to JPI **Urban Europe**. However, Swedish project participation rates within the JPIs **Neurodegenerative Diseases** and **Antimicrobial resistance** are also remarkably high.

The extent to which Sweden is involved in JTI projects varies widely according to the type of JTI. Swedish participation rates in the ECSEL JU and in the JTI Fuel Cell and Hydrogen are below Nordic average but still higher than in the German BSR and in Poland. In contrast, Sweden shows by far the highest participation rate of all BSR countries in projects related to the JTI **Innovative Medicines Initiative**, clearly ahead of Denmark (40), which ranks second. 50% or EUR

75.3 million of the JTI's budget that since 2008 has been transferred to the BSR went to Sweden, whereas Denmark received only 14% or EUR 20.9 million. Denmark (42) is however almost at the same level as Sweden (43) as far as non-EU funded JTI Medicine participations by large companies (in Sweden almost exclusively AstraZeneca and in Denmark mostly Novo Nordisk and H. Lundbeck) are concerned. Furthermore, and in contrast to all other BSR countries, Sweden shows very high participation rates in projects related to the **Shift2Rail JU**.

Swedish participation rates in COST actions correspond to the Nordic average but are lower than in Poland. In contrast, Sweden is clearly ahead of the other Nordic countries and Poland as far as the number of EUREKA and Eurostars project participations are concerned. A large majority of them are related to the technological areas **Electronics and ICT** as well as to **Medical technology, Biology and Biotechnology**.

Important research infrastructures of regional relevance

- materials science

MaxLab in Lund operates the strongest source of synchrotron radiation in the world. **Max IV** was inaugurated in 2016, and provides users with powerful X-ray illumination, which is used for experiments in chemistry, physics, biology, medicine and materials science. The entire complex, which also hosts the older synchrotron radiation facilities **Max I** (inaugurated 1986), **Max II** (1997) and **Max III** (2008), is currently serving about 1000 users from 30 nations annually. Plans for further development aim to include a free-electron laser and extended capacities to serve 3000 users by 2026.

The **European Spallation Source (ESS)** is currently under construction in Lund. The start of the user programme is scheduled for 2023 and completion of the entire facility for 2025. The ESS Data Management and Software Centre (DMSC) is located in Copenhagen. ESS is the world's next-generation neutron source, and will enable scientists to see and understand basic atomic structures and forces at length and time scales unachievable at other neutron sources, enabling new opportunities for researchers across the spectrum of scientific discovery, including materials and life sciences, energy, environmental technology, cultural heritage and fundamental physics.

- Physics and Engineering

EISCAT (European Incoherent Scatter Scientific Association) operates three incoherent scatter radar systems in Northern Scandinavia and one on Svalbard, used to study the interaction between the Sun and the Earth as revealed by disturbances in the ionosphere and magnetosphere. The EISCAT Headquarters are located in Kiruna. Within the BSR EISCAT cooperates with partners from Finland, Germany, Norway and Russia.

The **Onsala Space Observatory**, near Gothenburg, operates a 20m and 25m radio telescope, as well as a number of radar and visual telescopes in international cooperation. The space observatory is hosted by Chalmers University of Technology.

The **Swedish Institute for Solar Physics** is hosted by the Department of Astronomy at Stockholm University, and operates the 1m solar telescope on La Palma, currently the most highly resolving solar telescope in the world.

- Environmental sciences

Sweden is a major contributor of infrastructure and research to the Integrated Carbon Observation System, a European project to develop a consistent monitoring of the exchange of greenhouse gases between ecosystems and the atmosphere. Important research infrastructure is provided by the **Centre for Environmental and Climate Research (CEC)** at Lund University, which coordinates between universities, research institutes and field research sites. The field research sites are operated by the **Swedish Infrastructure for Ecosystem Science (SITES)**, which provide infrastructure for land-based research into climate, environment and ecosystems.

- Humanities and social sciences

Due to the particular availability of social data, Sweden hosts a number of surveys and databanks accessible to researchers in the social sciences. These include the **Swedish Longitudinal Occupational Survey of Health (SLOSH)**, the **Swedish Mammography Cohort (SMC)** and **Evaluation Through Follow-Up (ETF)**, which provides data on cohorts of school pupils born 1948 to 1998. Moreover, Sweden operates a **National Data Service (NDS)**, which stores and distributes research data for re-employment.

Sweden also operates **HumLab**, an interdisciplinary digital laboratory hosted at Umeå University. HumLab offers infrastructure and technical support in the development of Digital Humanities at universities in Sweden and the BSR.

- Life sciences

The **Science for Life Laboratory (SciLifeLab)** is Sweden´s centre for large-scale research in the fields of molecular biology, life sciences, computational biology and bioinformatics. It is a world leading institution in the fields of life science and environmental science and operated jointly by Karolinska Institutet, the Royal Institute of Technology (KTH) and Stockholm and Uppsala Universities. Apart from organic integration into the research infrastructures of the operating institutions, SciLifeLabs also hosts the **National Genomics Infrastructure (NGI)**, which provides large-scale DNA sequence data generation and analysis. SciLifeLab is scheduled to be the recipient of prioritized funding from state budget and research funding agencies in the near future.

- RISE

RISE Research Institutes of Sweden is a 100% state-owned company that forms a network of previously business-owned research institutes. These institutes cooperate closely with universities and business, with no formal attachment to either. They are primarily oriented towards applied science and industrial research.

Most relevant developments for BSR cooperation in the future

There is a currently evolving **cooperation between the Swedish, Estonian, Latvian and Lithuanian National Libraries**. They are working towards a joint project to make the cultural heritage of the Baltic States more accessible in the digital age. **HumLab** (an interdisciplinary digital lab at the Faculty of Arts at Umeå University) and **Centre for Baltic and East European Studies (CBEES)** at Södertörn University[109] are also involved.

[109] For a more detailed description of the CBEES see Chapter 3, Section "Cultural heritage and identity".

2. Regional framework conditions for the potential of scientific excellence – Analysis of the EU/BSR level

2.1 Assessing the current BSR research landscape

2.1.1. The tool of excellencemapping.net

This web application visualizes scientific excellence worldwide in several subject areas. For each institution (university or research-focused institution), the estimated probabilities of (i) publishing highly cited papers (Best Paper Rate) or (ii) publishing in the most influential journals (Best Journal Rate) are shown.

The web application is based on the results of **multilevel logistic regression models**. Multilevel models provide a very easy way to compare institutions, that is, whether they differ statistically significantly in their performance. In the models, the effect of single covariates (such as the gross domestic product of a country in which an institution is located) on institutional performance is examined and visualized. Covariate-adjusted rankings and mappings of the institutions are produced in which one of the following institutional-level or country-level covariates is held constant:

1. Proportion of papers from one institution which were produced in an international collaboration (international collaboration).
2. Corruption perception index.
3. Number of residents in a country (number of residents).
4. Gross domestic product (GDP) per capita of a country (gross domestic product).

The web application is based on Scopus data collected for the SCImago Institutions Ranking.[110] To obtain reliable data in terms of geo-coordinates and performance metrics, excellencemapping.net only considers those institutions that have published at least 500 articles, reviews and conference papers in the publication period. Institutions with fewer than 500 papers in a category are not considered. Furthermore, only subject categories offered at at least 50 institutions are included in the web application. Excellencemapping.net uses this threshold in order to have sufficient institutions for a worldwide comparison. The full counting method was used to attribute papers from the Scopus data base to institutions: if an institution appears in the affiliation field of a paper, it is attributed to this institution (with a weight of 1).

The performance of the institutions is measured with two indicators: Best Paper Rate or Best Journal Rate. The first indicator, called the **best paper rate**, shows the proportion of publications from an institution which belongs to the 10% most cited publications in their subject area and publication year. The best paper rate corresponds with the $PP_{(top\ 10\%)}$ used in the Leiden Ranking[111] and the Excellence Rate used in the SCImago Institutions Ranking.

The second indicator (not integrated in the first release of the tool) is the ratio of papers that an institution publishes in the most influential scholarly journals of the world (called the **best**

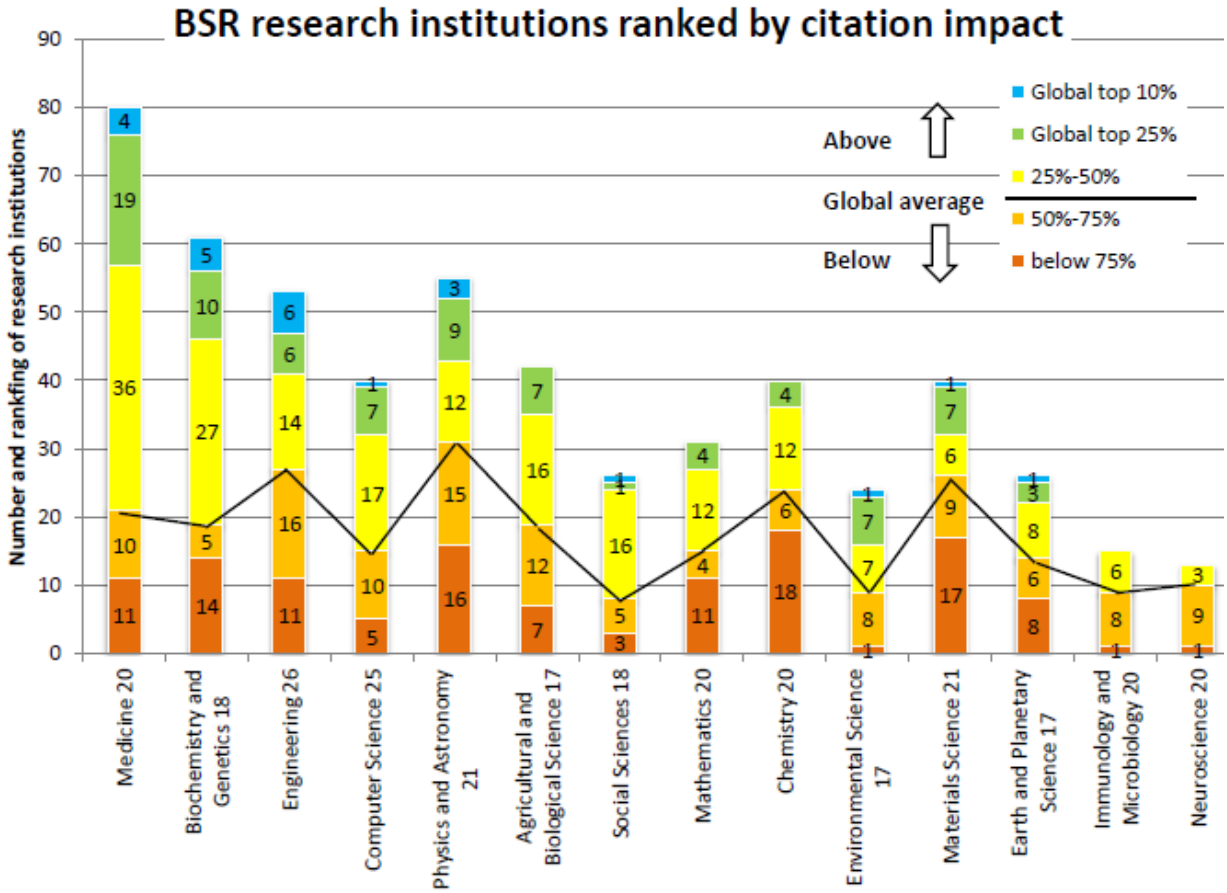
[110] http://www.scimagoir.com/

[111] http://www.leidenranking.com/

journal rate). The most influential journals are those which ranked in the first quartile (25%) of their subject categories (journal sets) as ordered by the SCImago Journal Rank SJR indicator. While the best paper rate gives information about the long-term success of an institution's publications, the best journal rate describes an earlier stage in the process, the ability of an institution to publish its research results in reputable journals.

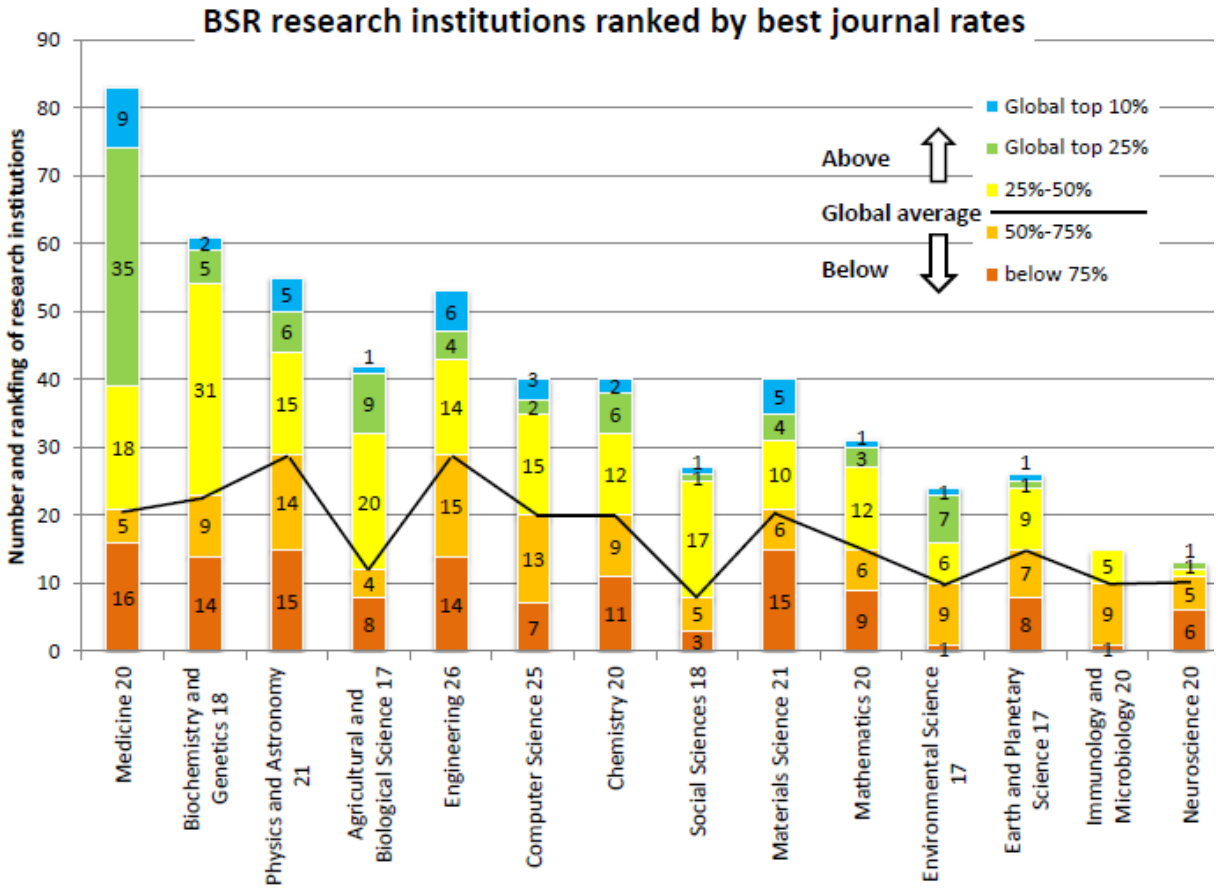
For the needs of the current report we have decided to refer to "best paper rate" as "**citation impact**" which we see as more comprehensible concept.

Figure 11. BSR research institutions ranked by citation impact



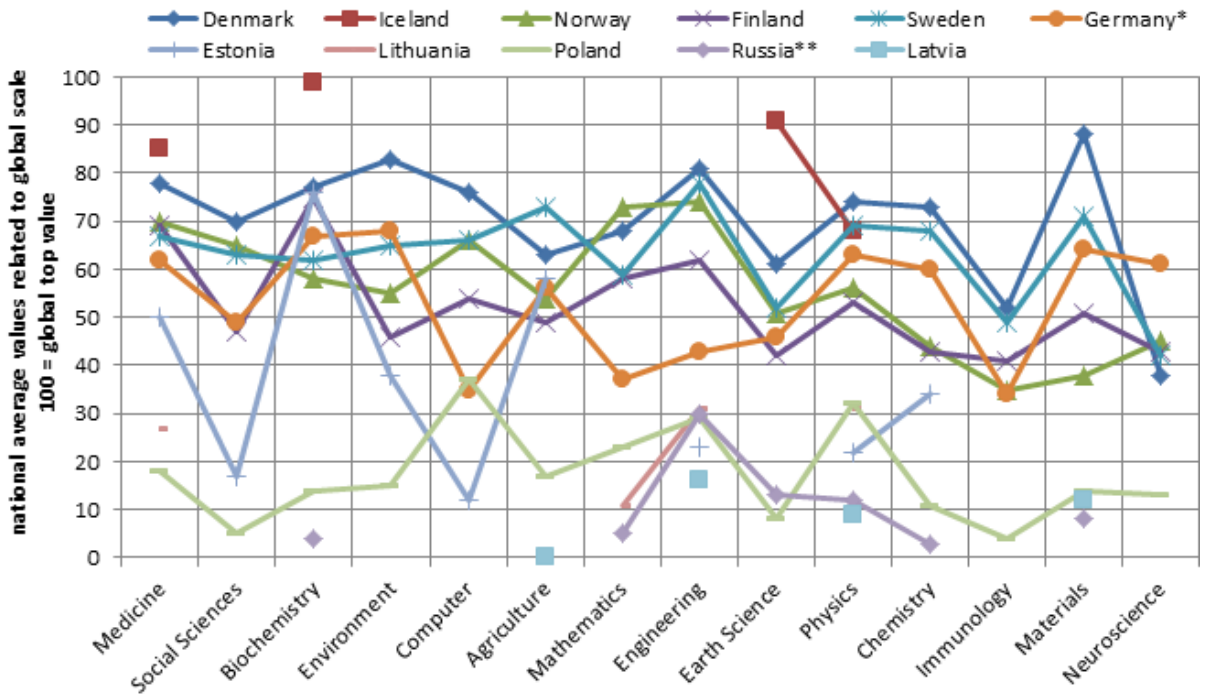
Medicine 20: every 20th of the worldwide examined institutions is from the BSR, a lower number thus means that a relatively high proportion of the world's research institutes within the respective research area is located in the BSR and vice versa.

Figure 12. BSR research institutions ranked by best journal rates



Source: Own calculation, based on: www.excellencemapping.net

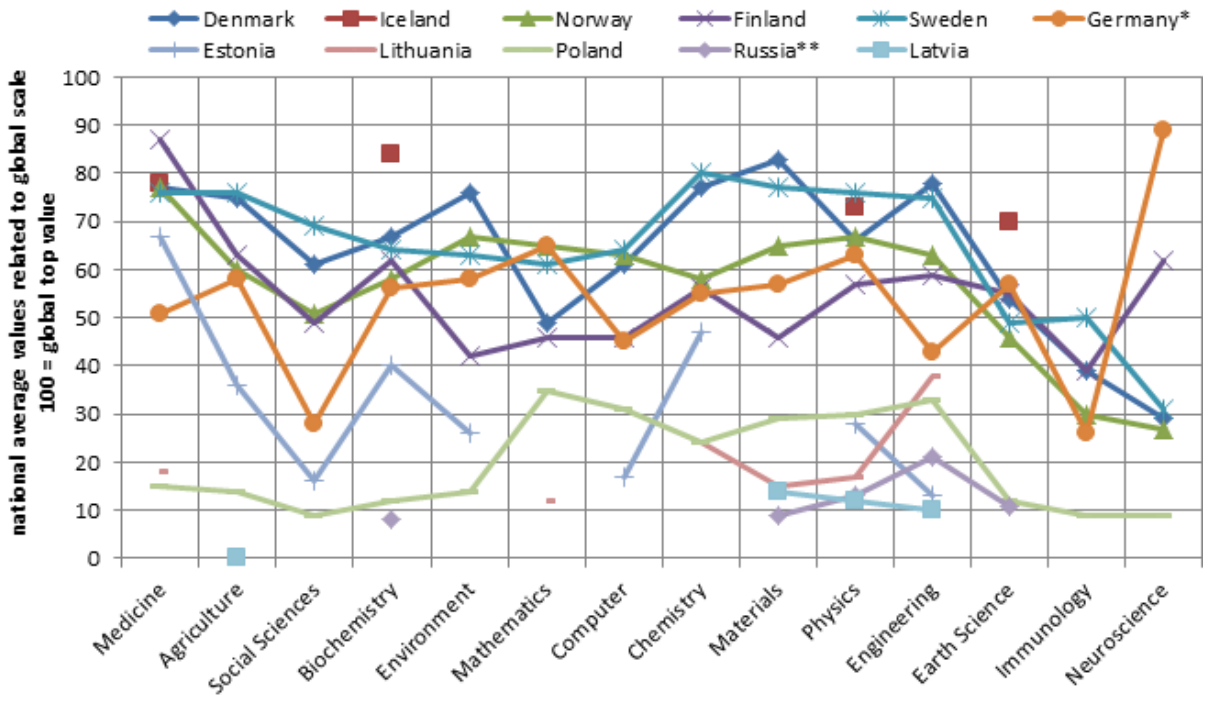
Figure 13. BSR countries and research areas ranked by publications' citation impact



The graphic shows for each country and research area an average value, which corresponds to the average position of all national research institutions in a global context, according to the "Mapping Scientific Excellence" database. The category "DK, Medicine" thus indicates

the average position of all Danish medical research institutions in terms of citation impact. Here, the average position for Denmark is 374, which has to be related to a total number of 1676 institutions worldwide. This means that the country on average reaches 78% of a theoretically possible 100%.

Figure 14. BSR countries and research areas ranked by publications' best journal rates



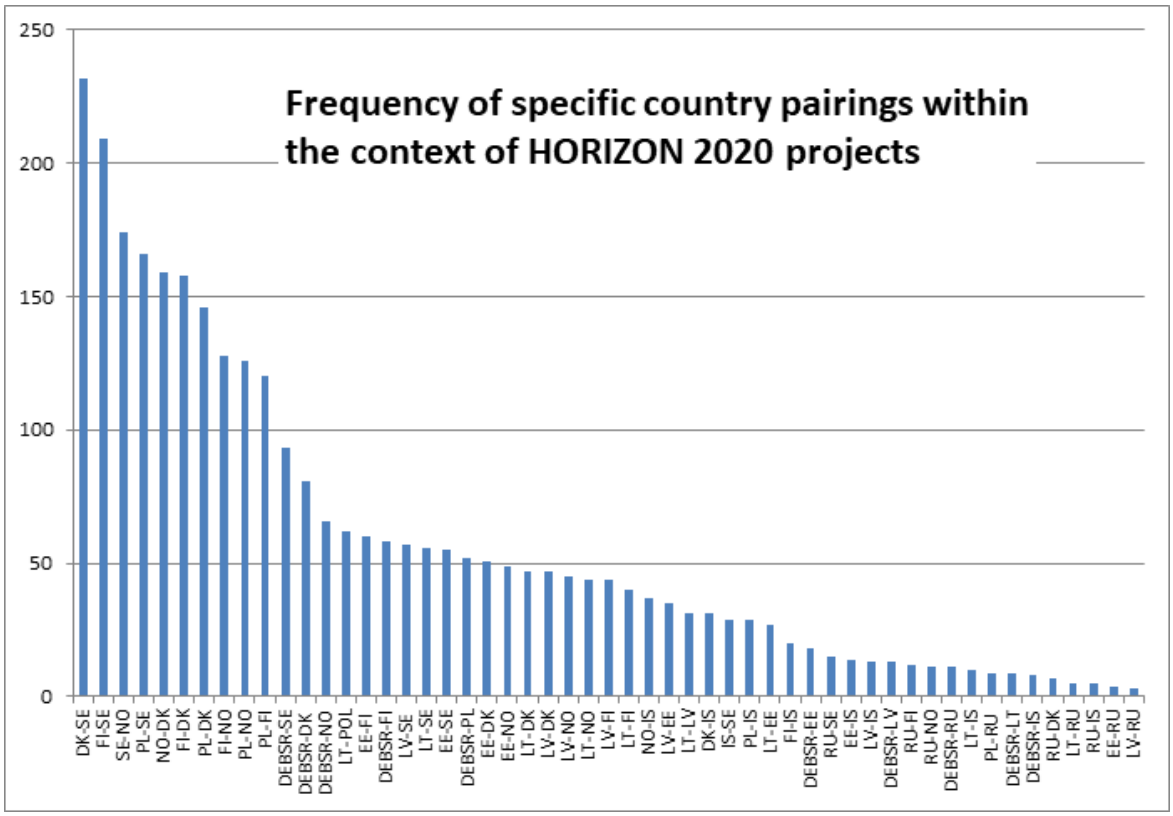
Source: Own calculation, based on: www.excellencemapping.net

As the current investigation has demonstrated, especially in smaller countries and in narrowly specialised research areas, excellencemapping.net is not always regarded as a reliable tool for measuring and mapping scientific excellence. For instance, the noticeable absence of the humanities arouses suspicion that the natural and life sciences are particularly privileged. The other point of criticism is a methodological requirement to consider only those institutions that have published at least 500 articles, reviews and conference papers in the publication period. This may leave small research groups in the emerging areas of science unnoticed because the number of publications they produce does not reach the limit of 500, even if they have proven to be excellent partners in Europe and worldwide. Therefore, the full potential of the Baltic Sea region should not be considered fully mapped if only this method is used. As a matter of fact, the results may be interpreted in a way that will lead to further widening of the participation gap, decreasing the potentiality for excellence of smaller institutions. As a remedy additional mapping methods that should highlight the "small but strong" institutions and their potential in defining areas of collaboration have been suggested for the study.

Still, the excellencemapping.net has been used for this study in the initial phase to arrive at an approximation of the disciplinary and institutional rankings in the BSR.

2.1.2. HORIZON 2020

Figure 15. Frequency of various BSR country pairings in H2020 project cooperation

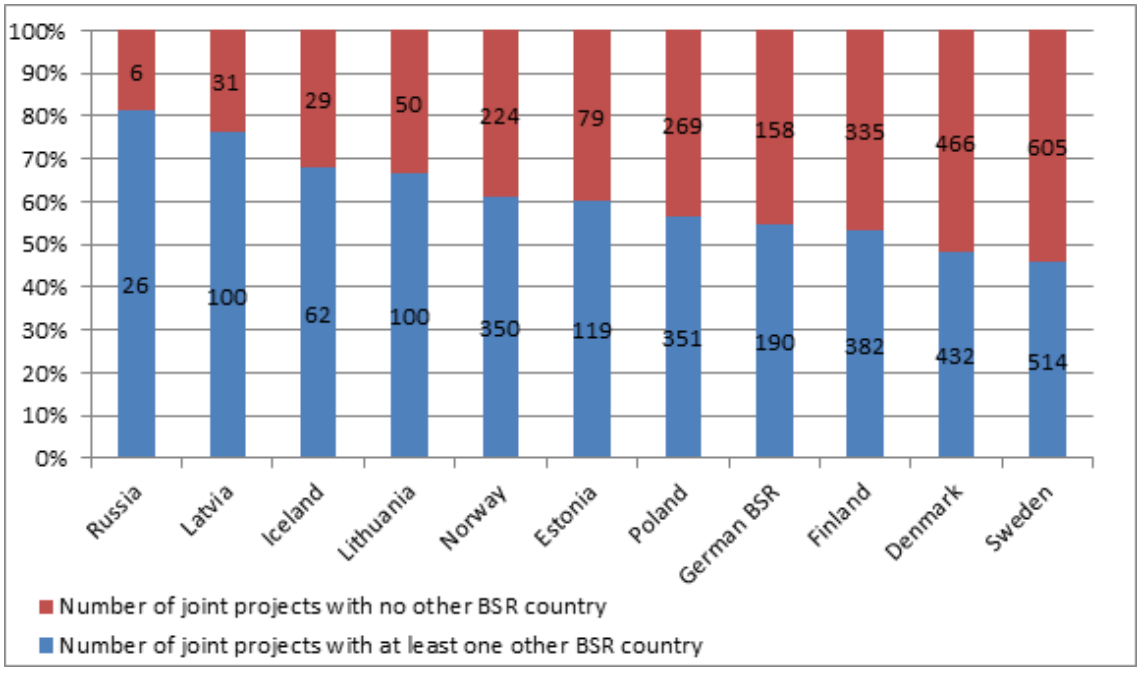


Source: Own calculations based on the eCORDA database, status 28 February 2017

The graphic illustrates the number of H2020 projects in which – among others – partners from each of the two countries mentioned in the horizontal axis are involved.

The graphic below illustrates the ratio of BSR countries' H2020 project collaborations which include other BSR countries to collaborations that do not include other BSR countries.

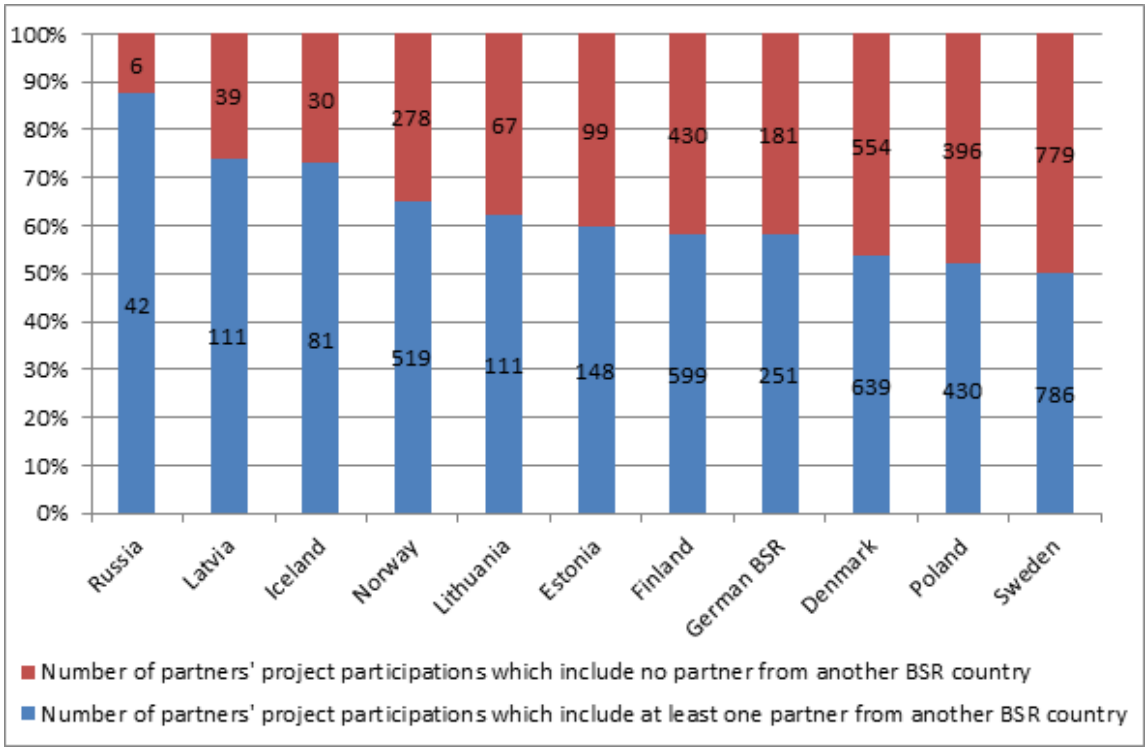
Figure 16. Share of BSR countries project collaborations with other BSR countries



Source: Own calculations based on the eCORDA database, status 28 February 2017

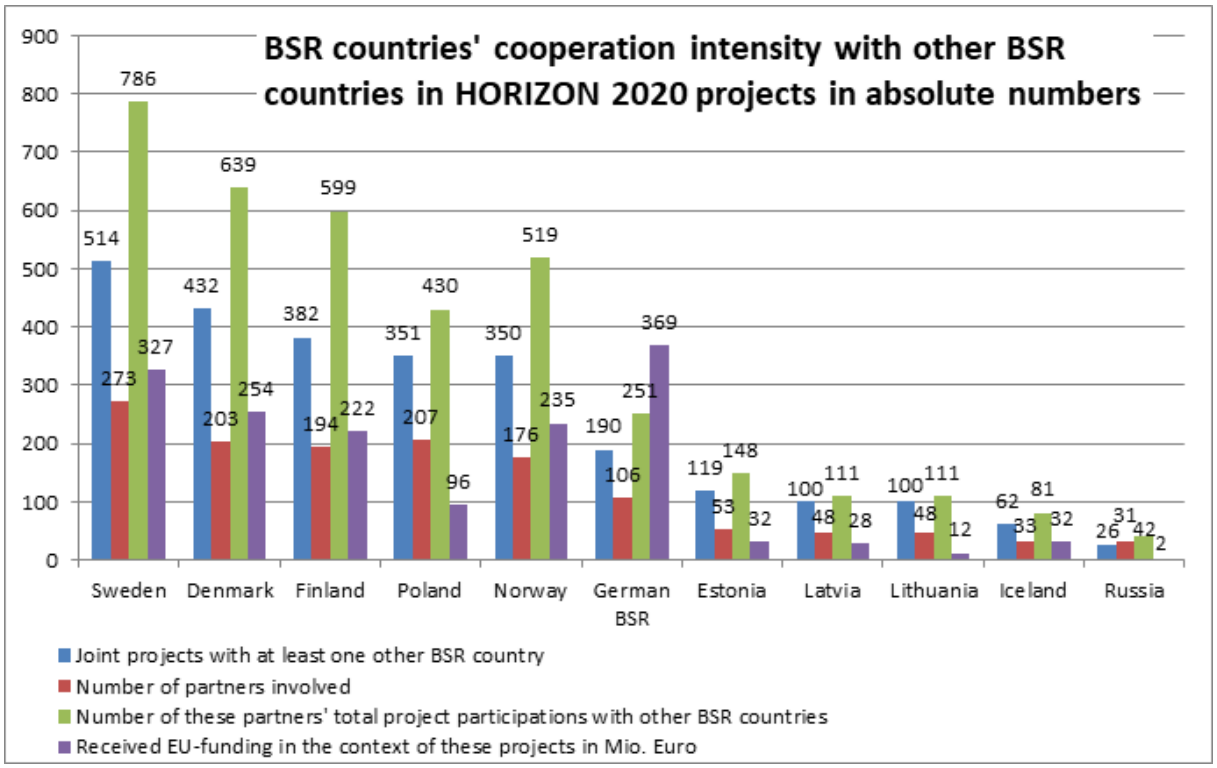
The graphic below illustrates the ratio of BSR country partners' H2020 project participations which include partners from other BSR countries to project participations that do not include partners from other BSR countries

Figure 17. Share of BSR country partners project participations with partners from other BSR countries



Source: Own calculations based on the eCORDA database, status 28 February 2017

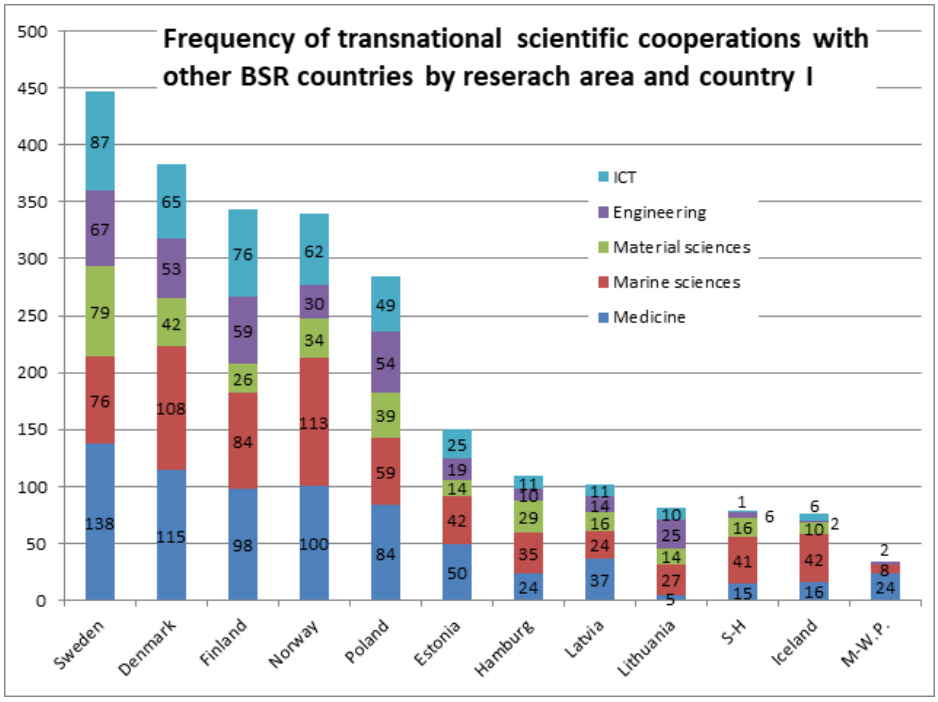
Figure 18. BSR countries' cooperation intensity with other BSR countries



Source: Own calculations based on the eCORDA database, status 28 February 2017

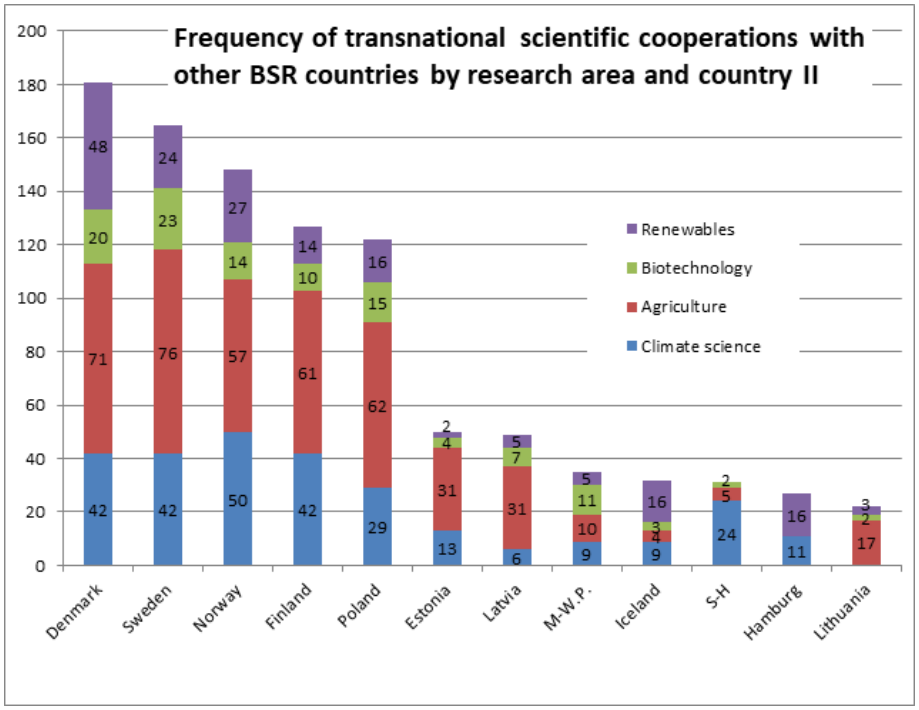
The two graphics below compare the number of BSR countries' transnational scientific relations within the context of H2020 projects by selected research areas. The figures on the vertical axis indicate for each BSR country the number of H2020 projects with participation of at least one partner from another BSR country.

Figure 19. Frequency of cooperation by research area and country I (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

Figure 20. Frequency of cooperation by research area and country II (2014-2017)



Source: Own calculation, based on:
https://data.europa.eu/euodp/de/data/dataset/cordisH2020projects

The tables demonstrate the number of participations of a given country in H2020 projects with at least one other BSR country.

A possible drawback of using H2020 is that participation in or coordination of H2020 projects may also be influenced by unsatisfactory pay conditions in some countries. (e.g. a Lithuanian or Polish top researcher who participates in a project receives a much lower salary than his/her Swedish counterpart, even if PPP is considered)

It may occur that disciplinary categories overlap or are conditioned by an adjacent discipline, e.g. urban planning, transport and welfare research, which blurs the picture and provides an unclear image of the cooperation.

2.1.3. JPI/JTI (joint programming initiatives)/(joint technology initiatives)

The Joint Programming process was launched by the European Commission in July 2008. The overall aim of the process is to pool national research efforts in order to make better use of Europe's precious public R&D resources and to tackle common European challenges more effectively in a few key areas. The EU member states are free to choose which JPIs they wish to participate in. The advantage of looking into JPI participation statistics lies in their capacity to demonstrate that the old disciplinary boundaries may not be relevant when defining future challenges that will require scientific answers. JPIs often cross and amalgamate disciplinary approaches and create new fields of scientific research that can provide solutions to concurrently evolving societal challenges. The table below compares the BSR countries' participation rates in JPI projects by areas of research.

Table 4. BSR countries' participation rates in JPI projects 2011-2017

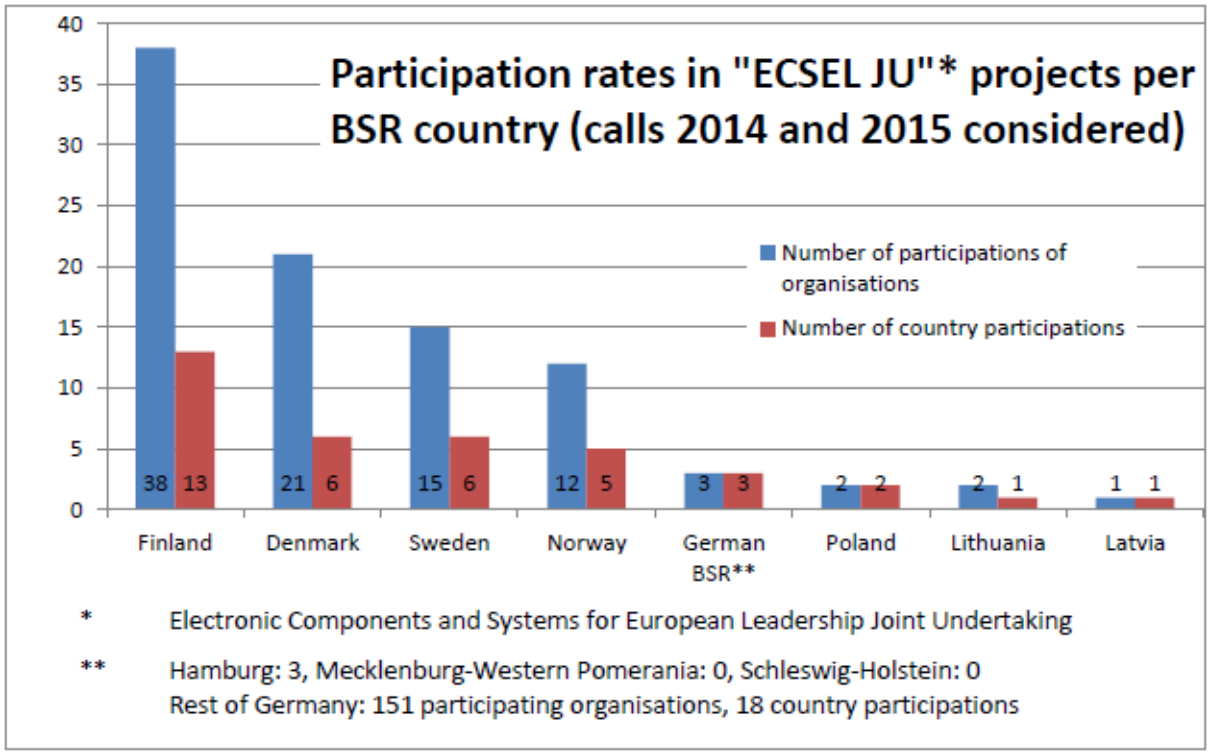
JPI	DK	EE	FI	Germany				LV	LT	NO	PL	SE
				HH	MWP	SH	Rest of Ger.					
Neurodegenerative diseases	8	0	8	0	1	0	80	0	0	11	7	26
Antimicrobial Resistance	8	0	0	0	0	0	41	0	0	8	4	18
Healthy Diet for a Healthy Life	4	0	1	0	0	1	10	0	0	1	4	0
More Years, Better Lives	4	0	4	0	0	0	4	0	0	1	0	2
Climate	3	0	3	1	0	2	10	0	0	12	0	9
Agriculture, Food Security and Climate Change	27	1	21	0	4	4	70	3	2	17	16	32
Water	15	1	8	0	1	0	21	0	0	11	3	16
Oceans	0	1	2	0	0	2	6	0	0	15	2	6
Urban Europe	8	0	11	0	0	0	2	0	0	10	2	39
Cultural Heritage	2	0	0	0	0	0	0	0	1	5	6	5
Total	71	3	58	1	6	9	244	3	3	91	44	153

Source: Own calculation, based on http://ec.europa.eu/research/era/joint-programming-initiatives_en.html

The overall aim of the Joint Technology Initiative (JTI) is to address strategic areas where research and innovation are essential to European competitiveness. JTIs are a means

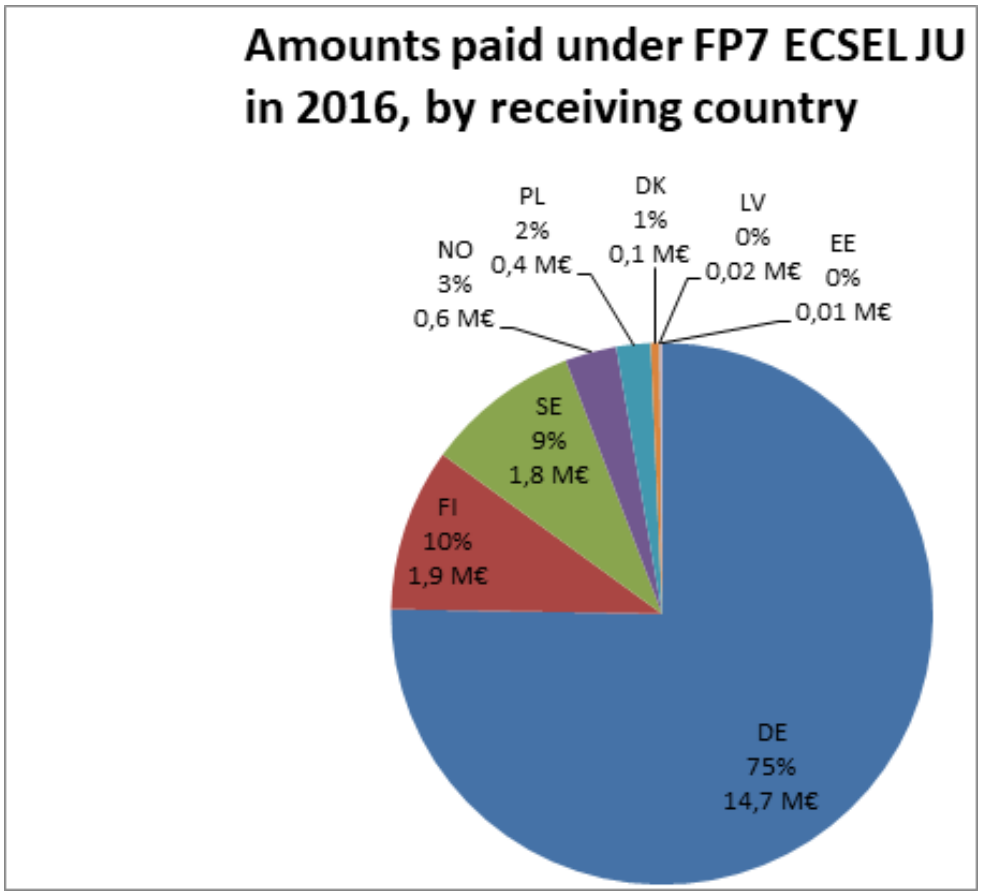
to implement the Strategic Research Agendas (SRAs) of a limited number of European Technology Platforms (ETPs) in cases where support through the regular instruments of the Framework Programme for Research and Development are not sufficient. To meet the needs of this small number of ETPs, the concept of "Joint Technology Initiatives" has been developed. The following figures reflect BSR countries' project participation rates related to different JTIs and – where available – inform on the budget shares received by the participating countries.

Figure 21. Participation rates in "ECSEL JU" projects per BSR country



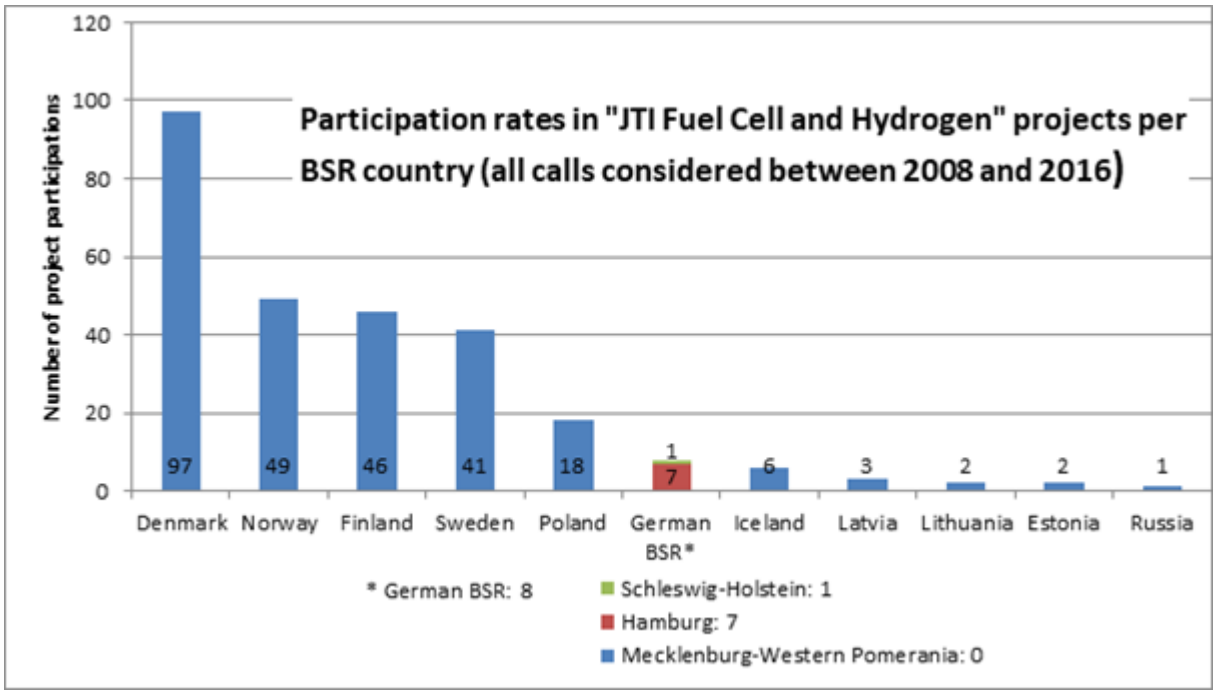
Source: Own calculation, based on www.ecsel.eu

Figure 22. Received ECSEL JU funding by BSR country



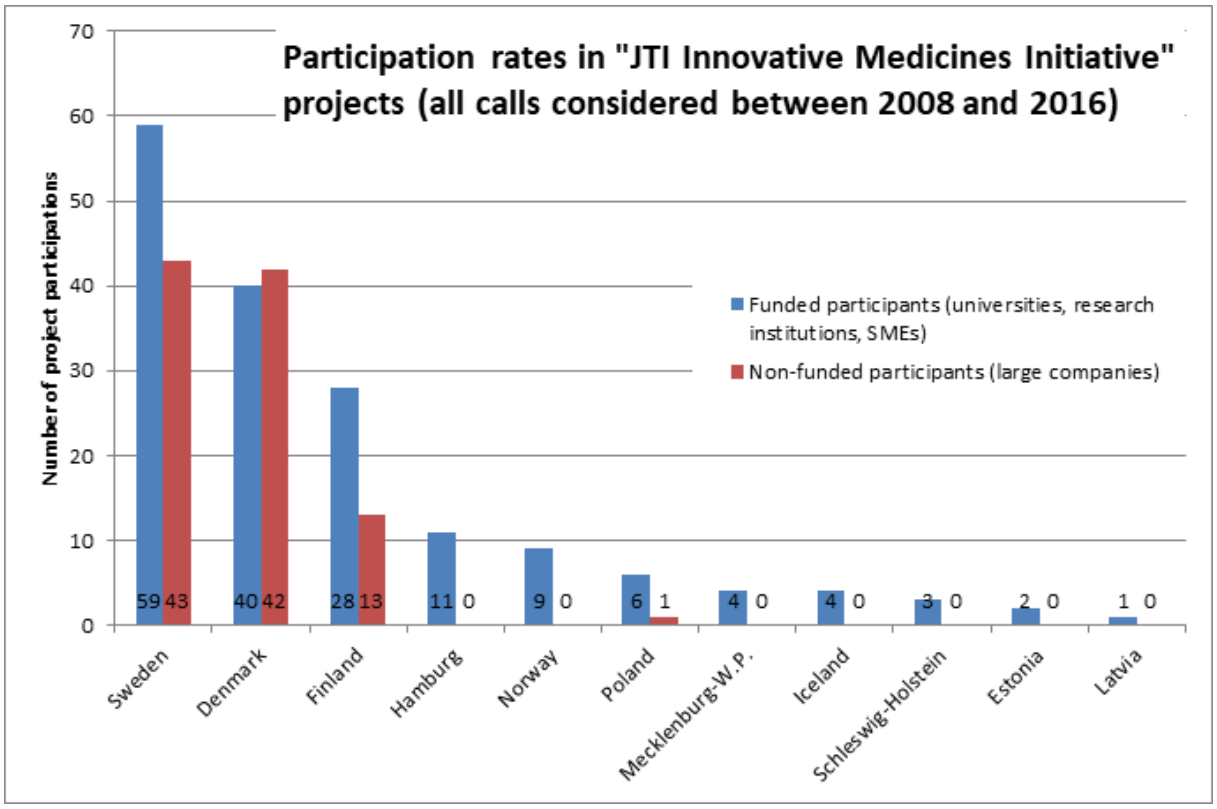
Source: Own compilation, based on ECSEL JU Annual Report 2016, Brussels 2017

Figure 23. Participation rates in "JTI Fuel Cell and Hydrogen" projects per BSR country



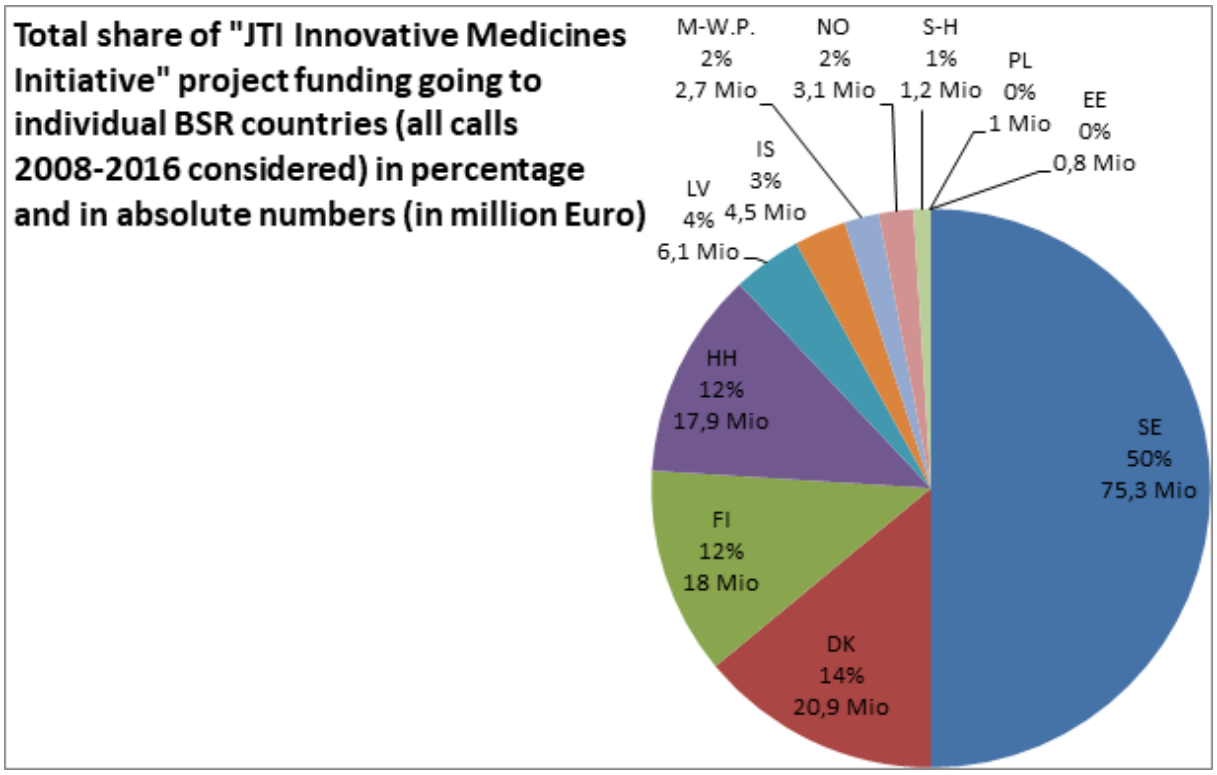
Source: Own calculation, based on: www.fch.europa.eu

Figure 24. Participation rates in "JTI Innovative Medicines Initiative" projects per BSR country



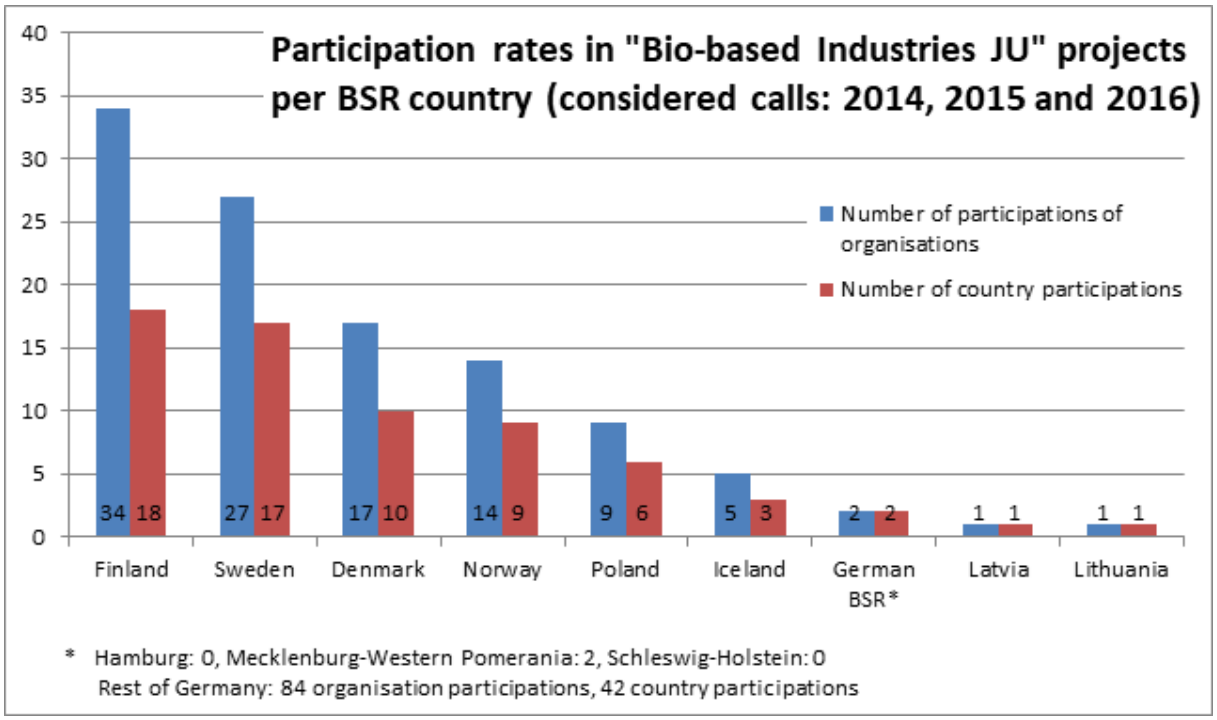
Source: Own calculation, based on: www.imi.europa.eu

Figure 25. Received JTI Medicines funding by BSR country



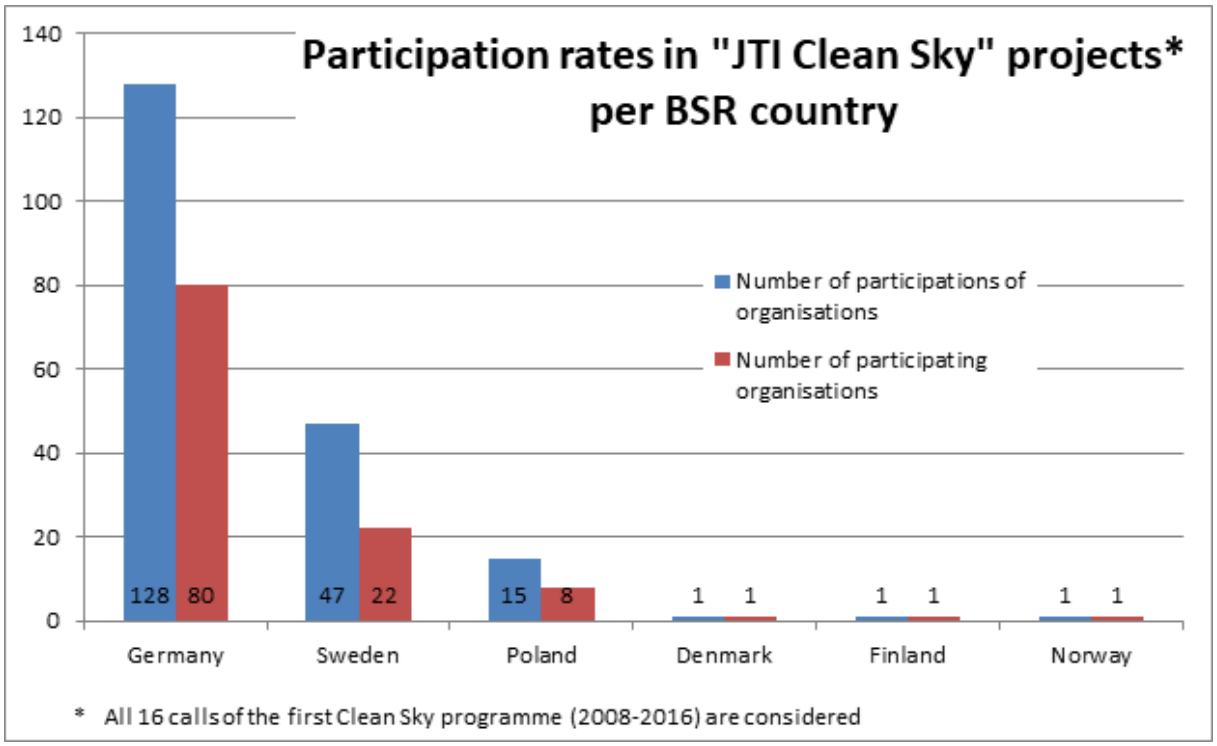
Source: Own calculation, based on: www.imi.europa.eu

Figure 26. Participation rates in "Bio-based Industries JU" projects per BSR country



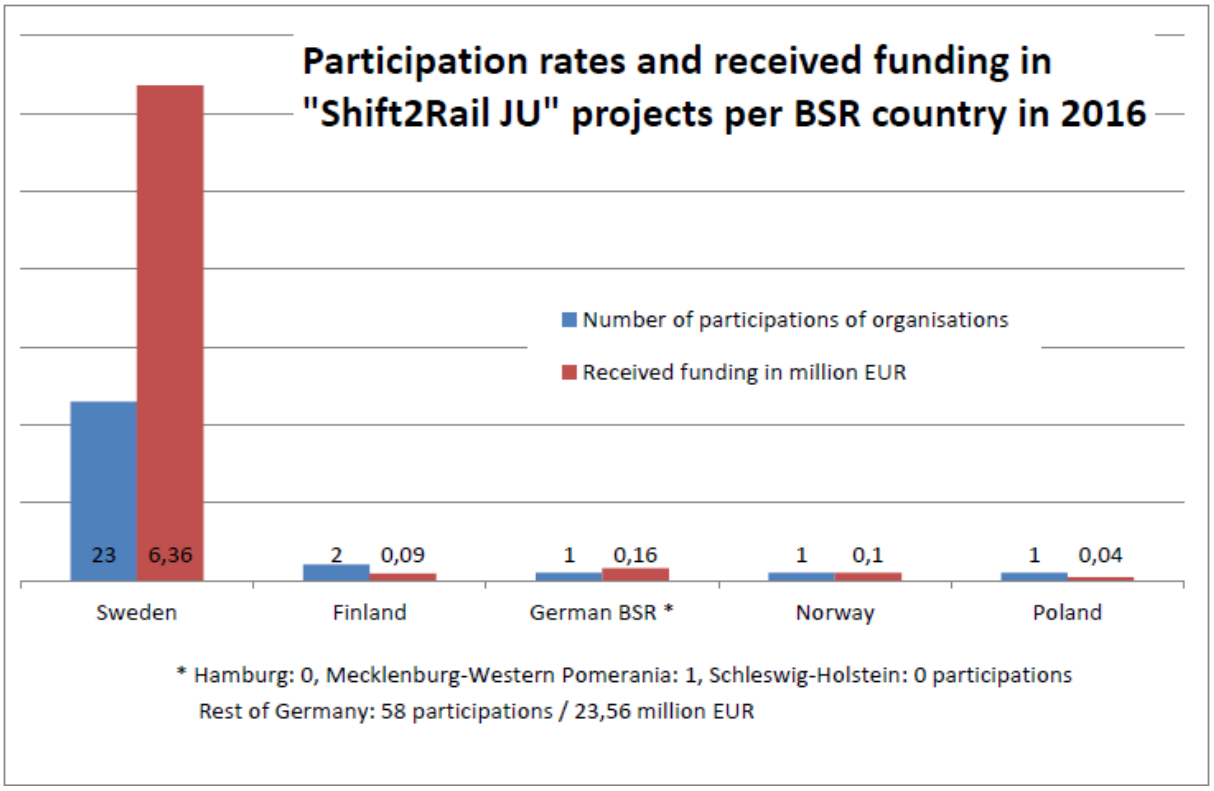
Source: Own calculation, based on https://www.bbi-europe.eu/projects

Figure 27. Participation rates in "JTI Clean Sky" projects per BSR country



Source: Own calculation, based on http://www.cleansky.eu/sites/default/files/inline-files/Clean%2520Sky%2520at%2520a%2520Glance%2520FINAL.pdf

Figure 28. Participation rates and received funding in "Shift2Rail JU" projects per BSR country



Source: Own calculation, based on https://shift2rail.org/

2.2. Analysing European and macro-regional science policies and strategies

HORIZON 2020

In the field of research and science policy, H2020 is one of the key funding sources with the main objectives of completing the ERA by coordinating national research policies and pooling research funding in some areas to avoid duplication; it provides grants to research and innovation projects through open and competitive calls for proposals. Furthermore, participation from outside the EU is explicitly encouraged; to date there are 16 associated non-EU countries which have signed an agreement for the purposes of this framework programme. H2020 is also implementing the European environmental research and innovation policy which contributes to the goal of sustainable development.

In general, the EU conceives of research as a future-oriented investment at the heart of the EU's blueprint for smart, sustainable and inclusive growth and jobs. With the aim of drawing research and innovation closer together, H2020 builds on three main research areas or so-called pillars, notably (1) excellent science, (2) industrial leadership and (3) societal challenges: "The goal is to ensure Europe produces world-class science, removes barriers to innovation and makes it easier for the public and private sectors to work together in delivering innovation."[112]

With a budget of EUR 24 billion, the *first pillar*, "Excellent Science", focuses on basic science. The European Research Council (ERC) delivers EUR 13 billion to researchers and teams

[112] https://ec.europa.eu/programmes/horizon2020/

of researchers based on the scientific excellence of the applications. This pillar funds Future and Emerging Technologies (FET, EUR 2.7 billion), researcher mobility (Marie Skłodowska-Curie Actions (MSCA), EUR 6.1 billion) and large European research infrastructures (EUR 2.5 billion).

The *second pillar* is "Industrial Leadership", with a budget of EUR 14 billion. It is managed by the Directorate-General for Enterprise and Industry of the European Commission and based on the Europe 2020 and Innovation Union strategies. The pillar consists of six sub-programmes within "Leadership in Enabling and Industrial Technologies": **information and communication technologies; nanotechnologies; advanced materials; advanced manufacturing and processing; biotechnology; space**. These technologies all have European Technology platforms (ETP; fora for research communities to meet) with their respective strategic research agendas (SRA). Some technologies have long term funding instruments, such as JTIs. Some technologies are labelled "Key Enabling Technologies" (KET). This pillar includes a special focus on SME funding and also offers risk financing (EUR 2.8 billion) e.g. through loans of the European Investment Bank.

The *third pillar* funds potential solutions to social and economic problems, "Societal Challenges" (SC), in the following seven sub-programmes: Health (EUR 7.5 billion); food, water, forestry, bioeconomy (EUR 3.8 billion); energy (EUR 5.9 billion); transport (EUR 6.3 billion); climate action, environment, resource efficiency, and raw materials (EUR 3.1 billion); European society (EUR 1.3 billion); security (EUR 1.7 billion). This pillar also funds themes named "Science with and for society" (EUR 0.5 billion) and "Spreading excellence and widening participation" (EUR 0.8 billion).

The structure follows the previous framework programme (FP7, 2007-13) to the level of the sub-programmes under the pillars. In the industrial pillar the goal is to find ways to modernize European industries that have suffered from a fragmented European market. In societal challenges the goal is implementation of solutions, and is less concentrated on technology development.

The European Research Council (ERC)

Complementing other funding activities in Europe and the EU such as those of the national research funding agencies and H2020, the ERC's core mission is to contribute to the formation of the ERA "through competitive funding and to support investigator-driven frontier research" – across all scientific fields on the basis of scientific excellence. Established by the European Commission, it is an independent public body governed by a Scientific Council of eminent European scientists and scholars as well as an Executive Agency, which is in charge of implementation. For the period of 2014-20, its budget – covered through H2020 – is over EUR 13 billion.

Open to researchers also from outside the EU, scientists from any field can compete for ERC grants that support pioneering and "high risk" ideas for projects, so-called frontier research. The ERC identifies itself as "'investigator-driven', or 'bottom-up', in nature, the ERC approach allows researchers to identify new opportunities and directions in any field of research, rather than being led by priorities set by politicians". In the long-term, the ERC aspires to have

a significant impact on the university landscape in Europe, by "gaug[ing] their performance and encourage[ing] them to develop better strategies to establish themselves as more effective global players."[113]

The EU Strategy for the Baltic Sea Region

The EUSBSR was presented by the European Commission in June 2009, and adopted in the same year by the European Council. The strategy was accompanied by an Action Plan which proposed the establishment of four pillars for "macro-regional" cooperation. The strategy aimed to improve the environmental state of the Baltic Sea, as well as promote more balanced economic development in the region, making it more accessible, attractive, safer, and securer. These areas were translated into fifteen different so-called Priority Areas which were assigned a set of highly relevant projects (also known as flagship projects) as the showcase for the EUSBSR.

The Action Plan was conceived as a "rolling" plan, which implied that it was designed in order to quickly absorb "lessons learned". Consequently, it has already been revised several times. Following the revisions introduced in the Action Plan of June 2015, the EUSBSR now subscribes to three core objectives, which focus on environmental protection ("Save the Sea"), economic development ("Increase Prosperity"), and improvement of the infrastructure ("Connect the Region"). The three overall objectives are now linked to 13 Policy Areas (PAs) and complemented by four Horizontal Actions (HAs) (e.g., HA "Neighbours" or HA "Spatial Planning") that cut across various policy areas. Different member states or organisations are responsible for the PAs and HAs. Several organisations operating at the macro-regional level – for example, the Council of the Baltic Sea States (CBSS), the Helsinki Commission (HELCOM), and Vision and Strategies around the Baltic Sea (VASAB) – actively participate in the implementation of the strategy as either Policy Area Coordinators (PACs), such as the CBSS for PA "Secure", or Horizontal Action Leaders (HALs), such as VASAB and HELCOM for HA "Spatial Planning".

While research and science (R&S) policy is a horizontal aspect in most of the PAs, it is PA Innovation and PA Education that are dealing with it somewhat more explicitly. Whereas PA Education is covering the aspect of "basic research" often involving universities, PA Innovation focusses strongly on matters of "commercialisation" of research. The Nordic Council of Ministers has been assigned with the responsibility of coordinating PA Innovation together with the Ministry of Economic Affairs and Communications in Estonia and the Ministry of Science and Higher Education in Poland. PA Education, in turn, is coordinated by the *Norden* Association in Sweden together with the Land of Hamburg. Still, as put by an official of the European Commission's Joint Research Centre (JRC)[114] it is paramount "to emphasise the horizontal role of research in regard of other priorities of macro-regional strategies."

The place of R&S policy in the strategy and the action plan

R&S policy is clearly embedded in the EU's overall objective of creating the ERA as well as other EU-wide policies. Thus, the EUSBSR emphasises that the ERA – together with its funding

[113] https://erc.europa.eu/about-erc/mission

[114] Author's interview, European Commission, May 29, 2017

instrument FP7, and now FP8 or H2020 – "will provide a sound scientific basis for sustainable management of the Baltic Sea basin."[115]

The ERA, in turn, is defined as "a unified research area open to the world based on the Internal Market, in which researchers, scientific knowledge and technology circulate freely and through which the Union and its Member States strengthen their scientific and technological bases, their competitiveness and their capacity to collectively address grand challenges" (*in original in italics*).[116] Without referring to EU macro-regional strategies or macro-regions as such, the European Commission mentions that "optimal transnational co-operation and competition" is amongst the ERA's core objectives.

The EUSBSR Action Plan translates these global objectives into a macro-regional frame, by declaring that its actions seek to:

- facilitate the cooperation of tertiary education, science and research policies in the BSR for a common tertiary education, research and innovation area;
- enhance transnational cooperation in the development and utilisation of existing and new research infrastructures;
- attract students and researchers from outside the BSR to the tertiary education and research institutions of the region;
- increase student and researcher mobility within the BSR;
- promote best practise and learning from each other in the field of tertiary education, science and research.[117]

Other policies and legislative acts such as the Marine Strategy Framework Directive and the Helsinki Commission (HELCOM) Baltic Sea Action Plan "guide the interventions on the environment, keeping in mind EU common policies affecting the marine environment such as agriculture, fisheries, transport"[118] and have an impact on the way R&S policy can be shaped with regard to a more macro-regional focus.

Consequently, the EUSBSR frames networking amongst existing actors in R&S as an opportunity: "Networking among research funding agencies from all EU Baltic States, supported by the Research Framework Programme, provides a sound basis for collaboration in research and knowledge transfer within the Region." In addition to networking, improved and better coordination as well as strategic use of community programmes are perceived of as "key ingredients, especially at a time of crisis, to ensure that funds and policies in the region contribute fully to the strategy." Furthermore, the European Commission requires that

[115] European Commission (2009), Communication – concerning the EU Strategy for the Baltic Sea Region, Brussels, 10.6.2009 – COM(2009) 248 final.
[116] European Commission (2012), A Reinforced European Research Area Partnership for Excellence and Growth, Brussels, 17.7.2012 COM(2012) 392 final.
[117] European Commission (2017), Commission staff working document. European Union Strategy for the Baltic Sea Region. Action Plan, Brussels, 20.3.2017 SWD(2017) 118 final
[118] European Commission (2009a), Communication – concerning the European Union Strategy for the Baltic Sea Region, Brussels, 10.6.2009 – COM(2009) 248 final.

the "results of research programmes in the area must be fully integrated into other programmes and policy areas."[119]

In a nutshell, R&S policy has *first* a strong horizontal dimension in that it is clearly linked to the overall objectives of the ERA and second, it exposes a horizontal dimension in that it is to inform other policies and programmes. Subsequently, the EUSBSR refers to the accompanying action plan which concretizes ways of fully exploiting the potential of the region in the realm of research and innovation. Clearly, R&S policy is a horizontal area cutting across most of the policy areas of the EUSBSR; however, in terms of governance, it is primarily addressed in the PA Innovation.

Similarly to the EUSBSR strategy document, the Action Plan denounces the East-West divide in terms of "more established R&D institutions on the northern and western shores versus newly established or reformed institutions on the eastern and south-eastern shores of the Baltic Sea."[120] It recommends that those "challenges where the Baltic Sea region is or has the potential to become stronger in a global context" should be prioritized. Hence rather than fostering an inward-looking approach, the transnational level is being activated in terms of "the cluster and SME network cooperation approach" in order to develop into cornerstones "when applying the smart specialisation concept (including joint initiatives involving cluster organisations to form cross-regional European cluster partnerships)". Furthermore, it is stressed that measures should be taken with a view to improving the business environment in the BSR. The PACs are further called upon to develop a "comprehensive system for the design, the monitoring and the follow-up of indicators and targets." In terms of actions, it is suggested that an ecosystem for innovation and entrepreneurship needs to be built by 2020 "based on smart specialisation and sustainable growth for increased competitiveness." The ecosystem should be informed by the results of all the flagships which address the following four challenges:

1. Reduce existing innovation barriers, including the harmonisation of different legal and regulatory environments for Foreign Direct Investment (FDI), particularly for further developing the demand-side approaches to innovation;
2. Facilitate trans-national cooperation for the development and commercial exploitation of joint research projects;
3. Utilize together the high-level human capital in the region and promote the mobility of researchers; and cooperation between students and companies;
4. Jointly develop new and better innovation support instruments, including Intellectual Property Rights (IPR) support.[121]

[119] European Commission (2009b), Commission Staff Working Document accompanying the Communication from the Commission concerning the European Union Strategy for the Baltic Sea Region. Impact Assessment, Brussels, COM(2009) final SEC(2009) 703.

[120] European Commission (2017a), Commission staff working document. European Union Strategy for the Baltic Sea Region. Action Plan, Brussels, 20.3.2017 SWD(2017) 118 final

[121] European Commission (2017a), *Commission staff working document. European Union Strategy for the Baltic Sea Region. Action Plan*, Brussels, 20.3.2017 SWD(2017) 118 final

Furthermore, the Action Plan reports on the setting up of a Policy Area Innovation Strategy Guide for 2016-2020 in order to achieve focus in the policy area. The main activity will be to initiate dialogue with the EU Member States and stakeholders in three different areas, research and innovation, entrepreneurship, and digital market including attractiveness of talent and investments.

The European Commission's Joint Research Centre (JRC)

The Joint Research Centre draws on more than 50 years of experience as the European Commission's in-house science and knowledge service. Its mission, in a nutshell, is to support EU policies with independent evidence throughout the whole policy cycle. In the case of the EU Strategy for the Danube Region (EUSDR), the JRC has been engaged in the initiative "Scientific support to the Danube Strategy" through different activities providing scientific support and momentum for initiatives and actions defined by the EUSDR. The support provided can best be described as addressing the scientific needs related to the implementation of the EUSDR; helping decision-makers and other stakeholders to identify the policy needs and actions required for the implementation of the Strategy; building capacity through concrete projects and analysis and through the reinforcement of ties and cooperation amongst scientific communities.[122]

In the context of the EUSBSR, the JRC has been involved to a lesser extent – primarily in the context of smart specialisation. Interestingly (but informally), it has been reported that there is some appetite inside the JRC to recognise macro-regional strategies across R&S programmes in the next financial period, i.e. after 2020. However, the European Commission officials of the Directorate-General for Research and Innovation seem to be more sceptical about macro-regional "filters" being integrated into global polices, such as future framework programmes.

The Project Support facility (PSF) of the Council of Baltic Sea States (CBSS)

Having been under consideration for some time in the Council of Baltic Sea States (CBSS), the overall political forum for intergovernmental cooperation in the Baltic Sea Region, the PSF was established on the occasion of 9th Baltic Sea States Summit in Stralsund in May 2012, subscribing to the project orientation of the CBSS after its reform in 2006/7. The main objective of the CBSS PSF is to co-finance the development and implementation of BSR cooperation projects contributing to CBSS long-term priorities, bringing added value for the Baltic Sea Region, showing impact in regional cooperation and fostering sustainable partnerships.[123]

The three priorities are: to develop a regional identity; to develop a sustainable and prosperous region; and to develop a safe and secure region. The total amount of the CBSS PSF for three years is EUR 1 million with one call per year. In short, the projects initiated by a legal entity of CBSS member states need to be transnational in character and aim to have a sustainable outcome.

[122] Author's interview, European Commission, May 29, 2017.
[123] http://www.cbss.org/project-support-facility/

BONUS

The Joint Baltic Sea Research and Development Programme BONUS is the EU's only transnational research and science programme at a macro-regional scale; it focusses on the protection of the Baltic Sea ecosystem. Its members are the national research funding institutions[124] in the eight EU member states around the Baltic Sea. They fund BONUS – jointly with the FP7 – by a total of EUR 100 million for the years 2011-2017. In addition, Russia participates in BONUS through bilateral agreements. The BONUS Secretariat (EEIG) is the legal management organisation of BONUS. The Programme was developed in several steps: while BONUS ERA-NET (2003-2008) developed preconditions for BONUS, BONUS+ (2009-2011) tested the mechanisms of collaboration among the national funding institutions with a total of 16 projects funded for EUR 22 million and involving over 100 research institutes and universities. Eventually, for the years 2010-2017, BONUS was officially launched in 2010 following a co-decision of the European Parliament and the Council of the EU.

In a nutshell, BONUS supports the sustainable development and ecosystem-based management of the BSR, the HELCOM Baltic Sea Action Plan and the EU Marine Strategy Framework Directive as well as other European, regional and national coastal and marine environmental policies and plans. In particular, BONUS issues calls for research on ecosystems and innovation for the scientific community and SMEs; it funds projects of high quality and relevance to produce knowledge, scientific evidence and innovative solutions needed by policymakers to engage end-users and society in the knowledge based governance of the fragile Baltic Sea. BONUS is also boosting the shared transnational use of infrastructures which are necessary prerequisites to carry out marine research, such as research vessels, field stations, data acquisitions systems, special equipment and laboratories.[125] It implements many principles of the EU H2020 (2014-2020) and thus responds to the EU's growth and jobs strategy by e.g. pursuing challenge-oriented interdisciplinary research, bringing science and innovation closer together and involving stakeholders across a multitude of sectors in all phases of the programme.

General remarks

The analysed European and macroregional research strategies have revealed the extent to which EU global policies in research and science policy have taken macro-regional strategies, such as the EU Strategy for the Baltic Sea Region, into account. Moreover, they have shown how deeply entrenched R&S policy is – both in its horizontal and vertical policy dimension – in the context of European integration. In particular, the discussion of the interface of EU-level R&D policies and the EUSBSR has demonstrated that there is increasing awareness for the need to better coordinate regional potential in order to withstand global competitive pressure.

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[124] Innovation Fund Denmark; Estonian Research Council; FiRD Coop (represented by Academy of Finland); *Forschungszentrum Jülich Beteiligungsgesellschaft mbH* (FZJ-Bt. GmbH, Germany); Ministry of Education and Science (Latvia, represented by State Education Development Agency); Research Council of Lithuania; National Centre for Research and Development (NCBR) (Poland); Swedish Agency for Marine and Water Management; Swedish Environmental Protection Agency; Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS).

[125] https://www.bonusportal.org/files/5621/BONUS_Briefing_27_Success_stories.pdf

The process of improving the networks amongst relevant stakeholders has only just begun. Undoubtedly, many countries of the BSR are fairly advanced in the area of digitalisation. Yet, a recent report mourns that "there is currently no coordinating body for digital policy collaboration across borders in the BSR. Also, the responsibility for digital policy is shared by many authorities at the national level, which may prevent cross-departmental collaboration both nationally and transnationally, due to differing institutional contexts for digital policy making".[126] This speaks to the coordination dilemma that exists in systems of multi-level governance.

Ultimately, the success of macro-regional strategies will be benchmarked towards the question whether or not they have achieved the establishment of a platform on which these issues can be addressed – and ultimately be solved reasonably well. Toward that end EU R&S policies provide several instruments – and in a number of them there is some awareness of the need to integrate macro-regional frames in a way that will not disturb the overall objectives of EU policies which are, in principle, geared towards the whole of Europe rather than exclusively framed for a territorial sub-unit or macro-region.

Yet there have been, especially in the BSR, examples of territorially defined programmes such as BONUS – and it might be time to reconsider whether or not there are other areas – such as for example in the field of R&S infrastructure where similar transnational funds – primarily financed by the member states concerned, or, alternatively, by transnational budget lines in national funding schemes. **Digitalisation** and **materials science** could be natural candidates for such an initiative in the BSR.

Hence, we conclude with two major findings: **First, research and science policy has developed a genuine macro-regional dimension in those areas** of transnational cooperation **that are essentially territorially and functionally defined** such as the Joint Baltic Sea Research and Development Programme BONUS in support of sustainable development and ecosystem based management of the BSR. **Second**, without creating territorially defined entry points, **EU global research and science policies**, such as H2020, **provide 'bottom-up' opportunities** – in conjunction with the EUSBSR – **to identify and improve the transnational use of research facilities** combined with closer cooperation between institutions for research and science.

2.3. Nordic Cooperation

For large parts of the BSR, Nordic Cooperation – partly supplemented by cooperation in the NB8 format among the Nordic and Baltic States (Denmark, Finland, Iceland, Norway and Sweden plus Estonia, Latvia and Lithuania) – provides an important international framework for research policy cooperation. Since 2005 this cooperation has been organised by NordForsk, an institution which operates under the Nordic Council of Ministers. Its aim is to jointly identify Nordic priorities with regard to science and research infrastructures, to provide funding and to carry out thematic research programmes.

[126] Policy Area Innovation. EU Strategy for the Baltic Sea Region (2016), *Transnational Digital Collaboration in the Baltic Sea Region*: Working Paper for the PA Inno Strategy Guide. Published by Baltic Development Forum (BDF).

Currently the following research programmes are funded by NordForsk:

- Education for Tomorrow (2012-2016);
- Gender in the Nordic Research and Innovation Area;
- Nordic Bioeconomy Programme (2017-2021);
- Nordic e-Infrastructure Collaboration, NeIC (2013-2023);
- Nordic Green Growth Research and Innovation Programme;
- Nordic Neutron Science Programme (2015-2020);
- Nordic Programme on Health and Welfare (2014-2018);
- Nordic Societal Security Programme;
- Nordic University Hubs (2018-2023);
- The Top-level Research Initiative (on climate research).

Furthermore, NordForsk supports trans-Nordic research cooperation through the establishment of Nordic Centres of Excellence (NCoEs). Eligibility criteria include requirements that NCoEs must be distributed over several research institutions and built on cooperation between at least three countries. Participating institutes must specialise in research areas that have high priority in the Nordic countries. Currently the NCoEs are related to three thematic framework programmes:

- Food, Nutrition and Health;
- Responsible Development of the Arctic: Opportunities and Challenges - Pathways to Action;
- Welfare Research.

As another area of activity NordForsk supports Nordic cooperation on specific, large-scale international research infrastructure projects. This includes efforts to increase joint Nordic use of and coordinated participation in international research facilities, including ESFRI Roadmap projects. Some of these are related to structural sciences, for instance **Nordsync**, a consortium organising the joint membership of Denmark, Finland, Norway and Sweden to ESRF or the **Nordic Neutron Science Programme** between Sweden, Denmark and Norway (with participation from Lithuania, Latvia and Estonia), to support the future use of ESS. Other joint Nordic participations in European RIs are related to life sciences, for instance the **Nordic EMBL Partnership for Molecular Medicine** coordinates Nordic participation in the European Molecular Biology Laboratory (EMBL). It facilitates scientific collaboration and access to scientific infrastructure, including databases, facilities and instrumentation, as well as services and training activities provided by its partners. In addition to their partnership with EMBL, the individual Nordic research centres engage in collaborations with other national partners, including research and public health institutes, hospitals and research councils, with the aim of establishing an extensive Nordic network for molecular medicine.

2.4. Ascertaining political potentiality

While focusing on the joint potentials in the BSR for scientific excellence, the two above mentioned frameworks of European and macro-regional policies and strategies as well as the success of Nordic cooperation in fostering scientific research, demonstrate the necessity of

political support for their development. The necessity of constructing common political agenda and support at the regional level for securing long term BSR science policy must not be underestimated. Without recognition of a common political interest in creating synergies in science policy the chances of gaining high potentiality of scientific excellence in the region are not high. At the same time, there is historical evidence in the region, exemplified by the HELCOM cooperation since the 1970s, that an epistemic community may be a trailblazer of science policy itself and contribute to setting norms for scientific collaboration, thereby overcoming or at least soothing political differences.

Therefore, especially in a time of returning uncertainty in the BSR when instead of meeting previously defined common challenges political bodies are often distracted by pressing agendas of threats and insecurity, ascertaining political potentiality for scientific collaboration is vital. Indeed, it may turn out that thanks to the evolving and still existing governance frameworks, such as the EUSBSR, the Turku process,[127] the Northern Dimension initiative[128] or the CBSS Baltic 2030 Action Plan,[129] there are sufficient foundations to make full use of the BSR scientific potential, regardless of a given institution or research infrastructure having its seat in an EU or non-EU country. For instance, Northern Dimension has established sectorial partnerships to deal with the following thematic issues: environment (NDEP); public health and social well-being (NDPHS); transport and logistics (NDPTL); culture (NDPC) that may be instrumental in producing excellent research, as demonstrated by the *Northern Dimension Antibiotic Resistance Studies NoDars* project. Another field where this framework could bring results is in polar research in the Barents region where especially climate change might prove to be the least controversial common denominator. The CBSS Baltic 2030 Action Plan with its renewed reflection on sustainable development goals confirms this direction and adds focus on urban centres and cities as potentially the most engaged stakeholders.

Political framework conditions may produce unexpected vehicles for developing scientific excellence where, despite the obvious competition, states may opt for transnational cooperation. Among such domains is the research and scientific cooperation in the energy sector. Energy is obviously a field of research and technological development which has a high priority for all BSR countries. There are also good reasons to assume that transnational scientific relations in this area will expand in the coming years. This is due to the relatively advanced deregulation of energy and electricity markets especially in the Nordic countries, the overall strong political will to reduce dependencies on monopoly-like supply structures and to the urgent need to achieve reductions of greenhouse gas emissions.[130] Moreover, the region has high potential to develop solutions to these challenges. The Norwegian economy is largely based on the extraction and processing of fossil energy resources. The renewable energies sector is well advanced in the other Nordic countries as well as in the German BSR states. The Baltic States and Poland are making great efforts to decrease dependencies on

[127] It was initiated by the cities of Turku, Hamburg and St. Petersburg to increase the number of Northwest Russian partners in the Baltic Sea region cooperation. http://www.centrumbalticum.org/en/projects/turku_process?app=1

[128] http://www.northerndimension.info/

[129] *Realizing the Vision: The Baltic 2030 Action Plan*, http://www.cbss.org/wp-content/uploads/2017/06/Baltic-2030-AP-Final-approved-by-the-CBSS-Foreign-Ministers-20.06.2017-1.pdf

[130] http://nordicway.org/2017/09/nordic-countries-challenged-sustainable-consumption-production-energy/

Russian oil and gas deliveries. Thus, there is a strong region-wide interest in focusing on the energy sector both economically and in terms of research and technical knowledge expansion (see also the table below "Synoptic overview of strategies").

However, there seem to be political constraints on the suitability of energy as a joint research area for the BSR. Energy related policy pathways depend first of all on individual national perceptions and interests that are not only guided by different geographic and natural preconditions (such as fossil resources in Norway, wind energy in Denmark and Northern Germany, hydropower in Sweden, coal mining in Poland) but also by different and to a certain extent even contradicting economic interests (for instance strong efforts in Norway and Poland to develop carbon capture and storage technologies, while other BSR countries have set a political goal of achieving carbon free economies within a few decades). What is more, the Baltic States have together with Poland and Sweden established the Baltic Region Initiative for Long Lasting Innovative Nuclear Technologies (**Baltic Brilliant**) cooperation platform,[131] which is supposed to develop modern nuclear technologies and electrical power solutions in the BSR countries and to develop synergies with ongoing Euratom projects. In contrast, Germany is currently phasing out nuclear energy. Even foreign and security policy has a strong impact on energy political developments. This has become obvious in the conflict over the North Stream pipeline.

These very divergent national interests and choices related to energy make it rather unlikely that energy will be agreed on as a joint area of research excellence at BSR level, at least as far as energy sources are concerned. By contrast, the technical and socioeconomic challenges related to electricity (such as expansion of power grids or development of transmission infrastructure) are a common concern for all the involved countries.

The table on the next page shows a synoptic comparison of several research and technology areas with regard to whether or not they are particularly highlighted in the individual countries' above presented research strategies. Not every area could be considered for this overview and the impression may not precisely reflect all aspects of the countries actual science policies since the way they are elaborated in the respective strategies varies widely as regards scope and substance. However, some explicit trends occur clearly in the comparison.

Medicine and health is the only research area which is highly prioritized in every country. However, this is not astonishing considering its huge importance for the welfare of every human society. For similar reasons, energy has also a high priority for almost all countries. A more striking result is that only relatively few countries explicitly highlight research areas such as climate and marine research, renewable energy and urban development. In contrast, materials science, ICT/digitalisation, biotechnology, agriculture/food and welfare society get rather broad political support for future expansion in most BSR countries.

[131] http://balticbrilliantproject.eu/activities.html

Table 5. Synoptic overview of research strategies

Strong emphasis														
No particular emphasis														
	Resource efficiency	Agriculture / food	Medicine / health	Biotechnology	Energy	Renewables	Climate research	Welfare / social cohesion	Urban development	Materials	ICT / digitalization	Marine / maritime research	Space	Mobility / transport
Denmark														
Estonia														
Finland														
Germany														
Hamburg														
Latvia														
Lithuania														
M.-W.P.														
Norway														
Poland														
Russia														
Sweden														
S.-H.														
H2020														

Source: Own findings, based on the performed case studies and expert interviews.

3. Potential areas of transnational scientific excellence

As an overall result of this study, five research areas have been identified, which can be regarded as the most promising fields of joint scientific excellence within the BSR. The process of selecting these areas has been guided by applying various scientific and analytical tools while at the same time political requirements and strategic considerations, put forward first and foremost by the BSN, had to be taken into account. In particular, the following aspects were decisive for selecting the research areas:

- **Scientific quality** was assessed through the application of analytical tools such as the excellencemapping.net database. Other applied quantitative methods which allow a comparison of research performances on an equal footing include the analysis of project participation rates in important EU-programmes (H2020) separately for specific scientific disciplines. In addition, qualitative methods such as expert interviews and the evaluation of country related reports were used in order to complete the impression on the scientific quality of the BSR research landscape.
- The study's final intention is not to consider the scientific strengths of the analysed countries in isolation from each other but to assess the **potential and readiness of national research landscapes to engage in transnational cooperation**. Thus, another selection criterion has been the extent to which a BSR wide cooperation network already has evolved around individual research areas. The density and sustainability of such networks has been assessed by means of a large quantitative analysis comprising all multinational H2020 projects. Joint participation rates were counted and compared by country and by research area,[132] thus allowing conclusions to be made about whether and in which research areas strong transnational scientific cooperation already exists. In addition, a qualitative analysis of selected individual research projects, which can be considered as role models for transregional cooperation, was carried out. Studying these cases has provided insights into the motives and conditions of existence of scientific cooperation between different parts of the BSR.
- In addition to the excellence driven approach, which mainly focuses on the actual existence of top research facilities and their potential to engage in transnational scientific cooperation, another selection criterion focused on **thematic driven incentives for scientific cooperation, that are rooted in the geographic, socioeconomic, cultural and other distinctiveness of the BSR**. The most apparent, albeit not the only example for a common regional interest that triggers research cooperation is the ambition to address marine pollution of the Baltic Sea by means of joint scientific efforts.
- Furthermore, **political, strategic and functional considerations** had to be taken into account when selecting research areas. In all BSR countries as well as at the subnational and supranational levels, political interests and societal challenges stand behind the related individual science policy strategies. Thus, one selection criterion was

[132] The total number of analysed H2020 projects with participants from at least two BSR countries amounts to 957.

to find joint research areas where most BSR countries as well as other politically relevant considerations converge in terms of interests and science policy objectives. Some requirements for selection have been directly set out in the BSN's specification for tender. These include the number of research areas to be selected (4-5), the ambition that each of them should bring together at least three BSR countries, and the intention that every BSR country should be included in at least one research area.

- Finally, the selection process has been guided by the intention to meet the BSN's basic long-term goals such as widening participation and increasing researcher mobility. A general ambition of the BSN is to increase the attractiveness of the BSR for researchers from within and beyond the BSR and thus to enhance the global competitiveness of research carried out in the BSR. With this consideration in mind, the study has put a particular emphasis on large research units, since these have – when they join forces – the greatest potential to achieve the critical mass necessary to develop large scale transnational clusters of excellence that are able to compete for the most talented researchers in a global context.

In addition to applying the above described criteria, the selection process has benefited from valuable suggestions, critical comments, and also from positive reinforcements made by stakeholders and experts in the course of conducting the study. Concrete proposals regarding the areas considered for selection were brought forward on the occasion of the presentation of the study's preliminary results during the 8th Annual Forum of the EUSBSR in Berlin in June 2017. Other important remarks were made by the interviewed science administrations' representatives as well as in the review reports of the two external reviewers.

As a result of this complex selection process, it is suggested that the following five research areas be taken into consideration when deciding about synergetic transnational science strategies in the BSR:

1. Marine research and maritime technology;
2. Cultural heritage and identity;
3. Life sciences (including health, medicine, biochemistry and genetics);
4. Welfare Society;
5. Materials science.

Marine research and maritime technology

Marine research and maritime technology is a research area that due to natural/geographic reasons brings together all BSR countries. All of them have natural reasons to strive for the protection of the Baltic Sea's marine environment and to use the sea in various ways for transport, maritime economy, tourism, recreation, off shore energy production, pipelines and safe shipping, to name the most obvious domains of common interest and concern.

Over the years there has also developed a common need for all countries to jointly engage in maritime spatial planning. This domain is becoming increasingly institutionalised thanks to such organisation as VASAB and HELCOM and thanks to the framework provided by the EU Strategy for the Baltic Sea Region.

A huge number of transnational cooperation structures already exist in marine research. The previously mentioned BONUS, various thematic networks, and strategic mapping projects like *SeaDataCloud*, which are further developing the pan-European infrastructure for marine and ocean data management,[133] include virtually all BSR countries.

Marine research and science related to maritime technology also offer potentiality for excellence because of their transversal character and ability to provide solutions and create synergies in adjacent disciplines and domains. An excellent example is reaching out to polar research that is of vital interest for most of the BSR partners as well as for other European countries that together cooperate in the EU-PolarNet. This is the world's largest consortium of expertise and infrastructure for polar research. The EU-PolarNet is currently (2015-2020) in the process of developing a strategic framework to prioritise science, optimise the use of polar infrastructure and enter new partnerships. In a similar way projects like *Baltic Earth: Earth System Science for the Baltic Sea Region,*[134] that link marine research and climate change research, provide an opportunity to face grand challenges in an interdisciplinary way.[135]

Cultural heritage and identity

Despite not being spectacularly represented or highly ascertained in the webometric tool excellencemapping.net, the disciplines of humanities and social sciences that address cultural heritage and identity questions potentially offer scientific excellence based on regionally focused significant research competence in these domains. Among them particularly worth mentioning are memory studies, borderlands studies, cultural studies, as well as the reinvented area studies that link together philological, ethnological, socio-political, historical and archaeological knowledge. Because of their nature, so far much of their research output has been presented in national languages, which has limited the potential for transnational communication and networking. Nevertheless, a number of institutions, projects and initiatives in this domain demonstrate potentiality for reaching scientific excellence when such places of knowledge creation become internationalised. A sample

[133] http://cordis.europa.eu/project/rcn/194588_en.html

[134] www.Baltic-earth.eu

[135] Collaborative ties among marine research institutions in the BSR may - apart from scientific reasons - even emerge because of socio-political objectives. A good example for this is the Baltic Consortium on Promoting Gender Equality in Marine Research Organisations *(Baltic Gender)*. The project (2016-2020), which is part of the H2020 programme "Science with and for Society" (SwafS), brings together eight marine research institutions in five countries around the Baltic Sea. The idea is to achieve a better gender balance in the traditionally male-dominated field of marine science and technology. This is intended to be realized by knowledge transfer and exchange of best practices and by the implementation of Gender Equality Plans in all participating institutions. For further information on this project see also section "Welfare Society".

of projects and institutions that are already demonstrating scientific excellence in the domains of cultural heritage and identity deserve special mention.

In Germany at the University of Greifswald an interdisciplinary research training group *Baltic Borderlands: Shifting Boundaries of Mind and Culture in the Borderlands of the Baltic Sea Region* examines the effects of borders and border changes in the region from a historical, linguistic, economic, social psychological, cultural and political science perspective. The programme is a cooperation between the universities of Lund, Tartu and Greifswald. Funding has been project based and is provided by the German Research Foundation (DFG).

In Sweden, the Centre for Baltic and East European Studies (CBEES) at Södertörn University focuses on cross-disciplinary studies in the Baltic Sea area and Eastern Europe. It was founded in 2005 to promote and coordinate research and doctoral studies on the Baltic Sea Region and Eastern Europe and, at the same time, to strengthen the multidisciplinary research environment mainly within the humanities and social sciences, as well as natural sciences where English is the working language. Partner institutions include universities in Germany, Poland, Russia and the Baltic States. In recent years CBEES has been instrumental in initiating and carrying out summer university courses for training PhD students in the domain of cultural memory and identity. Financial sustainability of the centre's activities is secured by the Swedish *Östersjöstiftelsen* (The Foundation for Baltic and East European Studies).

CoHERE is a H2020 project (2016-2019) that explores the ways in which identities in Europe are constructed. Furthermore, it investigates whether and how European heritages can contribute to the evolution of inclusive, communitarian identities and eventually engender socially-inclusive attitudes. Active partners in the BSR are Denmark, Latvia and Poland.

Established in 2014, the network of *Nordic-Baltic Tradition Archives* brings together libraries, museums and cultural research institutes from Latvia, Lithuania, and Estonia as well as from all five Nordic countries. The idea is to exchange knowledge and best practices across the tradition archives in the Nordic-Baltic region and thus to contribute to the general awareness of its cultural heritage. The network is funded by the Nordic-Baltic Mobility Programme for Public Administration from 2016-2018.[136]

Life sciences (including health, medicine, biochemistry and genetics)

Medicine and health are highly prioritized in all BSR countries' science policies and strategies. Thus, it is likely that throughout the region huge efforts will be made in the coming years to further expand and specialise within these areas, as well as in related scientific disciplines such as biochemistry, genetics, medical technology, biology, biotechnology, bioeconomics of forestry and pharmacology.

According to the excellencemapping.net database, research institutes in the BSR related to medicine as well as to biochemistry and genetics achieve the highest quality positions if compared to all other analysed scientific fields in global rankings as far as citation impact

[136] http://lulfmi.lv/Nordic-Baltic-Mobility-Programme

and number of publications in world leading journals are concerned. In the latter category, more than half of the 83 analysed large medical research institutes rank among the global top 25% and 9 of them even among the global top 10%.

There are other results of this study that indicate the high potential of life sciences to become an area of joint excellence in the BSR. Medicine is the scientific field that now accounts for the highest number of H2020 projects in which partners from different BSR countries cooperate. Furthermore, participation rates in JPI, JTI and EUREKA projects related to medical areas including medical technology, biology and biotechnology are generally among the highest in all BSR countries if compared to other scientific and technological fields.

Apart from these general assessments, it is worth noticing that a broad range of life science related networks has already been established throughout the BSR.

- The *ScanBalt* network aims to raise the profile of regional cooperations in the BSR in the life sciences/bioeconomics sector worldwide and coordinates joint projects in science and industry;
- The *Baltic Network against Life threatening viral infections* (Baltic Antiviral Network) emerged in 2013 from a Hepatitis C Network. It involves universities and medical research institutes from Sweden, Russia, Lithuania, Latvia, Estonia, Finland and Poland. The aim is to protect the population of the Baltic region from viral hepatitis, HIV-1 and pandemic influenza through new technologies of viral diagnostics, new vaccination strategies as well as professional and public education;
- *Northern Dimension Antibiotic Resistance Studies* (NoDars) project (2014-2017) – an example of involving Russian partners and utilizing functional proximity. The other partner countries are Finland, Germany, Latvia, Poland and Sweden. The aim is to investigate the levels of specified antimicrobial resistance and to provide policy makers with suggestions for changes to current national treatment recommendations and antimicrobial resistance strategies.

The two latter networks are examples of the fact that transnational cooperation in medicine and life sciences is also brought forward by reasons of geographical proximity. The spread of infections and antibiotic resistance are challenges that do not stop at national borders and thus need to be addressed within a broader geographical scale.

Furthermore, it is obvious that the relevance and development opportunities of life sciences cannot be assessed without taking other related research areas into account. There are strong links to materials science and the synergetic potentials of both disciplines are thus heavily emphasised in the *STRING* strategy. Moreover, medicine and health are strongly and mutually related to many aspects of welfare society and of social policies (for instance in fields like health education, healthy ageing and health care or in work related health issues). There are thus good arguments for focusing jointly on these research areas when developing fields of scientific excellence in the BSR.

Welfare Society

The idea of a welfare state is widely accepted in the societies of Nordic countries – and has developed into a core feature of "the" Nordic model in more general terms. Understanding the foundations, opportunities and challenges to the Nordic societies remains high on the research agenda of countries like Denmark, Norway and Sweden[137] – and arouses the interest of other countries well beyond the confines of the BSR. Despite all the differences, challenges to the sustainability of social security systems are a common problem not only for all BSR countries, but also for the EU as a whole.

Research on matters of welfare society is inter-disciplinary by nature. Thus, Nordic and other BSR countries' research strategies often focus on topics such as work and health, migration and integration, discrimination and inclusion, education, dynamics of urbanisation, social housing and accessibility, effective health and care services – often in combination with the application of digital tools. With the growth of the importance of e-health solutions – in particular against the backdrop of demographic change and an ageing society –, synergies can be drawn from fostering closer links between health and welfare sectors. This strategy may also attract those BSR countries which are lagging behind the Nordic countries in socio-economic terms. In the area of welfare society, excellent research facilities and infrastructures are in place, especially in Sweden, Norway and Denmark, and Poland. Moreover, the *Northern Dimension Partnership in Public Health and Social Well-being*, formally established at a ministerial-level meeting in October 2003, provides an established platform to foster links in this area. In addition to the challenge of the ageing society, the multi-faceted issue of migration has been pushed to the forefront for several of the BSR countries in the aftermath of the refugee crisis. Here again, welfare in its broadest sense can be linked to another key topic for Europe in general and the BSR countries in particular.

Another area of common interest, albeit perhaps lesser in scope than health and welfare, is the issue of gender balance. The *Baltic Gender* project funded by the EU serves as a flagship-like initiative, bringing together eight scientific institutions in five countries (Estonia, Finland, Germany, Lithuania and Sweden) around the Baltic Sea to work on reducing gender inequalities in marine science and technology. Yet another issue that is often an object of interest for sciences pertaining to welfare society research is the mobility of the highly skilled, the less skilled and students in the EU. Here the project *Youth mobility: maximising opportunities for individuals, labour markets and regions in Europe* (YMOBILITY); with Germany, Latvia, Sweden as partners, shows the potential of the BSR in addressing this challenge.[138]

Materials Science

Materials and structural sciences have a high potential for advancement as an area of joint scientific excellence in the BSR due to various factors. First, there exist a considerable number

[137] Welfare as a research topic is currently also addressed at Nordic level. One of NordForsk's running research programs is related to "Health and Welfare" and one of its three thematic framework programs for the establishment of Nordic Centres of Excellence is focusing on "Welfare Research".

[138] http://cordis.europa.eu/project/rcn/194588_en.html

of highly ranked research institutions throughout the region. According to the excellencemapping.net database, some of them range in the global top 10% with regard to either citation impact or to publication rates in world leading journals. Albeit not in all, but in many BSR countries (Denmark, German BSR, Poland, Sweden), materials science is among the disciplines in which research institutions achieve the best evaluation results. Second, the region is characterized by a unique density of existing and planned large research infrastructures of supra-regional importance related to materials and structural sciences (ESS, MaxLab, European XFEL, DESY, PNPI in Gatchina, Russia). All the countries involved have called for a further expansion and increasing utilisation of these facilities as a priority in their respective national science policy strategies. At the supranational level, materials science has been attributed a key position for achieving the EU's H2020 goals (as specified in the second pillar: 'industrial leadership' and in the third pillar 'societal challenges').

A broad spectrum of transnational formal and informal cooperation structures between several BSR countries has already emerged, connecting these facilities and capitalizing upon synergies. Such transnational partnerships have been particularly promoted within the framework of Nordic Cooperation structures and have resulted in the establishment of trans-Nordic consortia aiming at joint utilisation of large research infrastructures (such as ESS in Lund or ESRF in Grenoble), while partly including even the Baltic States. The German BSR has connected itself to some of these networks through cooperation agreements such as the *Röntgen-Ångström Cluster* (RÅC) between Sweden and Germany, which is intended to support the use of photon and neutron sources or – within a wider interdisciplinary scope – through the *STRING* strategy. Furthermore, intensive transnational cooperation has been established between German and Russian materials science research infrastructures in Ioffe Röntgen Institute (IRI).[139]

The potentiality of structural sciences as a domain of transnational scientific excellence where the BSR offers competitive advantage worldwide is currently best demonstrated in the development of the world's most powerful laser for X-ray light, in the consortium European XFEL in Hamburg and Schleswig-Holstein. A number of BSR partners (Germany, Poland, Russia, Sweden and Denmark) together with other European institutions participate as shareholders in this initiative. It addresses basic science and its practical applications, e.g. in materials science, biology and medicine. Generally, the high level of interconnectedness in the BSR in materials science is also reflected in the relatively large number of related H2020 projects that are jointly carried out with other BSR countries, especially in Sweden, Denmark, Poland, Latvia, Lithuania, as well as in the Federal States of Hamburg, and Schleswig-Holstein.

A final argument that speaks in favour of the enormous potential connected to the further expansion of materials science as an area of joint excellence in the BSR arises from benefits that can be associated with a region-wide division of labour. Accordingly, one can assume that basic research in materials science will bring about ground-breaking inventions within several other research areas that are important for the BSR as a whole (such as medicine, biotechnology, biomaterials, circular economy, nanotechnology or energy efficiency). Many of

[139] https://www.ioffe-roentgen.org/about/iri_a_new_player_in_the_german_russian_collaboration/index_eng.html

these are likely to boost the related economic sectors' R&D activities and thus enable a further expansion of mutually inspiring innovative networks connecting science and business communities all over the BSR.

Generic preconditions for scientific excellence in the Baltic Sea region

ICT and Digitalisation

Without extensive development and deployment of a sustainable eScience infrastructure, the attainment of scientific excellence in the Baltic Sea region in any domain will be very slow. The eScience Infrastructures comprise ICT based technology, virtual organisations, and associated services that support distributed global research. The technologies include computer facilities and peripherals, high-performance and high-capacity networks, databases, grids, and collaborative environments. As the example of the Nordic countries has shown, without the ICT based technology the development of scientific disciplines such as computational chemistry, bioinformatics, materials science, climate research, astrophysics, mechanics (especially computational fluid dynamics) and high energy physics is hard to imagine nowadays.[140] Furthermore, given the cutting edge attainment of some countries in the BSR in developing digital environments or building the most advanced grids based on black fibre optics, making these a generic tool for ICT and digitalisation should constitute one of the primary goals of transnational science in the BSR. This means deployment of the most advanced hardware and, perhaps even more importantly, development and delivery of the software that links local grids, overcomes the national heterogeneity problems and provides tools for automatic resource selection, remote job management, easy access to distributed data, etc. If the BSR is to enjoy sustainable development of its research and science, focusing on basic research in mathematics and information sciences as well as on related disciplines is a system wide prerequisite for success.

Internationalisation and communication based on proficient use of English

English has become a universal *lingua franca* in the world of science. Despite vested national interests and policies to develop scientific excellence on the basis of national languages, being able to communicate and collaborate in English must be regarded as a generic precondition to any transnational cooperation. While in the smaller countries of the BSR awareness of this prerequisite has been present for a longer while, it is not always equally ascertained in the larger countries. It is therefore necessary to intensify the international communication frameworks, administrative procedures, study groups, common courses, summer schools, research training etc. that can enhance the use of English and provide for full utilisation of national capacities in international settings. In order to develop state-of-the-art science, the BSR needs a common scientific vernacular, and while English is not a national language in any of the BSR countries, it may play this role better than any other of the larger languages in the region.

[140] Elmroth, Erik (2010), *Knowledge Infrastructure for the Fifth Freedom in the Baltic Sea Area*, Nordic Council of Ministers, Copenhagen, pp. 21-26.

Provision of regional funding schemes

So far two notable opportunities for acquiring regional funding of regional projects have been established in the BSR: BONUS and CBSS Project Support Facility. BONUS, which started operating in 2010, is currently the most important and the most substantial potential source of funding for projects realised in the natural sciences. BONUS is funded by its members, the national research funding institutions in the eight EU member states around the Baltic Sea and the European Union's Seventh Programme for research, technological development and demonstration by a total of EUR 100 million for the years 2011–2017. Russia participates in the BONUS programme through bilateral agreements. In its efforts to broaden its funding base, BONUS has taken the initiative to involve innovation funding agencies, and in particular the EUSBSR flagship project BSR Stars, in the BONUS programme.[141]

The other noteworthy initiative that offers potential funding for transnational projects is CBSS Project Support Facility (PSF) created, after lengthy discussions, in 2012. It is an instrument to finance the preparation and implementation of cooperation projects contributing to CBSS long-term priorities, bringing added value for the BSR, showing impact in regional cooperation and fostering sustainable partnerships. The projects should be transnational in character and aim to have a sustainable outcome. While the PSF does not have any disciplinary limitations, the maximum amount of co-financing granted is EUR 65 000, which is a rather modest sum in view of the many potential initiatives and actors in the BSR. Against the backdrop of these experiences, it might be desirable to establish a dedicated transnational funding line – Baltic Sea Region Fund – in an area of research and science policy where most BSR countries converge in terms of their national interest.

[141] https://www.bonusportal.org/programme/funding_development. BONUS has also been discussed in greater detail when analysing European and macro-regional science policies and strategies in chapter 2.2. in this volume.

Appendix:

1. List of investigators and contributors
2. List of interviewed government officials, researchers and science policy makers
3. Results and tables of Excellencemapping.net

Appendix 1: List of investigators and contributors

Main investigators	**Qualifications**
Dr. habil. Kazimierz Musiał Main investigator and case study contributor on Poland	Programme Director at the Norden Centrum Scientific Foundation in Warsaw, Associate Professor in Scandinavian Studies at the University of Gdansk, and in 2015-2017 Research Leader at the Centre for Baltic and East European Studies, Södertörn University; experienced researcher holding degrees in Danish Philology (MA), Political Science (PhD) and Sociology (habilitation); topical publications on BSR research and science policy, internationalisation and Nordic university systems; Polish native speaker, fluent in English, Danish, working knowledge of Norwegian, Swedish and German
Dr. Tom Schumacher Main investigator and case study contributor on German BSR, Norway and Denmark	Experienced researcher and political consultant with a focus on issues related to Baltic Sea cooperation and European integration, PhD in Political Science from Humboldt-University Berlin, research fellow at Kiel University, BONUS-Project on marine protection policies for the Baltic Sea, lecturer positions in Frankfurt am Main, Tallinn, Berlin, Riga and Greifswald, founding chairman of the Berlin based Research Group for Northern European Politics (FOR:N), German native speaker, fluent in English, Danish and Norwegian
Case study researchers	**Qualifications**
Dr. Stefan Gänzle Investigator of EUSBSR and main contributor to chapter 2.2. Analysing European and macro-regional science policies and strategies	Associate Professor at University of Agder, Kristiansand (Norway), research areas include Higher Education, Public Administration and regional cooperation in the EU – in particular in the BSR – and the implementation of EU macro-regional strategies across Europe
Dr. Yulia Gradskova	Lecturer at Södertörn University, Institute of Contemporary History; PhD from Södertörn University on gender aspects in

Investigator and case study contributor on Russia (Northwest)	Soviet Russia; Russian native speaker, fluent in English and Swedish
Dr. Ilona Kunda Investigator and case study contributor on Latvia	Senior Researcher at the Latvian Academy of Culture, Riga, with a focus on science and higher education policy and reforms in Latvia; PhD from the University of Latvia on innovation in universities; Latvian native speaker, fluent in English and Russian
Dr. Marco Nase Investigator and case study contributor on Sweden	Lecturer at Södertörn University and Stockholm University, PhD on science history from Södertörn University, Centre for Baltic and East European Studies; German native speaker, fluent in English and Swedish
Dr. Maarja Saar Investigator and case study contributor on Estonia	PhD in Sociology at Södertörn University, Stockholm (Sweden), Project assistant in the Norface project "Transwel – Mobile Welfare in Transnational Europe"; Estonian native speaker, fluent in English and Swedish, reading ability in Finnish
Dr. Jaakko Turunen Investigator and case study contributor on Finland	Lecturer at Södertörn University, Institute for Social Sciences, PhD from Uppsala University on semiotics of politics; Finnish native speaker, fluent in English, Polish, and Swedish
Aistis Žekevičius, MA Investigator and case study contributor on Lithuania	Lecturer at Vilnius University of Applied Sciences (Lithuania); Lithuanian native speaker, fluent in English
External reviewers	**Qualifications**
Dr. habil. Dominik Antonowicz	Associate Professor at Nicolaus Copernicus University in Toruń (Poland), research areas include university governance and mechanisms of research evaluation, since 2010 expert in a number of strategic advisory groups to the Ministry of Science and Higher Education in Poland, since 2012 member of the Evaluation Committee of Research Units (KEJN) responsible for institutional research assessment in Poland
Fredrik Melander, PhD.	PhD. in political sciences, works at Science Village Scandinavia, leading the establishment of academic outstations, research institutes and businesses at Science Village. Previously acted as senior advisor to the Danish Ministry of Higher Education and Science.

Appendix 2. List of interviewed government officials, researchers and science policy makers

Name	Position	Date and type of interaction
Ina Druviete	Vice-rector for humanities and education science, University of Latvia	May 2017, Face-to-face interview and follow-up e-mail exchange
Inga Jēkabsone	Deputy Director for EU issues of the Department of Higher Education, science and Innovation, Latvian Ministry of Education and Research	May and June 2017, face-to-face interview and e-mail exchange
Tālis Juhna	Deputy Chair of the Latvian Council of Science	May 2017, face-to-face interview
Liis Karo-Astover	Chief expert, Research Policy Department, Estonian Ministry of Education and Research	June and July 2017 E-mail exchange
Tomasz Jałukowicz	Chief expert, Department of Science, Ministry of Science and Higher Education, Poland	March – May 2017 Mail exchange and face-to-face interview
Tadas Juknevičius	Policy Analyst, Department of Science Policy Analysis, Research and Higher Education Monitoring and Analysis Centre, Lithuania	May 2017, e-mail exchanges
Angelika Kędzierska-Szczepaniak	Deputy Dean, Faculty of Management, University of Gdańsk	April – June 2017, face-to-face interview and e-mail exchange
Arnis Kokorevičs	Latvian State Institute of Wood Science, Scientific Secretary and Project Manager	March 2017, e-mail exchange
Linda Klūga-Rajceviča	Head of Latvian National Contact Point for H2020	May and June 2017, e-mail exchange
Taivo Raud	Head of Research Policy Department, Ministry of Education and Research, Estonia	Expert interview
Ieva Krūmiņa	Head of Latvian Young Scientists' Association	March-July 2017, Face-to-face interviews and e-mail exchange
Andrzej Kurkiewicz	Deputy Head of Department of Innovation and Development, Ministry of Science and Higher Education, Poland	May 2017 Face-to-face interview
Silver Lätt	Head of International Research Cooperation, Estonian Research Council	Written interview
Andreas Malzahn	Schleswig-Holstein Ministry of Education, Science and Cultural Affairs	April 2017, Face-to-face interview
Indriķis Muižnieks	Rector, University of Latvia	May 2017,

		Face-to-face interview
Arto Mustajoki	Professor at Helsinki University, Dean of Faculty of Arts (2014-2016), member of the Board of Academy of Finland and its Chair (2010-2014), Member of the Finnish Research and Innovation Council	May-June 2017, e-mail and phone interview
Ieva Ozola	Vice-rector for science, Liepāja University, Latvia	May 2017, Face-to-face interview
Josephine Them Parnas	Special Advisor, EU Cooperation on Research and Education, Ministry of Higher Education and Science, Danish Agency for Science and Higher Education	May 2017, Phone interview and e-mail exchanges
Līga Paula	Expert for higher education and science, Latvian Trade Union of Education and Science Employees (LIZDA)	March-May 2017, E-mail exchanges
Toivo Räim	Adviser, Research Policy Department, Ministry of Education and Research, Estonia	Expert interview
Izabela Raszczyk	Chief expert on strategic projects, Rector's Office, University of Gdansk	April 2017, Face-to-face interview
Renata Razmaitė	Chief Specialist, Department of Studies, Science and Technology, Ministry of Education and Science, Vilnius	April – May 2017, E-mail exchanges
Mārtiņš Rutkis	Director, Institute of Solid State Physics, University of Latvia	March 2017, Face-to-face interview
Peter Schenk	European Commission, Directorate General for Regional and Urban Policy	March 21, 2017, Face-to-face interview, Brussels
Ronalds Štrauhs	BSN project manager at the Latvian Ministry of Education and Science	April – May 2017, Face – to-face interview and e-mail follow-up
Pål Sørgaard	Avdelingsdirektør, Norwegian Ministry of Education and Research	May 2017 Phone interview
Dmitry Vasilenko	Vice-rector for international relations, UNECON, St. Petersburg, Russia.	May – June 2017, E-mail and phone interview
Miroslav Veskovic	Scientific/Technical Project Officer, European Commission, Joint Research Centre	May 29, 2017, Face-to-face interview, Brussels
Aistė Vilkanauskytė	Head of International Programme Department, Lithuanian Science Council	April – May 2017, E-mail exchanges
Mikko Ylikangas	Programme Manager, the Academy of Finland	May-June 2017, E-mail and phone interview

Appendix 3: Results and tables of Excellencemapping.net

Figure 29. Danish research institutions ranked by citation impact

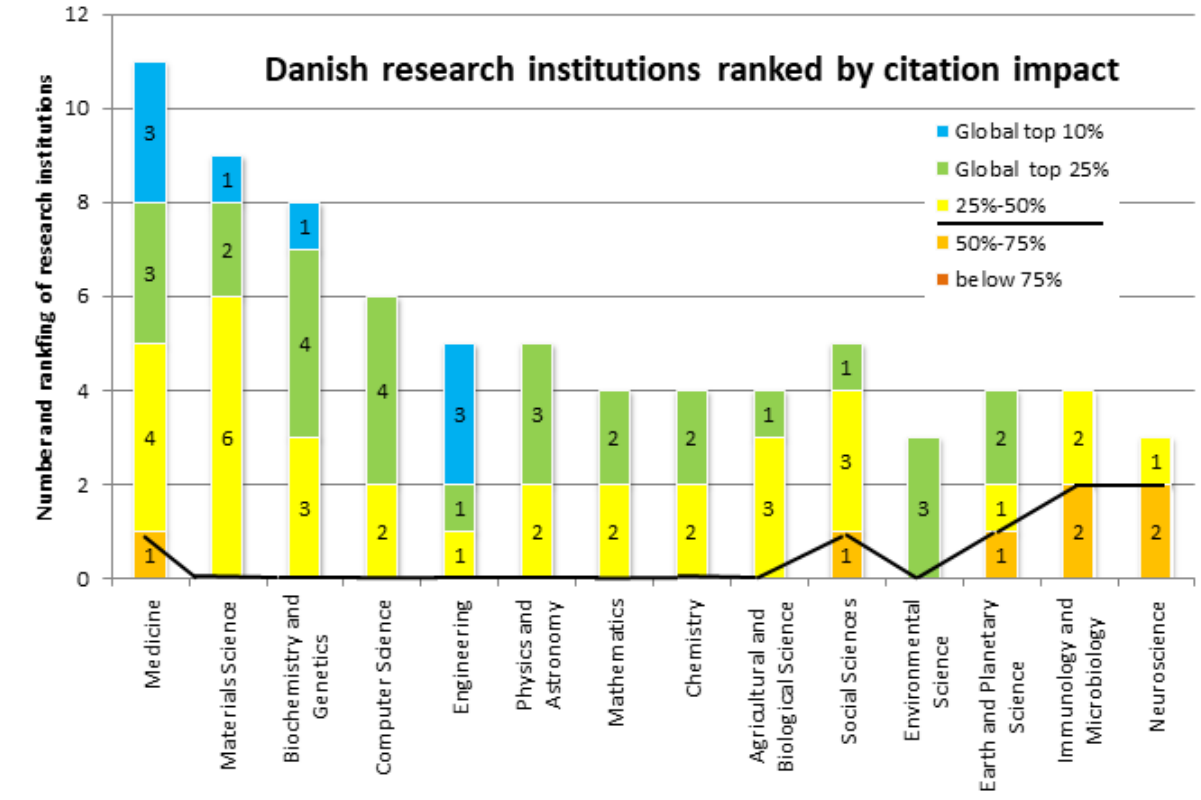


Figure 30. Danish research institutions ranked by best journal rates

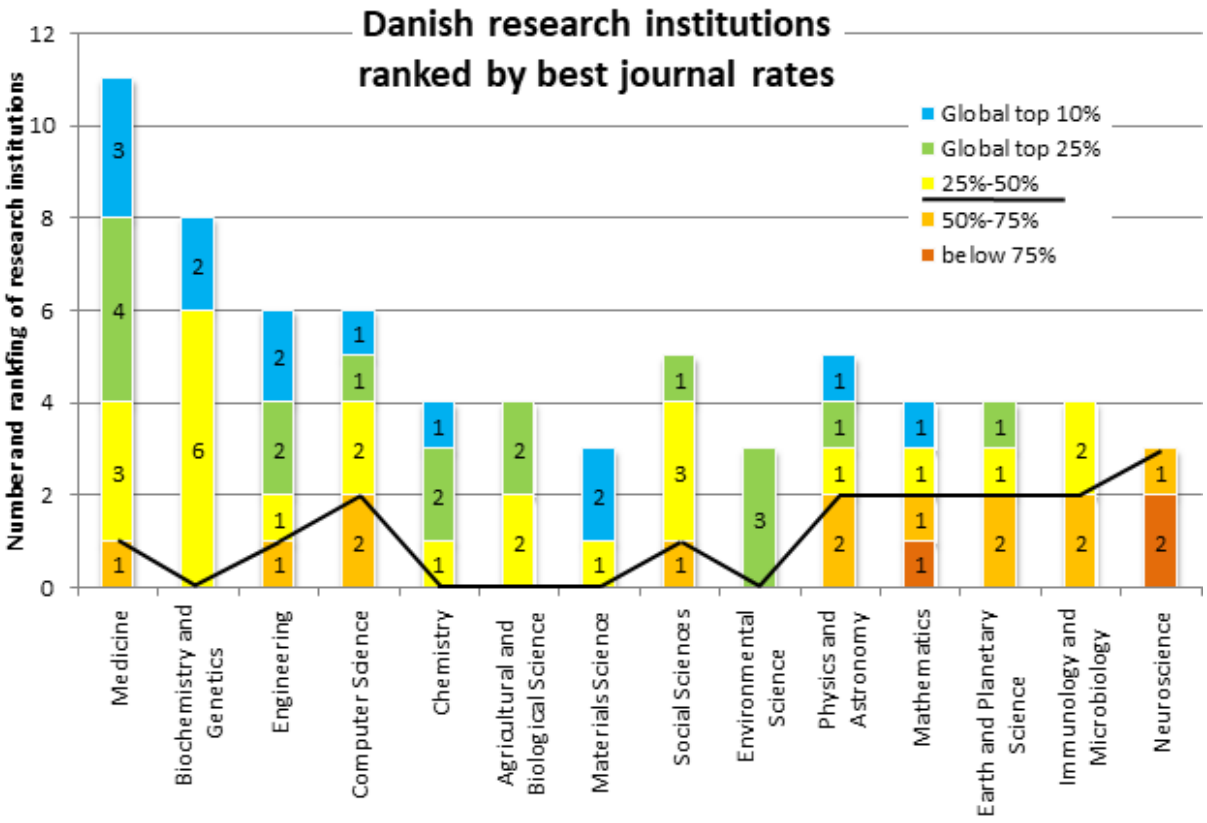


Figure 31. Estonian research institutions ranked by citation impact

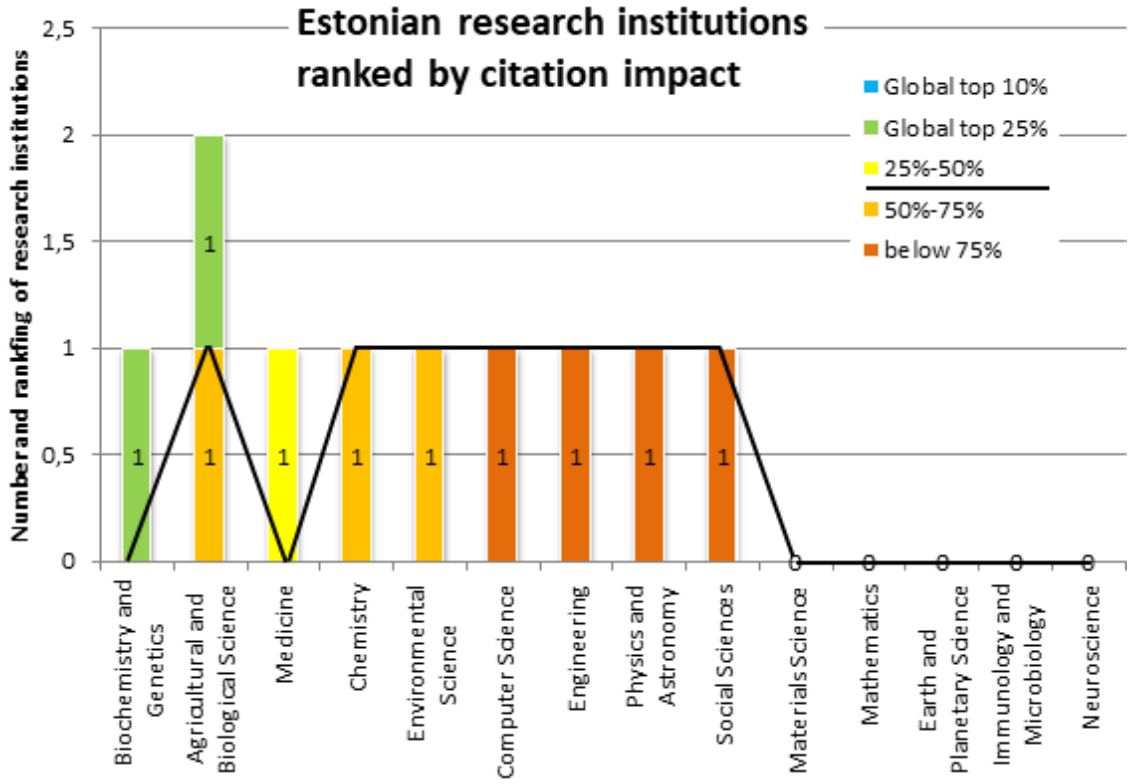


Figure 32. Estonian research institutions ranked by best journal rates

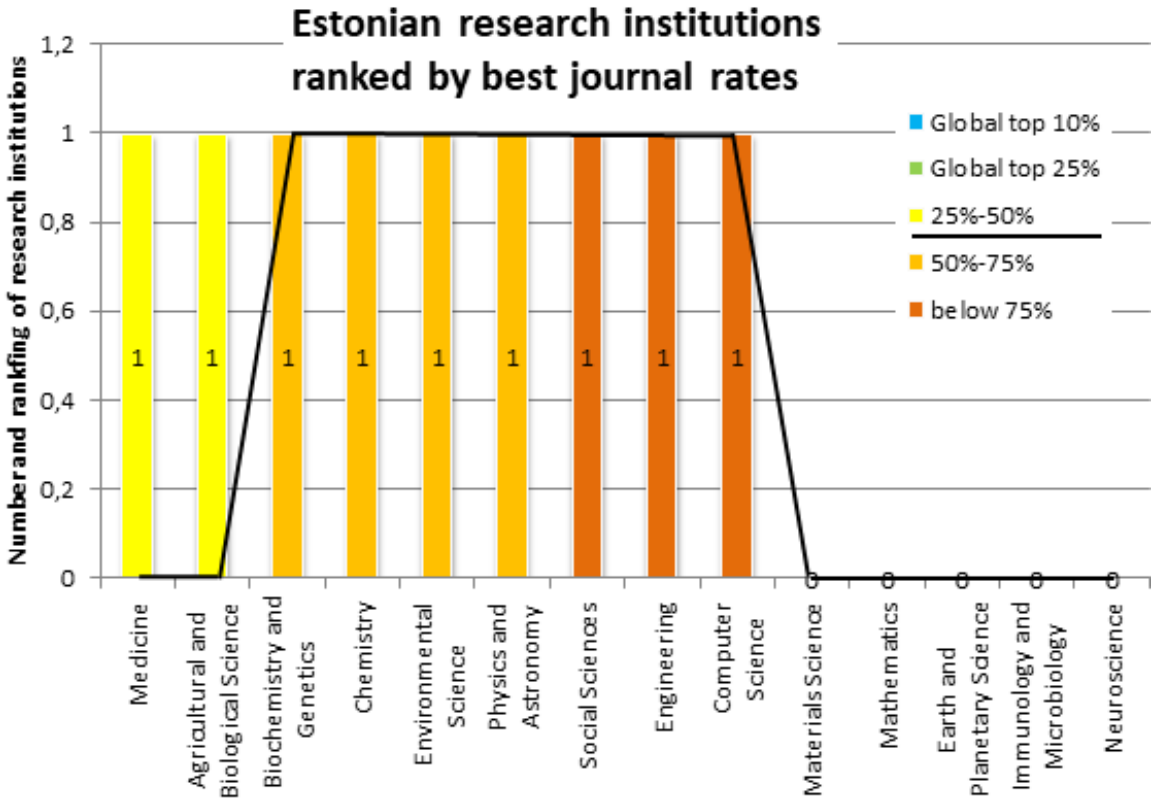


Figure 33. Finnish research institutions ranked by citation impact

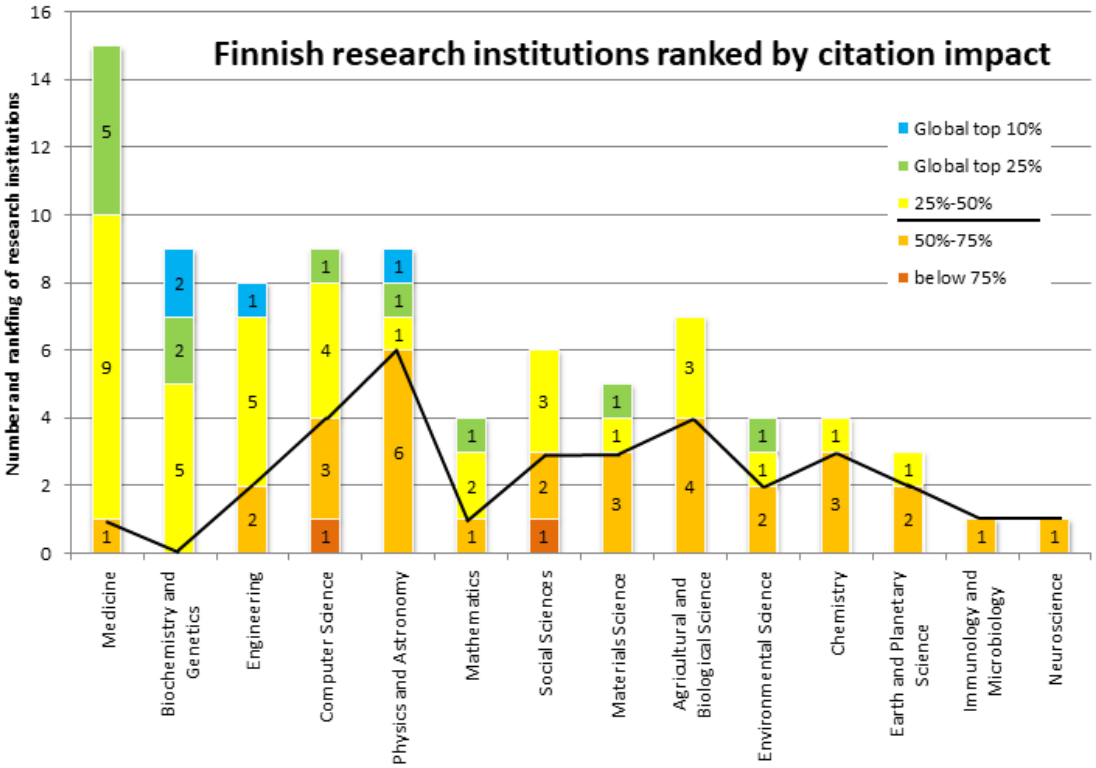


Figure 34. Finnish research institutions ranked by best journal rates

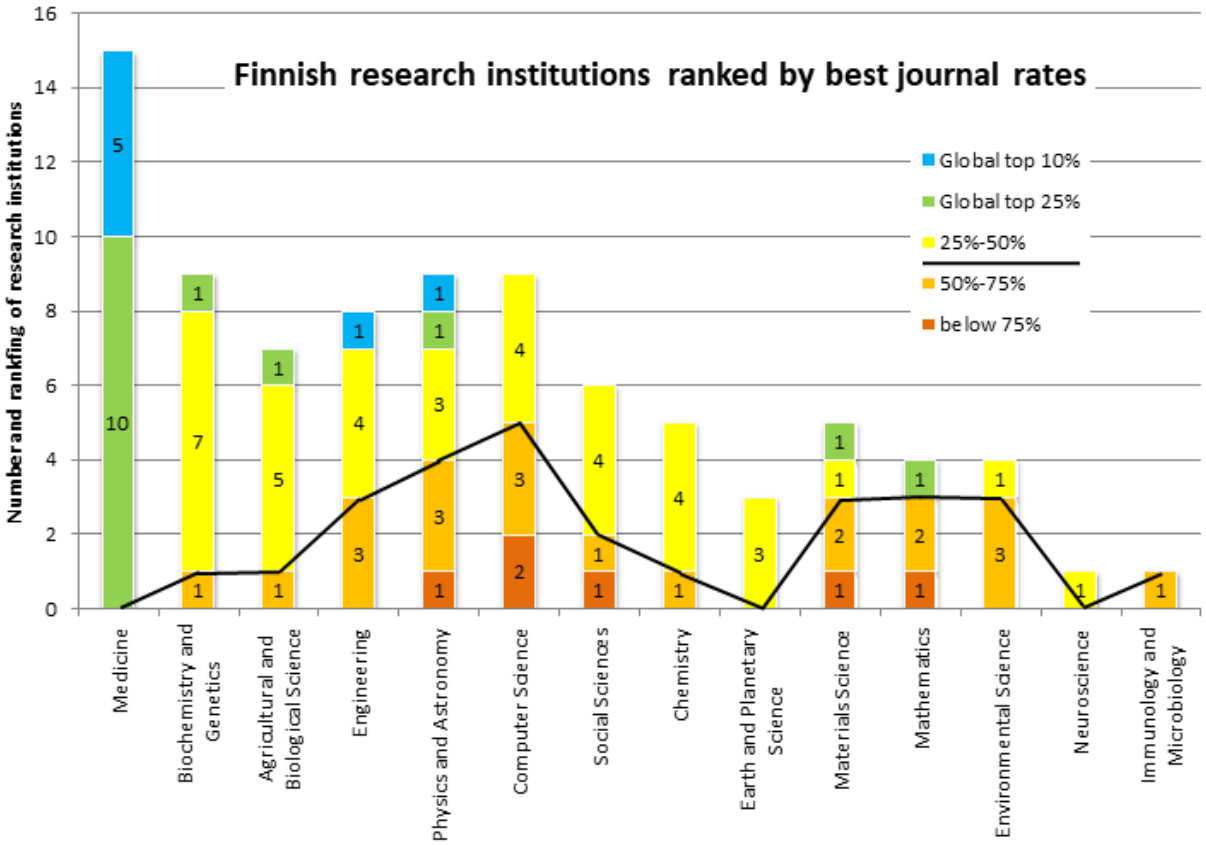


Figure 35. German BSR states' research institutions ranked by citation impact

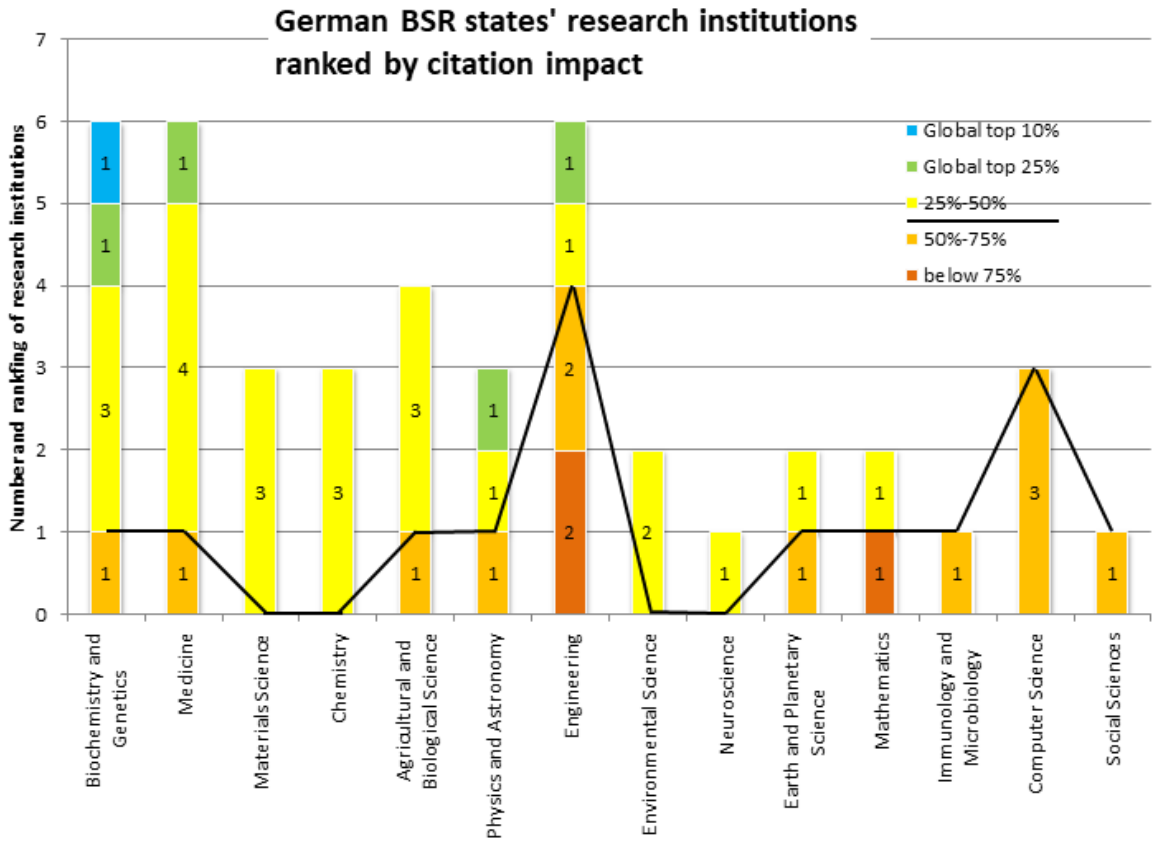


Figure 36. German BSR states' research institutions ranked by best journal rates

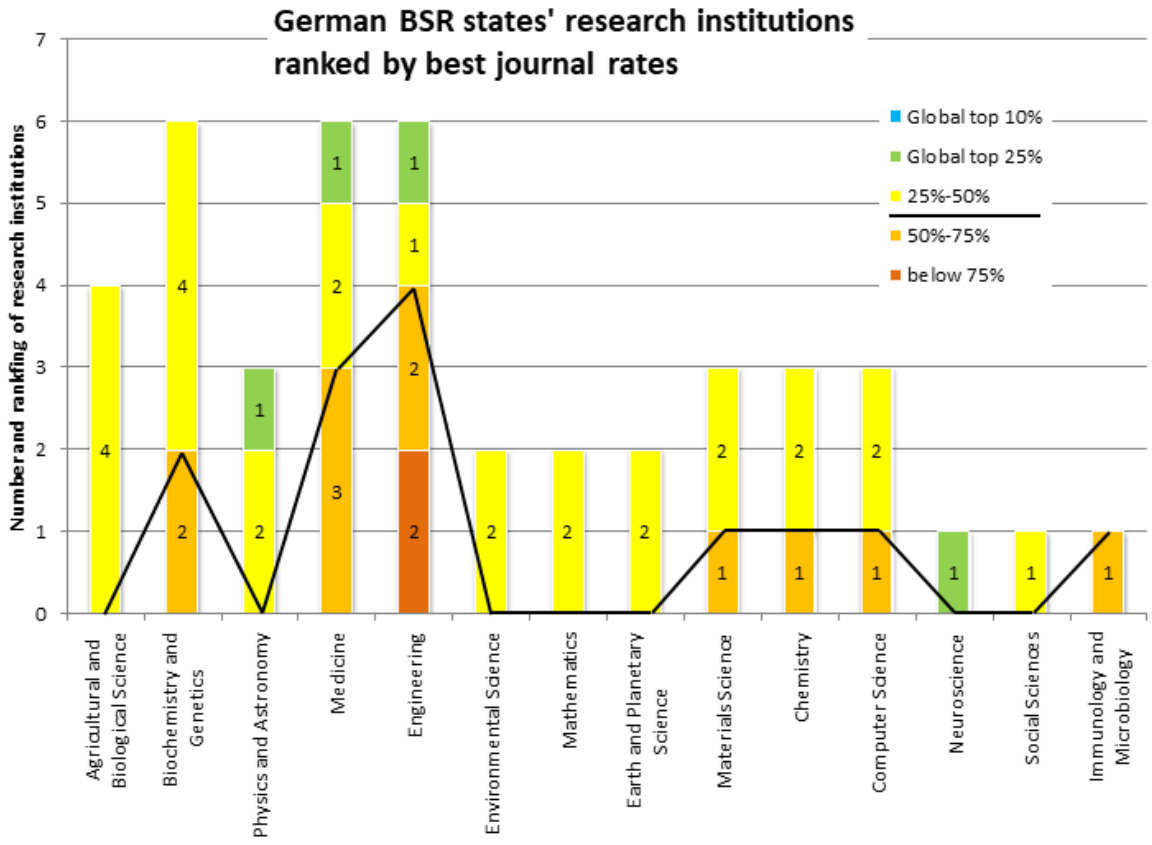


Figure 37. Icelandic research institutions ranked by citation impact

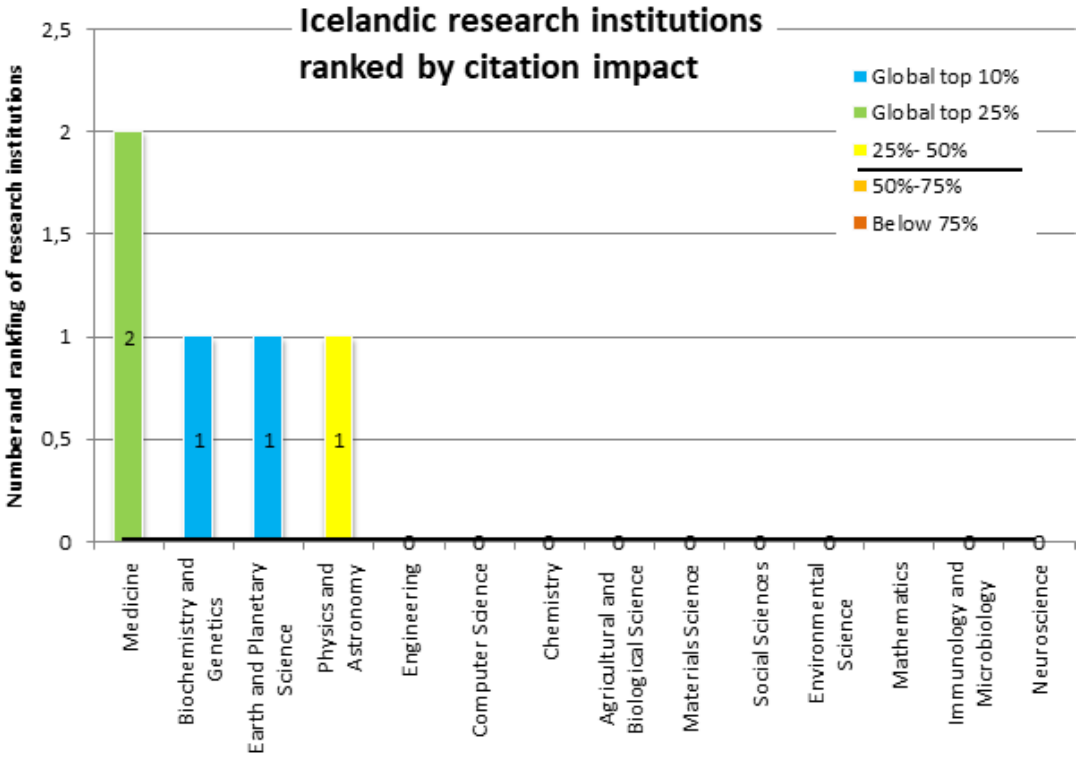


Figure 38. Icelandic research institutions ranked by best journal rates

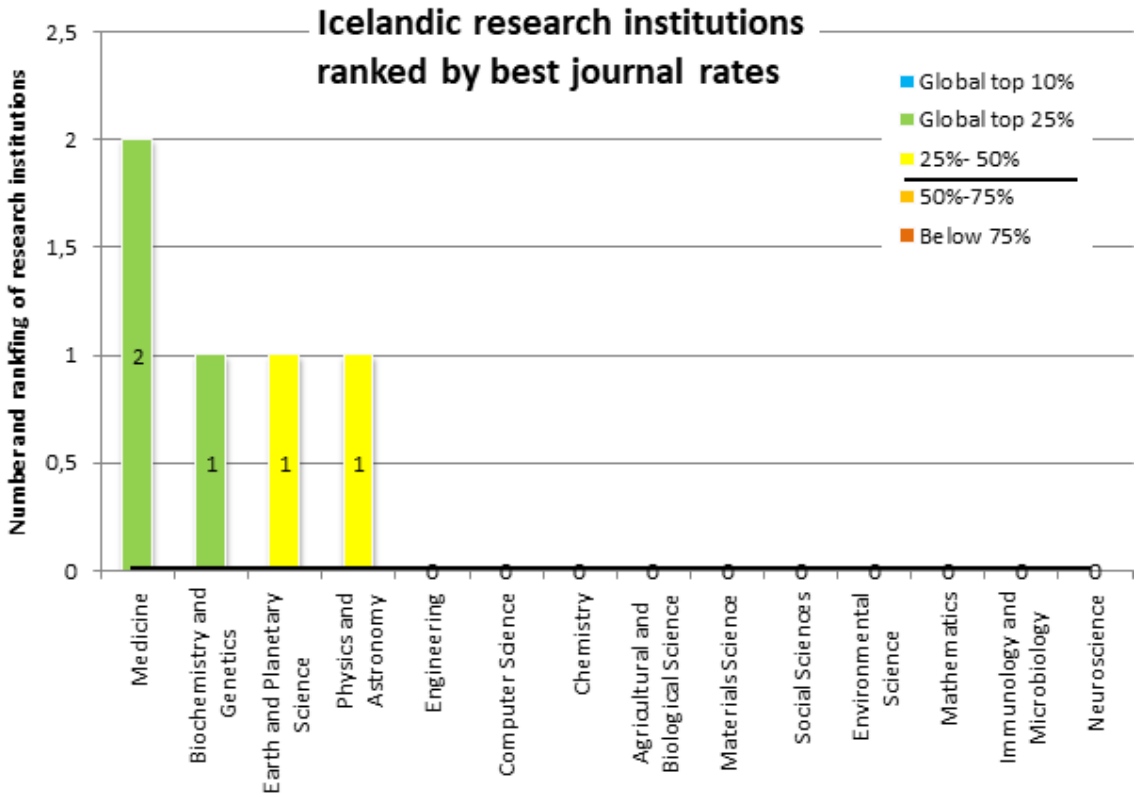


Figure 39. Latvian research institutions ranked by citation impact

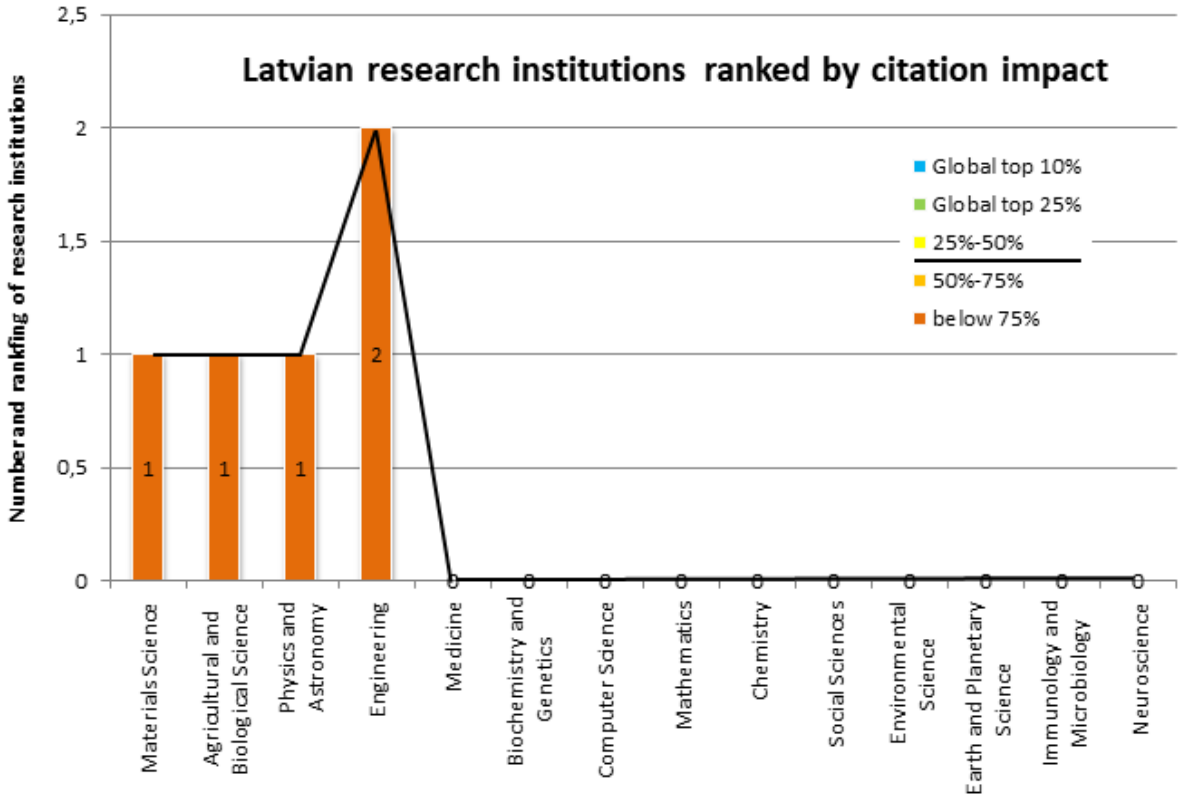


Figure 40. Latvian research institutions ranked by best journal rates

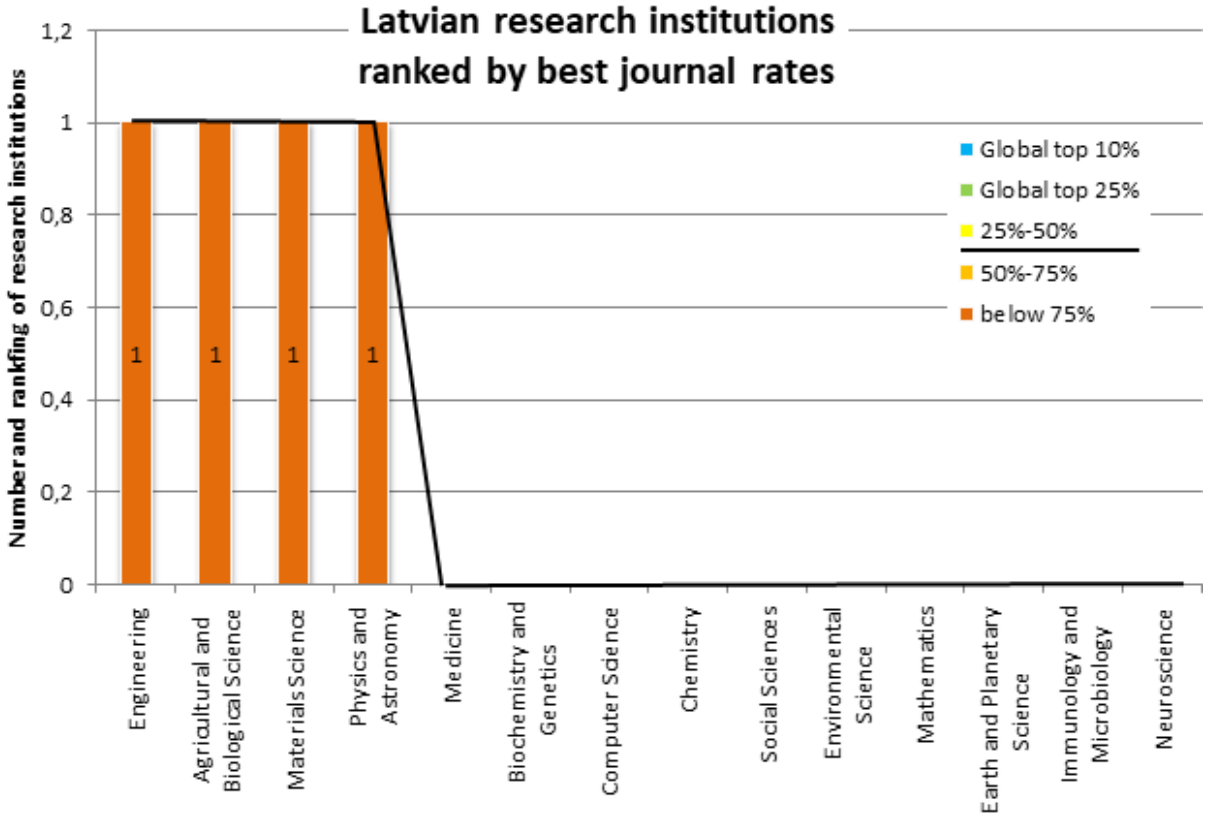


Figure 41. Lithuanian research institutions ranked by citation impact

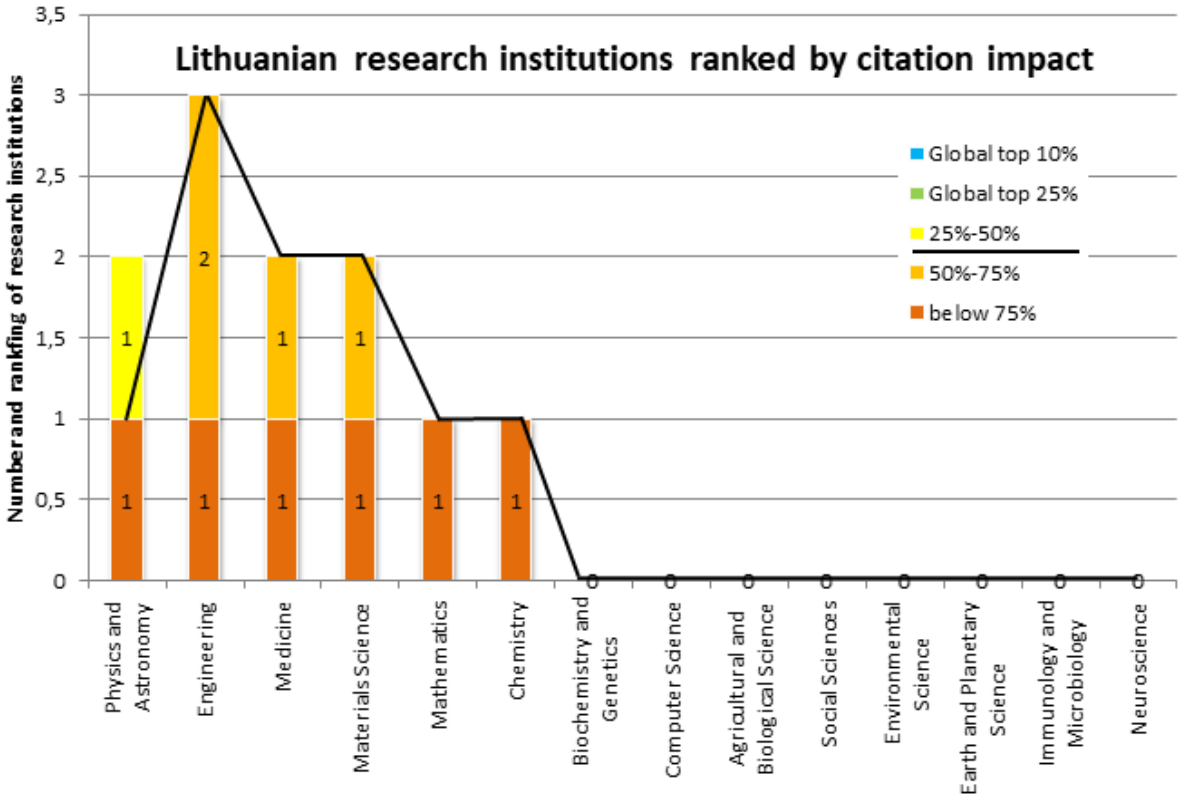


Figure 42. Lithuanian research institutions ranked by best journal rates

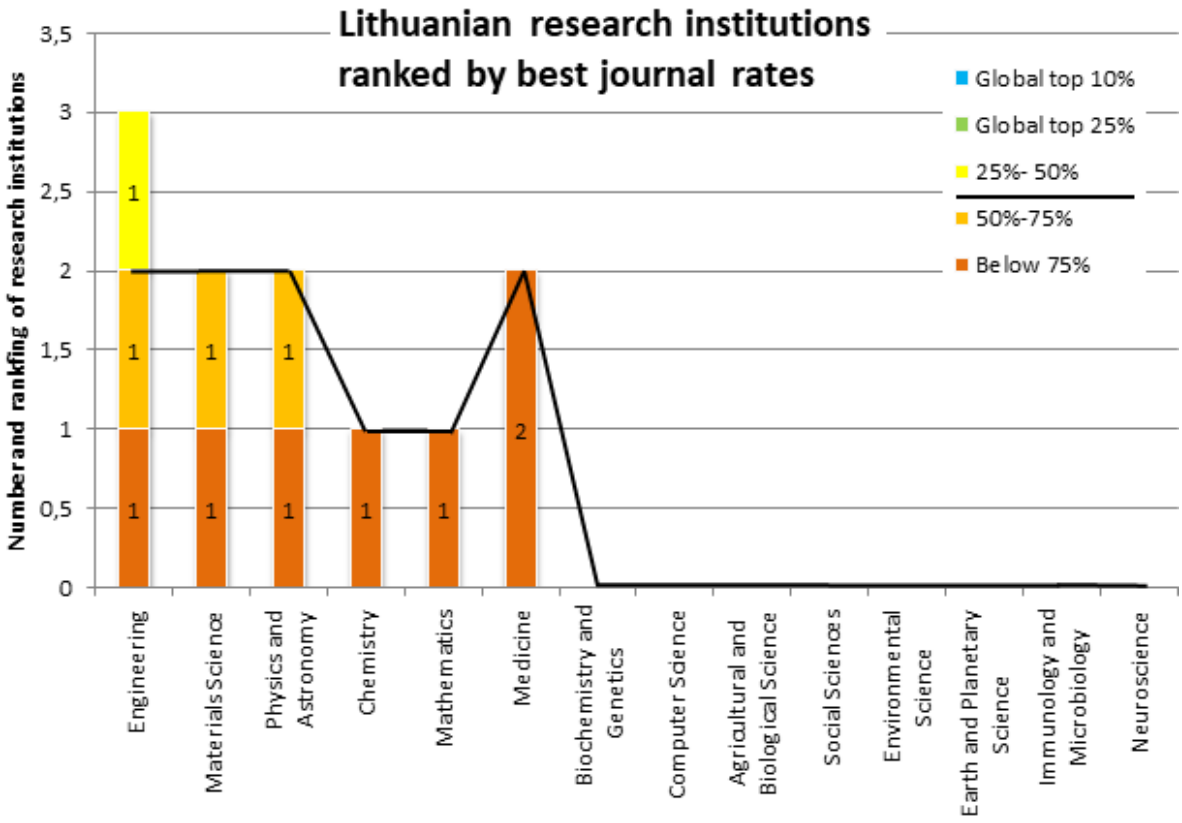


Figure 43. Norwegian research institutions ranked by citation impact

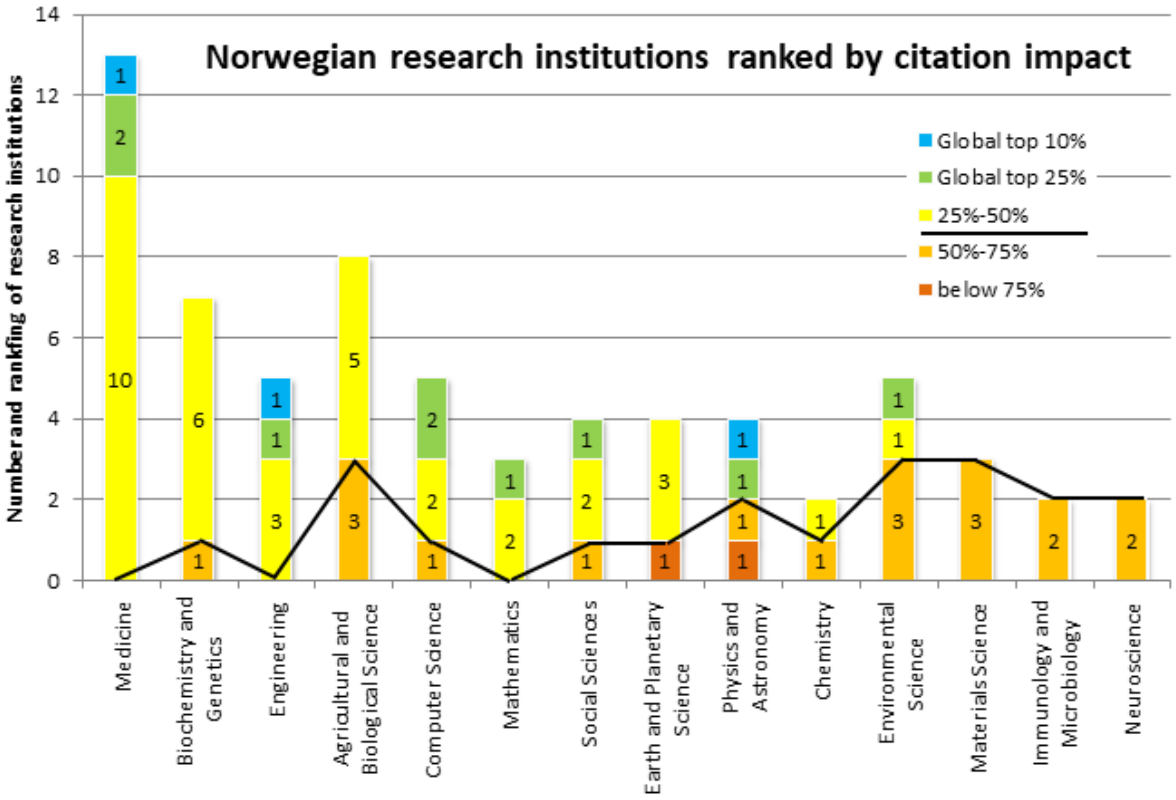


Figure 44. Norwegian research institutions ranked by best journal rates

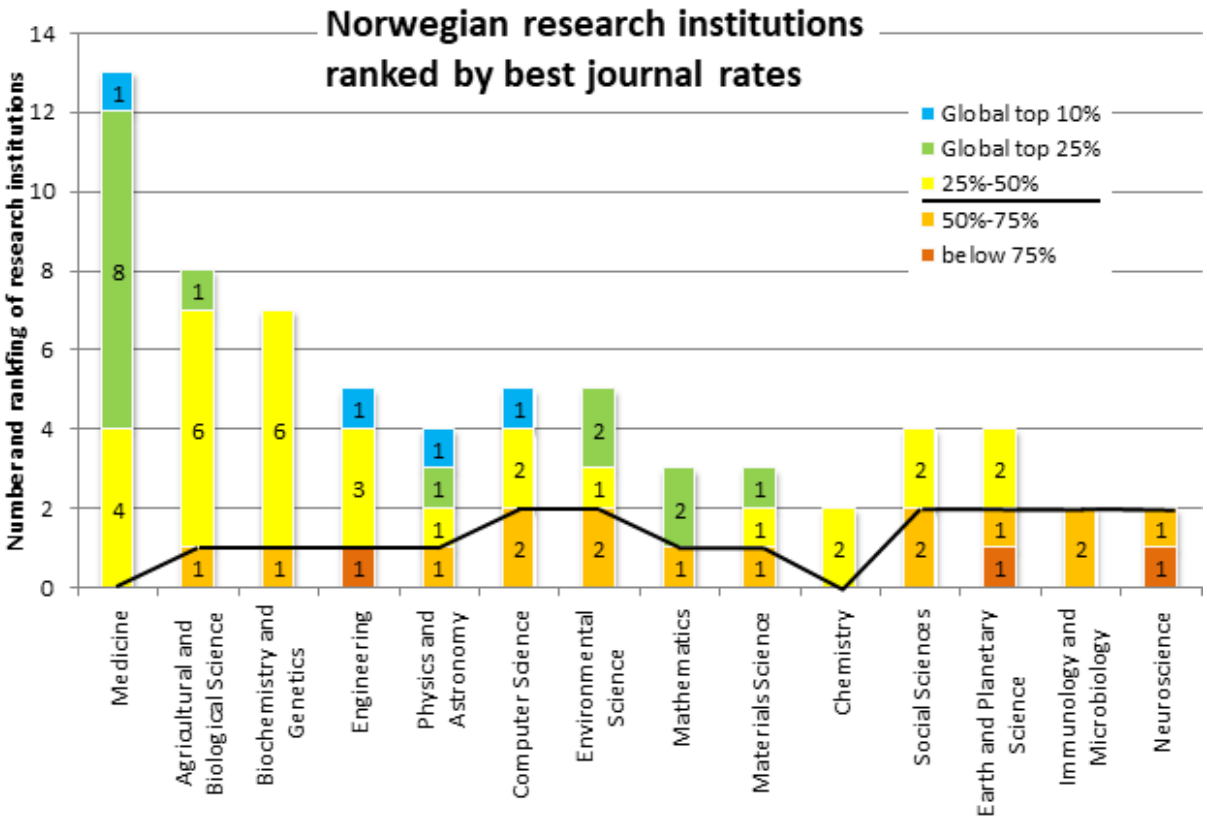


Figure 45. Polish research institutions ranked by citation impact

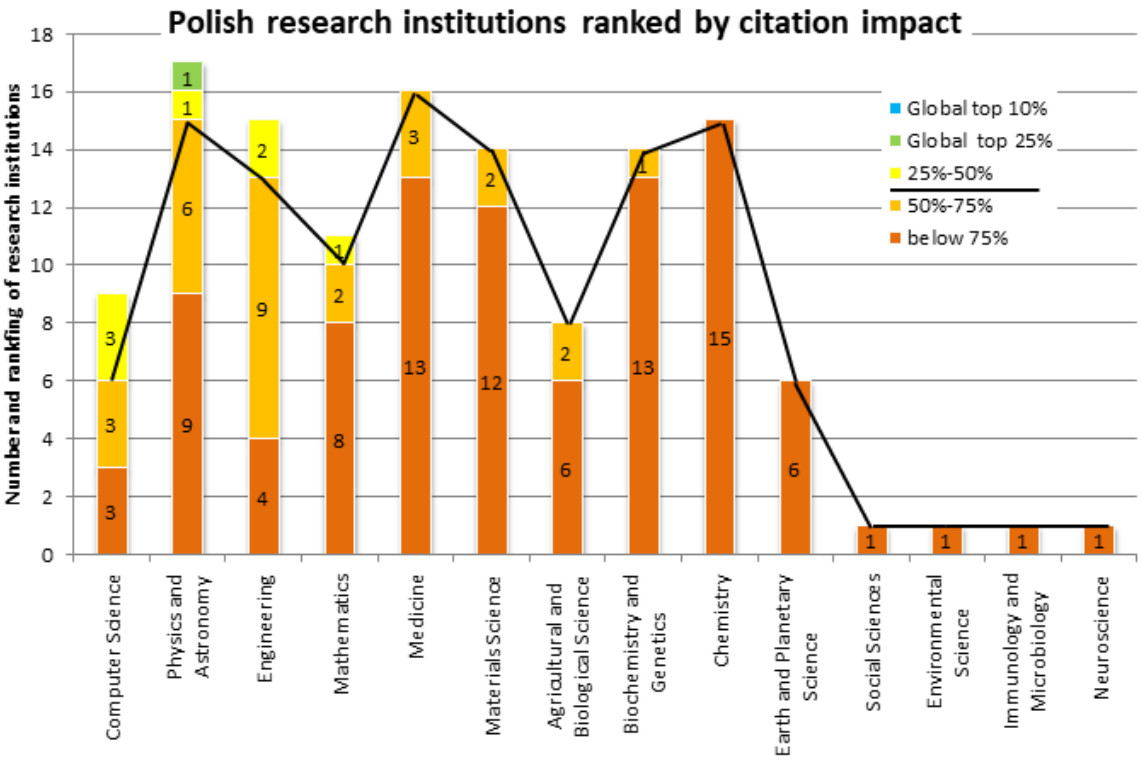


Figure 46. Polish research institutions ranked by best journal rates

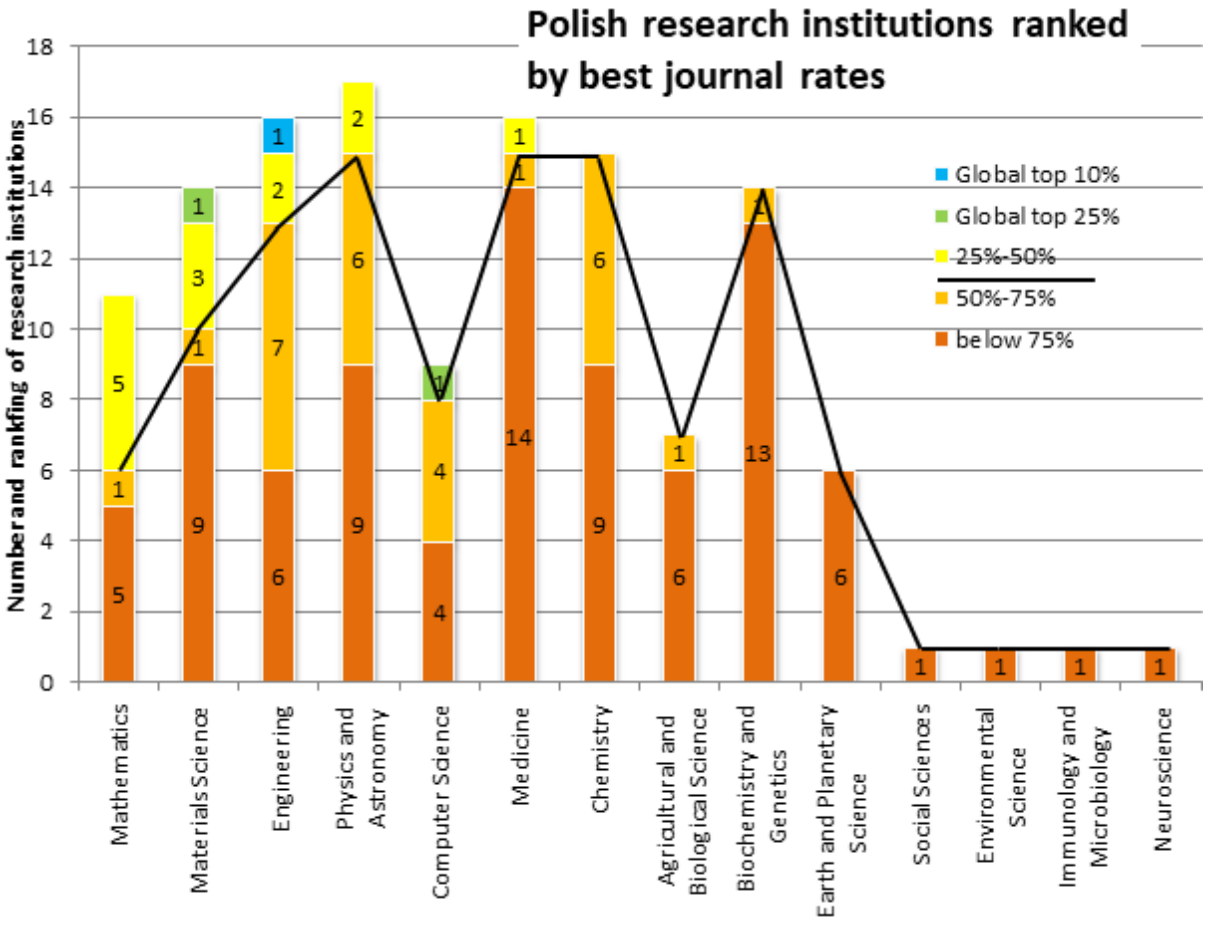


Figure 47. Swedish research institutions ranked by citation impact

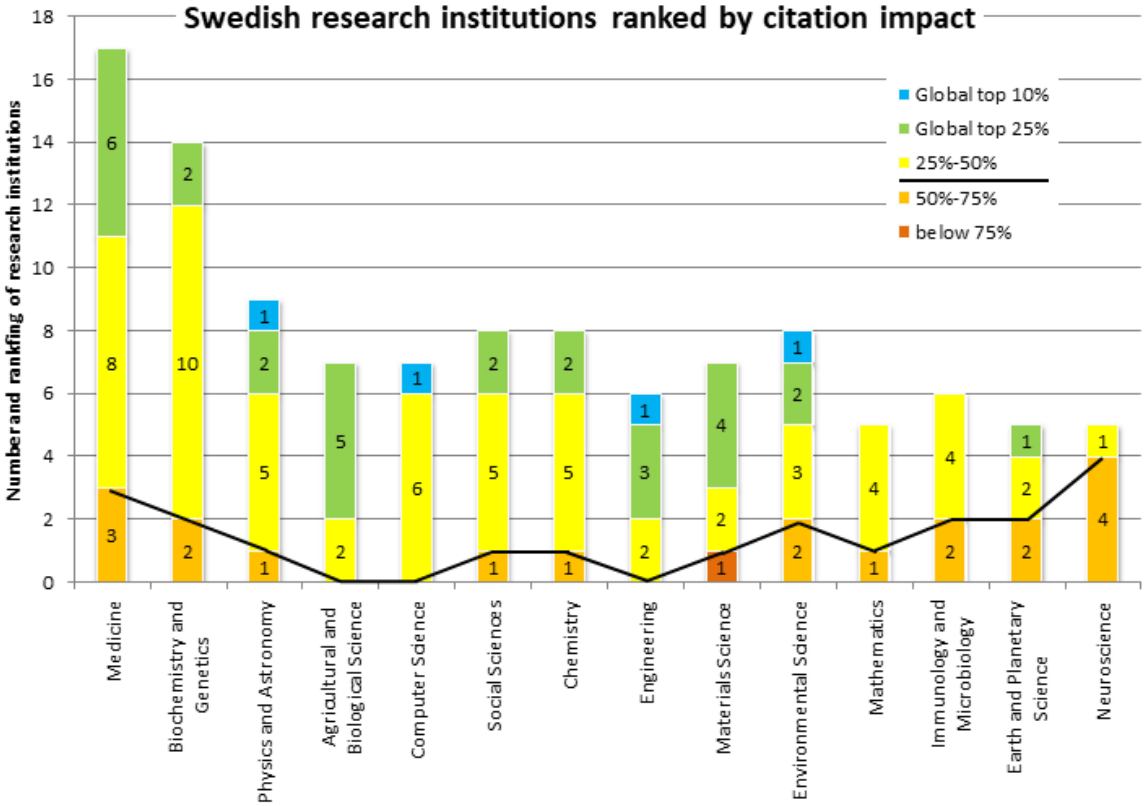
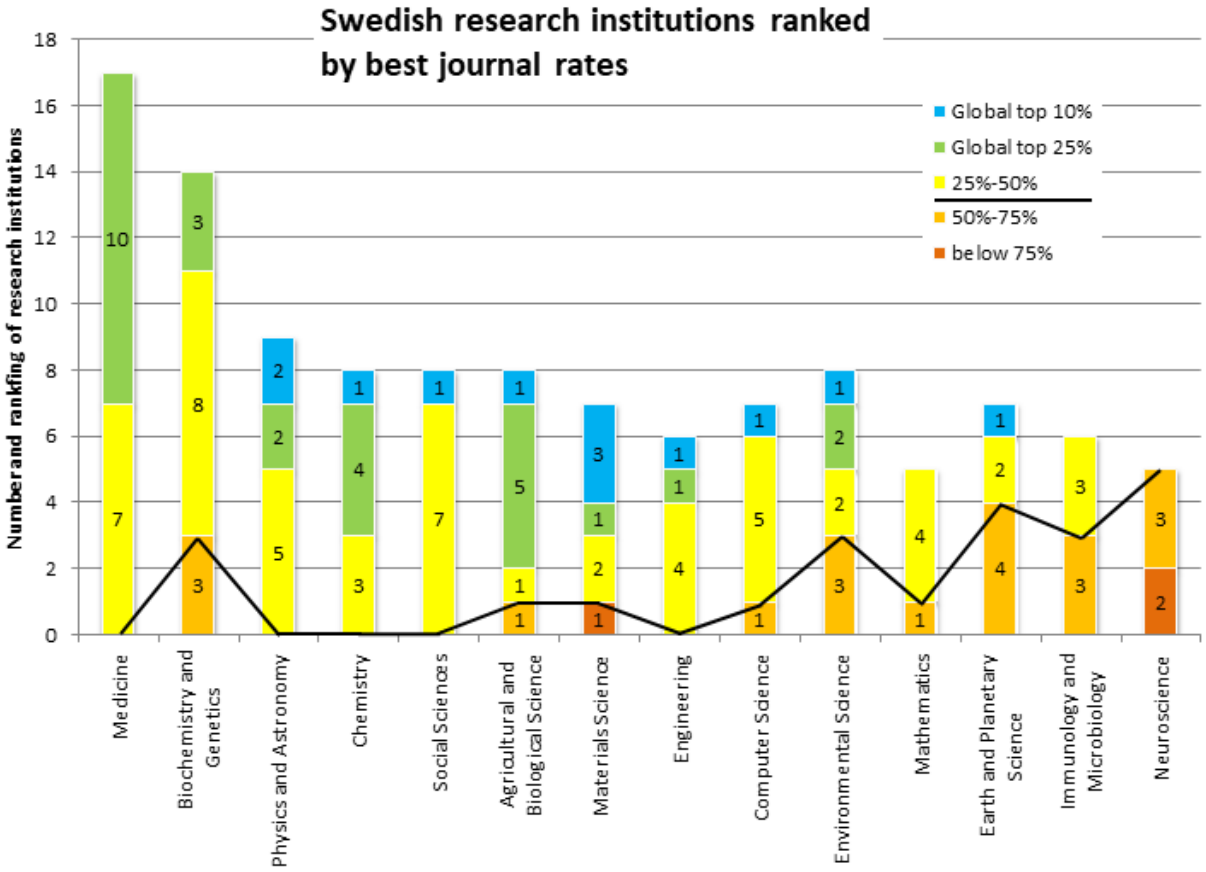
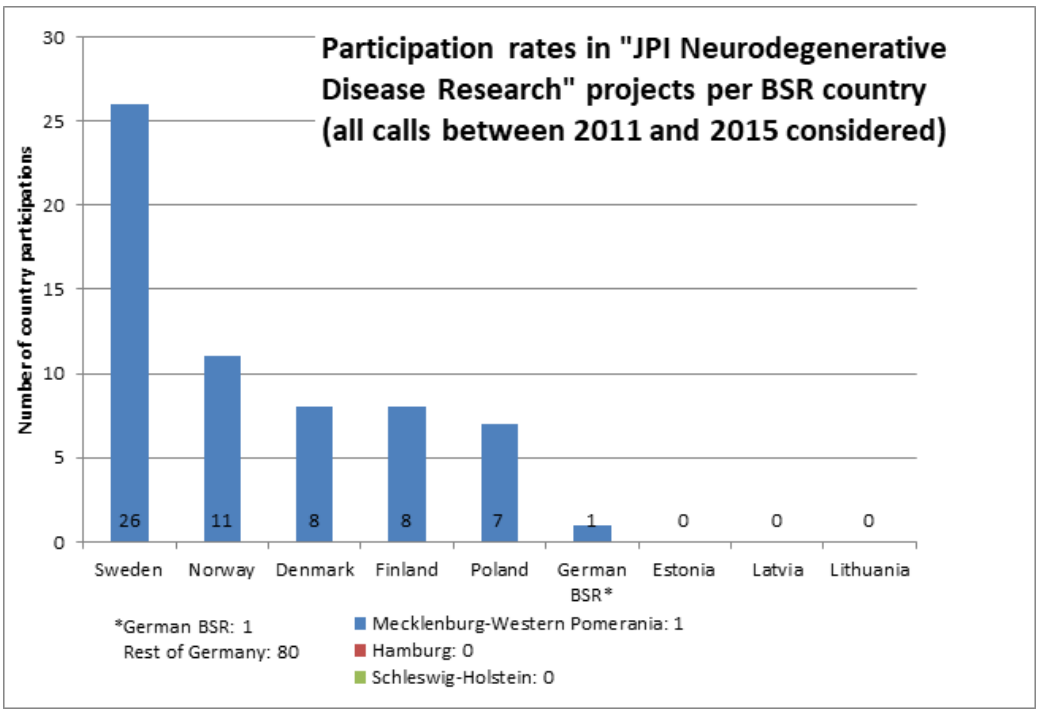


Figure 48. Swedish research institutions ranked by best journal rates



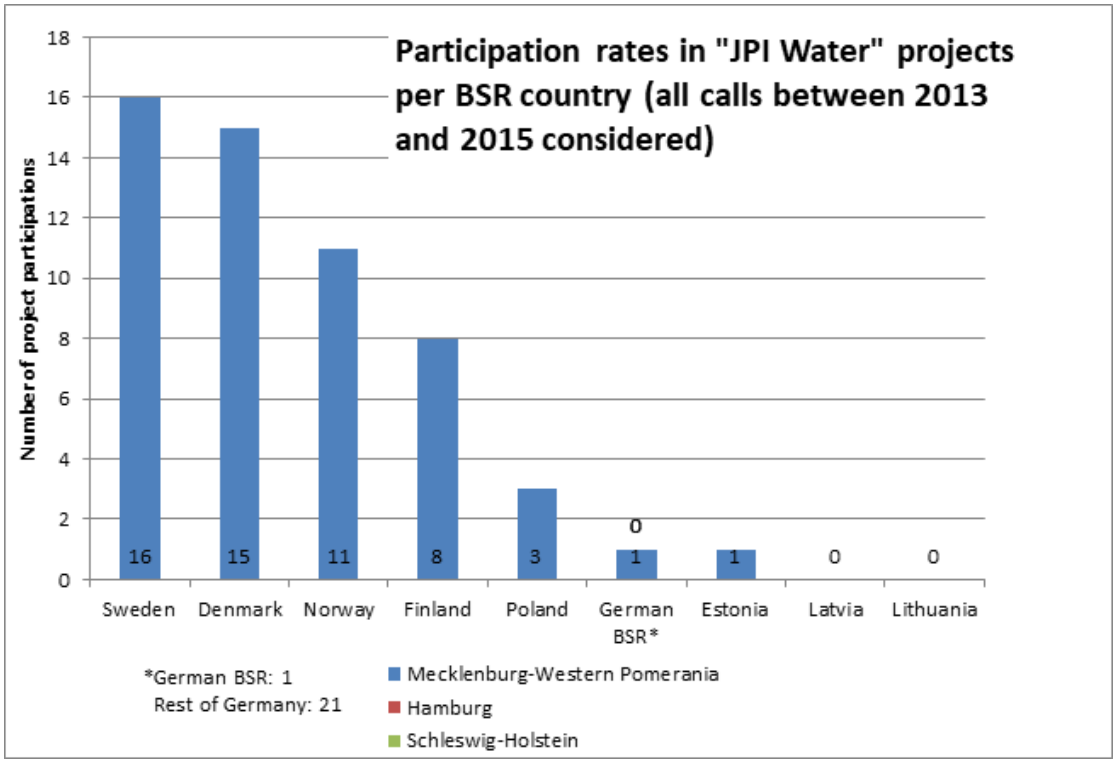
Results of the JPI participation

Figure 49. Participation rates in "JPI Neurodegenerative Disease Research" projects per BSR country



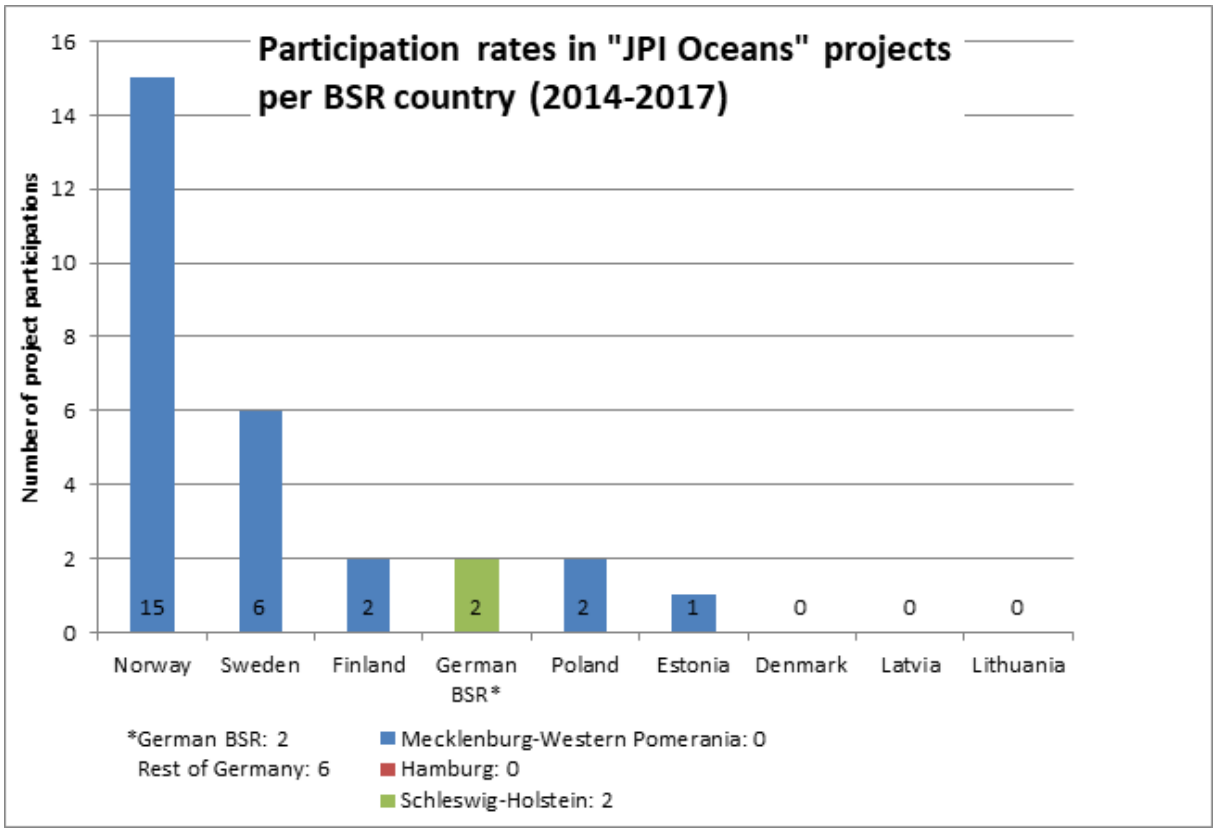
Source: Own calculation, based on: www.neurodegenerationresearch.eu

Figure 50. Participation rates in "JPI Water" projects per BSR country



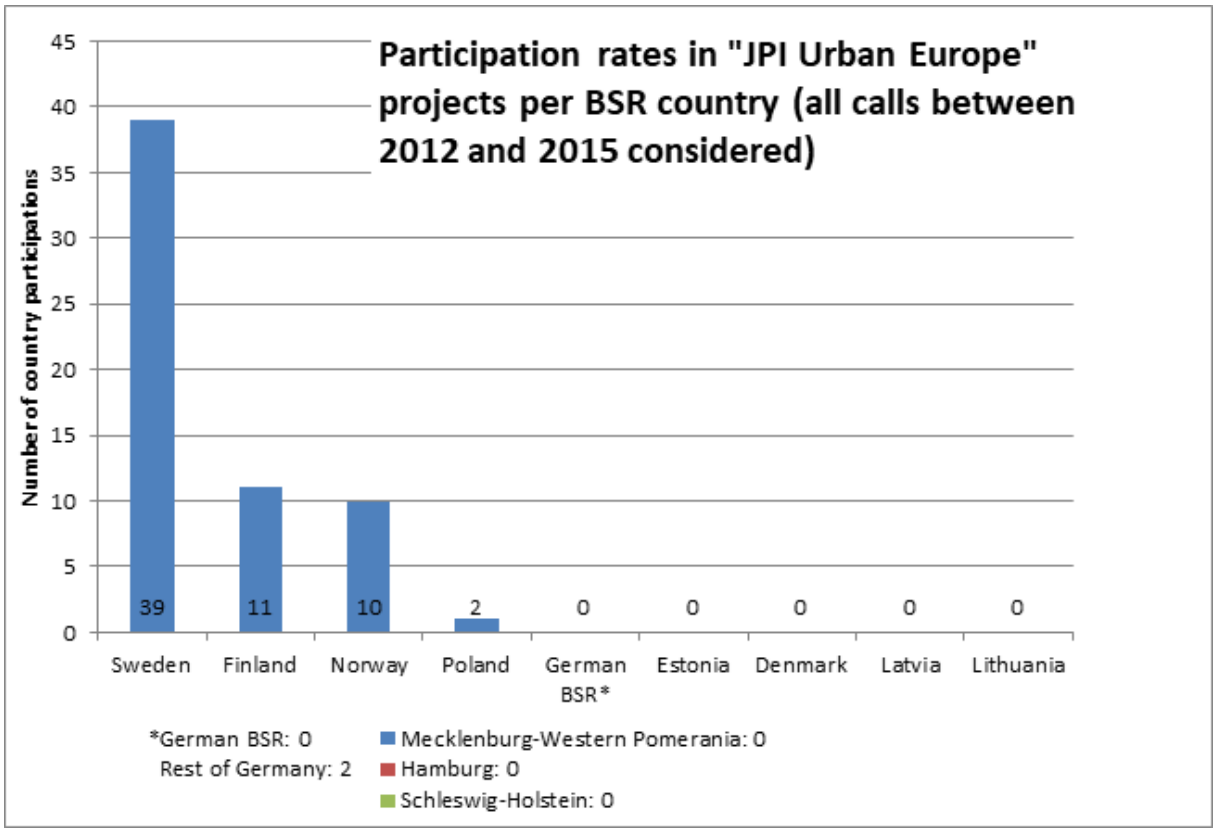
Source: Own calculation, based on: www.waterjpi.eu

Figure 51. Participation rates in "JPI Oceans" projects per BSR country



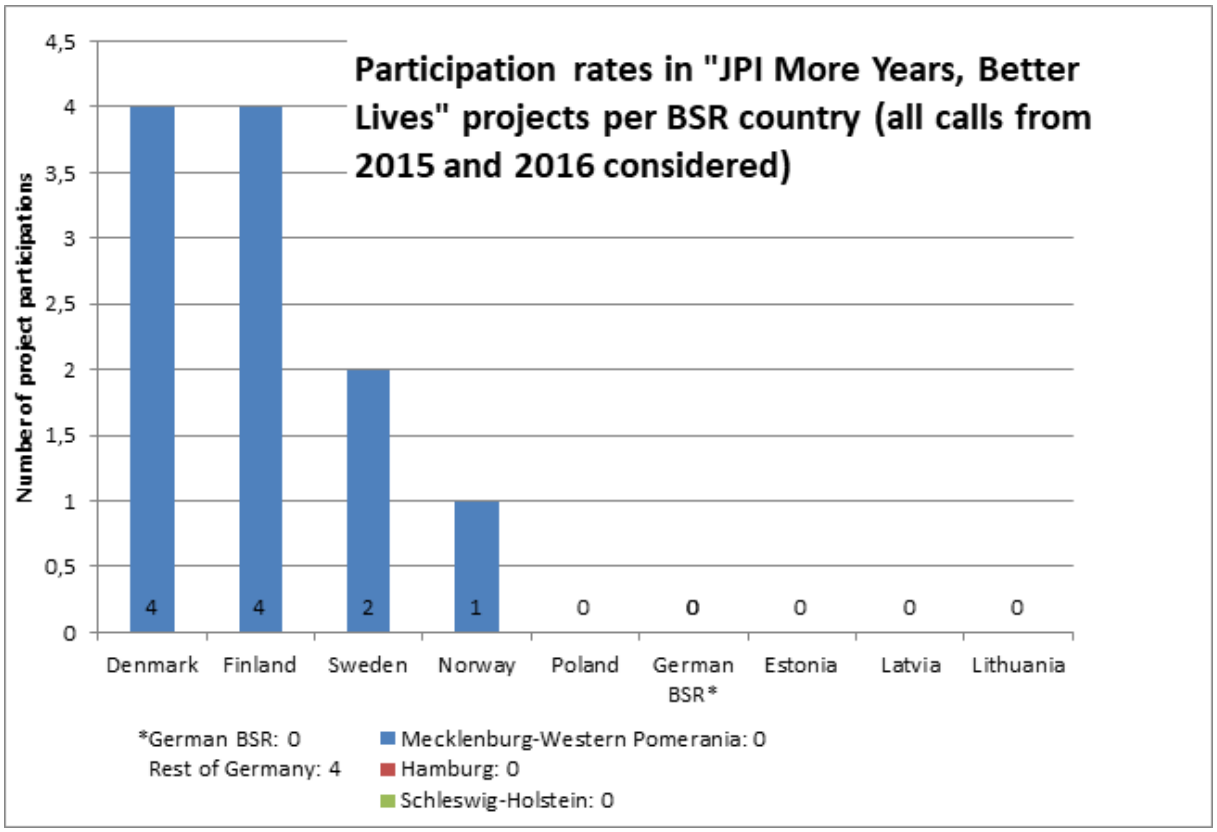
Source: Own calculation, based on: www.jpi-oceans.eu

Figure 52. Participation rates in "JPI Urban Europe" projects per BSR country



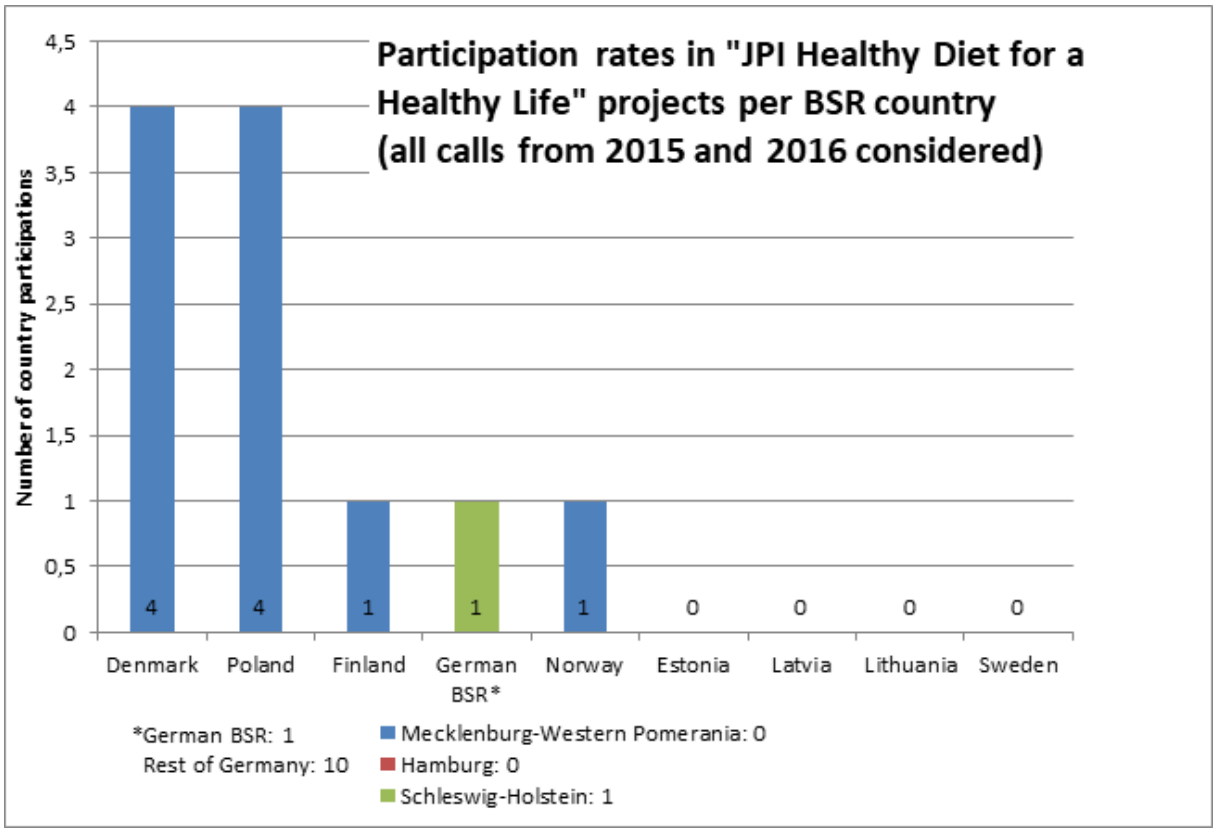
Source: Own calculation, based on: www.jpi-urbaneurope.eu

Figure 53. Participation rates in "JPI More Years, Better Lives" projects per BSR country



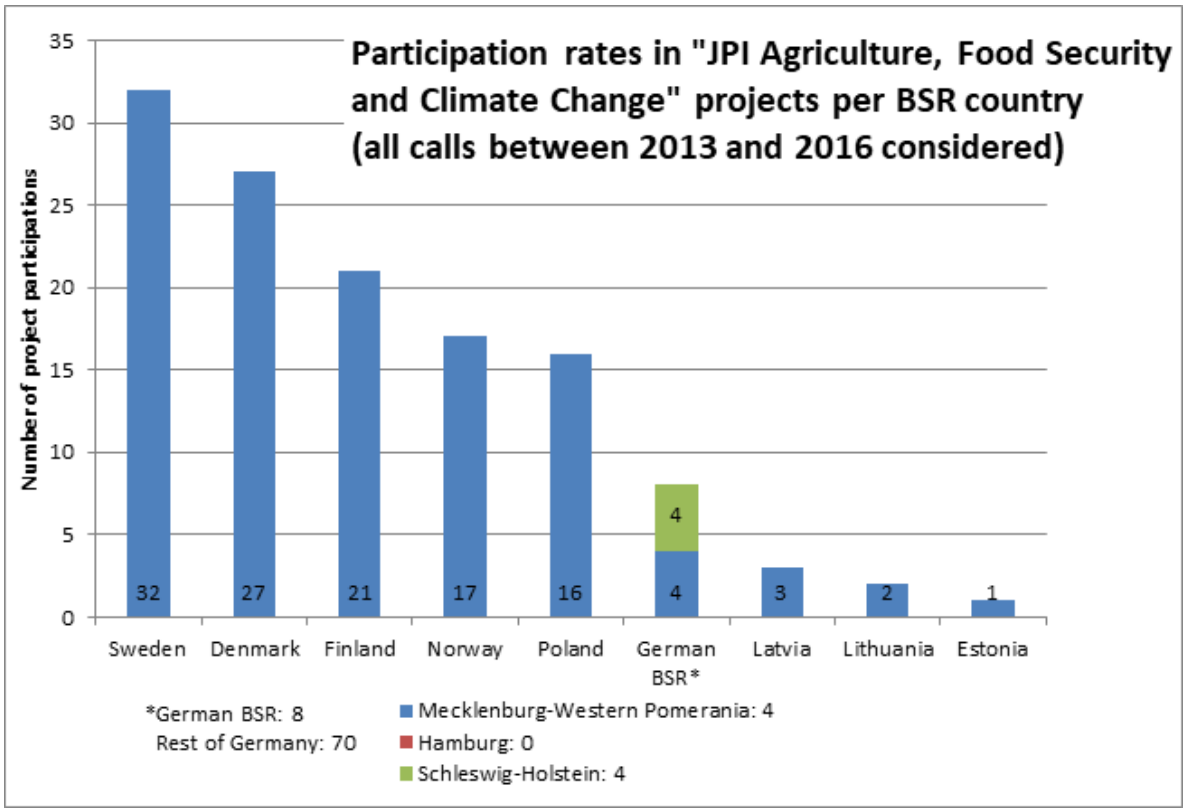
Source: Own calculation, based on: www.jp-demographic.eu

Figure 54. Participation rates in "JPI Healthy Diet for a Healthy Life" projects per BSR country



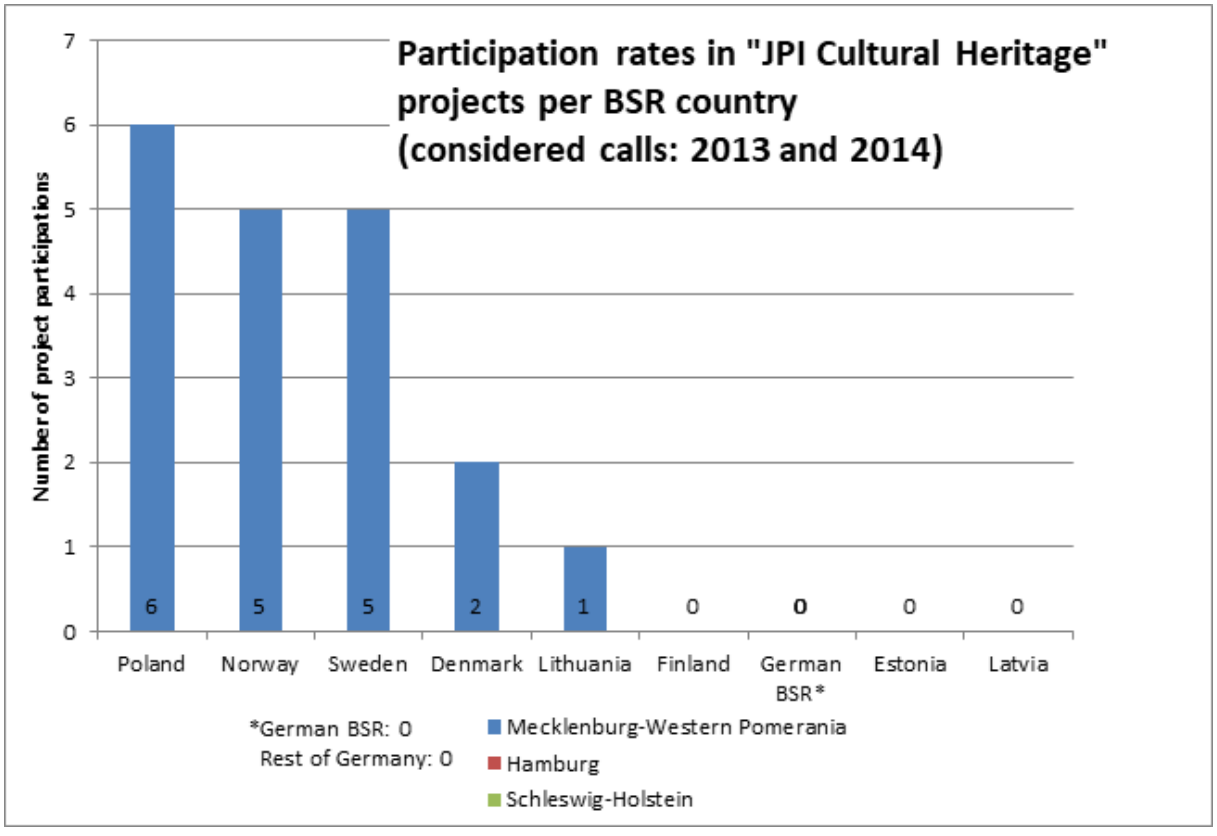
Source: Own calculation, based on: www.healthydietforhealthylife.eu

Figure 55. Participation rates in "JPI Agriculture, Food Security and Climate Change" projects per BSR country



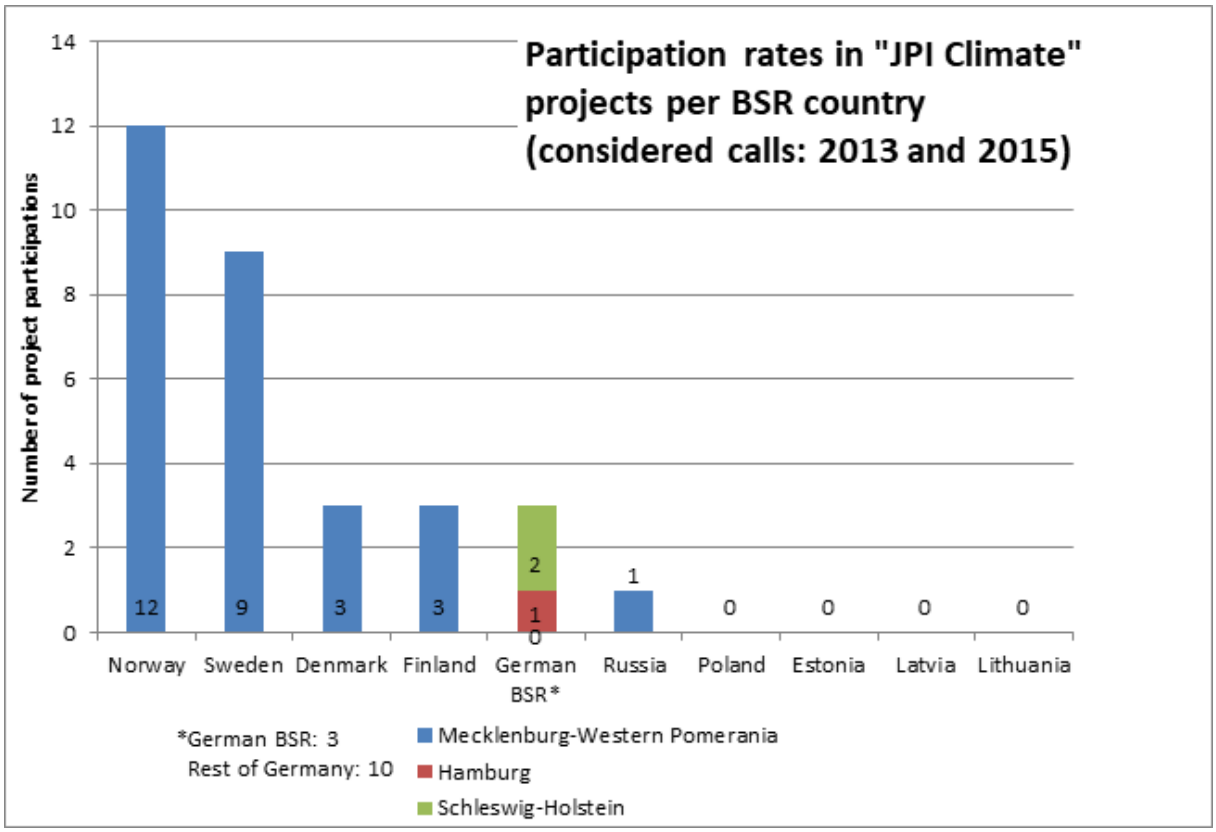
Source: Own calculation, based on: www.faccejpi.com

Figure 56. Participation rates in "JPI Cultural Heritage" projects per BSR country



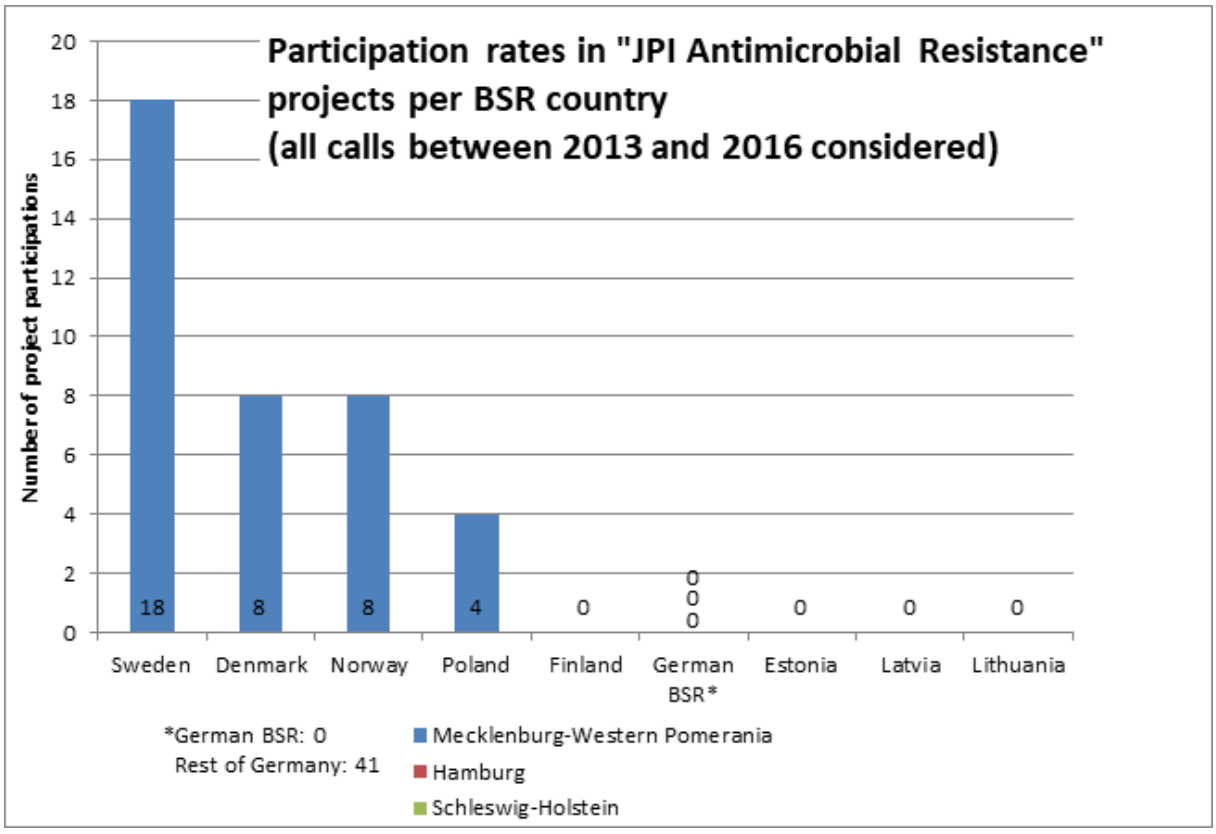
Source: Own calculation, based on: www.jpi-culturalheritage.eu

Figure 57. Participation rates in "JPI Climate" projects per BSR country



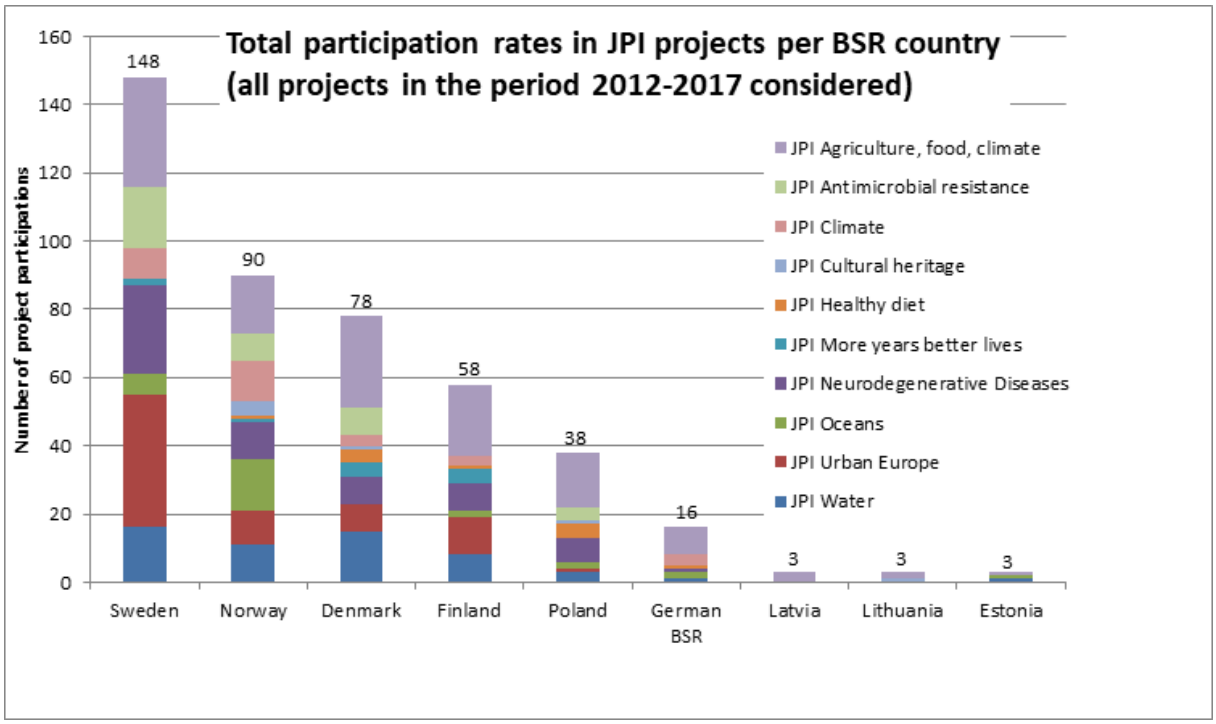
Source: Own calculation, based on: www.jpi-climate.eu

Figure 58. Participation rates in "JPI Antimicrobial Resistance" projects per BSR country



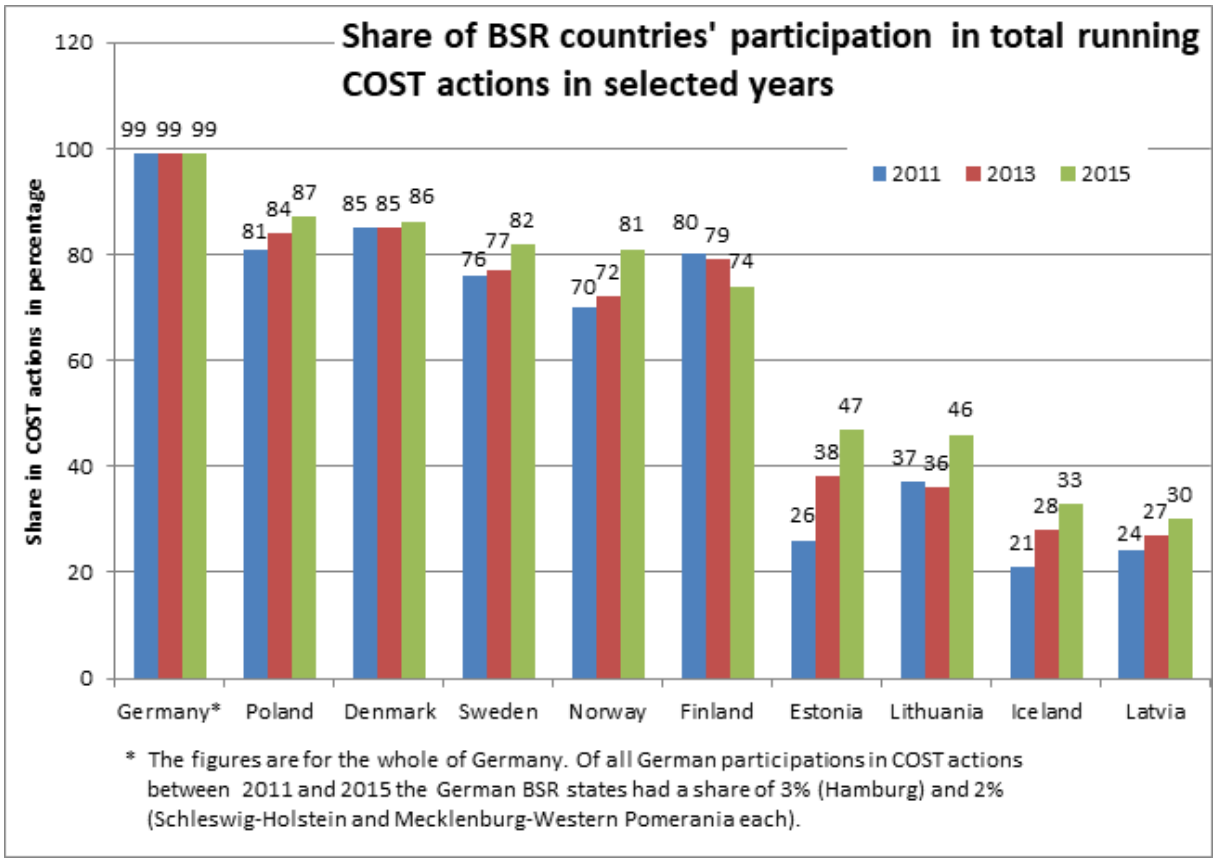
Source: Own calculation, based on: www.jpiamr.eu

Figure 59. Total participation rates in JPI projects per BSR country



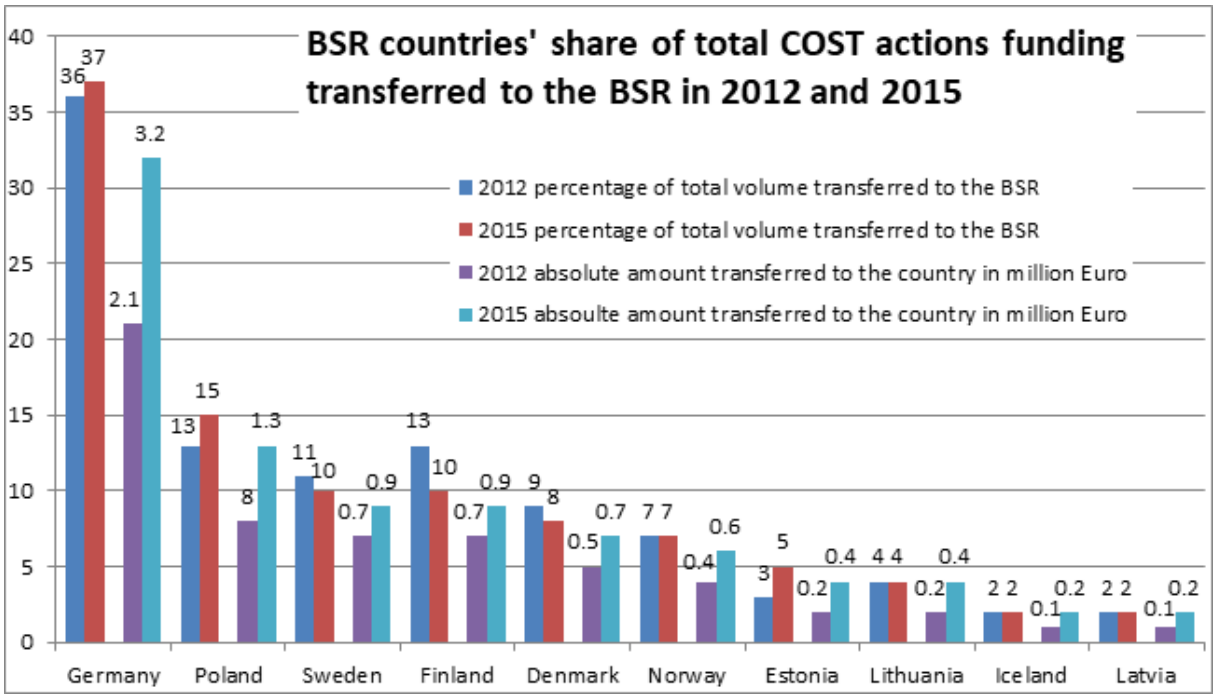
Results of the COST participation

Figure 60. Share of BSR countries' participation in COST actions



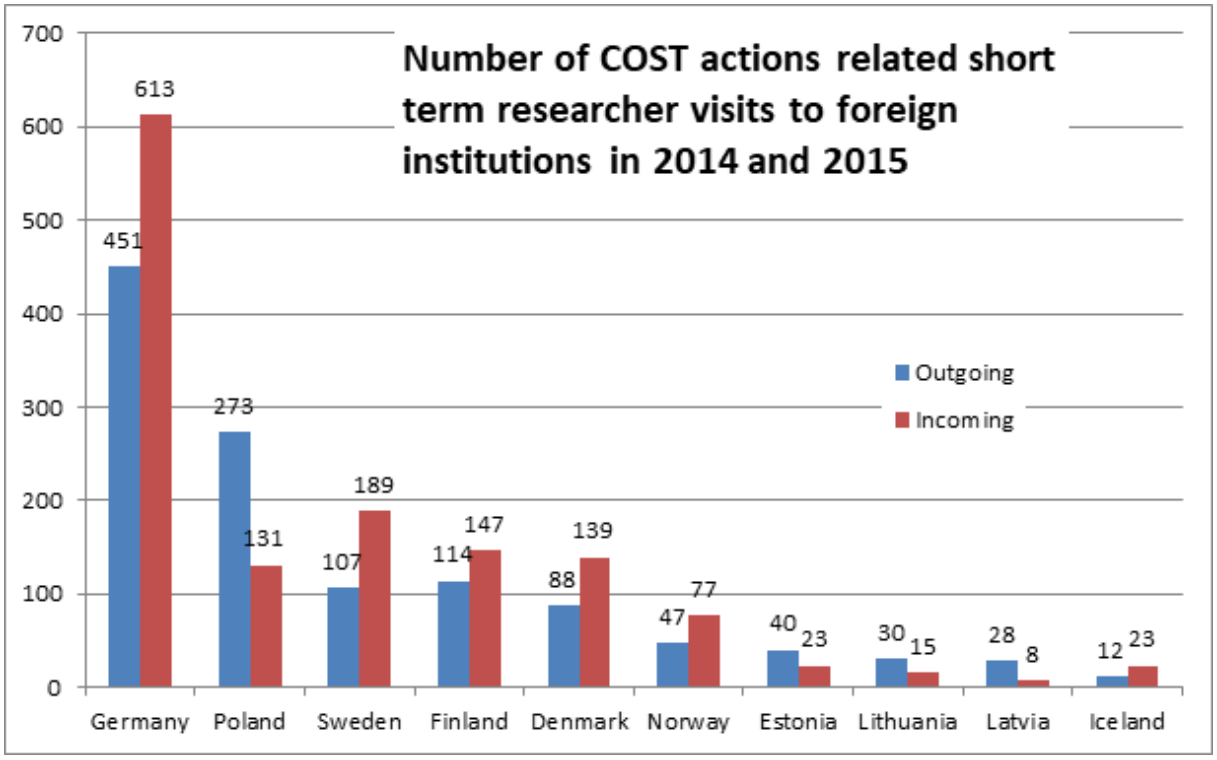
Source: Own calculation, based on: www.cost.eu

Figure 61. BSR countries' share of total COST actions funding



Source: Own calculation, based on: www.cost.eu

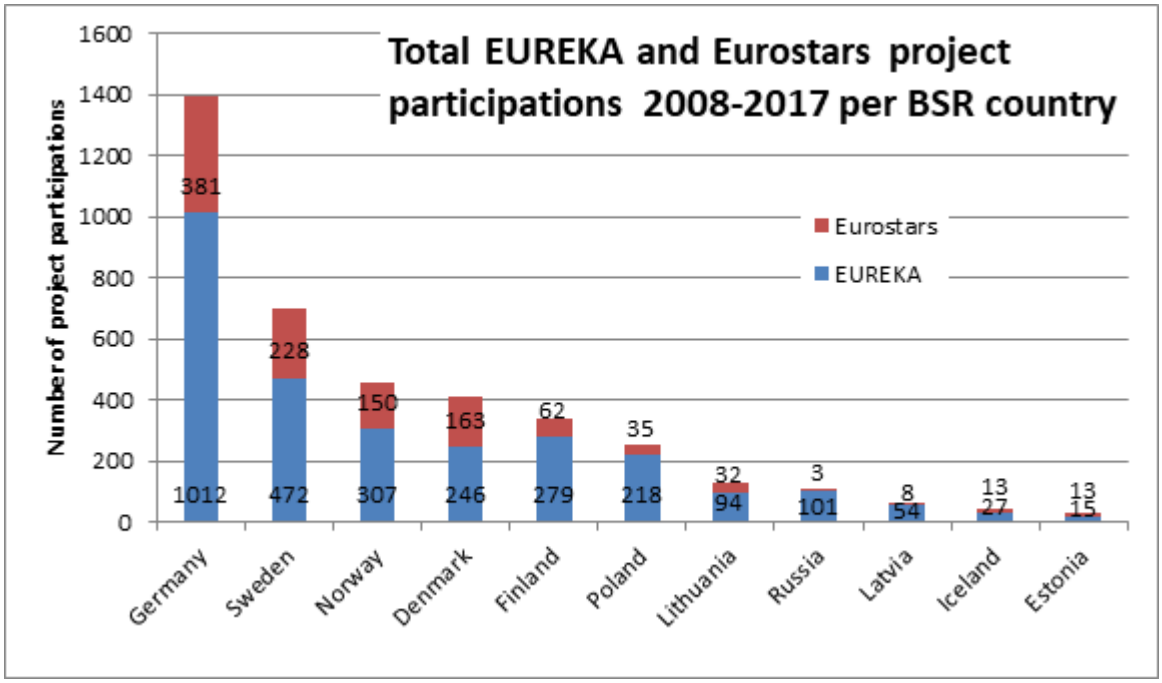
Figure 62. COST actions related short term researcher mobility by BSR country



Source: Own calculation, based on: www.cost.eu

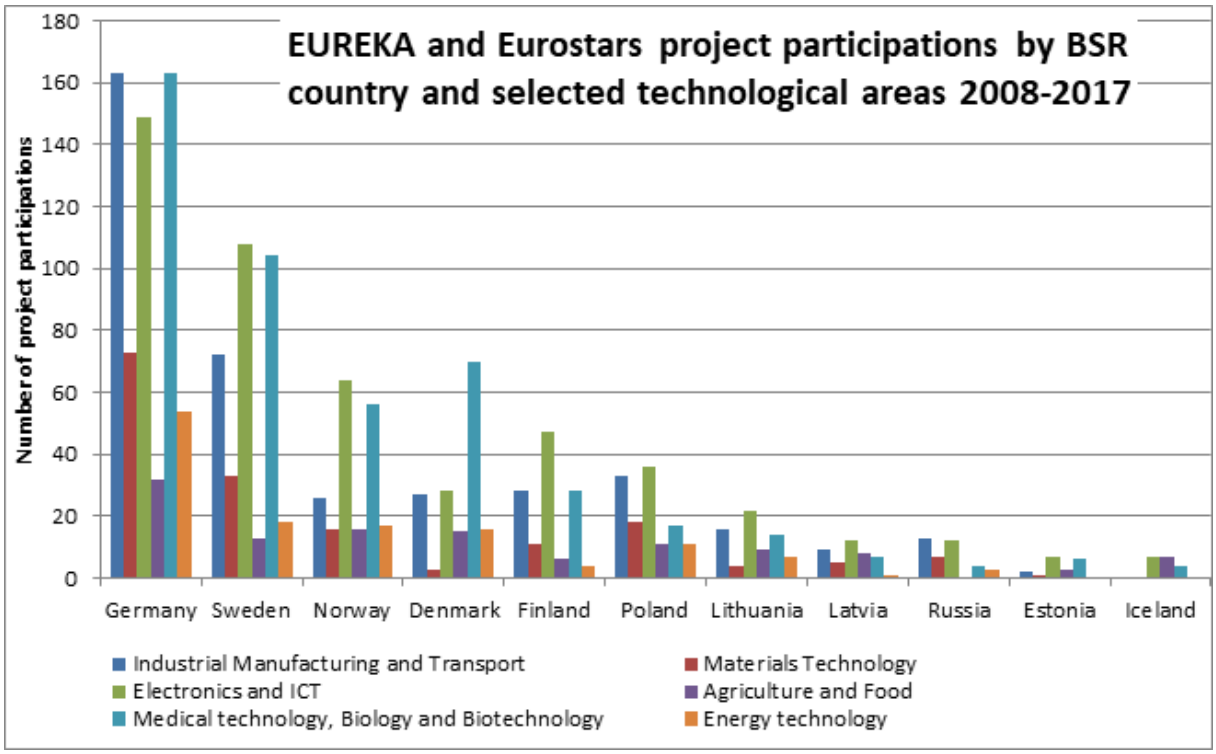
Results of the EUREKA participation

Figure 63. Number of EUREKA and Eurostars project participations per BSR country



Source: Own calculation, based on: www.eurekanetwork.org

Figure 64. EUREKA and Eurostars projects participations by BSR country and technological areas



Source: Own calculation, based on: www.eurekanetwork.org

Excellencemapping.net – evaluation by individual research institutions

Classifications:

Global top 10%
Global top 25%
Global top 50%
Below global average (50%-75%)
Far below global average (75%-100%)

Table 6. Agricultural and biological sciences: citation impact

Agricultural and Biological Sciences: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 42 ranking	Position in Global 729 ranking
Umea University	SWE	1027	22.9%	1	156
Lund University	SWE	2007	22.4%	2	163
Stockholm University	SWE	1416	22.2%	3	168
University of Tartu	EST	876	22.1%	4	171
Technical University of Denmark	DNK	1626	22.1%	5	172
Karolinska Institute	SWE	1104	22.1%	6	174
Uppsala University	SWE	1829	22.0%	7	180
Aarhus University	DNK	3535	21.8%	8	187
University of Oslo	NOR	1611	21.1%	9	208
University of Southern Denmark	DNK	599	21.0%	10	209
University of Copenhagen	DNK	4508	20.8%	11	214
Swedish University of Agricultural Sciences	SWE	3898	20.1%	12	239
Universitat Hamburg	DEU	1359	19.8%	13	247
University of Helsinki	FIN	3650	19.7%	14	252
University of Gothenburg	SWE	1262	19.1%	15	269
Christian-Albrechts-Universitat zu Kiel	DEU	1467	18.9%	16	280
MTT Agrifood Research Finland	FIN	601	18.9%	17	283
Norwegian University of Science and Technology	NOR	973	18.2%	18	302
Norwegian Institute for Nature Research	NOR	609	18.1%	19	307
University of Bergen	NOR	1479	17.3%	20	328
Norwegian University of Life Sciences	NOR	1917	17.0%	21	341
Ernst-Moritz-Arndt-Universitat Greifswald	DEU	516	16.8%	22	351
University of Turku	FIN	1112	16.6%	23	361
University of Tromso	NOR	924	16.4%	24	375
University of Oulu	FIN	761	16.1%	25	382
Institute of Marine Research	NOR	861	15.9%	27	386
Universitat Rostock	DEU	635	15.7%	28	391
University of Eastern Finland	FIN	1012	15.7%	29	392
University of Jyvaskyla	FIN	599	15.7%	30	394
Estonian University of Life Sciences	EST	689	13.9%	31	443
NOFIMA	NOR	600	13.4%	32	460
Jagiellonian University	POL	887	12.0%	33	489
Finnish Forest Research Institute	FIN	837	11.1%	34	516
Adam Mickiewicz University	POL	650	10.6%	35	528
Polish Academy of Sciences	POL	3039	9.2%	36	559
Warsaw University of Life Sciences	POL	924	7.4%	37	613
University of Life Sciences in Poznan	POL	1054	7.3%	38	617
University of Agriculture in Krakow	POL	761	5.5%	39	668
University of Warmia and Mazury	POL	868	5.4%	40	675
University of Life Sciences in Lublin	POL	607	3.5%	41	712
Latvia University of Agriculture	LVA	541	1.3%	42	729

Table 7. Agricultural and biological sciences: best journal rate

Agricultural and Biological Sciences: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 42 ranking	Position in global 729 ranking
Karolinska Institute	SWE	1104	95.5%	1	4
Umea University	SWE	1027	85.5%	2	92
Stockholm University	SWE	1416	84.1%	3	109
Technical University of Denmark	DNK	1626	83.8%	4	122
Uppsala University	SWE	1829	83.0%	5	134
Lund University	SWE	2007	82.2%	6	146
University of Oslo	NOR	1611	81.8%	7	150
University of Gothenburg	SWE	1262	81.3%	8	153
Finnish Forest Research Institute	FIN	837	81.0%	9	159
University of Southern Denmark	DNK	599	81.0%	10	160
Aarhus University	DNK	3535	78.2%	11	208
University of Copenhagen	DNK	4508	77.0%	12	229
University of Helsinki	FIN	3650	76.4%	13	238
University of Jyvaskyla	FIN	599	76.2%	14	245
University of Oulu	FIN	761	76.2%	15	247
Swedish University of Agricultural Sciences	SWE	3898	74.6%	16	264
NOFIMA	NOR	600	74.4%	17	270
Universitat Hamburg	DEU	1359	74.2%	18	273
University of Tromso	NOR	924	74.2%	19	274
University of Turku	FIN	1112	73.9%	20	281
University of Eastern Finland	FIN	1012	73.5%	21	283
Ernst-Moritz-Arndt-Universitat Greifswald	DEU	516	73.2%	22	291
Christian-Albrechts-Universitat zu Kiel	DEU	1467	73.1%	23	293
Institute of Marine Research	NOR	861	72.6%	24	303
Norwegian University of Science and Technology	NOR	973	72.2%	25	311
University of Bergen	NOR	1479	71.3%	27	324
Norwegian University of Life Sciences	NOR	1917	70.7%	28	330
University of Tartu	EST	876	69.0%	29	358
Universitat Rostock	DEU	635	68.6%	30	364
Norwegian Institute for Nature Research	NOR	609	66.8%	31	390
MTT Agrifood Research Finland	FIN	601	63.1%	32	429
Swedish Museum of Natural History	SWE	584	53.7%	33	502
Jagiellonian University	POL	887	49.0%	34	535
Polish Academy of Sciences	POL	3039	43.1%	35	568
Estonian University of Life Sciences	EST	689	41.2%	36	580
Adam Mickiewicz University	POL	650	36.8%	37	606
University of Agriculture in Krakow	POL	761	28.0%	38	646
University of Life Sciences in Poznan	POL	1054	27.6%	39	649
University of Warmia and Mazury	POL	868	22.4%	40	673
University of Life Sciences in Lublin	POL	607	14.5%	41	713
Latvia University of Agriculture	LVA	541	3.5%	42	729

Table 8. Arts and humanities: citation impact

Arts and Humanities: Best Paper Rate (proportion of publications that belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 9 ranking	Position in global 224 ranking
University of Bergen	NOR	660	30.8%	1	30
University of Copenhagen	DNK	1007	29.6%	2	40
Stockholm University	SWE	884	27.9%	3	48
Aarhus University	DNK	965	27.3%	4	58
Lund University	SWE	678	25.6%	5	81
Universitat Hamburg	DEU	568	23.7%	6	115
University of Gothenburg	SWE	531	23.2%	7	126
University of Helsinki	FIN	1068	22.1%	8	142
University of Oslo	NOR	878	17.9%	9	184

Table 9. Arts and humanities: best journal rate

Arts and Humanities: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 9 ranking	Position in global 224 ranking
Lund University	SWE	678	67.6%	1	66
Universitat Hamburg	DEU	568	66.1%	2	81
Stockholm University	SWE	884	64.9%	3	90
University of Bergen	NOR	660	62.8%	4	122
University of Helsinki	FIN	1068	60.0%	5	149
University of Gothenburg	SWE	531	59.5%	6	153
University of Copenhagen	DNK	1007	59.0%	7	157
Uppsala University	SWE	616	53.7%	8	177
University of Oslo	NOR	878	49.9%	9	189

Table 10. Biochemistry, genetics and molecular biology: citation impact

Biochemistry, Genetics and Molecular Biology: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 61 ranking	Position in Global 1041 ranking
University of Iceland	ISL	537	33.3%	1	12
Novo Nordisk A/S	DNK	725	31.2%	2	16
National Institute for Health and Welfare	FIN	896	24.5%	3	70
Universitätsklinikum Schleswig-Holstein	DEU	823	23.9%	4	82
Kuopio University Hospital	FIN	536	23.3%	5	95
Danish Cancer Society	DNK	548	21.8%	6	141
Tampere University Hospital	FIN	697	20.5%	7	171
Copenhagen University Hospital	DNK	2885	20.3%	8	178
Helsinki University Central Hospital	FIN	1317	20.0%	9	191
Odense University Hospital	DNK	696	19.6%	10	207
Christian-Albrechts-Universitat zu Kiel	DEU	1679	19.6%	11	208
Skane University Hospital	SWE	1395	19.6%	12	211
University of Copenhagen	DNK	6066	19.0%	13	243
Karolinska University Hospital	SWE	2237	19.0%	14	246
University of Tartu	EST	918	18.8%	15	251
Universitat zu Lubeck	DEU	873	18.7%	16	264
University of Tampere	FIN	829	18.4%	17	276
Karolinska Institute	SWE	6531	18.3%	18	282
Technical University of Denmark	DNK	1751	18.3%	19	284
Uppsala University Hospital	SWE	608	17.9%	20	303
Oslo University Hospital	NOR	2045	17.9%	21	304
University of Eastern Finland	FIN	1327	17.9%	22	308
University of Helsinki	FIN	4106	17.8%	23	317
Chalmers University of Technology	SWE	643	17.7%	24	320
Umea University	SWE	1779	17.6%	25	325
Haukeland University Hospital	NOR	751	17.5%	26	336
Universitat Hamburg	DEU	2668	17.0%	27	364
University of Southern Denmark	DNK	1747	16.8%	28	375
University of Tromso	NOR	898	16.8%	29	376
University of Oulu	FIN	1121	16.4%	30	402
University of Gothenburg	SWE	2428	16.3%	31	408
Uppsala University	SWE	3936	16.1%	32	415
Norwegian University of Science and Technology	NOR	1092	16.1%	33	416
Aarhus University	DNK	4311	15.9%	34	430
Royal Institute of Technology	SWE	854	15.9%	35	432

Lund University	SWE	3593	15.5%	36	453
University of Oslo	NOR	2890	15.2%	37	469
University of Bergen	NOR	1582	15.2%	38	470
Stockholm University	SWE	1602	15.2%	39	471
University of Turku	FIN	1630	14.8%	40	487
Sahlgrenska University Hospital	SWE	711	14.6%	41	494
Ernst-Moritz-Arndt-Universitat Greifswald	DEU	1233	14.3%	42	509
Swedish University of Agricultural Sciences	SWE	1553	13.4%	43	574
Universitat Rostock	DEU	1178	12.4%	44	629
Linkoping University	SWE	1182	12.3%	45	634
Maria Sklodowska-Curie Memorial Institute of Oncology	POL	570	12.1%	46	640
Norwegian University of Life Sciences	NOR	864	11.2%	47	694
University of Warsaw	POL	832	8.6%	48	806
Medical University of Silesia	POL	589	8.5%	49	808
Medical University of Warsaw	POL	697	7.6%	50	864
Jagiellonian University	POL	1659	7.4%	51	871
Poznan University of Medical Sciences	POL	756	7.4%	52	872
Medical University of Gdansk	POL	745	7.2%	53	882
Adam Mickiewicz University	POL	614	6.8%	54	897
Polish Academy of Sciences	POL	3239	6.7%	55	906
University of Lodz	POL	508	5.8%	56	951
Nicolaus Copernicus University	POL	569	5.6%	57	960
Medical University of Lodz	POL	890	5.5%	58	964
Saint Petersburg State University	RUS	507	4.7%	59	1000
Wroclaw Medical University	POL	841	4.0%	60	1020
Medical University of Lublin	POL	884	3.4%	61	1033

Table 11. Biochemistry, genetics and molecular biology: best journal rate

Biochemistry, Genetics and Molecular Biology: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 61 ranking	Position in global 1041 ranking
Danish Cancer Society	DNK	548	78.0%	1	58
Novo Nordisk A/S	DNK	725	76.8%	2	68
Umea University	SWE	1779	74.6%	3	105
Stockholm University	SWE	1602	72.3%	4	159
University of Iceland	ISL	537	72.0%	5	166
National Institute for Health and Welfare	FIN	896	71.5%	6	185
Karolinska Institute	SWE	6531	71.5%	7	187
Lund University	SWE	3593	68.6%	8	272
Uppsala University	SWE	3936	68.5%	9	276
Universitat zu Lubeck	DEU	873	67.6%	10	304
Oslo University Hospital	NOR	2045	67.3%	11	315
University of Helsinki	FIN	4106	67.3%	12	316
Skane University Hospital	SWE	1395	67.2%	13	320
Haukeland University Hospital	NOR	751	66.8%	14	333

University of Gothenburg	SWE	2428	66.6%	15	335
Royal Institute of Technology	SWE	854	66.4%	16	340
University of Southern Denmark	DNK	1747	66.3%	17	346
Helsinki University Central Hospital	FIN	1317	66.1%	18	354
University of Oslo	NOR	2890	65.9%	19	359
Christian-Albrechts-Universitat zu Kiel	DEU	1679	65.9%	20	361
University of Copenhagen	DNK	6066	64.8%	21	390
University of Tampere	FIN	829	64.7%	22	393
Universitat Hamburg	DEU	2668	64.7%	23	394
Universitatsklinikum Schleswig-Holstein	DEU	823	64.6%	24	401
University of Turku	FIN	1630	64.3%	25	411
Norwegian University of Science and Technology	NOR	1092	64.1%	26	418
Copenhagen University Hospital	DNK	2885	64.0%	27	422
Tampere University Hospital	FIN	697	63.8%	28	429
Karolinska University Hospital	SWE	2237	63.5%	29	433
Kuopio University Hospital	FIN	536	63.5%	30	435
Technical University of Denmark	DNK	1751	62.9%	31	451
University of Oulu	FIN	1121	62.2%	32	470
University of Tromso	NOR	898	62.2%	33	471
University of Bergen	NOR	1582	62.0%	34	481
Odense University Hospital	DNK	696	61.6%	35	497
Sahlgrenska University Hospital	SWE	711	61.3%	36	507
Aarhus University	DNK	4311	60.8%	37	515
Chalmers University of Technology	SWE	643	60.6%	38	519
University of Eastern Finland	FIN	1327	59.3%	39	550
Ernst-Moritz-Arndt-Universitat Greifswald	DEU	1233	58.7%	40	564
Linkoping University	SWE	1182	58.4%	41	575
Uppsala University Hospital	SWE	608	57.6%	42	590
University of Tartu	EST	918	55.7%	43	623
University of Warsaw	POL	832	55.5%	44	627
Swedish University of Agricultural Sciences	SWE	1553	53.2%	45	662
Norwegian University of Life Sciences	NOR	864	49.8%	46	714
Universitat Rostock	DEU	1178	49.7%	47	720
Polish Academy of Sciences	POL	3239	41.1%	48	828
Adam Mickiewicz University	POL	614	39.1%	49	860
Medical University of Gdansk	POL	745	37.1%	50	875
Maria Sklodowska-Curie Memorial Institute of Oncology	POL	570	35.7%	51	895
Jagiellonian University	POL	1659	33.8%	52	912
Medical University of Warsaw	POL	697	32.9%	53	918
Saint Petersburg State University	RUS	507	26.0%	54	959
Nicolaus Copernicus University	POL	569	23.8%	55	976
Poznan University of Medical Sciences	POL	756	22.0%	56	981

University of Lodz	POL	508	21.2%	57	985
Medical University of Silesia	POL	589	21.0%	58	986
Medical University of Lodz	POL	890	20.3%	59	992
Wroclaw Medical University	POL	841	15.6%	60	1018
Medical University of Lublin	POL	884	12.7%	61	1030

Table 12. Business, management and accounting: citation impact

Business, Management and Accounting: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 3 ranking	Position in global 83 ranking
Copenhagen Business School	DNK	694	30.9%	1	17
Aalto University	FIN	634	26.1%	2	41
Aarhus University	DNK	512	21.3%	3	57

Table 13. Business, management and accounting: best journal rate

Business, Management and Accounting: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 3 ranking	Position in global 83 ranking
Copenhagen Business School	DNK	694	55.3%	1	53
Aarhus University	DNK	512	50.0%	2	57
Aalto University	FIN	634	48.8%	3	60

Table 14. Chemical engineering: citation impact

Chemical Engineering: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 13 ranking	Position in Global 317 ranking
Chalmers University of Technology	SWE	828	19.2%	1	58
Technical University of Denmark	DNK	1258	18.9%	2	62
Lund University	SWE	824	17.1%	3	90
Royal Institute of Technology	SWE	941	17.0%	4	92
Uppsala University	SWE	504	14.6%	5	131
Universitat Rostock	DEU	614	14.1%	6	143
Norwegian University of Science and Technology	NOR	845	12.7%	7	188
Abo Academy University	FIN	533	10.9%	8	231
Aalto University	FIN	685	10.1%	9	252
Warsaw University of Technology	POL	575	8.4%	10	281
Wroclaw University of Technology	POL	598	6.1%	11	305
Polish Academy of Sciences	POL	1176	5.3%	12	308
Technical University of Lodz	POL	590	4.1%	13	310

Table 15. Chemical engineering: best journal rate

Chemical Engineering: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 13 ranking	Position in Global 317 ranking
Lund University	SWE	824	74.3%	1	23
Royal Institute of Technology	SWE	941	67.6%	2	85
Technical University of Denmark	DNK	1258	67.6%	3	86
Uppsala University	SWE	504	66.3%	4	103
Chalmers University of Technology	SWE	828	65.0%	5	120
Aalto University	FIN	685	62.9%	6	140
Universitat Rostock	DEU	614	60.6%	7	168
Norwegian University of Science and Technology	NOR	845	60.4%	8	169
Abo Academy University	FIN	533	56.9%	9	195
Polish Academy of Sciences	POL	1176	46.9%	10	255
Warsaw University of Technology	POL	575	40.8%	11	275
Wroclaw University of Technology	POL	598	27.9%	12	307
Technical University of Lodz	POL	590	24.0%	13	310

Table 16. Chemistry: citation impact

Chemistry: Best Paper Rate (proportion of publications that belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 40 ranking	Position in global 794 ranking
Stockholm University	SWE	1312	17.9%	1	134
Technical University of Denmark	DNK	1852	17.2%	2	153
Aarhus University	DNK	1449	16.8%	3	159
Linkoping University	SWE	598	16.0%	4	189
Royal Institute of Technology	SWE	1768	15.3%	5	221
Uppsala University	SWE	1582	15.2%	6	223
Universitat Rostock	DEU	1396	15.1%	7	233
Lund University	SWE	1792	14.8%	8	244
Chalmers University of Technology	SWE	1207	14.4%	9	255
University of Copenhagen	DNK	1652	14.4%	10	259
University of Southern Denmark	DNK	707	13.9%	11	275
University of Jyvaskyla	FIN	581	13.0%	12	322
University of Gothenburg	SWE	574	12.6%	13	344
Christian-Albrechts-Universitat zu Kiel	DEU	896	12.6%	14	347
University of Oslo	NOR	983	12.4%	15	360
Universitat Hamburg	DEU	922	12.0%	16	372
Aalto University	FIN	952	11.1%	17	416
Umea University	SWE	507	10.7%	18	435
University of Helsinki	FIN	1206	10.5%	19	443
University of Eastern Finland	FIN	555	10.1%	20	465
University of Tartu	EST	504	9.0%	21	526
Norwegian University of Science and Technology	NOR	1103	8.9%	22	534
Abo Academy University	FIN	631	7.3%	23	610
Warsaw University of Technology	POL	972	7.1%	24	618
Gdansk University of Technology	POL	611	6.9%	25	630
University of Warsaw	POL	1270	6.3%	26	656
Jagiellonian University	POL	1375	6.1%	27	660
Nicolaus Copernicus University	POL	657	6.0%	28	662
Poznan University of Technology	POL	501	5.9%	29	667
Vilnius University	LTU	508	5.7%	30	691
Polish Academy of Sciences	POL	3493	4.9%	31	718
University of Silesia	POL	735	4.8%	32	724
University of Wroclaw	POL	1069	4.5%	33	732
Wroclaw University of Technology	POL	1025	4.4%	34	736
Adam Mickiewicz University	POL	1257	3.4%	35	761
West Pomeranian University of Technology	POL	601	3.3%	36	764
Saint Petersburg State University	RUS	1441	3.3%	37	766
Technical University of Lodz	POL	908	3.1%	38	769
Maria Curie Sklodowska University	POL	705	2.9%	39	772
AGH University of Science and Technology	POL	678	2.9%	40	773

Table 17. Chemistry: best journal rate

Chemistry: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 40 ranking	Position in global 794 ranking
Stockholm University	SWE	1312	82.2%	1	58
Aarhus University	DNK	1449	81.0%	2	74
Lund University	SWE	1792	79.9%	3	99
Linkoping University	SWE	598	79.4%	4	120
University of Gothenburg	SWE	574	78.6%	5	141
Uppsala University	SWE	1582	78.4%	6	145
University of Southern Denmark	DNK	707	76.7%	7	188
Technical University of Denmark	DNK	1852	76.5%	8	191
Umea University	SWE	507	75.2%	9	222
Chalmers University of Technology	SWE	1207	74.7%	10	232
Royal Institute of Technology	SWE	1768	74.2%	11	249
University of Copenhagen	DNK	1652	73.7%	12	266
University of Helsinki	FIN	1206	72.8%	13	289
University of Jyvaskyla	FIN	581	72.2%	14	301
University of Oslo	NOR	983	71.7%	15	311
Universitat Rostock	DEU	1396	71.5%	16	313
Aalto University	FIN	952	70.6%	17	332
Universitat Hamburg	DEU	922	70.1%	18	340
Norwegian University of Science and Technology	NOR	1103	69.6%	19	349
Abo Academy University	FIN	631	67.9%	20	377
Christian-Albrechts-Universitat zu Kiel	DEU	896	65.5%	21	417
University of Tartu	EST	504	65.4%	22	421
University of Warsaw	POL	1270	64.6%	23	429
University of Eastern Finland	FIN	555	62.3%	24	453
Polish Academy of Sciences	POL	3493	57.9%	25	503
Warsaw University of Technology	POL	972	56.1%	26	519
Jagiellonian University	POL	1375	56.1%	27	519
Gdansk University of Technology	POL	611	52.0%	28	552
University of Wroclaw	POL	1069	48.1%	29	583
Vilnius University	LTU	508	46.0%	30	600
Nicolaus Copernicus University	POL	657	45.0%	31	610
Adam Mickiewicz University	POL	1257	44.6%	32	611
Wroclaw University of Technology	POL	1025	43.7%	33	621
AGH University of Science and Technology	POL	678	42.0%	34	632
University of Silesia	POL	735	40.7%	35	641
Maria Curie Sklodowska University	POL	705	40.2%	36	647
Poznan University of Technology	POL	501	35.8%	37	685
Saint Petersburg State University	RUS	1441	34.4%	38	695
Technical University of Lodz	POL	908	32.6%	39	706
West Pomeranian University of Technology	POL	601	25.3%	40	744

Table 18. Computer science: citation impact

Computer Science: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 40 ranking	Position in global 998 ranking
Uppsala University	SWE	1266	22.6%	1	80
University of Copenhagen	DNK	930	21.1%	2	119
Aarhus University	DNK	1084	20.7%	3	130
Helsinki Institute for Information Technology	FIN	607	19.5%	4	170
University of Bergen	NOR	917	19.2%	5	189
IT University of Copenhagen	DNK	653	18.8%	6	201
University of Oslo	NOR	1473	18.7%	7	207
University of Southern Denmark	DNK	658	18.5%	8	214
University of Helsinki	FIN	1122	17.9%	9	253
Blekinge Tekniska Hogskola	SWE	622	17.1%	10	303
Polish Academy of Sciences	POL	1706	16.7%	11	325
Lund University	SWE	1562	16.3%	12	342
SINTEF Group	NOR	617	16.1%	13	350
Technical University of Denmark	DNK	2427	15.8%	14	366
Royal Institute of Technology	SWE	3242	15.6%	15	394
Stockholm University	SWE	577	15.5%	16	399
Linkoping University	SWE	1563	15.4%	17	403
University of Oulu	FIN	1529	15.3%	18	415
University of Eastern Finland	FIN	553	15.3%	19	417
Aalborg University	DNK	2394	14.9%	20	431
University of Jyvaskyla	FIN	651	14.8%	21	437
Norwegian University of Science and Technology	NOR	2324	14.7%	22	443
Chalmers University of Technology	SWE	2001	14.3%	23	467
University of Warsaw	POL	1108	14.2%	24	473
AGH University of Science and Technology	POL	1582	13.9%	25	492
University of Turku	FIN	836	13.8%	26	500
University of Agder	NOR	504	13.8%	27	502
Aalto University	FIN	3472	13.8%	28	503
Christian-Albrechts-Universitat zu Kiel	DEU	690	11.6%	29	625
Tampere University of Technology	FIN	2027	11.2%	30	648
Universitat Hamburg	DEU	968	11.2%	31	649
Poznan University of Technology	POL	1012	11.0%	32	656
Silesian University of Technology	POL	1102	10.5%	33	673
Universitat Rostock	DEU	869	10.3%	34	682
Wroclaw University of Technology	POL	1828	10.2%	35	688
Warsaw University of Technology	POL	2033	8.8%	36	754
Gdansk University of Technology	POL	747	8.4%	37	776
VTT Technical Research Centre of Finland	FIN	1003	7.5%	38	810
Technical University of Lodz	POL	708	6.6%	39	847
Tallinn University of Technology	EST	603	6.0%	40	882

Table 19. Computer science: best journal rate

Computer Science: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 40 ranking	Position in global 998 ranking
University of Bergen	NOR	917	28.4%	1	44
Uppsala University	SWE	1266	27.4%	2	62
University of Copenhagen	DNK	930	26.7%	3	75
Polish Academy of Sciences	POL	1706	23.1%	4	165
University of Southern Denmark	DNK	658	22.6%	5	184
Lund University	SWE	1562	20.5%	6	261
University of Oslo	NOR	1473	20.1%	7	281
University of Helsinki	FIN	1122	20.1%	8	283
Linkoping University	SWE	1563	19.2%	9	330
Aarhus University	DNK	1084	19.2%	10	331
Royal Institute of Technology	SWE	3242	18.6%	11	362
Technical University of Denmark	DNK	2427	18.6%	12	364
Norwegian University of Science and Technology	NOR	2324	18.2%	13	384
University of Eastern Finland	FIN	553	18.0%	14	393
Stockholm University	SWE	577	17.9%	15	398
Helsinki Institute for Information Technology	FIN	607	17.7%	16	407
University of Turku	FIN	836	17.6%	17	409
Chalmers University of Technology	SWE	2001	16.6%	18	476
Christian-Albrechts-Universitat zu Kiel	DEU	690	16.6%	19	477
Universitat Hamburg	DEU	968	16.2%	20	496
SINTEF Group	NOR	617	15.4%	21	543
Aalto University	FIN	3472	15.1%	22	555
University of Warsaw	POL	1108	14.7%	23	567
University of Jyvaskyla	FIN	651	14.4%	24	576
Aalborg University	DNK	2394	13.8%	25	602
University of Oulu	FIN	1529	13.7%	26	608
University of Agder	NOR	504	13.7%	27	610
Blekinge Tekniska Hogskola	SWE	622	13.5%	28	616
Universitat Rostock	DEU	869	11.8%	29	679
Gdansk University of Technology	POL	747	10.3%	30	726
Poznan University of Technology	POL	1012	10.2%	31	727
AGH University of Science and Technology	POL	1582	9.7%	32	746
IT University of Copenhagen	DNK	653	9.6%	33	748
Wroclaw University of Technology	POL	1828	9.5%	34	754
Tampere University of Technology	FIN	2027	8.9%	35	776
Warsaw University of Technology	POL	2033	7.6%	36	824
Technical University of Lodz	POL	708	7.4%	37	828
Tallinn University of Technology	EST	603	7.4%	38	831
VTT Technical Research Centre of Finland	FIN	1003	7.0%	39	843
Silesian University of Technology	POL	1102	5.5%	40	901

Table 20. Earth and planetary sciences: citation impact

Earth and Planetary Sciences: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 26 ranking	Position in global 447 ranking
University of Iceland	ISL	566	28.1%	1	39
Stockholm University	SWE	1822	26.1%	2	68
Aarhus University	DNK	1089	24.0%	3	104
University of Copenhagen	DNK	1995	23.8%	4	109
University of Oslo	NOR	1568	22.8%	5	125
Lund University	SWE	917	21.4%	6	163
Geological Survey of Norway	NOR	516	21.0%	7	177
Royal Institute of Technology	SWE	611	20.0%	8	196
University of Bergen	NOR	1311	19.9%	9	200
Christian-Albrechts-Universität zu Kiel	DEU	1201	19.7%	10	208
University of Helsinki	FIN	1550	19.5%	11	217
Technical University of Denmark	DNK	861	19.3%	12	220
Geological Survey of Denmark and Greenland	DNK	594	17.0%	13	266
Universitat Hamburg	DEU	1282	16.6%	14	271
Finnish Meteorological Institute	FIN	1054	16.6%	15	272
University of Turku	FIN	521	16.0%	16	287
Chalmers University of Technology	SWE	613	14.0%	17	315
Uppsala University	SWE	1044	13.7%	18	322
University of Warsaw	POL	1015	11.0%	19	358
Norwegian University of Science and Technology	NOR	875	10.1%	20	372
Saint Petersburg State University	RUS	805	8.9%	21	388
Jagiellonian University	POL	628	8.5%	22	394
Polish Academy of Sciences	POL	2271	7.5%	23	406
Adam Mickiewicz University	POL	570	5.3%	24	428
Panstwowy Instytut Geologiczny	POL	585	4.6%	25	436
AGH University of Science and Technology	POL	815	4.3%	26	438

Table 21. Earth and planetary sciences: best journal rate

Earth and Planetary Sciences: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 26 ranking	Position in global 447 ranking
Stockholm University	SWE	1822	83.6%	1	44
University of Copenhagen	DNK	1995	79.3%	2	101
University of Bergen	NOR	1311	77.4%	3	131
University of Iceland	ISL	566	77.4%	4	132
Aarhus University	DNK	1089	76.3%	5	154
University of Oslo	NOR	1568	74.6%	6	171
Finnish Meteorological Institute	FIN	1054	73.8%	7	184
Christian-Albrechts-Universitat zu Kiel	DEU	1201	73.6%	8	185
Universitat Hamburg	DEU	1282	72.8%	9	194
University of Turku	FIN	521	71.3%	10	210
University of Helsinki	FIN	1550	71.1%	11	213
Uppsala University	SWE	1044	69.2%	12	237
Lund University	SWE	917	68.0%	13	253
Geological Survey of Norway	NOR	516	65.5%	14	272
Chalmers University of Technology	SWE	613	65.1%	15	274
Geological Survey of Denmark and Greenland	DNK	594	64.5%	16	278
Technical University of Denmark	DNK	861	63.2%	17	287
Royal Institute of Technology	SWE	611	54.3%	18	333
Jagiellonian University	POL	628	51.7%	19	348
University of Warsaw	POL	1015	49.0%	20	361
Polish Academy of Sciences	POL	2271	46.3%	21	370
Norwegian University of Science and Technology	NOR	875	40.6%	22	384
Saint Petersburg State University	RUS	805	35.2%	23	400
Adam Mickiewicz University	POL	570	33.6%	24	405
AGH University of Science and Technology	POL	815	14.8%	25	434
Panstwowy Instytut Geologiczny	POL	585	13.3%	26	437

Table 22. Energy: citation impact

Energy: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 7 ranking	Position in global 178 ranking
Technical University of Denmark	DNK	1382	21.0%	1	18
Chalmers University of Technology	SWE	749	20.3%	2	22
Lund University	SWE	516	18.8%	3	34
Royal Institute of Technology	SWE	1168	17.0%	4	55
Aalborg University	DNK	669	16.6%	5	56
SINTEF Group	NOR	731	9.0%	6	137
Norwegian University of Science and Technology	NOR	1453	8.9%	7	139

Table 23. Energy: best journal rate

Energy: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 7 ranking	Position in global 178 ranking
Lund University	SWE	516	75.7%	1	6
Royal Institute of Technology	SWE	1168	62.1%	2	26
Chalmers University of Technology	SWE	749	60.6%	3	38
Technical University of Denmark	DNK	1382	56.0%	4	54
Norwegian University of Science and Technology	NOR	1453	39.3%	5	129
SINTEF Group	NOR	731	35.0%	6	143
Aalborg University	DNK	669	34.2%	7	145

Table 24. Engineering: citation impact

Engineering: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 53 ranking	Position in global 1330 ranking
University of Copenhagen	DNK	673	34.4%	1	9
Aarhus University	DNK	779	30.9%	2	20
University of Helsinki	FIN	746	28.0%	3	41
Lund University	SWE	2724	25.2%	4	84
University of Oslo	NOR	1162	24.8%	5	94
University of Southern Denmark	DNK	528	23.4%	6	132
Uppsala University	SWE	1497	23.4%	7	134
Universitat Hamburg	DEU	1000	21.4%	8	193
Technical University of Denmark	DNK	4710	21.3%	9	194
Linkoping University	SWE	1985	20.0%	10	258
Royal Institute of Technology	SWE	5608	19.2%	11	301
University of Stavanger	NOR	520	18.9%	12	322
Chalmers University of Technology	SWE	3661	18.7%	13	337
University of Agder	NOR	551	18.5%	14	346
Aalborg University	DNK	3149	18.5%	15	351
Aalto University	FIN	3653	18.3%	16	375
University of Turku	FIN	560	18.2%	17	379
University of Warsaw	POL	614	17.0%	18	465
SINTEF Group	NOR	1342	16.9%	19	471
Christian-Albrechts-Universitat zu Kiel	DEU	679	16.8%	20	477
Norwegian University of Science and Technology	NOR	4114	16.5%	21	499
University of Eastern Finland	FIN	583	16.4%	22	510
Polish Academy of Sciences	POL	2846	15.8%	23	553
Lappeenranta University of Technology	FIN	761	15.3%	24	594
Lulea University of Technology	SWE	1243	14.5%	25	636
University of Oulu	FIN	1478	14.3%	26	657
Tampere University of Technology	FIN	2336	13.1%	27	732
Vilnius University	LTU	536	13.0%	28	743
Technische Universitat Hamburg-Harburg	DEU	1188	12.3%	29	791
VTT Technical Research Centre of Finland	FIN	1699	12.1%	30	803
Saint Petersburg State University	RUS	758	11.6%	31	826
Vilnius Gediminas Technical University	LTU	1055	11.1%	32	854
AGH University of Science and	POL	2136	10.9%	33	864

Technology					
Bialystok University of Technology	POL	719	10.9%	34	867
Silesian University of Technology	POL	1735	10.7%	35	873
Gdansk University of Technology	POL	1184	9.8%	36	925
Wroclaw University of Technology	POL	2516	9.3%	37	945
Warsaw University of Technology	POL	3360	9.3%	38	946
Military University of Technology	POL	891	9.3%	39	947
Universitat Rostock	DEU	952	8.8%	40	968
Poznan University of Technology	POL	1378	8.5%	41	986
Lublin University of Technology	POL	616	8.4%	42	990
University of Latvia	LVA	638	8.3%	43	999
AIRBUS Germany	DEU	791	8.2%	44	1003
West Pomeranian University of Technology	POL	682	8.0%	45	1010
Tallinn University of Technology	EST	1289	7.7%	46	1025
Saint Petersburg State University of Information Technologies, Mechanics and Optics	RUS	651	7.5%	47	1038
Technical University of Lodz	POL	1667	7.2%	48	1053
Tadeusz Kosciuszko Cracow University of Technology	POL	546	6.8%	49	1082
Czestochowa University of Technology	POL	709	6.8%	50	1083
Helmut Schmidt Universitat - Universitat der Bundeswehr Hamburg	DEU	516	6.1%	51	1119
Kaunas University of Technology	LTU	1204	5.3%	52	1164
Riga Technical University	LVA	935	3.6%	53	1236

Table 25. Engineering: best journal rate

Engineering: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 53 ranking	Position in global 1330 ranking
University of Copenhagen	DNK	673	56.6%	1	12
University of Helsinki	FIN	746	50.8%	2	36
Uppsala University	SWE	1497	48.3%	3	60
Aarhus University	DNK	779	48.2%	4	63
University of Oslo	NOR	1162	45.1%	5	108
Polish Academy of Sciences	POL	2846	44.6%	6	117
Lund University	SWE	2724	42.2%	7	189
Universitat Hamburg	DEU	1000	40.8%	8	233
Technical University of Denmark	DNK	4710	39.3%	9	284
University of Southern Denmark	DNK	528	38.7%	10	304
University of Warsaw	POL	614	38.3%	11	614
Royal Institute of Technology	SWE	5608	36.8%	12	380
University of Eastern Finland	FIN	583	36.7%	13	382
SINTEF Group	NOR	1342	36.5%	14	391
Norwegian University of Science and Technology	NOR	4114	36.2%	15	412
Linkoping University	SWE	1985	36.0%	16	420

Chalmers University of Technology	SWE	3661	36.0%	17	421
Lappeenranta University of Technology	FIN	761	35.1%	18	467
University of Stavanger	NOR	520	34.7%	19	487
Aalto University	FIN	3653	34.0%	20	524
University of Turku	FIN	560	33.8%	21	531
Lulea University of Technology	SWE	1243	33.6%	22	536
Christian-Albrechts-Universitat zu Kiel	DEU	679	33.5%	23	540
Vilnius University	LTU	536	33.5%	24	542
University of Oulu	FIN	1478	29.7%	25	677
Technische Universitat Hamburg-Harburg	DEU	1188	28.7%	26	724
VTT Technical Research Centre of Finland	FIN	1699	26.5%	27	796
Technical University of Lodz	POL	1667	26.5%	28	797
Aalborg University	DNK	3149	25.6%	29	820
Saint Petersburg State University	RUS	758	25.5%	30	824
AGH University of Science and Technology	POL	2136	25.1%	31	838
Tadeusz Kosciuszko Cracow University of Technology	POL	546	22.4%	32	908
Tampere University of Technology	FIN	2336	22.4%	33	910
West Pomeranian University of Technology	POL	682	22.2%	34	915
Gdansk University of Technology	POL	1184	22.1%	35	919
Kaunas University of Technology	LTU	1204	21.9%	36	926
Universitat Rostock	DEU	952	20.1%	37	964
Warsaw University of Technology	POL	3360	19.1%	38	988
Poznan University of Technology	POL	1378	18.9%	39	992
Wroclaw University of Technology	POL	2516	18.4%	40	1005
Czestochowa University of Technology	POL	709	18.3%	41	1006
Bialystok University of Technology	POL	719	18.2%	42	1007
Helmut Schmidt Universitat - Universitat der Bundeswehr Hamburg	DEU	516	17.8%	43	1014
Vilnius Gediminas Technical University	LTU	1055	17.2%	44	1019
Lublin University of Technology	POL	616	16.4%	45	1041
University of Agder	NOR	551	16.1%	46	1051
Military University of Technology	POL	891	14.8%	47	1089
AIRBUS Germany	DEU	791	14.6%	48	1097
University of Latvia	LVA	638	14.0%	49	1111
Silesian University of Technology	POL	1735	13.7%	50	1114
Tallinn University of Technology	EST	1289	11.1%	51	1160
Riga Technical University	LVA	935	6.7%	52	1268
Saint Petersburg State University of Information Technologies, Mechanics and Optics	RUS	651	6.5%	53	1270

Table 26. Environmental science: citation impact

Environmental Science: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 24 ranking	Position in global 406 ranking
Stockholm University	SWE	1365	25.0%	1	42
University of Copenhagen	DNK	1636	24.3%	2	52
University of Oslo	NOR	1051	22.9%	3	65
Technical University of Denmark	DNK	1728	22.9%	4	66
Lund University	SWE	1339	21.5%	5	83
Aarhus University	DNK	1584	21.4%	6	86
Chalmers University of Technology	SWE	615	21.4%	7	88
Finnish Environment Institute	FIN	500	21.3%	8	89
Universitat Hamburg	DEU	622	20.1%	9	115
Umea University	SWE	630	19.4%	10	138
Christian-Albrechts-Universitat zu Kiel	DEU	628	19.1%	11	143
Uppsala University	SWE	803	18.7%	12	152
Swedish University of Agricultural Sciences	SWE	1682	18.0%	13	167
Norwegian University of Science and Technology	NOR	971	17.0%	14	192
University of Helsinki	FIN	1623	16.6%	15	200
University of Gothenburg	SWE	744	16.4%	16	204
University of Bergen	NOR	712	16.1%	17	208
Norwegian University of Life Sciences	NOR	779	15.9%	18	213
University of Tromso	NOR	507	15.0%	19	238
University of Tartu	EST	530	14.6%	20	253
Royal Institute of Technology	SWE	823	13.8%	21	270
University of Eastern Finland	FIN	708	12.8%	22	292
Finnish Forest Research Institute	FIN	572	12.6%	23	298
Polish Academy of Sciences	POL	1197	10.3%	24	343

Table 27. Environmental science: best journal rate

Environmental Science: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 24 ranking	Position in global 406 ranking
Stockholm University	SWE	1365	82.6%	1	11
University of Bergen	NOR	712	77.7%	2	50
University of Oslo	NOR	1051	75.6%	3	70
Umea University	SWE	630	74.6%	4	84
University of Gothenburg	SWE	744	74.3%	5	86
Aarhus University	DNK	1584	73.9%	6	94
Technical University of Denmark	DNK	1728	73.8%	7	98
University of Copenhagen	DNK	1636	73.7%	8	101
University of Tromso	NOR	507	71.8%	9	126
Uppsala University	SWE	803	71.8%	10	127
Finnish Environment Institute	FIN	500	70.9%	11	143
Universitat Hamburg	DEU	622	70.0%	12	154
Swedish University of Agricultural Sciences	SWE	1682	69.8%	13	157
Christian-Albrechts-Universitat zu Kiel	DEU	628	67.6%	14	189
Norwegian University of Science and Technology	NOR	971	65.8%	15	207
Lund University	SWE	1339	65.6%	16	210
Norwegian University of Life Sciences	NOR	779	65.2%	17	215
University of Helsinki	FIN	1623	63.6%	18	240
Chalmers University of Technology	SWE	615	62.6%	19	248
University of Eastern Finland	FIN	708	60.2%	20	271
Royal Institute of Technology	SWE	823	58.3%	21	281
Finnish Forest Research Institute	FIN	572	57.4%	22	286
University of Tartu	EST	530	54.8%	23	302
Polish Academy of Sciences	POL	1197	43.1%	24	350

Table 28. Health professions: citation impact

Health Professions: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications)	Country	Number of Papers	Rate	Position in BSR 2 ranking	Position in global 63 ranking
University of Copenhagen	DNK	545	26.6%	1	2
Karolinska Institute	SWE	814	20.0%	2	31

Table 29. Health professions: best journal rate

Health Professions: Best Journal Rate (ratio of papers, published in the world's most influential publications)	Country	Number of Papers	Rate	Position in BSR 2 ranking	Position in global 63 ranking
University of Copenhagen	DNK	545	76.1%	1	6
Karolinska Institute	SWE	814	64.9%	2	35

Table 30. Immunology and microbiology: citation impact

Immunology and Microbiology: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 15 ranking	Position in global 297 ranking
Copenhagen University Hospital	DNK	840	19.6%	1	112
Uppsala University	SWE	711	18.9%	2	131
Karolinska University Hospital	SWE	862	18.8%	3	132
Karolinska Institute	SWE	1791	18.6%	4	137
Technical University of Denmark	DNK	806	18.5%	5	139
Lund University	SWE	921	18.5%	6	141
Aarhus University	DNK	798	16.9%	7	158
Swedish University of Agricultural Sciences	SWE	516	16.8%	8	159
University of Copenhagen	DNK	1506	16.5%	9	164
University of Helsinki	FIN	1101	15.9%	10	174
Oslo University Hospital	NOR	501	15.2%	11	191
University of Oslo	NOR	649	15.0%	12	194
Friedrich Loeffler Institutes Bundesforschungsinstitut für Tiergesundheit	DEU	513	14.6%	13	197
University of Gothenburg	SWE	658	14.2%	14	202
Polish Academy of Sciences	POL	565	5.0%	15	284

Table 31. Immunology and microbiology: best journal rate

Immunology and Microbiology: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 15 ranking	Position in global 297 ranking
Lund University	SWE	921	69.1%	1	87
Uppsala University	SWE	711	65.9%	2	124
Karolinska Institute	SWE	1791	63.4%	3	141
University of Copenhagen	DNK	1506	62.9%	4	144
Technical University of Denmark	DNK	806	62.6%	5	146
Karolinska University Hospital	SWE	862	60.8%	6	171
Swedish University of Agricultural Sciences	SWE	516	59.9%	7	174
University of Helsinki	FIN	1101	58.4%	8	180
University of Gothenburg	SWE	658	57.2%	9	188
University of Oslo	NOR	649	56.0%	10	198
Aarhus University	DNK	798	54.2%	11	209
Oslo University Hospital	NOR	501	52.6%	12	218
Copenhagen University Hospital	DNK	840	52.5%	13	219
Friedrich Loeffler Institutes Bundesforschungsinstitut fur Tiergesundheit	DEU	513	52.5%	14	220
Polish Academy of Sciences	POL	565	29.9%	15	271

Table 32. Materials science: citation impact

Materials Science: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 40 ranking	Position in global 829 ranking
Aarhus University	DNK	787	26.5%	1	25
Lund University	SWE	1481	20.7%	2	84
University of Copenhagen	DNK	598	20.3%	3	92
Stockholm University	SWE	615	19.6%	4	110
Linkoping University	SWE	1241	18.4%	5	135
University of Helsinki	FIN	735	17.6%	6	153
Technical University of Denmark	DNK	2879	17.2%	7	170
Uppsala University	SWE	1727	16.9%	8	179
Aalto University	FIN	2011	15.4%	9	228
Chalmers University of Technology	SWE	1666	14.8%	10	254
Universitat Hamburg	DEU	1063	14.7%	11	260
Universitat Rostock	DEU	608	14.2%	12	284
Royal Institute of Technology	SWE	3036	13.6%	13	306
Christian-Albrechts-Universitat zu Kiel	DEU	678	12.9%	14	345
University of Oulu	FIN	635	11.2%	15	454
University of Oslo	NOR	662	10.1%	16	478
Norwegian University of Science and Technology	NOR	1526	10.1%	17	480
Jagiellonian University	POL	722	8.5%	18	566
VTT Technical Research Centre of Finland	FIN	841	8.5%	19	567
SINTEF Group	NOR	696	8.1%	20	587
University of Warsaw	POL	752	7.7%	21	608
Tampere University of Technology	FIN	1039	7.7%	22	610
Vilnius University	LTU	586	7.6%	23	615
Adam Mickiewicz University	POL	633	7.3%	24	637
Lulea University of Technology	SWE	636	7.2%	25	638
Warsaw University of Technology	POL	1861	6.2%	26	679
Polish Academy of Sciences	POL	3697	6.1%	27	683
Saint Petersburg State University	RUS	1118	5.6%	28	699
Wroclaw University of Technology	POL	1272	5.4%	29	708
Gdansk University of Technology	POL	584	5.3%	30	713
University of Latvia	LVA	602	5.1%	31	716
University of Wroclaw	POL	544	4.4%	32	749
Military University of Technology	POL	710	4.1%	33	760
Silesian University of Technology	POL	1150	4.0%	34	766
University of Silesia	POL	859	4.0%	35	767
Czestochowa University of Technology	POL	556	3.7%	36	780
Technical University of Lodz	POL	1024	3.0%	37	800
AGH University of Science and Technology	POL	1802	2.7%	38	806
Kaunas University of Technology	LTU	776	2.5%	39	811
St, Petersburg State Polytechnic University	RUS	518	2.2%	40	818

Table 33. Materials science: citation impact

Materials Science: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 40 ranking	Position in global 829 ranking
Aarhus University	DNK	787	82.4%	1	7
Stockholm University	SWE	615	80.3%	2	11
University of Copenhagen	DNK	598	76.7%	3	32
Uppsala University	SWE	1727	76.7%	4	33
Lund University	SWE	1481	74.6%	5	51
University of Helsinki	FIN	735	71.4%	6	86
University of Oslo	NOR	662	69.1%	7	116
Jagiellonian University	POL	722	67.8%	8	140
Linkoping University	SWE	1241	67.3%	9	149
Chalmers University of Technology	SWE	1666	64.8%	10	213
Royal Institute of Technology	SWE	3036	63.1%	11	253
Christian-Albrechts-Universitat zu Kiel	DEU	678	61.8%	12	285
Norwegian University of Science and Technology	NOR	1526	61.8%	13	288
Universitat Hamburg	DEU	1063	61.5%	14	293
Aalto University	FIN	2011	60.0%	15	331
University of Warsaw	POL	752	59.6%	16	337
Technical University of Denmark	DNK	2879	57.8%	17	382
Polish Academy of Sciences	POL	3697	57.7%	18	284
Adam Mickiewicz University	POL	633	56.2%	19	412
SINTEF Group	NOR	696	52.9%	20	470
Universitat Rostock	DEU	608	52.3%	21	482
University of Wroclaw	POL	544	47.5%	22	560
University of Oulu	FIN	635	45.8%	23	591
VTT Technical Research Centre of Finland	FIN	841	44.2%	24	606
Vilnius University	LTU	586	44.0%	25	609
Tampere University of Technology	FIN	1039	42.1%	26	626
Lulea University of Technology	SWE	636	42.0%	27	630
Gdansk University of Technology	POL	584	38.9%	28	665
University of Silesia	POL	859	36.0%	29	687
Saint Petersburg State University	RUS	1118	35.5%	30	689
Wroclaw University of Technology	POL	1272	35.0%	31	696
AGH University of Science and Technology	POL	1802	34.8%	32	697
Warsaw University of Technology	POL	1861	34.1%	33	703
University of Latvia	LVA	602	32.8%	34	716
Czestochowa University of Technology	POL	556	29.5%	35	739
Technical University of Lodz	POL	1024	26.0%	36	768
Military University of Technology	POL	710	23.6%	37	779
Kaunas University of Technology	LTU	776	19.6%	38	803
Silesian University of Technology	POL	1150	19.4%	39	806
St, Petersburg State Polytechnic University	RUS	518	15.7%	40	819

Table 34. Mathematics: citation impact

Mathematics: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 31 ranking	Position in global 610 ranking
Technical University of Denmark	DNK	1327	18.5%	1	79
University of Helsinki	FIN	1013	17.5%	2	116
University of Bergen	NOR	820	16.6%	3	149
University of Copenhagen	DNK	1016	16.6%	4	152
Norwegian University of Science and Technology	NOR	1367	16.5%	5	156
Uppsala University	SWE	963	16.4%	6	161
University of Oslo	NOR	980	16.0%	7	180
Lund University	SWE	864	15.3%	8	230
Aalto University	FIN	1503	15.2%	9	236
University of Oulu	FIN	587	15.2%	10	237
Aarhus University	DNK	830	15.0%	11	249
Royal Institute of Technology	SWE	1476	14.9%	12	257
Chalmers University of Technology	SWE	1088	14.5%	13	271
Universitat Hamburg	DEU	786	14.3%	14	283
University of Warsaw	POL	1398	14.3%	15	286
Aalborg University	DNK	887	13.9%	16	301
Linkoping University	SWE	740	13.3%	17	342
Tampere University of Technology	FIN	605	11.6%	18	431
Polish Academy of Sciences	POL	1937	11.3%	19	444
Silesian University of Technology	POL	582	11.2%	20	448
AGH University of Science and Technology	POL	881	10.9%	21	468
Jagiellonian University	POL	857	10.8%	22	471
Christian-Albrechts-Universitat zu Kiel	DEU	569	10.5%	23	483
Nicolaus Copernicus University	POL	504	10.3%	24	490
University of Wroclaw	POL	544	10.3%	25	492
Poznan University of Technology	POL	571	10.2%	26	494
Adam Mickiewicz University	POL	555	10.0%	27	501
Wroclaw University of Technology	POL	1233	9.2%	28	531
Vilnius University	LTU	554	8.9%	29	544
Warsaw University of Technology	POL	1383	8.6%	30	556
Saint Petersburg State University	RUS	1158	7.4%	31	581

Table 35. Mathematics: best journal rate

Mathematics: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 15 ranking	Position in global 610 ranking
University of Copenhagen	DNK	1016	43.1%	1	58
University of Helsinki	FIN	1013	38.8%	2	112
Norwegian University of Science and Technology	NOR	1367	37.8%	3	121
University of Oslo	NOR	980	37.5%	4	126
Christian-Albrechts-Universitat zu Kiel	DEU	569	35.3%	5	172
Adam Mickiewicz University	POL	555	34.8%	6	183
Uppsala University	SWE	963	34.7%	7	184
Lund University	SWE	864	34.4%	8	193
Jagiellonian University	POL	857	33.5%	9	213
Chalmers University of Technology	SWE	1088	32.9%	10	224
University of Wroclaw	POL	544	32.6%	11	236
Polish Academy of Sciences	POL	1937	32.1%	12	249
Universitat Hamburg	DEU	786	32.0%	13	252
Royal Institute of Technology	SWE	1476	31.9%	14	253
Aarhus University	DNK	830	31.9%	15	255
University of Warsaw	POL	1398	30.3%	16	283
Linkoping University	SWE	740	28.6%	17	320
Aalto University	FIN	1503	27.7%	18	341
Nicolaus Copernicus University	POL	504	27.2%	19	356
University of Oulu	FIN	587	27.1%	20	358
Technical University of Denmark	DNK	1327	25.6%	21	395
University of Bergen	NOR	820	24.9%	22	402
Tampere University of Technology	FIN	605	18.9%	23	511
Saint Petersburg State University	RUS	1158	17.9%	24	524
Aalborg University	DNK	887	17.3%	25	533
Vilnius University	LTU	554	16.8%	26	536
AGH University of Science and Technology	POL	881	15.6%	27	554
Warsaw University of Technology	POL	1383	14.4%	28	564
Wroclaw University of Technology	POL	1233	13.1%	29	575
Poznan University of Technology	POL	571	11.9%	30	578
Silesian University of Technology	POL	582	10.6%	31	582

Table 36. Medicine: citation impact

Medicine: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 83 ranking	Position in global 1676 ranking
Danish Cancer Society	DNK	1030	32.3%	1	46
Novo Nordisk A/S	DNK	781	30.2%	2	84
Statens Serum Institut	DNK	1362	27.5%	3	160
Norwegian School of Sport Sciences	NOR	554	27.3%	4	162
Stavanger University Hospital	NOR	718	27.2%	5	170
Folkhalsan	FIN	623	27.0%	6	178
Orebro University Hospital	SWE	1043	27.0%	7	180
Christian-Albrechts-Universitat zu Kiel	DEU	2233	26.4%	8	204
Landspitali National University Hospital	ISL	775	26.3%	9	211
Copenhagen University Hospital	DNK	11427	25.7%	10	234
University of Copenhagen	DNK	9183	25.6%	11	239
Helsinki University Central Hospital	FIN	4478	25.1%	12	261
Turku University Hospital	FIN	1776	24.5%	13	298
Karolinska Institute	SWE	15282	24.5%	14	301
University of Iceland	ISL	1132	24.4%	15	305
Karolinska University Hospital	SWE	6704	24.0%	16	328
University of Gothenburg	SWE	5196	24.0%	17	329
Norwegian Institute of Public Health	NOR	1467	23.9%	18	333
Kuopio University Hospital	FIN	1668	23.8%	19	339
Skane University Hospital	SWE	4455	23.8%	20	342
Aarhus University	DNK	9044	23.7%	21	351
Tampere University Hospital	FIN	2002	23.4%	22	386
Uppsala University Hospital	SWE	2186	23.2%	23	400
National Institute for Health and Welfare	FIN	2987	23.0%	24	423
Sahlgrenska University Hospital	SWE	2966	22.9%	25	430
University of Southern Denmark	DNK	3552	22.9%	26	432
Uppsala University	SWE	5881	22.7%	27	447
Haukeland University Hospital	NOR	2537	22.7%	28	449
University of Helsinki	FIN	6163	22.7%	29	452
Technical University of Denmark	DNK	1581	22.5%	30	462
Lund University	SWE	6249	22.5%	31	465
University of Bergen	NOR	3968	22.4%	32	473
University of Eastern Finland	FIN	2475	22.1%	33	492
Universitat Hamburg	DEU	6861	22.1%	34	500
Odense University Hospital	DNK	2544	22.0%	35	511
University of Turku	FIN	2699	21.9%	36	520
Oslo University Hospital	NOR	6332	21.8%	37	533
Umea University	SWE	3533	21.7%	38	539
Norwegian University of Science and Technology	NOR	2866	21.7%	39	541
University Hospital of Northern Norway	NOR	1095	21.4%	40	566
St, Olavs University Hospital	NOR	1638	21.3%	41	570
University of Tromso	NOR	2257	21.1%	42	584

Swedish University of Agricultural Sciences	SWE	843	20.7%	43	614
Universitat zu Lubeck	DEU	2167	20.6%	44	618
Universitatsklinikum Schleswig-Holstein	DEU	2963	20.4%	45	636
Oulu University Hospital	FIN	1245	20.3%	46	643
University of Tampere	FIN	2402	20.0%	47	668
Aalto University	FIN	586	20.0%	48	669
University of Oslo	NOR	7106	19.9%	49	683
Akershus University Hospital	NOR	830	19.6%	50	716
Finnish Institute Occupational Health	FIN	892	19.5%	51	719
Linkoping University Hospital	SWE	879	19.5%	52	725
Stockholm University	SWE	2004	19.5%	53	726
Aalborg University Hospital	DNK	1364	19.5%	54	728
Linkoping University	SWE	2951	19.2%	55	747
University of Oulu	FIN	2037	18.8%	56	779
Ernst-Moritz-Arndt-Universitat Greifswald	DEU	2172	18.4%	57	812
Norwegian University of Life Sciences	NOR	599	18.1%	58	836
University of Tartu	EST	1096	18.1%	59	838
Aalborg University	DNK	1115	17.7%	60	866
Royal Institute of Technology	SWE	969	17.7%	61	867
University of Jyvaskyla	FIN	928	16.8%	62	916
Orebro Universitet	SWE	721	15.9%	63	960
Maria Sklodowska-Curie Memorial Institute of Oncology	POL	1136	15.5%	64	991
Chalmers University of Technology	SWE	668	15.3%	65	1003
Children's Memorial Health Institute	POL	682	15.1%	66	1019
Universitat Rostock	DEU	2239	14.9%	67	1027
Vilnius University	LTU	574	13.3%	68	1126
Institute of Cardiology	POL	670	11.3%	69	1251
Polish Academy of Sciences	POL	2599	10.7%	70	1298
Lithuanian University of Health Sciences	LTU	806	10.3%	71	1319
Jagiellonian University	POL	3604	10.2%	72	1323
University of Warsaw	POL	603	9.7%	73	1360
Medical University of Gdansk	POL	1775	9.7%	74	1364
Medical University of Silesia	POL	2385	8.8%	75	1407
Pomeranian Medical University	POL	1156	8.5%	76	1419
Medical University of Lodz	POL	2918	8.2%	77	1441
Medical University of Warsaw	POL	3144	7.9%	78	1460
Medical University of Bialystok	POL	1454	7.5%	79	1475
Wroclaw Medical University	POL	2440	7.5%	80	1478
Nicolaus Copernicus University	POL	1155	6.4%	81	1531
Poznan University of Medical Sciences	POL	2954	5.8%	82	1551
Medical University of Lublin	POL	2139	3.8%	83	1634

Table 37. Medicine: best journal rate

Medicine: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 83 ranking	Position in global 1676 ranking
Danish Cancer Society	DNK	1030	88.3%	1	9
Folkhalsan	FIN	623	87.1%	2	14
National Institute for Health and Welfare	FIN	2987	80.6%	3	61
Novo Nordisk A/S	DNK	781	78.4%	4	85
University of Helsinki	FIN	6163	78.0%	5	92
Statens Serum Institut	DNK	1362	77.8%	6	97
Norwegian Institute of Public Health	NOR	1467	76.4%	7	133
Helsinki University Central Hospital	FIN	4478	76.2%	8	140
Aalto University	FIN	586	76.0%	9	147
Uppsala University	SWE	5881	75.0%	10	178
Finnish Institute Occupational Health	FIN	892	74.7%	11	187
Stockholm University	SWE	2004	74.4%	12	204
Norwegian School of Sport Sciences	NOR	554	74.3%	13	209
Kuopio University Hospital	FIN	1668	74.1%	14	214
Karolinska Institute	SWE	15282	73.8%	15	225
University of Copenhagen	DNK	9183	73.7%	16	231
Lund University	SWE	6249	73.5%	17	239
University of Turku	FIN	2699	73.1%	18	265
Tampere University Hospital	FIN	2002	73.0%	19	268
Christian-Albrechts-Universitat zu Kiel	DEU	2233	72.8%	20	276
University of Eastern Finland	FIN	2475	72.5%	21	283
Swedish University of Agricultural Sciences	SWE	843	72.5%	22	284
Turku University Hospital	FIN	1776	72.1%	23	297
Akershus University Hospital	NOR	830	72.0%	24	298
Umea University	SWE	3533	71.9%	25	302
Oulu University Hospital	FIN	1245	71.9%	26	304
University of Oslo	NOR	7106	71.6%	27	317
University of Jyvaskyla	FIN	928	71.5%	28	319
Orebro University Hospital	SWE	1043	71.4%	29	324
Royal Institute of Technology	SWE	969	71.4%	30	326
Skane University Hospital	SWE	4455	71.3%	31	332
University of Gothenburg	SWE	5196	71.3%	32	334
Technical University of Denmark	DNK	1581	71.1%	33	340
University of Southern Denmark	DNK	3552	71.0%	34	345
University of Oulu	FIN	2037	70.9%	35	349
University of Iceland	ISL	1132	70.9%	36	351
University of Bergen	NOR	3968	70.7%	37	359
Oslo University Hospital	NOR	6332	70.4%	38	367
Haukeland University Hospital	NOR	2537	70.1%	39	383
University of Tampere	FIN	2402	70.0%	40	387
Norwegian University of Life Sciences	NOR	599	70.0%	41	390

Landspitali National University Hospital	ISL	775	69.8%	42	397
Stavanger University Hospital	NOR	718	69.7%	43	402
Aarhus University	DNK	9044	69.5%	44	412
Karolinska University Hospital	SWE	6704	68.8%	45	438
Norwegian University of Science and Technology	NOR	2866	68.7%	46	442
St, Olavs University Hospital	NOR	1638	68.0%	47	472
Uppsala University Hospital	SWE	2186	67.4%	48	496
Sahlgrenska University Hospital	SWE	2966	67.3%	49	497
Linkoping University	SWE	2951	67.3%	50	499
University of Tromso	NOR	2257	67.1%	51	505
Copenhagen University Hospital	DNK	11427	67.1%	52	506
University of Tartu	EST	1096	66.0%	53	555
Linkoping University Hospital	SWE	879	65.1%	54	596
University Hospital of Northern Norway	NOR	1095	64.2%	55	630
Chalmers University of Technology	SWE	668	63.1%	56	677
Odense University Hospital	DNK	2544	63.0%	57	680
Aalborg University Hospital	DNK	1364	62.8%	58	694
University of Warsaw	POL	603	62.5%	59	705
Universitat Hamburg	DEU	6861	62.2%	60	721
Orebro Universitet	SWE	721	61.8%	61	734
Universitat zu Lubeck	DEU	2167	60.2%	62	796
Aalborg University	DNK	1115	57.9%	63	878
Ernst-Moritz-Arndt-Universitat Greifswald	DEU	2172	57.9%	64	881
Universitat Rostock	DEU	2239	52.6%	65	1073
Polish Academy of Sciences	POL	2599	52.5%	66	1076
Universitatsklinikum Schleswig-Holstein	DEU	2963	50.0%	67	1138
Vilnius University	LTU	574	44.4%	68	1258
Maria Sklodowska-Curie Memorial Institute of Oncology	POL	1136	38.6%	69	1383
Children's Memorial Health Institute	POL	682	36.7%	70	1409
Jagiellonian University	POL	3604	36.3%	71	1415
Institute of Cardiology	POL	670	35.1%	72	1436
Medical University of Gdansk	POL	1775	34.0%	73	1449
Pomeranian Medical University	POL	1156	30.3%	74	1494
Lithuanian University of Health Sciences	LTU	806	29.7%	75	1500
Medical University of Silesia	POL	2385	27.4%	76	1521
Medical University of Bialystok	POL	1454	26.1%	77	1532
Medical University of Warsaw	POL	3144	24.5%	78	1551
Nicolaus Copernicus University	POL	1155	24.0%	79	1555
Medical University of Lodz	POL	2918	23.8%	80	1556
Wroclaw Medical University	POL	2440	20.4%	81	1588
Poznan University of Medical Sciences	POL	2954	20.2%	82	1591
Medical University of Lublin	POL	2139	15.8%	83	1641

Table 38. Neuroscience: citation impact

Neuroscience: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 13 ranking	Position in global 262 ranking
Universitat Hamburg	DEU	961	17.7%	1	101
Aarhus University	DNK	843	17.6%	2	108
Karolinska University Hospital	SWE	514	17.5%	3	109
University of Gothenburg	SWE	725	16.1%	4	133
University of Oslo	NOR	744	16.1%	5	134
Karolinska Institute	SWE	1884	15.7%	6	145
University of Helsinki	FIN	846	15.5%	7	149
Oslo University Hospital	NOR	552	15.4%	8	151
Copenhagen University Hospital	DNK	966	13.6%	9	183
Lund University	SWE	701	13.5%	10	185
Uppsala University	SWE	583	13.0%	11	191
University of Copenhagen	DNK	1015	12.9%	12	194
Polish Academy of Sciences	POL	665	9.6%	13	229

Table 39. Neuroscience: best journal rate

Neuroscience: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 13 ranking	Position in global 262 ranking
Universitat Hamburg	DEU	961	64.6%	1	28
University of Helsinki	FIN	846	58.9%	2	100
Karolinska Institute	SWE	1884	55.8%	3	136
Aarhus University	DNK	843	53.5%	4	160
University of Oslo	NOR	744	52.5%	5	166
Lund University	SWE	701	52.1%	6	170
Karolinska University Hospital	SWE	514	49.6%	7	189
University of Copenhagen	DNK	1015	48.8%	8	199
Copenhagen University Hospital	DNK	966	48.5%	9	202
Uppsala University	SWE	583	48.5%	10	203
University of Gothenburg	SWE	725	48.1%	11	208
Oslo University Hospital	NOR	552	46.2%	12	218
Polish Academy of Sciences	POL	665	37.1%	13	238

Table 40. Nursing: citation impact

Nursing: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications)	Country	Number of Papers	Rate	Position in BSR 3 ranking	Position in global 69 ranking
Karolinska Institute	SWE	945	26.7%	1	25
University of Oslo	NOR	603	26.2%	2	26
Aarhus University	DNK	564	24.3%	3	43

Table 41. Nursing: best journal rate

Nursing: Best Journal Rate (ratio of papers, published in the world's most influential publications)	Country	Number of Papers	Rate	Position in BSR 3 ranking	Position in global 69 ranking
University of Oslo	NOR	603	74.8%	1	9
Aarhus University	DNK	564	73.7%	2	11
Karolinska Institute	SWE	945	73.4%	3	13

Table 42. Pharmacology, toxicology and pharmaceutics: citation impact

Pharmacology, Toxicology and Pharmaceutics: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 8 ranking	Position in global 232 ranking
Aarhus University	DNK	509	23.1%	1	47
University of Copenhagen	DNK	1210	22.2%	2	59
University of Helsinki	FIN	695	21.8%	3	69
Karolinska Institute	SWE	1062	21.0%	4	80
Uppsala University	SWE	808	20.3%	5	94
Polish Academy of Sciences	POL	808	11.0%	6	179
Jagiellonian University	POL	691	9.1%	7	198
Medical University of Lublin	POL	739	4.4%	8	228

Table 43. Pharmacology, toxicology and pharmaceutics: best journal rate

Pharmacology, Toxicology and Pharmaceutics: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 8 ranking	Position in global 232 ranking
University of Copenhagen	DNK	1210	70.9%	1	72
Karolinska Institute	SWE	1062	70.7%	2	73
Uppsala University	SWE	808	70.3%	3	77
University of Helsinki	FIN	695	69.4%	4	89
Aarhus University	DNK	509	67.9%	5	101
Polish Academy of Sciences	POL	808	50.9%	6	174
Jagiellonian University	POL	691	38.7%	7	198
Medical University of Lublin	POL	739	14.3%	8	229

Table 44. Physics and astronomy: citation impact

Physics and Astronomy: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 55 ranking	Position in global 1131 ranking
The Oskar Klein Centre for Cosmoparticle Physics	SWE	855	42.1%	1	4
Helsinki Institute of Physics	FIN	1272	33.9%	2	35
University of Bergen	NOR	951	29.8%	3	72
University of Copenhagen	DNK	2823	27.2%	4	126
Stockholm University	SWE	2558	26.6%	5	143
National Centre for Nuclear Research	POL	1721	26.5%	6	145
Lund University	SWE	2988	25.5%	7	176
Universitat Hamburg	DEU	3571	25.4%	8	180
Aarhus University	DNK	1907	23.8%	9	221
University of Helsinki	FIN	2310	22.8%	10	254
University of Southern Denmark	DNK	736	22.1%	11	278
University of Oslo	NOR	2079	22.0%	12	281
Uppsala University	SWE	3288	21.1%	13	322
University of Iceland	ISL	515	20.0%	14	364
University of Warsaw	POL	2990	19.9%	15	370
Technical University of Denmark	DNK	4198	19.7%	16	385
University of Jyvaskyla	FIN	1254	19.5%	17	391
Universitat Rostock	DEU	1315	19.3%	18	398
University of Gothenburg	SWE	680	18.2%	19	448
Vilnius University	LTU	1358	18.1%	20	449
Aalborg University	DNK	576	18.1%	21	450
Royal Institute of Technology	SWE	4583	17.5%	22	473
Linkoping University	SWE	1559	17.3%	23	487
Chalmers University of Technology	SWE	2745	16.3%	24	526
Aalto University	FIN	2816	15.5%	25	577
Jagiellonian University	POL	2409	15.1%	26	589
Umea University	SWE	592	14.7%	27	608
AGH University of Science and Technology	POL	2213	14.2%	28	633
Tampere University of Technology	FIN	1128	14.1%	29	640
University of Turku	FIN	1008	14.1%	30	641
VTT Technical Research Centre of Finland	FIN	886	13.9%	31	650
Warsaw University of Technology	POL	2421	13.4%	32	678
University of Wroclaw	POL	1035	13.4%	33	679
Christian-Albrechts-Universitat zu Kiel	DEU	1257	13.3%	34	682
Norwegian University of Science and	NOR	1825	12.3%	35	731

Technology					
University of Oulu	FIN	981	12.1%	36	741
Polish Academy of Sciences	POL	7728	12.1%	37	743
Nicolaus Copernicus University	POL	917	11.8%	38	753
University of Eastern Finland	FIN	637	10.5%	39	820
Military University of Technology	POL	931	9.9%	40	853
University of Lodz	POL	527	9.5%	41	875
University of Tartu	EST	670	9.4%	42	879
SINTEF Group	NOR	585	8.9%	43	906
University of Silesia	POL	1321	8.8%	44	912
Saint Petersburg State University	RUS	2626	8.7%	45	917
Wroclaw University of Technology	POL	1656	8.4%	46	933
Adam Mickiewicz University	POL	1155	7.8%	47	959
Maria Curie Sklodowska University	POL	755	7.8%	48	966
Silesian University of Technology	POL	935	7.5%	49	983
St, Petersburg State Polytechnic University	RUS	1156	6.7%	50	1018
Technical University of Lodz	POL	674	6.4%	51	1029
University of Latvia	LVA	867	6.4%	52	1033
Saint Petersburg State University of Information Technologies, Mechanics and Optics	RUS	919	5.8%	53	1051
Gdansk University of Technology	POL	806	5.8%	54	1056
Kaunas University of Technology	LTU	506	3.3%	55	1115

Table 45. Physics and astronomy: best journal rate

Physics and Astronomy: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 55 ranking	Position in global 1131 ranking
The Oskar Klein Centre for Cosmoparticle Physics	SWE	855	80.8%	1	6
University of Bergen	NOR	951	74.6%	2	39
University of Copenhagen	DNK	2823	72.6%	3	60
Helsinki Institute of Physics	FIN	1272	72.0%	4	64
Stockholm University	SWE	2558	69.7%	5	99
Lund University	SWE	2988	68.9%	6	119
Aarhus University	DNK	1907	68.1%	7	148
Uppsala University	SWE	3288	66.9%	8	180
University of Oslo	NOR	2079	65.4%	9	217
Universitat Hamburg	DEU	3571	64.1%	10	255
University of Helsinki	FIN	2310	63.7%	11	267
University of Iceland	ISL	515	62.5%	12	302
University of Jyvaskyla	FIN	1254	61.5%	13	329
Umea University	SWE	592	60.2%	14	369
University of Turku	FIN	1008	60.0%	15	377
University of Warsaw	POL	2990	59.1%	16	397
University of Gothenburg	SWE	680	59.0%	17	400

Chalmers University of Technology	SWE	2745	58.4%	18	417
Royal Institute of Technology	SWE	4583	57.6%	19	437
University of Southern Denmark	DNK	736	57.5%	20	441
Linkoping University	SWE	1559	56.9%	21	456
Aalto University	FIN	2816	56.4%	22	468
Universitat Rostock	DEU	1315	55.3%	23	496
Christian-Albrechts-Universitat zu Kiel	DEU	1257	55.3%	24	498
Norwegian University of Science and Technology	NOR	1825	54.3%	25	519
Jagiellonian University	POL	2409	52.8%	26	558
Technical University of Denmark	DNK	4198	51.7%	27	594
National Centre for Nuclear Research	POL	1721	51.1%	28	609
Nicolaus Copernicus University	POL	917	50.5%	29	619
University of Oulu	FIN	981	49.5%	30	637
University of Eastern Finland	FIN	637	49.1%	31	649
University of Wroclaw	POL	1035	48.4%	32	667
Adam Mickiewicz University	POL	1155	48.1%	33	674
Aalborg University	DNK	576	48.1%	34	676
Polish Academy of Sciences	POL	7728	47.8%	35	679
University of Lodz	POL	527	47.6%	36	684
SINTEF Group	NOR	585	46.4%	37	701
Tampere University of Technology	FIN	1128	45.6%	38	719
Vilnius University	LTU	1358	42.6%	39	767
University of Tartu	EST	670	40.2%	40	812
VTT Technical Research Centre of Finland	FIN	886	37.8%	41	854
AGH University of Science and Technology	POL	2213	37.7%	42	856
Saint Petersburg State University	RUS	2626	35.0%	43	893
University of Silesia	POL	1321	34.8%	44	896
Maria Curie Sklodowska University	POL	755	34.6%	45	899
Warsaw University of Technology	POL	2421	33.2%	46	915
Wroclaw University of Technology	POL	1656	32.3%	47	920
Gdansk University of Technology	POL	806	29.3%	48	954
St, Petersburg State Polytechnic University	RUS	1156	27.0%	49	974
Technical University of Lodz	POL	674	26.9%	50	975
University of Latvia	LVA	867	26.1%	51	990
Military University of Technology	POL	931	16.8%	52	1088
Saint Petersburg State University of Information Technologies, Mechanics and Optics	RUS	919	15.6%	53	1097
Kaunas University of Technology	LTU	506	12.5%	54	1111
Silesian University of Technology	POL	935	12.2%	55	1113

Table 46. Psychology: citation impact

Psychology: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 5 ranking	Position in global 172 ranking
Karolinska Institute	SWE	798	23.4%	1	19
Aarhus University	DNK	576	21.6%	2	32
Universitat Hamburg	DEU	716	13.2%	3	138
University of Oslo	NOR	724	12.8%	4	143
University of Helsinki	FIN	630	12.1%	5	149

Table 47. Psychology: best journal rate

Psychology: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 5 ranking	Position in global 172 ranking
Karolinska Institute	SWE	798	68.9%	1	23
Aarhus University	DNK	576	61.2%	2	72
University of Helsinki	FIN	630	54.3%	3	115
University of Oslo	NOR	724	54.3%	4	116
Universitat Hamburg	DEU	716	48.3%	5	147

Table 48. Social sciences: citation impact

Social Sciences: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 26 ranking	Position in global 472 ranking
Copenhagen Business School	DNK	520	25.8%	1	47
University of Bergen	NOR	929	25.3%	2	53
University of Copenhagen	DNK	1534	24.4%	3	70
Stockholm University	SWE	1566	23.3%	4	94
Royal Institute of Technology	SWE	630	23.1%	5	97
Aarhus University	DNK	1461	23.1%	6	98
Karolinska Institute	SWE	544	22.2%	7	119
Lund University	SWE	1399	22.1%	8	121
Aalto University	FIN	533	21.2%	9	144
Norwegian University of Science and Technology	NOR	984	20.8%	10	154
Linkoping University	SWE	789	19.7%	11	185
University of Jyvaskyla	FIN	676	19.4%	12	196
University of Turku	FIN	653	19.4%	13	201
University of Oslo	NOR	1687	19.3%	14	203
University of Southern Denmark	DNK	653	19.2%	15	211
University of Gothenburg	SWE	1231	19.0%	16	215
Uppsala University	SWE	1113	18.8%	17	221
Universitat Hamburg	DEU	889	18.2%	18	241
University of Helsinki	FIN	1695	18.0%	19	246
University of Tromso	NOR	519	17.7%	20	254
Aalborg University	DNK	601	16.8%	21	277
Umea University	SWE	768	15.4%	22	333
University of Tampere	FIN	571	15.1%	23	340
University of Eastern Finland	FIN	535	13.1%	24	376
University of Tartu	EST	626	11.9%	25	391
University of Warsaw	POL	614	6.1%	26	446

Table 49. Social sciences: best journal rate

Social Sciences: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 26 ranking	Position in global 472 ranking
Karolinska Institute	SWE	544	63.8%	1	16
University of Copenhagen	DNK	1534	58.4%	2	63
Stockholm University	SWE	1566	53.5%	3	130
Lund University	SWE	1399	52.9%	4	137
University of Gothenburg	SWE	1231	52.8%	5	138
University of Bergen	NOR	929	52.8%	6	139
Royal Institute of Technology	SWE	630	52.7%	7	140
University of Tampere	FIN	571	52.6%	8	142
University of Southern Denmark	DNK	653	51.1%	9	170
Uppsala University	SWE	1113	50.7%	10	177
Copenhagen Business School	DNK	520	50.7%	11	178
Umea University	SWE	768	49.9%	12	189
University of Turku	FIN	653	49.4%	13	204
University of Helsinki	FIN	1695	49.4%	14	205
University of Oslo	NOR	1687	49.1%	15	209
University of Jyvaskyla	FIN	676	48.2%	16	227
Linkoping University	SWE	789	47.9%	17	233
Aarhus University	DNK	1461	47.8%	18	236
Norwegian University of Science and Technology	NOR	984	46.7%	19	262
Aalborg University	DNK	601	45.4%	20	285
Aalto University	FIN	533	45.0%	21	293
University of Tromso	NOR	519	43.0%	22	319
Universitat Hamburg	DEU	889	41.3%	23	339
University of Eastern Finland	FIN	535	39.0%	24	362
University of Tartu	EST	626	33.1%	25	395
University of Warsaw	POL	614	23.0%	26	428

Table 50. Veterinary: citation impact

Veterinary: Best Paper Rate (proportion of publications which belongs to the world's 10% most cited publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 4 ranking	Position in global 53 ranking
University of Copenhagen	DNK	621	24.3%	1	3
Swedish University of Agricultural Sciences	SWE	694	18.6%	2	17
National Veterinary Research Institute	POL	528	3.0%	3	48
University of Warmia and Mazury	POL	523	2.9%	4	50

Table 51. Veterinary: best journal rate

Veterinary: Best Journal Rate (ratio of papers, published in the world's most influential publications 2009-2013)	Country	Number of Papers	Rate	Position in BSR 4 ranking	Position in global 53 ranking
University of Copenhagen	DNK	621	74.3%	1	13
Swedish University of Agricultural Sciences	SWE	694	71.8%	2	21
National Veterinary Research Institute	POL	528	8.6%	3	49
University of Warmia and Mazury	POL	523	7.0%	4	50