Missed opportunities: National research labs in Norway

Report comparing independent research organizations in Norway to organizations in selected Western countries

Kyrre Lekve, PhD
Deputy managing director

simula.research.laboratory - by thinking constantly about it
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Executive summary and major findings

Norway is different from the other countries investigated in this report in that Norway has a very low proportion of basic research outside the university sector. National research labs are found to contribute significantly to the research quality of the countries investigated. Norwegian authorities should consider to create a sector of independent, national research laboratories.

Norway distinguishes itself from the countries investigated by not utilizing the full breadth of its research policy. The other countries (Austria, France, Germany, the Netherlands, the UK, and the US) have a distinct policy for organizations outside the university system oriented toward basic research. In Norway, research policy is concentrated in two policy areas: Policy for universities and university colleges and policy for “research institutes.” The latter group is widely diverse, ranging from applied oriented technical research institutes to organizations dedicated to fundamental research.

Organizations outside the university sector (“national research labs”; see below) conduct a considerable amount of research in the countries investigated. In Germany and France, the share of research conducted by the national research labs is about the same as the share conducted by the universities. In the US, the UK and Netherlands the national research labs contribute significantly. In Austria, a new national research lab – IST Austria – was created in 2006. IST Austria has been given a long-term budget enabling the organization to be a major contributor to Austrian research. The plan from the government is that IST Austria will be 1000 employees by 2026. In the UK the sector of research organizations outside the university system has been considerably reduced the past three decades, still performing a significant share of research. Norway stands out with a low part of basic research conducted outside the university sector.

Most of the countries investigated have explicit policy for organizations outside the university system oriented towards basic research. Either as distinct policy areas (e.g., the Netherlands, Germany, the UK and France), according to funding agencies (the US) or in the special case of Austria with a dedicated policy towards a few organizations. Norway have pooled most organizations outside the university system as “research institutes”, being operated by one common set of rules and one common set of funding mechanisms.

The research quality of the national research labs is very high. Considering citations, high quality publication output and leadership in publications, the national research labs are leading in several of the countries. In Germany and France, they totally dominate the top ten lists. In the Netherlands, Austria and Norway different organizations are leading, with the national research labs among the best performers. The US and the UK stand out with a very strong domination of health research organizations among the leading performers.

Research, education and innovation is the center of politics and policies of most countries in their struggle to succeed in the global competition. The findings of this report demonstrate that there is a potential to increase the quality of the output from the Norwegian research system by strengthening organizations outside the university sector. Independent organizations dedicated to fundamental research represent a valuable supplement to research conducted in the university sector.

There is no research tradition investigating the type of organizations investigated in this report. While both research institutes and the university sector have been comprehensively studied, few attempts have been made to distinguish between different organizations outside the university sector. Thus, no recognized concepts exist to describe research organizations dedicated to fundamental research outside the university sector. We have settled on the term national research laboratories in this report. The raison d’être for the national research labs in the countries investigated are twofold. First, they all conduct fundamental research of interest to the authorities of the respective countries and are regarded as especially fit to conduct such research because
their planning can be more long term than that of universities. Second, in many of the instances, the research labs operate a national research infrastructure. This aspect is especially explicit in the research policy of the US.

If the Norwegian authorities decide to establish a sector of national research labs, changes in the research policy system are necessary.

- The national labs should be clearly separated from other sectors and the policy and funding mechanisms should be especially designed with this kind of organization in mind.
- The societal task of the national research labs should be to conduct long-term, independent fundamental research within confined research areas. The national research labs must be highly internationally oriented and their research must be of high quality. The national labs may be responsible for research infrastructure when appropriate.
- The management of national research labs must be based on dialog with the authorities. Clear commitments on the size of budgets will become a new way of operating this part of the research system of Norway. The national research labs should be evaluated on a regular basis and the results of the evaluations should have consequences for funding.
- The national research labs should have a commitment to education, thus relieving the universities of some of their educational load. National research labs should be given the right to award PhDs after accreditation from the Norwegian Agency for Quality Assurance in Education (NOKUT).
- The national research labs should be organized as limited companies owned by public bodies. They should be managed according to the Working Environment Act (and not the Civil Service Act).

Today, Simula Research Laboratory is the only Norwegian research organization that fits the description of a national research laboratory. There are at least three not reciprocally exclusive pathways the authorities can take to develop such a sector. The authorities may establish new organizations within selected research areas to take on the role as research labs. Organizations affiliated with universities may be separated from their current university and established as independent organizations. Some of the organizations within the “research institute sector” may be included in a new sector of national research labs.

In this report, we investigate the research policy system and selected research organizations of six countries in addition to Norway. In Chapter 2, we review the methods applied. We summarize the research systems and the national labs of the countries investigated in Chapter 3. In Chapter 4, we derive at the possible policy consequences of our findings. In Chapter 5 we provide the details of each country.

The authors would like to thank everyone who has contributed to this report, especially the representatives of the 11 research organizations of the five countries visited. Any mistakes or misconceptions rests on us.
Main findings

- National research labs conduct a considerable amount of research in the countries investigated. In Germany and France, the share of research conducted by the National research labs is about the same as the share conducted by the universities. In the US, the UK and Netherlands the National research labs contribute significantly. In Austria, a new National Research Lab – IST Austria – was created in 2006. IST Austria has been given a long-term budget enabling the organization to be a major contributor to Austrian research. Norway stands out with a low part of basic research conducted outside the university sector.

- The research quality of the National research labs is very high. Considering citations, high quality publication output and leadership in publications, the National research labs are leading in several of the countries. In Germany and France, they totally dominate the top ten lists. In the Netherlands, Austria and Norway different organizations are leading, with the National research labs among the best performers. The US and the UK stand out with a very strong domination of health research organizations among the leading performers.

- Most of the countries investigated have explicit policy for organizations outside the university system oriented towards basic research. Either as distinct policy areas (e.g., the Netherlands, Germany, the UK and France), according to funding agencies (the US) or in the special case of Austria with a dedicated policy towards a few organizations. Norway have pooled most organizations outside the university system as “research institutes”, being operated by one common set of rules and one common set of funding mechanisms.
Norwegian summary

Norge skiller seg fra landene undersøkt i denne rapporten ved å mangle en egen forskningspolitikk for grunnforskningsrettede organisasjonene utenfor universitets- og høgskolesektoren. I alle landene som er undersøkt i forbindelse med denne rapporten (Frankrike, Tyskland, USA, Nederland, Østerrike og Storbritannia) er denne typen organisasjonene skilt ut i egne politikkområder. I Norge er forskningen og forskningspolitikken organisert i tre politikkområder: universitet og høyskoler, forskningstitutter og privat næringsliv. Det gjøres ikke noe skille mellom forskningstitutter rettet mot anvendt forskning og forskningsorganisasjoner som er rettet mot grunnleggende forskning.


Dersom myndighetene ønsker å bygge opp en livskraftig gruppe av forskningslaboratorier, er det nødvendig å gjøre endringer i det norske forskningssystemet. Noen av de viktigste endringene vil være:


- Forskningslaboratoriene bør ha en rolle også i undervisningen, og være en bidragsyter til undervisningen ved universiteter og høgskoler. Forskningslaboratorier bør kunne ha retten til å akkreditere doktorgarader etter en kvalitetsvurdering av NOKUT.
Forskningslaboratoriene bør være aksjeselskap eid av offentlige aktører innenfor forskning, og de bør drives etter Arbeidsmiljøloven.

Per i dag eksiterer det bare én organisasjon som passer til beskrivelsen som et forskningslaboratorium – Simula Research Laboratory. Den eneste andre norske organisasjonen som kan sammenliknes er Forsvarets Forskningsinstitutt (FFI). De kan minne om national labs i USA som drives av det amerikanske forsvarsdepartementet. Dersom Norge ønsker å utbygge en sektor av forskningslaboratorier er det i hvert fall tre måter å fram for å skape slike organisasjoner:


2. **Universiteteres randsoneaktiviteter**: Det er store reorganiseringsprosesser i gang i den norske UH-sektoren. I disse prosessene kan det være relevant å undersøke om enkelte randsonеaktiviteter kan settes opp som forskningslaboratorier.


I denne rapporten har vi undersøkt forskningssystemene og utvalgte forskningsorganisasjoner i seks land, i tillegg til Norge. I kapittel 2 gjenomgår vi hvordan vi har gjort ulike skrivebordstudier av alle landene på en mest mulig standar- disert måte, og hvordan vi har gitt et mål for vitenskapelig suksess i de ulike landene. I forbindelse med arbeidet med rapporten har vi besøkt 11 organisasjoner i 5 land (Storbritannia er ikke besøkt). Beskrivelsen av felles trekk ved forskningslaboratoriene i andre land er oppsummert i kapittel 3 og detaljer for hvert land er gjennomgått i kapittel 5 og i vedleggene. I kapittel 4 oppsummerer vi våre funn og utleder mulige konsekvenser for forskningspolitikken av funnene våre.

Forfatteren vil takke alle som har bidratt, spesielt alle dem involvert i besøkene i utlandet. Alle feil står for forfatterens regning.
1 Introduction

Science is increasingly seen as an instrument to increase a nation’s global competitiveness (Bush, 1945; McMillan, Narin, & Deeds, 2000; OECD, 2014b). National innovation policies seek to improve domestic advantages in “a world in search of an effective growth strategy” (page 21 in Soete, Schneeegans, Eröcal, Angathevar, & Rasiah, 2015; UNESCO, 2015). This was illustrated through the economic crisis following the collapse of the subprime loan industry in real estate in the US. During and following the crisis, many countries responded by increasing budgets for research and development (R&D) in the form of stimulus packages. For example, 10 OECD (Organisation for Economic Cooperation and Development) countries exhibited real growth in public expenditures for R&D, exceeding 10% in 2009, to counteract the negative effects of the economic crisis (Solberg, 2015).

Increased R&D spending has been an integral part of the growth of the Chinese economy during the past decades. In 1993, the R&D expenditure of China was 7% of the US expenditure. Two decades later, the corresponding figure is 70% and projected to surpass the US by 2016 (Solberg, 2015). The world is transforming from a unimodal research scene led by the US into a multimodal research scene with important points of gravity in the European Union, China, and the US (Augustine et al., 2010).

Countries apply a wide range of measures to improve their global competitiveness. First, governments have implemented measures to strengthen research, education, and innovation at universities (e.g., the German federal government’s excellences initiative; see Section 5.3.4). These measures are designed to strengthen the country’s independent fundamental research. A second set of measures is substantiated by societal needs and global challenges. Public policy derived from such reasoning is more mission oriented and project based. In many countries, new institutions are created to meet these research needs. The creation of the National Labs in post-war US (see Section 5.6.1) and of leading institutes of the Netherlands (see Section 5.4.1) are examples of this kind of institution building. A third set of measures is to strengthen applied science, primarily through applied research technology organizations (see Section 2.1) and research institutes. A fourth measure deals with increasing the business sector’s ability to conduct research, development, and innovation. Generally, the increased effort within these fields has led to fierce global completion for talent (e.g., Florida, 2005, 2006).

We report from an investigation of the science policy and selected research organizations of seven countries. We have especially investigated how research is organized outside the university sector and the business sector. What becomes apparent from investigating these countries is that the research organizations outside the university oriented toward fundamental research have been successful and conduct a substantial part of the fundamental research of these countries. The two exceptions are Austria and Norway. In both these countries, a small share of fundamental research is conducted outside the university sector. However, Austria recently established the Institute of Science and Technology Austria, with a long-term commitment from the government to fund substantial growth of the organization (see Section 5.1.3).

In Norway, only a few institutions fit the description of organizations outside the university sector dedicated to fundamental research. The Department of Defense-run Norwegian Defence Research Establishment and a few research institutes (partly) fit the description. Simula Research Laboratory is the only organization in Norway similar to the national research laboratories (see Section 2.2 for a definition) of the other countries investigated in this report. Norway is...
thus the outlier of this group of countries, utilizing only parts of the policy measures available. From the findings in this report, it is reasonable to expect that the quality of Norway’s scientific output will be improved if the scope of its science policy is expanded.
2 Methods and scope of the report

In this report, we have investigated different aspects of independent research organizations outside the university system, primarily conducting fundamental/basic/pure research. Unfortunately, there exists no well-established terminology describing various research organizations. We will therefore explain certain terms that will be applied throughout this report.

2.1 Independent national research laboratories

Independent organizations: All the organizations we have investigated receive considerable support from their country’s government (or regional authority). In a financial sense, none of them are independent. However, certain checks and balances are built into the system that make it harder for governments to exercise direct control through financial means. First, the funding of research is almost universally regarded as an area of politics in which governments are supposed to keep at arm’s length. It is furthermore regarded as a long-term investment. It is thus politically costly to lead an unstable budgetary policy for research. It is regarded as politically inappropriate to directly interfere with research organizations, whether they are part of the university sector or not. In practice, therefore, most research organizations experience rather stable and predictable financial conditions. Most of the instances in which research organizations experience reductions in funding are part of sector-wide changes.

Equally important is that the organizations we investigate are set up to conduct their research independently. This means the following: these organizations predispose considerable parts of their revenue independently; they have organizational structures—such as boards, senates, and councils—that are not directed or dominated by the government; they have leadership that cannot be directed by the government. It is, however, quite common for the leadership of research organizations, especially large ones, to maintain extensive contact and dialog with the authorities in matters of research policy and research priorities.

Outside the university sector: The organizations we investigate are not part of any university. They all, however, have extensive cooperation and often partnerships with one or several universities.

Setup to conduct fundamental research: The distinction between fundamental and applied research is largely obsolete. Fundamental research and applied research are two extreme points on a continuous scale and both are conducted in the same organizations. It is, however, of interest for this report to identify organizations that are dominated by fundamental research. There are several ways to approach this topic. First, we can use the information the organizations themselves use. For example, Fraunhofer in Germany describes itself as “Europe’s largest application-oriented research organization.” It is thus reasonable to regard Fraunhofer as not specifically set up to conduct fundamental research. We nevertheless recognize that Fraunhofer conducts fundamental research, as well as the other German organizations dedicated to fundamental research (e.g., the Max Planck Society) conduct applied research. Second, we can take into account the degree of contract research conducted by the organization. For example, about 75% of the income of CEA LIST (see Section 5.2.3) is from “external sources” (i.e., understood as either from non-governmental sources or through competition for funds), while only 25% of the income of the French Institute for Research in Computer Science and Automation (Inria) is from external sources. It thus seems reasonable to characterize CEA LIST as more application oriented than Inria.

2.2 The term national research laboratories

The discussion above does not lead to any consistent term to use for “independent research organizations outside the university sector set up

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3 See https://en.wikipedia.org/wiki/Fundamental_research; We will use both the term “fundamental research” and “basic research” throughout this report.

to conduct fundamental research.” These organizations are not clearly defined in any of the countries we have investigated and the Frascati Manual (OECD, 2002) does not define them either.

The Organisation for Economic Cooperation and Development (OECD) has studied “public research institutions” (PRIs; OECD, 2011). However, the OECD study and the term PRI includes all research organizations excluding universities and is thus too comprehensive for our use.

The OECD has furthermore defined four types of public research organizations (PROs). They distinguish between four ideal types.

1. Traditional mission-oriented centers (MOCs) are owned and sometimes run by government departments or ministries at the national and sub-national levels; their role is to undertake research in specific topics or sectors to provide knowledge and technological capabilities to support policy making. Some of the organizations studied in this report, for example, Inria of France, may fit in this category.

2. Public research centers and councils (PRCs) perform (and in some cases fund) basic and applied research in several fields; these overarching institutions tend to be of considerable size in several countries, representing a significant share of the national R&D capabilities. The OECD considers the National Center for Scientific Research (CNRS) of France in this category.

3. Research technology organizations (RTOs), also known as industrial research institutes, are mainly dedicated to the development and transfer of science and technology to the private sector and society; although some are owned by the government, generally, the administrative links of RTOs with governments tend to be looser than the rest. The OECD considers the Fraunhofer Society in this category. The Norwegian research institutes belong in this category.

4. Independent research institutes (IRIs) perform both basic and applied research focused on “issues” or “problems” rather than just fields. Different kinds of mission-oriented (often of limited duration) institutes and centers fit in this category.

We observe that elements from all four types, except RTOs, are relevant to this study. However, within all types there are both organizations dedicated to fundamental research and organizations dedicated to applied research. Thus, these typologies do not provide a consistent definition either.

Since we are not aware of any term that fully captures organizations with the characteristics described in the previous section (where Independent national research laboratories), we have to settle for a term that is not precise. In this report, we use the term national research laboratories or, for short, research labs or national labs (the latter term is explicitly used in the US). In some areas we use the broad term PROs; sometimes prescribed by terms such as fundamental research oriented or basic research dominated, and so forth. Hopefully, the context will make it clear whether we are talking about organizations outside the university sector set up to conduct fundamental research or the more general group of PROs.

2.3 Methods
This report is not a scientific one. However, we have provided relevant references to the literature in the text. Several of the themes considered would require a more thorough treatment to draw universal conclusions. It is especially difficult to provide a valid assessment of the quality of the scientific output of the national labs we have investigated. A comprehensive evaluation of the quality should involve, for instance, a bibliometric analysis and/or some kind of independent peer review. This is outside the scope of this report. We recommend that the government commission such an analysis to compare research labs primarily conducting fundamental research to obtain a more quality-assured assessment.

2.3.1 Countries and research labs selected
The countries and research labs selected for this investigation were selected based on, first, general experience with research systems. Second,
we drew on the contacts of Simula Research Laboratory as well as personal contacts in research labs. Third, we conducted several Internet searches and desktop studies to gain an overview of the research systems in these countries to select relevant research labs.

Generally, we investigated research labs in four of the largest Western countries in terms of research: the US, Germany, France, and the UK. These four countries have had a profound impact on the research policy of Norway, as well as on research policy in the rest of the world. Second, we chose two countries similar to Norway: Austria and the Netherlands. These are small, rich countries with open and advanced economies. Thus, they are comparable to Norway and have similar conditions for their research systems. We deliberately excluded the other Nordic countries from this study. The Nordic countries are subject to a large amount of investigations in Norway and knowledge and comparisons between Norway and the other Nordic countries can be found many other places.8

2.3.2 Internet and desktop studies and site visits
Each of the countries and research labs investigated was studied by reading their homepages and studying scientific literature and reports. Work conducted by the OECD9 and ERAWATCH10 provided standardized information well suited for comparisons between countries and research labs.

During 2015, the author visited research labs in different countries (see the complete list in “Interviews and meetings”). During these visits, we obtained first-hand appraisals of the research labs and of the R&D systems of which they are part. These meetings can be characterized as informal and unsystematic interviews. The information obtained is used throughout the text.

2.3.2.1 Assessment of scientific performance
To provide a coarse assessment of the quality of the research labs investigated in this report, we utilized information from Scimago Institutions Rankings (SIR).11 This project uses the SCOPUS database to develop indicators, divided into three groups intended to reflect the scientific, economic, and social characteristics of institutions. The SIR includes both size-dependent and size-independent indicators, that is, indicators influenced and not influenced by the size of the institutions. In this manner, the SIR provides overall statistics of the scientific publications and other output of institutions, at the same time enabling comparison between institutions of different sizes. We concentrate on size-independent indicators and those relevant to aspects of fundamental research. We used the SIR-webpages12 to assess the quality of some of the research labs, especially compared to the universities of their country. The analysis is based on the results obtained in the five-year period ending in 2012. Altogether, the dataset includes 4,840 institutions with more than 100 published works in the SCOPUS database during the last year.

Specifically, we have chosen the three following size-independent indicators (from the method section of the SIR, see footnote 11).

- Normalized impact: The normalized impact of the led output is computed using the methodology established by the Karolinska Institutet in Sweden, where it is called the item oriented field normalized citation score average. The normalization of citation values is carried out at the individual article level. The values (in decimal numbers) show the relation between an institution’s average scientific impact and the world average, set to a score of one; that is, a normalized impact score of 0.8 means the institution citations are 20% below the world average and 1.3 means the institution citations are 30% above average (González-Pereira, Guerrero-Bote, & Moya-Anegón, 2010; Rehn & Kronman, 2008).
- Excellence rate: The excellence rate indicates the amount (in percent) of an institution’s scientific output that is included in the set of the 10% of the most cited papers in their respective scientific fields. It is a measure of the high-quality output of research institutions (Bornmann, de Moya-Anegón, &

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8 See, for example, work by the Swedish professors Mats Benner and Gunnar Öquist (Benner & Öquist, 2014; Öquist & Benner, 2012) at http://tinyurl.com/ngj5auz and http://tinyurl.com/obnb3tk, respectively. See also https://www.regjeringen.no/no/dokumenter/forskning-barometeret.2015/id2409822/ (in Norwegian).

- **Excellence with leadership:** Excellence with leadership indicates the amount of highly cited articles in which the institution is the main contributor (Moya-Anegón, Guerrero-Bote, Bornmann, & Moed, 2013).

Note that once indicators are calculated, the resulting values of the institutions are normalized on a scale from zero to 100. We then calculate the average normalized score of these three indicators for each institution as an overall measure of scientific quality.

There are, obviously, many other ways of assessing scientific quality. This approach only provides a coarse approximation of the impact of the research labs. However, since these three indicators are based on bibliometry, we believe that they reflect important aspects of scientific quality in terms of fundamental research. Publications in peer-reviewed journals are, after all, the main output of fundamental research. This analysis thus gives us information of interest and illustrates interesting differences between the research systems of different countries.
3 Independent national research laboratories

In this chapter, we summarize the traits of the research and development (R&D) systems of the countries investigated in this report. The presentation does not aspire to provide a full description of the R&D systems. We only select traits of special interest to the theme of the report.

3.1 Research system trends

The global trends described in the introduction (Chapter 1) have consequences for national science and innovation policy. Although many countries increased public spending on R&D to counter the effects of the economic crisis of 2008, including most of the countries in this report, expenditures on R&D by the business sector decreased substantially, making total R&D growth weak or negative for 2009 (see Figure 1). The effect of the stimulus packages can be especially seen in 2010 and 2011 in the countries we have investigated. The negative effect on R&D when the stimulus packages were phased out (Solberg, 2015) can also be seen for these countries (Figure 1).

Figure 1. Real growth in R&D expenses in 2003–2013 for the countries investigated in this report. Data are from the Organisation for Economic Co-operation and Development (OECD) Main Science and Technology Indicators (http://www.oecd.org/sti/msti.htm), compiled by (Solberg, 2015).

Some important changes in research policies especially relevant to national research laboratories are the following. First, research public policy and research funding have focused on global issues and grand challenges. This has made science, technology, and innovation policy increasingly mission oriented. Many of the research organizations investigated in this report find that governments prefer to fund large-scale projects aimed at solving societal or environmental chal-

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13 In this report we use the term R&D systems or just research systems. Other publications use the terms science, technology, and innovation systems or research, development, and innovation systems. We attribute similar meaning to these terms.

lenges. An interesting example is the Joint Center for Artificial Photosynthesis (JCAP), led by the California Institute of Technology, with the Lawrence Berkeley National Laboratory as a key partner. This is an example of cooperation between one of the strongest research universities in the US and one of the academically strongest national (research) labs (see also Section 5.6.1). Furthermore, this project is funded by the Department of Energy (DOE) as an innovation lab, thus explicitly linking grand challenges and innovation. Institutes or research labs have been set up in several countries (e.g., the Netherlands) to solve societal challenges.

Second, public research funding has increasingly relied on project funding, often on a competitive basis, at the expense of institutional core funding (OECD, 2014b). This shift has sometimes been justified by budgetary difficulties. However, more often this shift has been formulated as a means of increasing excellence and relevance. Most of the research organizations we visited report increased pressure to increase competitive funding. In some of the organizations we visited, the level of competitive funding versus core funding has been explicitly discussed by the boards, which have limited the amount of external funding the organizations should try to obtain (e.g., Helmholtz Zentrum Munich and Rathenau Instituut).

A third change in research policy, which in some ways is a hybrid of old and new practices, is the “excellence initiatives.” These initiatives combine institutional and project funding mechanisms to encourage outstanding research and support challenge-led research. The German initiative (see Section 5.3.4) has been very visible and of high profile, but initiatives in other countries have similar elements (e.g., the creation of the Institute of Science and Technology (IST) Austria; see Section 5.1.3).

### 3.2 The significance of research laboratories

The research labs are important in the R&D systems of all seven countries considered in this report (Austria, France, Germany, the Netherlands, Norway, the UK, and the US). The national labs perform a comparable share of R&D as the universities in some countries (e.g., France and Germany) and a considerable volume in all countries investigated.

In terms of scientific performance, the research labs seem to perform rather well. Although the methodology applied by the Scimago Institutions Rankings (SIR) is coarse and simplified (see section 2.3, “Methods”), the bibliometric indicators applied demonstrate quality within certain dimensions of scientific performance. Using this methodology, the research labs perform very well (see the separate sections for each country in Chapter 5). In France and Germany, the research labs completely dominate in terms of scientific performance, occupying 19 of 20 spots in the two top 10 lists. On the other hand, in the UK and the US, health research organizations are dominant. In Austria, the Netherlands, and Norway, there is a more varied representation on the list of top 10 scientific performers. Only in Austria, however, do higher education institutions dominate the list of top 10 scientific performers but are not at the top (since that spot is held by the newly created research lab IST Austria; Section 5.1.3).

### 3.3 Organization

The research organizations investigated and visited in preparation for this report vary considerably in their funding, organization, strategic position, and scientific scope. Some of these aspects are investigated below.

#### 3.3.1 Funding

All the organizations visited for this report receive substantial core funding from public sources. In Germany (see Section 5.3), the core funding for the three research organizations outside the university sector (i.e., the Max Planck Society, the Helmholtz Association, the Leibniz Association) varies from about 66% for the Helmholtz Association to more than 80% for the two others. In France (see Section 5.2), the National Center for Scientific Research (CNRS) receives substantial core funding. The CNRS is, however, somewhat hard to categorize due to its multiple functions, including its function as a funding agency (Thèves, Lepori, & Larédo, 2007). The other large public research organizations all receive substantial core funding, often more than 70%. CEA LIST has a basic funding of around 50%. However, it does not see itself as a basic research organization. In Austria (see Section 5.1), IST Austria is the only large research organization outside the university sector. The long-term budget of IST Austria is almost entirely based on government core funding. In the Netherlands (see Section 5.4), both the
Netherlands Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW) funds several research organizations dedicated to basic research. All of these research organizations have a share of core funding well above 50%. In the US (see Section 5.6), the National Labs, the Federally Funded Research and Development Centers (FFRDCs), and the University Affiliated Research Centers all receive substantial parts of their funding as core funding or as funding to operate research infrastructures. The National Labs funded by the Department of Energy receive on average more than 80% of their funding as core funding. In Norway (see Section 5.5), the research institutes generally receive less than one-third of their funding as core funding from the government, with clearly lower funding for technological research institutes. Simula Research Laboratory receives about one-third of its funding as core funding from the government.

In this sample of countries, Norway clearly stands out, with low funding of basic research outside the university sector. It should also be noted that the Norwegian universities have some of the highest shares of core funding among OECD countries (along with universities in the other Nordic countries; Lepori et al., 2007; Schmidt, 2012).

3.3.2 Organization and leadership models

In some of the countries covered in this report, the research labs are clearly visible in the research system. In the Netherlands, the NWO and KNAW institutes are separate in documents and policy and clearly set apart from applied research institutes. In France, several categories of research organizations outside the universities are defined, overlapping somewhat and the distinction between research labs and applied research institutes is less well defined. In Germany, four research associations dominate research outside the university sector. One of them (Fraunhofer) is clearly applied research oriented, while the three others are typical research labs (i.e., the Max Planck Society, the Helmholtz Association, the Leibniz Association). In Austria, there is only one significant typical research lab. In Norway, there is no separate organization or policy for research labs.

The organizations investigated for this report vary in ownership and legal status. In some countries, the organizational status is decided by governmental law/regulation (e.g., Germany and the US). In other countries (e.g., the Netherlands and Norway), the research organizations are of different legal statuses. Foundations seem to be the most common form, while some organizations (e.g., Simula Research Laboratory) are limited companies. From the interviews conducted and from the desktop studies conducted for this report, the legal status of organizations does not seem to be very important for performance. Regardless of organizational form, research policy, political decisions, funding schemes, and other aspects of external forces seem to be more influential than the organizational form as such.

All organizations have some sort of board. Some of the funding agencies appoint members to these boards (sometimes leaving this task to a governmental agency more distant from direct political influence). The director is appointed by either the board or the funding agency in charge of the organization (e.g., the NWO and KNAW institutes in the Netherlands). To our knowledge, the organizations investigated here do not apply university-style appointments of directors (e.g., referendum style elections or senate hearings). Generally, many of the organizations investigated are operated differently from universities, resembling private companies.

3.3.3 Relationships with the authorities

All organizations interviewed for this report are sensitive to the policies of funding agencies and governments. The budgets of the organizations are determined through dialog, however, with the funding agencies as the most significant player. The relationships between research labs and research policy are regularly scrutinized, often by parliament and often when parliaments are newly elected. The DOE National Labs have been subject to more than 50 commissions, panels, reviews, and studies over the past four decades (Glauthier et al., 2015). Most of the persons interviewed expressed concern that they risk cuts in their funding due to unpredictable political processes.

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15 See also http://www.acup.cat/sites/default/files/peter-maassen-nordic-university-funding_2.ppt.
3.4 Mission of independent research laboratories
Most of the research organizations examined here have mission statements that clearly signal ambitions of conducting high-quality basic research. Two exceptions are noteworthy: Fraunhofer in Germany clearly labels itself an applied research organization. The generalizations and policy implications in this report are thus not based on the experiences of Fraunhofer. The same goes for CEA LIST, however, to a lesser degree. Another important exception is the research labs of the US. Among these organizations is a continuum from clearly basic research-oriented organizations (e.g., the Lawrence Berkeley National Laboratory) to more applied-oriented or management-oriented organizations (e.g., the Savannah River FFRDC conducting nuclear waste cleanup from the early period of nuclear weapon and nuclear energy development).

3.4.1 Education
The organizations interviewed expressed conscious consideration of their obligations in education. Most of these organizations are explicitly set up to conduct research. Still, most of them are engaged in education. Some share responsibilities with cooperating universities. Mainly, the education of the research labs is at the graduate level. Some of the organizations investigated have set up separate organizations to handle their education activities. Of these, some are set up to handle the requirement of the research labs, while others are joint organizations with the universities set up to assist both organizations (e.g., some of the Max Planck Institutes). IST Austria is unique in awarding PhDs independent of universities.

3.4.2 Innovation
Although the large majority of the organizations investigated for this report are dedicated to fundamental/basic research, they also have an integrated policy and dedicated activities for innovation and, more specifically, the commercialization of outputs from their research activities. Examples are the Centrum Wiskunde & Informatica (CWI) in the Netherlands (see Section 5.4.3) and the Institute for Research in Computer Science and Automation (Inria) of France (see Section 5.2.3). Both of these organizations have well developed systems to take care of intellectual property rights and to create start-ups based on their research. This also goes for almost all of the other organizations.
4 Summary and policy implications

4.1 Norway, the outlier
Compared to the other countries investigated in this report, Norway is the outlier. With the possible exceptions of Austria and the UK, in the other four countries (France, Germany, the Netherlands, and the US) a substantial portion of basic research is conducted outside the university sector. In France and Germany, research organizations/research labs outside the university system perform about the same amount of basic research as the universities. In the Netherlands, the amount of basic research conducted outside the university system is substantial. In the US, there are several very strong research universities performing basic research. However, the research labs (see Section 5.6.1) are a major performer of federally funded research, especially within the physical sciences. In both the US and the UK, health research has become dominant in terms of basic research, providing new funding methods and science policy into the system. Austria does not have a large research lab sector. However, IST Austria was created by governmental law in 2007 in response to perceived deficiencies in the scientific performance of the Austrian research system. The political level made IST Austria an alternative to the universities. IST Austria was given a long-term funding plan until 2026, with the aim of growing to 1,000 employees, thus becoming a significant research performer in Austria (it has already achieved high quality; see Section 5.1.2).
Like the other countries, the UK has significant research labs. However, the UK has reduced the number of research labs through privatization and fiscal reduction over the last three decades.

4.2 Diverse science policies
The science policies of the countries investigated are more diversified than in Norway in terms of supporting a variety of research organizations. The Norwegian science system is basically divided into two subsystems (disregarding research in private companies). The higher education institutions (HEIs, i.e., universities and university colleges, both public and private) are regulated by a common law and a common system of funding. The research institutes are run by another set of regulations and a common system of funding different from that of the HEIs. While the HEIs are homogeneous in many respects, the research institutes of Norway constitute a very varied group of organizations, with substantial differences in their research alignment and scope. The largest group of organizations can be described as research technology organizations (RTOs; see Section 2.1, e.g., SINTEF). However, several organizations within this group are similar to the research labs of the other countries investigated in this report. We return to some of these later in the chapter.

One common denominator of the science systems investigated in this report is that different agencies have semi-independent roles in supporting different research organizations. In the US, the Department of Energy stands out as an important agent of research (see Section 5.6.3) in a kind of non-explicit competition with the Department of Defense and the National Science Foundation. In Germany, both the federal government and the authorities of the different länder pursue distinct research agendas, sometimes in cooperation, but often with slightly differing agendas. In Germany, the three large research organizations outside the university system conducting basic science (the Max Planck Society, the Helmholtz Association, and the Leibniz Association) have all gained considerable reputation as independent science policy actors. A similar picture can be seen in France, although actors interwoven across institutions and policy fields characterize its system. In the Netherlands, both the Royal Netherlands Academy of Arts and Sciences and the Netherlands Organisation for Scientific Research operate a range of research organizations within both the basic science domain and the applied research domain. In Austria, IST Austria is a rather new construct, reflecting a political ambition to create a new structure different from the existing organizations (specifically as an alternative to university research). The consequence of different agencies acting as stewards of different segments of the basic research domain is diversity. Thus, in these systems, several diverse organizations are acting outside the university system, performing considerable amounts of basic research. The preliminary and coarse studies conducted in this report confirm that these organizations conduct basic
research of high quality (see, e.g., Section 3.2, “The significance of research laboratories”).

4.3 Possible changes in the Norwegian science policy system

This report demonstrates that Norway is different from several countries that are relevant benchmarks for Norwegian research policy, both large and dominant research nations (the US, the UK, France, and Germany), as well as nations of similar size and resource base as Norway (the Netherlands, Austria). These research systems perform at least as well as the Norwegian system and, more often, better. It is a reasonable hypothesis that the Norwegian research system can profit from incorporating some of the experiences from other countries into their current research policy. As of now, Simula Research Laboratory is the only basic research-oriented organization outside the university system of any significance that is not defined as a research institute and not managed by the corresponding funding system. In many respects, Simula Research Laboratory can be viewed as a research laboratory; Simula is quite independent; Simula conducts basic research; Simula has predictable, long-term basic funding of reasonable size; Simula contributes significantly to the quality of Norwegian research (Aksnes, 2012; RCN, 2012). The Norwegian Defence Research Establishment (FFI) is another organization similar to research labs. FFI is funded by the Department of Defense of Norway and resembles the National Labs of the US funded by the corresponding Department of Defense. FFI conducts basic research and has long-term horizons for its work but does not interact with the research community through publications the same way as Simula.

From the findings of this report, it is a reasonable hypothesis that the scientific quality of the Norwegian research system will increase if more organizations of the research lab type were present. The key question is therefore if the Norwegian authorities will consider developing a broader sector of basic research outside the university system. If the answer to this question is positive, there are at least three not reciprocally exclusive pathways the authorities can take to develop such a sector.

1. **New organizations**: The authorities may find it useful to establish entirely new organizations within selected fields to take the role of research labs. Today Norway does not have any strong hubs within the life sciences. The universities are conducting large volumes of research within the field, but no independent research organizations exist.

2. **Organization within universities and university colleges**: The Norwegian landscape of higher education is currently undergoing profound changes, with mergers and consolidations. As this process concludes, sub-organizations can potentially be singled out and transformed into national research labs. University-affiliated institutions often conduct research in a manner similar to research labs.

3. **Research institutes**: Some of the organizations within the research institute sector of Norway are very similar to Simula Research Laboratory and the other research labs exemplified in this report. They are typically oriented toward basic research, often in a very international context. Several of these may profit from a more independent role, outside the research institute context. Examples of such organizations are CICERO, the Peace Research Institute Oslo, and the Institute for Social Research.

4.3.1 Necessary changes in the research system

If the Norwegian government wishes to establish a sector of research labs, several changes in the research system may be necessary. The conceptually most significant are long-term predictability and dialog. In many respects, the development of the research organizations of Norway has been decentralized to the organizations themselves. The organizations receive core funding from the state and this core funding has been nominally stable over time outside the university sector. The growth of most of the research organizations in Norway has been based on growth in funding from external sources. From a fiscal point of view, this strategy has been a

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17 From [http://www.cicero.uio.no/en/](http://www.cicero.uio.no/en/): “CICERO is Norway’s foremost institute for interdisciplinary climate Research. We deliver new insight that help solve the climate challenge and strengthen international climate cooperation.”
18 From [https://www.prio.org/](https://www.prio.org/): “The Peace Research Institute Oslo (PRIO) conducts research on the conditions for peaceful relations between states, groups and people.”
19 From [http://www.socialresearch.no/](http://www.socialresearch.no/): “The Institute for Social Research […] seek to create an inter-disciplinary research environment without sharp distinctions between basic and applied research.”
success. The volume of research conducted in the research institutes has increased substantially. However, in recent years, this growth has lagged behind that of other sectors and the research institutes have experienced increased pressure on their scientific independence and ability to make strategic decisions. As the proportion of external funding and especially contract research increases, all research organizations experience loss of strategic maneuverability. For some of the organizations visited in connection with this report (e.g., Helmholtz Zentrum Munich and Rathenau Instituut), their boards have explicitly discussed this issue. In the Norwegian context, however, increases in external funding have been taken for granted. The most important change needed in the research system to create a sector of national research labs is to establish a routine for negotiating growth and budgets for these organizations. This will require the government to decide and formulate the level at which they expect these organizations to operate and especially the balance between core funding and external funding. The organizations will have to institute clear research management, following the signals of the funding authorities. The decision of when to seek external funding cannot be made by the individual researchers but must add up to a level in line with the ambitions negotiated between the government and the research lab.

The obligations, authority, and privileges of the research labs must be clearly defined. The research labs should be expected to take on educational obligations, including teaching at cooperating universities and supervising master’s and PhD students. National research laboratories should have wide privileges and authority. Inspired by IST Austria (see Section 5.1.3), the government should consider whether national research labs should have the right to award PhD degrees.
5 Research systems and national research labs of selected countries

In this chapter, the research systems of seven countries—Austria, France, Germany, Norway, the Netherlands, the UK, and the US—are examined. Only selected parts of the research systems are included. These are the parts that shed light on the function and position of national research labs. There are important differences between the research systems, many of these stemming from historical processes. To make comparisons possible, the presentation of each country is standardized, possibly hiding some of these differences. We still believe the main features of the research systems can be accessed.
5.1 Austria: PhD awarded outside the universities

Summary

- Austria has traditionally had a small sector of research organizations dedicated to fundamental research outside the university sector. This changed when IST Austria was created as a result of political processes in 2007.
- IST Austria is typical national research laboratory and the government provided a 20-year budget outlining the development of IST Austria.
- In very short time, IST Austria has become the foremost basic research organization of Austria.
- IST Austria is entitled to grant PhDs.
- IST Austria is organized with no departments and each professor leads one research group.

Austria is a small, rich country\(^\text{20}\) with an open and advanced economy. The country has seen rapid progress in its research and innovation system in the past 20 years (Organisation for Economic Co-operation and Development; OECD, 2014b). Its gross domestic expenditure on research and development (R&D), or GERD, was 2.86% of its GDP in 2013, well ahead of the EU-28 and OECD averages (see also Figure 2).

5.1.1 The research system of Austria

The three major sources of R&D financing in Austria are the corporate sector (46.2%), the public sector (35.8%), and international sources (18%, almost 10% from the European Union, or EU).\(^\text{21}\)

The corporate sector is the largest R&D performing sector in Austria, accounting for 68.8% of the country’s total R&D. Foreign sources fund a considerable portion of the research in the corporate sector (close to 17%; source EUROSTAT\(^\text{21}\)). The universities perform well above 20% of the R&D, while the public research organizations (PROs) perform about 5% of the R&D. The private non-profit sector is small and accounts for a low share in both financing and performing R&D.

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\(^{20}\) Austria had an estimated population of 8.6 million in 2015 (https://en.wikipedia.org/wiki/Austria) and was the 16th richest country in the world in terms of gross domestic product (GDP) per capita (United Nations, 2013; see https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita).

5.1.2 Scientific significance of research labs in Austria

The top 10 scientific performers in the Austrian research community are spread among institutions from different categories (Table 1). The top three performers are PROs/research labs, with IST Austria scoring the highest. The Austrian Academy of Science may be considered a special case, playing also an advisory role in the research system. The universities of Austria are well represented among the country’s top scientific performers.

Table 1. The top 10 scientific institutions of Austria based on three indicators from the Scimago Institutions Rankings (SIR) methodology (see section 2.3.2.1 in the methods chapter). Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Institute of Science and Technology, Austria</td>
<td>99</td>
<td>Gov</td>
</tr>
<tr>
<td>International Institute for Applied Systems Analysis</td>
<td>375</td>
<td>Gov</td>
</tr>
<tr>
<td>Osterreichische Akademie der Wissenschaften</td>
<td>524</td>
<td>Gov</td>
</tr>
<tr>
<td>Medizinische Universität Wien</td>
<td>605</td>
<td>HEI</td>
</tr>
<tr>
<td>Wirtschaftsuniversität Wien</td>
<td>608</td>
<td>HEI</td>
</tr>
<tr>
<td>Allgemeines Krankenhaus Wien</td>
<td>713</td>
<td>Health</td>
</tr>
<tr>
<td>Medizinische Universität Innsbruck</td>
<td>890</td>
<td>HEI</td>
</tr>
<tr>
<td>Universität Innsbruck</td>
<td>898</td>
<td>HEI</td>
</tr>
<tr>
<td>Medizinische Universität Graz</td>
<td>986</td>
<td>HEI</td>
</tr>
<tr>
<td>Karl Franzens Universität Graz</td>
<td>1,067</td>
<td>HEI</td>
</tr>
</tbody>
</table>

5.1.3 IST Austria

IST Austria was created by Austrian law in 2006. There are several noteworthy aspects of the creation of IST Austria, illustrating some central and controversial issues of Austria’s science and technology policy.

The broad background behind the creation of IST Austria seems to have been a feeling of underachievement in the Austrian R&D system and the need for a disruptive force. Bold R&D initiatives were underway in other Western countries, with the Danish Globalization Strategy as a prominent example. At about the same time, Germany initiated its German Universities Excellence Initiative.23 Inspired by development in other countries, the political ground seemed fertile. However, the idea of establishing a new institution outside the university system came from the scientific community, with the draft concept developed by the prominent Austrian physicist Anton Zeilinger in 2002. As the initiative passed into the political processes, several controversies arose, resulting in a partial “withdrawal” of the scientific community from the development of the new institution. Since the project was on a weak footing, an international committee of prominent scientists was appointed to develop the blueprint of the new institution. Their recommendations were to create an institution with first-class, curiosity-driven research as the core value of the concept.

This somewhat complicated history, with the initiative passing from the scientific community into the political sphere and back again, could explain one very particular trait about IST Austria: IST Austria is one of the few research institutes worldwide entitled to award PhD degrees (an example of this announcement is given in Figure 3). In any other country, the suggestion of granting such a right to an institution outside the university system would have stirred up major controversy. Somehow, maybe due to the prior process, this crucial part of the law regulating IST Austria was passed “under the radar” of the university sector. Today, there does not seem to be strong conflicts about this issue.

The creation of IST Austria can also be understood in the context of regional development. Several of the nine states (Bundesländer) run a

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kind of cluster initiative, following the lead of Styria, an early mover of the cluster policy with an automotive cluster founded in 1995. IST Austria was set up in Klosterneuburg, in the state of Lower Austria. Lower Austria has subsequently invested heavily in infrastructure for IST Austria, making it a regional center for research-based innovation.

5.1.3.1 Funding and recruitment: 20-year budget (2007–2026)

Initially, IST Austria was provided a 10-year growth budget and in 2012 the funding plan was extended to 2026. IST Austria has been growing steadily and now comprises 37 professors. The funding plan will allow IST Austria to grow to 90 to 100 research groups (professors) with up to 1,000 scientists by 2026. In this long-term budget, almost the entire budget is based on core funding from the government (of which about one-third is conditioned on performance).

The recruitment philosophy of IST Austria is to use scientific excellence as the only hiring criterion. Therefore, there are no predefined professorial slots or research topics. Furthermore, there are no departments within IST Austria, to avoid internal hierarchies and boundaries. This further means that there is a one-to-one relationship between professors and research groups. The positive effect of this philosophy is low bureaucracy and a short distance from leadership to the research conducted. A possible problem in the future is the development of ideas that are dependent on multiscale efforts by multiple research groups.

The Institute of Science and Technology Austria (IST Austria) is looking for highly qualified candidates from all over the world to apply for our ISTScholar PhD program. We offer fully-funded PhD positions in the natural and mathematical sciences in a world-class research environment on the outskirts of Vienna.

Our PhD program is characterized by innovative training with a special focus on interdisciplinarity, close mentoring by outstanding faculty within small research groups, and access to first-rate facilities. Students spend the first year completing coursework and rotations before choosing a thesis group and passing the qualifying exam. Our PhD graduates have gone on to top positions in academia and industry all over the world.

Students with a bachelor’s or master’s degree in biology, neuroscience, mathematics, computer science, physics, and related areas are encouraged to apply. We offer internationally competitive salaries co-funded by an EU Marie Sklodowska-Curie grant, full health benefits, and on-campus housing in the first year. The program is conducted entirely in English.

Figure 3. Example of an announcement from November 2015 for PhD positions at the research school of IST Austria.
5.2 France: Strong research outside the university sector

Summary

- France has a complicated research system, with overlap between policies, sectors, and organizations.
- Research organizations outside the university sector (PROs) conduct a considerable portion of research in France.
- It is difficult to demarcate the share of the fundamental research of the PROs. However, all the large PROs demonstrate substantial activity in fundamental research. The larger National Center for Scientific Research (CNRS) is also a funding body.
- The distinction between civil servants and other employees creates differences between different parts of the research system, while the concept of “mixed organizations” provides a framework for close cooperation within the PROs.

France has the second largest research system in the European Union (EU) after Germany in terms of R&D expenditure, being responsible for 17.2% of aggregate EU-28 R&D expenditure. R&D intensity (the GERD-to-GDP ratio) was 2.26% in 2012, with a private sector share of about 64%.

5.2.1 The research system of France

Higher education institutions (HEIs) perform about 21% of the R&D in France, while the PROs perform 13.7% of it. The HEIs receive 55% of governmental funding, while the PROs receive 32% (see also Figure 4).

Among the PROs, the CNRS is the largest (employing almost three times as many staff members as the second largest PRO, i.e., CEA; OECD 2014a, Figure 5). The annual budget of the CNRS was €3.3 billion in 2012, making it the largest fundamental research organization in Europe. The CNRS’s annual budget represents a quarter of France’s public spending on civilian research.

The French R&D system is very complicated (OECD, 2014a). First, there is organizational overlap between the sectors, especially between HEIs and PROs. For example, more than 80% of the research laboratories of the CNRS are

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mixed research units (unites mixtes de recherche).\textsuperscript{24} This, in effect, also makes CNRS a financing body. The CNRS is in itself a very different organization from almost all the organizations in the other countries (Thèves et al., 2007). Second, there is a tendency for French R&D policy to launch new initiatives on top of existing policy, thus building layer upon organizational layer in the system. For example, CEA LIST\textsuperscript{26} is part of CEA Tech\textsuperscript{27} but is also a Carnot Institute.\textsuperscript{28} Another example is the construction of communities of universities and institutions (communautés d’universités et d’établissements), which are to be clusters of higher education and research institutions. Third, public research scientists have a variety of statuses: At the CNRS and Inria, they are civil servants, as in universities, while at CEA they are employed under private-law contracts (for details, see OECD 2014a, p. 124). Status as a civil servant means a permanent position and provides the employee with very strong job security. This may make cooperation easy for organizations with the same employee organization, but may create barriers against mobility between parts of the research system with different organization of employees. Fourth, in contrast to most other Western countries, the PROs are very independent. The PROs bring together different functions that, in other countries, are spread out among several institutions: the orientation (planning), funding, execution, and evaluation of research in their respective fields.\textsuperscript{29}

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Research field</th>
<th>Total budget (EUR billions)</th>
<th>Staff numbers (FTE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNRS</td>
<td>Basic research; all disciplines (including human and social sciences)</td>
<td>3.310\textsuperscript{*}</td>
<td>33 200</td>
</tr>
<tr>
<td>INRA</td>
<td>Agriculture</td>
<td>0.844\textsuperscript{*}</td>
<td>10 100</td>
</tr>
<tr>
<td>INSERM</td>
<td>Health</td>
<td>0.598</td>
<td>7 900</td>
</tr>
<tr>
<td>INRIA</td>
<td>Digital science and technology</td>
<td>0.167</td>
<td>2 690</td>
</tr>
<tr>
<td>CEA</td>
<td>Nuclear, energy</td>
<td>2.681</td>
<td>13 000</td>
</tr>
<tr>
<td>CNES</td>
<td>Space</td>
<td>2.163\textsuperscript{*}</td>
<td>2 400</td>
</tr>
</tbody>
</table>

* 2011 data.
The budget data for the CEA relate only to the civil sector and are derived from the CEA 2012 financial report.

5.2.2 Scientific significance of research labs in France
The top 10 scientific performers in the French research community are dominated by the CNRS institutes, with seven out of the top 10 performers (Table 2). The research labs and other governmental research organizations dominate in the list of top scientific performers of France, with the highest ranking university (Ecole Nationale Supérieure de Chimie de Paris) in position 27.

\textsuperscript{26} See http://www-list.cea.fr/index.php/en/.
\textsuperscript{27} See http://www.cea-tech.fr/cea-tech/english.
\textsuperscript{28} See http://www.instituts-carnot.eu/en/carnot-institute/cea-list. Inria is also a Carnot Institute like. A “Carnot Institute” is a label the organization get and provides additional funding.
### Table 2: The top 10 scientific institutions of France based on three indicators from the SIR methodology (see section 2.3.2.1 in the methods chapter)

Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratoire d’Ecologie Alpine (CNRS)</td>
<td>10</td>
<td>Gov</td>
</tr>
<tr>
<td>Institut Jean-Pierre Bourgin (INRA)</td>
<td>12</td>
<td>Gov</td>
</tr>
<tr>
<td>Institut Lavoisier de Versailles (CNRS)</td>
<td>62</td>
<td>Gov</td>
</tr>
<tr>
<td>Centre d’Immunologie Marseille-Luminy</td>
<td>77</td>
<td>Gov</td>
</tr>
<tr>
<td>Laboratoire d’Etudes en Geophysique et Océanographie Spatiales (CNRS)</td>
<td>81</td>
<td>Gov</td>
</tr>
<tr>
<td>International Agency for Research on Cancer</td>
<td>95</td>
<td>Health</td>
</tr>
<tr>
<td>Institut de Biologie de l’Ecole Normale Supérieure (CNRS, INSERM)</td>
<td>98</td>
<td>Gov</td>
</tr>
<tr>
<td>Laboratoire d’Annecy-le-Vieux de Physique des Particules (CNRS)</td>
<td>146</td>
<td>Gov</td>
</tr>
<tr>
<td>Ecologie, Systématique et Evolution (CNRS)</td>
<td>188</td>
<td>Gov</td>
</tr>
<tr>
<td>Laboratoire des Sciences du Climat et l’Environnement (CNRS, CEA)</td>
<td>189</td>
<td>Gov</td>
</tr>
</tbody>
</table>

#### 5.2.3 Inria and CEA LIST

Inria specializes in computer science and applied mathematics. It was created under the name Institut de recherche en informatique et en automatique (IRIA) in 1967 at Rocquencourt, near Paris (current headquarters location). In 1979, IRIA became Inria. Inria receives about 70% of its revenue from the government. With a staff of 4,500 (2,700 full-time equivalents, Figure 5), Inria appears rather small compared to several of the other research organizations. However, Inria is quite specialized.

The total permanent staff of CEA (French Alternative Energies and Atomic Energy Commission) numbers about 16,000. However, the CEA is located in 10 research centers, half of them specializing in military applications. CEA LIST is one of these research centers and one of three institutes (the others being LETI and LITEN) that constitute the CEA’s technological research directorate. CEA LIST has lower basic funding than Inria, with about 25% core funding and another 31% from incentives. CEA LIST concentrates more on applications than, for example, Inria.

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30 Sources: [https://en.wikipedia.org/wiki/French_Institute_for_Research_in_Computer_Science_and_Automation](https://en.wikipedia.org/wiki/French_Institute_for_Research_in_Computer_Science_and_Automation) and [https://en.wikipedia.org/wiki/Commissariat_%C3%A0_l%C3%A9nergie_atomique_et_%C3%A0_l%27%C3%A9nergie_alternatives](https://en.wikipedia.org/wiki/Commissariat_%C3%A0_l%C3%A9nergie_atomique_et_%C3%A0_l%27%C3%A9nergie_alternatives) and site visits on June 10–11, 2015.
5.3 Germany: Excellence outside the university sector

Summary

- Research organizations outside the university system (research labs) conduct a considerable portion of research in Germany, 15%, compared to 18% for the universities.
- There are four very large research labs in Germany (i.e., the Max Planck Society, or MPG; the Fraunhofer Society, or FhG; the HGF; and the Leibniz Association, or WGL). Fraunhofer is oriented toward applied research, while the other three research labs are dedicated to fundamental research.
- The research labs receive quite substantial funding from public sources.
- The research labs, especially the MPG, perform very well compared to other German research organizations.
- The cooperation between the universities and research labs is strong and sometimes formalized in separate organizations.

Germany has the largest research system in the EU in terms of R&D expenditure, being responsible for 29.2% of aggregate EU-27 R&D expenditure. Germany is close to the EU goals for R&D expenditure (R&D intensity of 2.92%) and the ideal composition, with a business sector share of about two-thirds (see also Figure 6).

5.3.1 The research system of Germany

In general, the R&D landscape and the funding level in Germany have remained rather stable over years.

The German research landscape is rather complex and characterized by shared responsibilities between the federal level and the 16 German states (Länder). The governments of the Länder are responsible for financing research and teaching at the public universities in their respective states.

Non-university research institutions (research labs, i.e., MPG, FhG, HGF, WGL) carry out a large share of the basic research in Germany. The Länder and the federal government jointly finance the latter. Currently, the Länder are due

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to provide about 44% of the overall public budget for R&D (including universities); that is, the share of the Länder is slightly decreasing (in 2000 it was at about 48% of total budget provisions for R&D set out by the federal government and Länder).

There is a wide range of research labs in Germany. In 2012, they performed about 15% of total R&D activities in Germany, that is, their quantitative significance in the German research system is comparable to that of universities (which account for about 18% of total R&D activities). The research labs consist of many different organizations and institutions with a variety of governance and financing models and very different roles within the German research system, ranging from institutes solely devoted to fundamental research (e.g., engaged in PhD education) to institutes of applied research focusing mainly on cooperation with industry. A common feature of all research labs is that they receive basic funding from federal and/or Länder governments, although to varying degrees.

5.3.2 Scientific significance of research labs in Germany

The top 10 scientific performers of the German research community are almost totally dominated by members of the MPG. The European Molecular Biology Laboratory laboratory of Heidelberg is the only non-MPG institution among the top 10 scientific performers of Germany (Table 3). The first university institute (Hasso Plattner Institute) is ranked 11th in Germany, followed by another seven MPG institutes in the top 20. We also note that German institutions are ranked very well in the total ranking. Only the US has a better average score for their top 10 institutions.

Table 3. The top 10 scientific institutions of Germany based on three indicators from the SIR methodology (see section 2.3.2.1 in the methods chapter). Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Planck Institut für Molekulare Pflanzenphysiologie (MPG)</td>
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<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Pflanzenzuchtungsforschung (MPG)</td>
<td>11</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Entwicklungsbiologie (MPG)</td>
<td>13</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Kohlenforschung (MPG)</td>
<td>14</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Biochemie (MPG)</td>
<td>16</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Evolutionäre Anthropologie (MPG)</td>
<td>25</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Terrestrische Mikrobiologie (MPG)</td>
<td>29</td>
<td>Gov</td>
</tr>
<tr>
<td>European Molecular Biology Laboratory Heidelberg</td>
<td>30</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Molekulare Zellbiologie und Genetik (MPG)</td>
<td>35</td>
<td>Gov</td>
</tr>
<tr>
<td>Max Planck Institut für Bildungsforschung (MPG)</td>
<td>36</td>
<td>Gov</td>
</tr>
</tbody>
</table>

5.3.3 The research labs of Germany

Most of the non-university PROs are organized under the umbrella of the following four main organizations (see also Figure 7).

- The MPG currently maintains 80 institutes, research units, and working groups, mainly in the field of basic research. Its basic (institutional) funding in 2012 was €1.5 billion.
- The FhG maintains over 80 research units and conducts applied research and offers scientific and technical expertise for enterprises, particularly for small and medium-sized enterprises. In 2012, its funding was €1.8 billion, of which €1.5 billion was generated through contract research. More than 70% of the FhG’s contract research revenue is derived from contracts with industry and from publicly financed research projects. Almost 30% is contributed by the German federal and Länder governments in the form of base funding.
- The HGF is a community of 18 research centers and is Germany’s largest scientific research association focusing on research that requires large-scale installations. Its mission is to perform research that contributes substantially to address the grand challenges of our time. Its budget in 2012...
amounted to €3.6 billion. About two-thirds of this funding comes from public sponsors (in a 9:1 split between federal and Länder authorities). The individual Helmholtz Centres are responsible for attracting more than 30% in the form of contract funding provided by public and private sector sponsors.

- The WGL, which comprises 86 research institutions and service facilities, works at the interface of problem-oriented basic research and applied research. Its institutional budget in 2012 was €1.4 billion.
5.3.3.1 Funding of research labs

The non-university research labs each receive considerable basic funding from public sources. FhG has the lowest share of basic funding from the government, with about 30%; the HGF has about two-thirds, while MPG and WGL each have more than 80% basic funding.
There are some interesting differences between the four organizations:

- The relationship between the organizations and the German federal level varies according to the share of basic funding provided by the Länder (Figure 8). HGF and FhG direct their attention at the state level, since about 90% of their basic funding is provided at the federal level. The MPG and WGL, on the other hand, is much more dependent on funding decisions at the Länder level.

- The FhG conducts the most applied research of the four large PROs of Germany, while the three other are clearly oriented toward fundamental/basic research.

- MPG and FhG are integrated organizations with strong headquarters, while HGF and WGL are comparatively loose umbrella organizations of legally independent institutes. Project administering agencies developed out of the research institutions.

5.3.3.2 Cooperation between research labs and universities

There is considerable cooperation between research labs and universities. One of the key mechanisms promoting such cooperation is personnel overlap. Helmholtz Zentrum München (HGMU), the German Research Center for Environmental Health, is typical in that all their institute heads are professors at one of the nearby universities. From inspecting the homepages of many of the individual institutes within the research labs, we conclude that it is quite common to set up joint organizations between research labs and universities to handle education activities. The Helmholtz Graduate School for Environmental Health, HELENA, is an example. This graduate school was launched in 2011 to support doctoral students. HGMU took the initiative jointly with the Ludwig Maximilian University of Munich (LMU) and the Technical University of Munich.

5.3.3.3 HGMU

HGMU is one of the research centers within the HGF. HGMU was founded in 1964 as the Gesellschaft für Strahlenforschung as an autonomous limited company engaged in radiation research. Through the 1980s and 1990s, the research focus of Gesellschaft für Strahlenforschung changed to environmental research and eventually to health. HGMU has about 2,200 employees.
5.3.4 Political reform initiatives and trends in the German R&D system

In recent years, two political initiatives have been launched to improve the performance of the German R&D system.

The German (Universities) Excellence Initiative aims to strengthen selected universities more than others to raise their international visibility. Altogether €2.7 billion will be distributed over the period 2007–2017, most of the funding has been allocated to cluster activities (60%). However, the funding of Future Concepts (about 30%) has received the most attention, probably due to the prestige of being one of 11 chosen from 140 universities. One of the most significant effects of the Excellence Initiative might be somewhat unexpected: Normally, German professors owe their loyalty to their scientific community more than to their university. The Excellence Initiative has influenced this soft value in that the initiative has legitimized the strategic behavior of the university as a unit.

The Pact for Research and Innovation, on the other hand, was initiated to raise the block funding of the PROs by 5%.

One of the overall purposes of both these initiatives was to increase the cooperation between universities and research labs. The overall result seems to be that the research labs have prioritized education activities more than before, while the universities have developed into more flexible organizations.

A bibliometric study was recently conducted on behalf of the German Ministry of Education and Research. We observe from this report (Mund, Conchi, Frietsch, Hornbostel, & Winterhager, 2014) that the universities publish about two-thirds of the scientific output in Germany (Figure 9). This somewhat contradicts the fact that the universities and research labs perform almost the same amount of R&D. We observe, however, that the three research labs oriented toward fundamental research (MPG, HGF, and WGL) all have consistently higher rates of high-quality publications compared to the universities (Figure 10). The Max Planck institutions especially have a very high share of high-quality publications. We also note that the quality of the publications of the Fraunhofer institutes is comparable to those of the universities, however, with much greater variability. An obvious conclusion is that the research labs of Germany publish less, but better; they are more quality conscious.

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Figure 9. The number of publications from the universities and the four large research labs of Germany, 2003–2013 (Mund et al., 2014). In this figure, MPG stands for the Max Planck Society; FhG, the Fraunhofer Society; HGF, the Helmholtz Association; WGL, the Leibniz Association; and Uni, all universities combined.

33 Institute for Research Information and Quality Assurance, personal communication.
Figure 10. The share of publications among the 10% highest cited publications of the universities, the four large research labs of Germany, and the national share overall, 2003–2013 (Mund et al., 2014). In this figure, MPG stands for the Max Planck Society; FhG, the Fraunhofer Society; HGF, the Helmholtz Association; WGL, the Leibniz Association; and Uni, all universities combined.
5.4 The Netherlands: Well organized national research labs

Summary

- The research organizations set up for basic research outside the university sector (national research labs) are clearly defined in the research system of the Netherlands.
- The research labs are organized under the Netherlands Organisation for Scientific Research (NWO) and the Royal Netherlands Academy of Arts and Sciences (KNAW).
- The research labs perform well in the Dutch research system.
- The CWI is a typical research lab, receiving about 60% of their revenue as basic funding from the government.
- The research labs have a distinct role in providing infrastructure for research.

The Netherlands is a medium-sized, rich country\textsuperscript{35} with an open and advanced economy. The country “is a strong performer in both science and innovation. In terms of both quantity and quality, scientific output is among the highest in the EU, when population is taken into account” (UNESCO, 2015). The country’s GERD intensity (gross domestic expenditure on R&D) was 2.16% of its GDP in 2012, slightly behind the EU-28 and OECD averages.

The major sources of R&D financing in The Netherlands are the corporate sector (44.2%), whose percentage is well below that of the other countries in this report, except for Norway. The share of funding from the public sector is relatively high (40.4%), while that of international sources is about average (11%).\textsuperscript{36}

The corporate sector is the largest R&D-performing sector in the Netherlands, accounting for 56.6%. The universities perform 32.7% of the R&D, which is well above the EU mean of 23.8%. The PROs perform about 11% of the

\begin{tabular}{l}
\textbf{Population:} \\
16.7 million (2013) \\
\textbf{GDP per capita:} \\
€ 32,800 (2012) \\
\textbf{GERD intensity (GERD/GDP, %):} \\
2.16 (provisional) (2012) \\
\textbf{Private sector share of R&D (%):} \\
57 (2012) \\
\textbf{Public sector share of R&D (%):} \\
43 (2012)
\end{tabular}

\textsuperscript{35} It had an estimated population of 16.9 million in 2015 (https://en.wikipedia.org/wiki/Netherlands) and was the 15th richest country in the world in terms of GDP per capita (UN, 2013; https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita).

5.4.1 The research system of the Netherlands

The Netherlands have a wide variety of PROs. Three kinds of PROs are recognized. The first group comprises institutes set up for knowledge development in a particular prioritized research theme. The leading institutes, the large technological institutes, the agricultural institutes, and some other institutes belong to this group. The second group is the applied research institutes, with the Netherlands Organisation for Applied Scientific Research dominating strongly.

The third kind of PROs is the most interesting for this report: the research institutes of the NWO and the KNAW. Sometimes labeled para-university institutes, these organizations were set up for fundamental scientific research outside universities. They are thus in line with the concept of national research laboratories (see Section 2.2). In the 1990s, these research labs were directly financed by the Ministry of Education, Culture and Science. The transfer of institutes from the federal level to NWO (nine institutes) and KNAW (19 institutes) created a more rigorous system of evaluation and more explicit governance. NWO and KNAW each have a total budget of €125 million funding their institutes. Although the 28 institutes have varied organizational forms, they are all governed by their respective parent organizations, regardless of form.

Since the 1990s, the universities of the Netherlands have been characterized by strong management, organized research, and professionalism. These well-organized universities may partly explain the success the country has experienced in EU funding programs and scientific quality (UNESCO, 2015). At regular intervals, politicians debate the existence of the research institutes of NOW and KNAW (often when new parliaments are established after elections), asking why these institutes are not part of the universities. The NWO institutes (oriented toward science and technology) draw legitimacy from their unique role in managing national research facilities and providing laboratories and other research-specific accommodations to researchers (Steen, 2008) as well as incubating new talent and research areas. The KNAW institutes (in the humanities and social sciences) probably draw legitimacy from the uniqueness of their specific research niches.

5.4.2 Scientific significance of research labs in the Netherlands

The top 10 scientific performers in the Dutch research community are evenly spread among institutions from different categories (Table 4), with one of the NWO research labs at the top.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOM Institute for Atomic and Molecular Physics</td>
<td>34</td>
<td>Gov</td>
</tr>
<tr>
<td>Netherlands Cancer Institute—Antoni van Leeuwenhoek Hospital</td>
<td>148</td>
<td>Health</td>
</tr>
<tr>
<td>Erasmus University Rotterdam</td>
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<td>HEI</td>
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<tr>
<td>Royal Netherlands Academy of Arts and Sciences</td>
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<tr>
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<td>Utrecht University</td>
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<td>Royal Netherlands Meteorological Institute</td>
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<td>Gov</td>
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<tr>
<td>Royal Netherlands Institute for Sea Research</td>
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</tr>
<tr>
<td>National Institute for Public Health and the Environment</td>
<td>333</td>
<td>Health</td>
</tr>
</tbody>
</table>

Table 4. The top 10 scientific institutions of the Netherlands based on three indicators from the SIR methodology (see section 2.3.2.1 in the methods chapter). Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field.

37 See note 36. However, a slightly different categorization can be found in http://www.government.nl/documents... and-publications/leaflets/2012/04/17/the-science-system-in-the-netherlands.html.
38 https://www.tno.nl/cn/
5.4.3 CWI

The mission statement of CWI is “to conduct pioneering research in mathematics and computer science, generating new knowledge in these fields and conveying it to trade, industry and society at large.”

CWI is a typical NWO institute (see above), with about 200 full-time equivalents, a turnover of €17.0 million, €10.9 million of which is basic funding from the NWO. It has a reasonable scientific output and does satisfactorily on the SIR calculated for this report (see Section 2.3.2.1), with a global rank of 992 (but since the Netherlands generally do much better than, e.g., Austria and Norway, 30 research institutes in the Netherlands rank above CWI). CWI’s focus is strategic long-term research. However, it also conducts PhD education and has a systematic approach to commercialization and innovation (with 22 spin-offs as of 2015). It maintains strong relations with almost all universities (its general director and other key leaders also hold positions at different universities).

Of special interest in this report is CWI’s budgetary thinking. Its stated internal policy is that the core funding from the NWO should equal the costs for running costs and tenured staff. In addition, the tenured staff is (on average) expected to acquire external funding equal to their cost to fund PhDs, post-doctoral students, and other temporary staff. Figure 12 shows how this level is upheld quite closely over time. The overall balance of CWI is 60% basic funding versus 40% project funding.

![Funding/cost balance of CWI](image)

**Figure 12. Balance between core funding and different cost categories of the CWI.**

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5.5  **Norway: “Research institutes” outside the university sector**

**Summary**

- Most research organizations outside the universities in Norway are grouped as “research institutes” and managed under one common set of rules and one common set of funding mechanisms, despite wide differences in scientific orientation.
- The research institutes have a low share of core funding compared to other countries. The core funding is especially low for the industrial/technological institutes with at share of 11%.
- Small research organizations are doing well relative to the universities measuring scientific quality.

Norway is a small, very rich country\(^{40}\) with an open and advanced economy. Its GERD intensity (gross domestic expenditure on R&D) was 1.66% of GDP in 2012, clearly behind the EU-28 (2.06%) and OECD (2.40%) averages.

The three major sources of R&D financing in Norway are the corporate sector (44%), the public sector (35.8%), and international sources (8%).\(^{41}\)

The corporate sector is the largest R&D-performing sector in Norway, accounting for 63%, clearly lower than the OECD and EU levels. The higher education sector (including university hospitals) stands for 24% of R&D expenditures and the institutional sector 12% (see also Figure 13).

**5.5.1  The research system of Norway**

The Norwegian research and innovation system is characterized by a multitude of actors at the political and performing level, while at the strategic level there are fewer actors and more overall coordination. At the political level, the responsibility for research is organized according to the “sector principle”. Several ministries allocate sizable resources to research that are related

\(^{40}\) Its estimated population was 5.1 million in 2015 and it ranked second to fourth of the richest countries in the world in terms of GDP per capita ([https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita](https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita)).

to the sectors under their respective responsibilities. However, the Ministry of Education and Research is the largest source of government research funds and is responsible for the inter-ministerial coordination of the national research policy and the government’s overall research funding. At the strategic level, i.e. below the ministerial level, three agencies, the Research Council of Norway (RCN), Innovation Norway and the Industrial Development Corporation of Norway (SIVA), are the main institutions for implementing the research and innovation policies of the government.

Norway’s multiannual R&D strategies are defined in periodical (every four years) white papers to the Norwegian Parliament. Public funding for R&D is provided within the framework of an annual budget. In the latest white paper on research, published in 2013 (“Long-term perspectives – knowledge provides opportunity”), the government stresses the importance of ensuring and increasing the long-range perspective, predictability and transparency with regard to national investments in R&D and higher education. This has been followed by a long-term national plan, setting out political priorities for research and higher education in a 10-year perspective.

A specific characteristic of the Norwegian science policy is that almost all research organizations outside the university sector are subject to a common overall administrative framework. The (Research) Institute sector consists of both private and governmental organizations. A relatively high share of R&D is performed by the Institute sector, which covers several different type of institutions, including both privately and publicly funded research institutes.

The research institute sector comprises, in all, 113 institutions. Sixty-three institutions are counted as “research institutes” (R&D being their primary task) and 50 as “institutes with research” (“institutions with R&D”). Included are institutes in both the government and business sectors. The former group accounts for 85% of the total research performed within the research institute category. This group falls under the guidelines for government support of research institutes, entitled to core institutional funding, amounting to, on average, about 15% of total annual turnover. This ranges from 24% for social science institutes to 11% for technical-industrial institutes.

Laws regulating universities offer the opportunities for universities to establish independent companies to perform commissioned research or to buy into existing companies. This has created some tension between universities and research institutes. The government has indicated that it prefers collaborative schemes between universities and institutes over the establishment of new, separate research organizations inside the universities. Thus, to an increasing extent, collaboration takes place on the basis of formal alliances and agreements, if not yet mergers (see Denmark for comparison), between universities and independent institutes.

Collaboration between institutes and universities is, however, not new but has in some cases been extensively practiced over a long period of time. The largest research institute for (primarily) industrial research (SINTEF) has, since its inception in 1950, a long history of close, formal collaboration with the Norwegian University for Science and Technology (NTNU).

In Norway there are in total eight universities, 18 university colleges and seven specialized university colleges. All universities are publicly owned. The eight universities perform the largest part (about 80%) of research in the HEI sector. A large part of the funding for HEI research is the core funding channelled directly from the Ministry of Education and Research, but funds are also provided from project funding through the RCN. As a share of total R&D expenditure in Norway the higher education sector has increased from 26% in 2001 to 32% in 2011.

Since the commercialization act was introduced in 2003, universities and university colleges have been increasingly setting up technology transfer offices (TTOs) and using science parks and incubators to link up with industry.

5.5.2 Scientific significance of research labs in Norway

The top 10 scientific performers of the Norwegian research community are somewhat dominated by research labs (Table 5). All five research labs in the table are rather small. Of the two universities and one university college (School of Sport Science), the Norwegian University of Science and Technology is the largest. The University of Oslo and Oslo University Hospital, which often score highest in international rankings, are 14th and 11th nationally, respectively.
Table 5. The top 10 scientific institutions of Norway based on three indicators from the SIR methodology (see section 2.3.2.1 in the methods chapter). Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwegian Institute for Air Research</td>
<td>236</td>
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<tr>
<td>Simula Research Laboratory</td>
<td>266</td>
<td>Gov</td>
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<tr>
<td>Norwegian School of Sport Sciences</td>
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<tr>
<td>Stavanger University Hospital</td>
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<td>Health</td>
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<tr>
<td>Geological Survey of Norway</td>
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<td>HEI</td>
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<td>Norwegian University of Science and Technology</td>
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<td>HEI</td>
</tr>
<tr>
<td>Norwegian Institute for Nature Research</td>
<td>1251</td>
<td>Gov</td>
</tr>
</tbody>
</table>
5.6 The US: national labs of strong importance

Summary

- Research organizations directly funded by the government (National Labs) are a significant component of the US research system.
- The National Labs of the US perform a large proportion of research, especially that funded by public sources.
- The National Labs conduct a wide variety of research in different fields. Some of them are oriented toward basic science, while others are more mission oriented. Some are quite monodisciplinary, while others have a broad portfolio of activities in various fields of science.
- The National Labs have a specific role in conducting long-term research and managing large research facilities.

The US has been at the forefront of cutting-edge science, technology, and innovation since World War II (OECD, 2014b). US expenditures on R&D constituted more than 40% of the total OECD spending. Its GERD (gross domestic expenditure on R&D) was 2.79% of its GDP in 2013, well ahead of the EU-28 and OECD averages. The major sources of R&D financing in the US are the corporate sector (60%) and the public sector (32%).

The corporate sector is the largest R&D-performing sector in the US, accounting for more than 70%. The higher education sector performs 13% of R&D, with a dominant role in basic research, where it performs more than half of the research. PROs perform slightly more R&D than the universities (see also Figure 14).


5.6.1 The US R&D system: The creation of the National Labs

Important changes in the US R&D system were initiated in the wake of World War II. First, a system of National Labs was created. During the war, the US defense organizations required a rapid and focused R&D capability to apply advanced technologies to the war effort (Hruby et al., 2011), most notably the Manhattan project. After the war, the authorities still found the need for the continued development of technical

43 The following description is based on (Dale & Moy, 2000; Hruby, Manley, Stoltz, Webb, & Woodard, 2011).
capabilities, especially to fulfill security and defense needs. Starting with the establishment of the RAND Corporation as an FFRDC in 1947, the FFRDCs flourished in the 1950s, 1960s, and 1970s, peaking in 1969 with 74 such organizations (Dale & Moy, 2000). The FFRDCs are fully funded by different federal agencies. Currently, there are 41 recognized FFRDCs sponsored by the US government, performing R&D costing close to US$16 billion in 2013,⁴⁴ which is about 10% of the federal spending on R&D (Glaudthier et al., 2015). In addition, the Department of Defense sponsors about 15 University Affiliated Research Centers (UARCs). The UARCs are similar to the FFRDCs. These two classes of large federal labs⁴⁵ (the FFRDCs and the UARCs) perform the largest part of government-sponsored research, apart from the universities. Altogether, there are more than 600 federal laboratories and nearly 700 smaller federal laboratory facilities in the US.

Second, the end of the war also saw a fundamental change in the university system (see Atkinson & Blanpied, 2008 for a comprehensive account). The report “Science—The Endless Frontier,”⁴⁶ headed by Vannevar Bush (1945)⁴⁷ in response to four questions posed by President Franklin D. Roosevelt on how to organize the post-war research system, became very influential. The report argued that it was in the interest of the nation to fund university research. This was the start of a period of strong expansion of federal support to universities, “resulting in a flowering of the American academic research system” (page 30; Atkinson & Blanpied, 2008) in the 1950s through the 1970s. While there are about 4,500 degree-granting institutions in the US, there are about 200 universities that are research universities according to the Carnegie Classification of Institutions of Higher Education.⁴⁸ About half of these are in the category of research universities with very high research activities.

Strong research universities (33 of the highest-ranked universities in the Academic Ranking of World Universities, or ARWU,⁴⁹ are from the US), strong federal labs, and an enterprise sector prone to invest in research put the US in the absolute lead of R&D in the post-war era. However, today, the US research system is experiencing much stronger competition from the rest of the world, most notably from the dramatic growth of the Chinese research system. Recently, concerns have been raised about the quality of fundamental aspects of the US education, research, and innovation system (see, e.g., Augustine et al., 2010).

The large concerted research efforts, exemplified by the FFRDCs and the quest to land a man on the moon, that is, “big science” (Weinberg, 1961) has been an integral part of the US research agenda ever since World War II. The concept of big science regularly comes under scrutiny (Theil, 2015; Weinberg, 1961). However, the success of the Human Genome Project⁵⁰ and other large-scale projects has secured this as a tool in US research policy.

5.6.2 Scientific significance of research labs in the US

The top 10 scientific performers in the US research community are strongly dominated by research organizations within the health research field. Eight out of the top-10 performers are from the health category (Table 6). However, several are funding organizations (e.g., the American Cancer Society) and do not necessarily conduct research. The highest-ranking university (Rockefeller University) ranks 20th. The performance of US institutions dominates the top 100 scientific performers, with 43 out of the 100 highest-ranking institutions. The positions of the highest-ranking US universities illustrate the difference between this coarse ranking based on bibliometry compared to a broader ranking, for example, the Shanghai ranking (ARWU⁵¹). The top four institutions in the ARWU ranking are American but rank lower in the ranking used in

⁴⁴ See http://nescedata.nsf.gov/ffrdc/2013/html/FFRDC2013_DSF_01.html. However, (Glaudthier et al., 2015) states that the DOE National Laboratories alone receive US$11.7 billion, conducting altogether US$14.3 billion of R&D.

⁴⁵ We return to the discussion about the terms national labs and federal labs. (section 5.6.3)


⁴⁷ At that time, Bush was the director of the Office of Scientific Research and Development (OSRD) within the Executive Office of the President. The OSRD had considerable authority and was instrumental in the wartime R&D effort of the US.

⁴⁸ See http://carnegieclassifications.iu.edu/resources/.


this report, based purely on bibliometric indicators: Harvard University ranks first in the ARWU ranking but 111th here; Stanford University ranks, respectively, second and 91st; the Massachusetts Institute of Technology (MIT) ranks, respectively, third and 69th; and the University of California, Berkeley ranks, respectively, fourth and 134th.

Table 6. The top 10 scientific institutions of the US based on three indicators from the SIR methodology (see section 2.3.2.1 in the methods chapter). Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Whitehead Institute for Biomedical Research</td>
<td>1</td>
<td>Health</td>
</tr>
<tr>
<td>American Cancer Society</td>
<td>2</td>
<td>Health</td>
</tr>
<tr>
<td>J. David Gladstone Institutes</td>
<td>3</td>
<td>Health</td>
</tr>
<tr>
<td>Broad Institute of MIT and Harvard</td>
<td>4</td>
<td>Health</td>
</tr>
<tr>
<td>Cold Spring Harbor Laboratory</td>
<td>5</td>
<td>Health</td>
</tr>
<tr>
<td>Howard Hughes Medical Institute</td>
<td>9</td>
<td>Health</td>
</tr>
<tr>
<td>Boyce Thompson Institute for Plant Research</td>
<td>15</td>
<td>Others</td>
</tr>
<tr>
<td>National Center for Biotechnology Information (NIH)</td>
<td>17</td>
<td>Gov</td>
</tr>
<tr>
<td>Salk Institute for Biological Studies</td>
<td>22</td>
<td>Health</td>
</tr>
<tr>
<td>Stowers Institute for Medical Research</td>
<td>23</td>
<td>Health</td>
</tr>
</tbody>
</table>

5.6.3 Case: The National Labs
The majority of the FFRDCs can trace their present mode of operations back to wartime effort origins, although many of the organizations already existed before the war. Many have continued along the path started during the war, although many have restricted or abandoned their military-oriented research (e.g., the Jet Propulsion Laboratory). In the 1980s and 1990s limitations were set on the Department of Defense’s funding of FFRDCs, forbidding the Department of Defense to fund any non-military research (Dale & Moy, 2000). This further reinforced the split between military and civil research and led to the creation of the UARCs.

The FFRDCs constitute a very varied group of entities. They vary in a number of ways that influence their orientation in the research system of the US, as follows.

- **Government sponsorship**: There are 10 different departments or agencies funding FFRDCs, with the DOE funding 16 and the Department of Defense funding 10. There seems to be a political struggle about the term National Labs. The DOE provides more than 40% of the total national funding for physics, chemistry, materials science, and other areas of the physical sciences. In addition to its role as a major funding agency, the DOE and especially their Office of Science assume a strategic role. The DOE coordinates all the DOE-sponsored FFRDCs (H. Simon, personal communication) and these FFRDCs have a common conception of their role as leading national

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51 The account is based on written sources and site visits to the California Institute of Technology, the Jet Propulsion Laboratory, and the Lawrence Berkeley National Laboratory in October 2015.

labs. The DOE National Labs are well organized and successful. From a European point of view, it may seem strange that the National Science Foundation set up its own (three) FFRDCs and assumes the same role as any other government agency funding a federal research lab.

- **Organization and management.** At the highest level, the governmental sponsor is one source of differences in an organization. However, the variations in models of operating agencies are even more pronounced. One center (the National Energy Technology Laboratory) is government owned and directly operated by the government. About seven are managed by single universities and university consortia (e.g., the three National Science Foundation FFRDCs) operate a few more. Due to controversies over management and associations to the weapons industry, university–enterprise partnerships were established as limited liability companies to manage some of the FFDRCs (e.g., the Los Alamos National Laboratory and the Lawrence Livermore National Laboratory). A few FFDRCs are operated by non-profit/not-for-profit companies, while one FFDRC is run by a private company (Sandia National Laboratories, operated by a subsidiary of Lockheed Martin). The different types of operational agencies bring about different management philosophies, but also create budgetary differences and differences in employee benefits and human resource management, both within the FFDRCs and between the FFDRCs and universities, that constitute hurdles to cooperation (H. Simon, personal communication).

- **Scientific orientation.** The orientation of the FFDRCs varies, with some conducting basic research (e.g., the Lawrence Berkeley National Laboratory, or Berkeley Lab\(^{53}\)) while the majority are more application oriented (e.g., the Jet Propulsion Laboratory\(^{54}\)). Some of the FFDRCs are closely associated with universities (the two aforementioned FFDRCs), while others are independent of the university system (e.g., FFDRCs administered by the RAND Corporation). There are some tendencies of interest: FFDRCs managed by single universities seem to be more basic research oriented than FFDRCs managed by university consortia, which, again, are more basic research oriented than FFDRCs managed by private entities. However, several exceptions exist; for example, the NASA-funded Jet Propulsion Laboratory is run by one of the strongest research universities in the US (the California Institute of Technology) but is still very application oriented.

### 5.6.4 Why National Laboratories?

The National Laboratories regularly come under scrutiny (Hruby et al., 2011). When National Labs diversify and experience academic success (the Berkeley Lab ranks number 114 in the Science Watch indicators used in this report), the demarcation between National Labs and universities becomes especially interesting. The legitimacy of the National Laboratories rests on several arguments, with two of special interest for this report.

- **Large facilities:** The National Labs run many of the large and expensive research facilities in the US (e.g., the National Energy Research Scientific Computing Center at the Berkeley Lab). These facilities are “beyond the scale or role of purely academic or commercial entities” (Hruby et al., 2011). The universities experience greater diversity in conflicting interests than the national labs. The educational commitments of the universities can be an especially important consideration that may be in conflict with the management of large research facilities.

- **Long-term research and continuity:** Many of the research projects at the universities are organized around PhDs. This is reinforced by the ambition of funding agents to fund recruitment positions. After a PhD has been obtained, the candidate often moves on to other institutions. There is therefore a competence leak from university research groups. The National Labs, on the other hand, are in a position to employ researchers permanently or for periods matching the scope of the scientific problem at hand.

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5.7 UK: Decline of national research labs

Summary

- The UK is one of Europe’s leading science nations.
- Government laboratories and research council institutes are collectively known as public sector research establishments (PSREs). The PSRE sector has been considerably reduced in recent years.

The UK has the third largest population of the EU member states and one of the most advanced science systems in the world (UNESCO, 2015). Its GERD intensity (gross domestic expenditure on R&D) was 1.72% of its GDP in 2012, clearly behind the EU-28 (2.06%) and OECD (2.40%) averages.

The largest sources of R&D funding in the UK are the corporate sector (46%) and the public sector (39%). International funding is very high (20%).

The corporate sector is the largest R&D-performing sector in the UK, accounting for 65%, about the EU level (63%). The higher education sector accounts for 26% of R&D expenditures and the governmental sector accounts for 7% (see also Figure 15).

5.7.1 The research system of the UK

The UK research system distinguishes between the following key research performers: the higher education sector, largely comprised of the UK’s universities; the private sector; research and technology organizations, and the government laboratories and research council institutes (the latter two collectively known as PSREs). The HEIs and PSREs collectively form the UK Science Base.

ERAWATCH points out that the PSRE sector has been considerably reduced in recent years (quoted from note 56): Over the past thirty years or so the policies of successive governments coupled with market developments have produced some dramatic changes in the UK’s public laboratories. Formerly established to conduct research in support of their parent Departments’ policy responsibilities, many of these laboratories have undergone a shift from contractor status, through ‘arms-length’ executive agency status to full privatisation. As a result, many erstwhile government laboratories, with international reputations (such as the National Physical

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55 The UK is the 23rd richest country in the world in terms of GDP per capita (UN 2013; https://en.wikipedia.org/wiki/List_of_countries_by_GDP_(nominal)_per_capita).

Laboratory, the Laboratory of the Government Chemist, now reside either partly or wholly in the private sector, under a variety of, often quite complex, contractual arrangements. This has led to a shift in the relationship between these agencies and their former parent departments or ministries and the latter have largely become customers (rather than sponsors) of the research and services these agencies undertake, with the latter having to compete against other contract research organisations, including universities, for government contract research funds.

Despite this shift towards privatisation, a number of government departments have retained their intramural research capabilities in some form or other. To these must also be added the institutes and centres maintained by the Research Councils. Collectively, these form an important component of the Science and Engineering base, alongside the (much larger) component represented by the University sector.

5.7.2 Scientific significance of research labs in the UK

Similar to the US results, the top 10 scientific performers of the UK are dominated by research organizations within the health research field, with five of the top 10 performers (Table 7).

Table 7. The top 10 scientific institutions of the UK based on three indicators from the SIR methodology (see section 2.3.2.1 in the methods chapter). Overall rank is the rank of all 4,840 institutions included in the webpage. “Gov” is government organizations, “HEI” is Higher Education Institutions (most often universities) and “Health” is research organizations in the health field. “Priv” is private institutions.

<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>OVERALL RANK</th>
<th>CATEGORY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wellcome Trust</td>
<td>7</td>
<td>Health</td>
</tr>
<tr>
<td>European Bioinformatics Institute EMBL</td>
<td>20</td>
<td>Gov</td>
</tr>
<tr>
<td>Wellcome Trust Sanger Institute</td>
<td>24</td>
<td>Health</td>
</tr>
<tr>
<td>Cancer Research UK</td>
<td>53</td>
<td>Health</td>
</tr>
<tr>
<td>Institute of Cancer Research</td>
<td>54</td>
<td>Health</td>
</tr>
<tr>
<td>Medical Research Council</td>
<td>66</td>
<td>Health</td>
</tr>
<tr>
<td>Microsoft Research Cambridge</td>
<td>73</td>
<td>Priv</td>
</tr>
<tr>
<td>London Business School</td>
<td>85</td>
<td>HEI</td>
</tr>
<tr>
<td>Biotechnology and Biological Sciences Research Council</td>
<td>108</td>
<td>Gov</td>
</tr>
<tr>
<td>Met Office</td>
<td>145</td>
<td>Gov</td>
</tr>
</tbody>
</table>
Appendix 1 References


doi: http://dx.doi.org/10.1016/j.joi.2012.07.001


## Appendix 2   List of abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EU-28</td>
<td>European Union including the 28 member states</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross domestic product</td>
</tr>
<tr>
<td>GERD</td>
<td>Gross domestic expenditure on R&amp;D</td>
</tr>
<tr>
<td>HEI</td>
<td>Higher education institution</td>
</tr>
<tr>
<td>OECD</td>
<td>Organisation for Economic Cooperation and Development</td>
</tr>
<tr>
<td>PRO</td>
<td>Public research organization</td>
</tr>
<tr>
<td>R&amp;D</td>
<td>Research and development</td>
</tr>
</tbody>
</table>
Appendix 3  Interviews and meetings

The following persons supplied information during site visits.

A-3.1 Austria

A-3.1.1 IST Austria
Oliver Lehmann, Stakeholder Relations and Communications
Laurenz Niel, Academic Affairs
Hania Köver, Graduate School
Joszef Csicsvari, Professor
Herbert Edelsbrunner, Professor

A-3.2 France

A-3.2.1 CEA LIST
Jean-Noël Patillon, Deputy Director
Florent Kirchner, PhD, Head of Laboratory

A-3.2.2 Inria
Dr. Thierry Priol, Director of European Partnerships
Marie-Hélène Pautrat, European Affairs Manager

A-3.2.3 HeSam Université
Hugues Brunet, Délégué Général

A-3.3 Germany

A-3.3.1 Institute for Research Information and Quality Assurance (iFQ)
Professor Dr. Stefan Hornbostel
Dr. Sybille Hinze
Dr. Antje Wegner
Dr. Nathalie Huber
Valeria Aman, Researcher

A-3.3.2 Helmholtz Zentrum München (HMGU)
Dr. Martina Hansen
A-3.4 The Netherlands

A-3.4.1 Rathenau Instituut
Prof. Dr. Barend van der Meulen, Head of Department,

A-3.4.2 Centrum Wiskunde & Informatica
Han La Poutré, Management Team Member and Computer Scientist
Roeland Merks, Researcher and Theme Coordinator, Life Sciences
Peter Hildering, Communication Manager
Dick Broekhuis, Chief Financial Officer

A-3.5 The US

A-3.5.1 California Institute of Technology
Hall P. Daily, Director of Government Relations, Office of the President
Xenia Amashukell, Deputy Director at the Caltech Site of Joint Center for Artificial Photosynthesis (JCAP)
Fred Farina, Chief Innovation and Corporate Partnerships Officer
Hannah Dvorak Carbone, Director for Innovation, Patents & Licensing
Palas Policroniades Borraz, Corporate Partnerships Officer

A-3.5.2 Jet Propulsion Laboratory
Dean V. Wiberg, Manager, Commercial Technology Partnerships Office

A-3.5.3 Lawrence Berkeley National Laboratory
Dr. Horst Simon, Deputy Laboratory Director
Dr. Daniel Gunter, Research Scientist, Computational Research Division
Dr. Jonathan Carter, Deputy Director, Computational Research Division
Dr. Inder Monga, Chief Technology Officer, Energy Sciences Network (ESnet)
Dr. Davis Skinner, Strategic Partnerships Lead, National Energy Research Scientific Computer Center
Appendix 4  Details of national research laboratories in selected Western countries

A-4.1 Germany

A-4.1.1 Max Planck Society
(http://www.mpg.de/en)

"The scientific attractiveness of the Max Planck Society is based on its understanding of research: The Max Planck institutes are built solely around the world’s leading researchers."

Established in 1948
Ownership: “Registered association”
Key figures (2013):
• Budget: €2,092.2 million (about 17.9 billion NOK)
  o Public service subsidiary: €1,599.5 million
  o 16,988 staff members
  o 5,516 scientists
• Structure:
  o 83 institutes and research facilities (as of January 1, 2014)
  o Five institutes and one research facility abroad
• Education: Together with the Association of Universities and other education institutions in Germany, the Max Planck Society established numerous (33) International Max Planck Research Schools (IMPRSs) to promote junior scientists.

• The financing of the Max Planck Society is predominantly comprised of basic financing from the public sector: Including the MPI for plasma physics, the Max Planck Society was financed with approximately €1.6 billion in 2014. In addition, third-party funding contributed to basic financing. The German federal government together with the state governments have each assumed half of the funding for the budget of the Max Planck Society (budget A). The calculation of the financial contributions provided by the states is based on a distribution formula that is recalculated each year, as well as on the “home state quota,” which has been steady at 50% since 2000. In addition, all partners may agree to provide funding in addition to the specified quotas.

• Research fields (ordered by decreasing magnitude of spending): 1) life sciences, 2) physics, 3) chemistry, 4) astronomy and astrophysics, 5) history and social sciences, pedagogy, psychology, and linguistics, 6) medically oriented research, 7) jurisprudence, 8) atmospheric sciences and geosciences, 9) mathematics, computer science, technical sciences, and engineering, and 10) economics.

Information and communication technologies (ICT)-relevant research:
The research activities are divided into three broad topics: biology and medicine, humanities and social sciences, and chemistry, physics, and technology. Within the latter we find computer sciences, with the following relevant institutes.

  o Example: Max Planck Institute for Informatics, Saarbrücken.
    - Cooperation with Saarland University
    - 27 senior scientists
    - 121 PhD students
- 77 post-doctoral students
- 42 administrative staff members
- External funding of about €12.4 million
- The institute, along with the Max Planck Institute for Software Systems (MPI-SWS), the German Research Centre for Artificial Intelligence, and the entire computer science department of Saarland University, is involved in the Internationales Begegnungs- und Forschungszentrum für Informatik,
- Education: The International Max Planck Research School for Computer Science is the graduate school of the MPII and the MPI-SWS. It was founded in 2000 and offers a fully funded PhD program in cooperation with Saarland University: 23 PhD dissertations and five master’s theses (2014).
  o Max Planck Institute for Intelligent Systems, Tübingen site, Tübingen
  o Max Planck Institute for Software Systems, Kaiserslautern site, Kaiserslautern
  o Max Planck Institute for Software Systems, Saarbrücken site, Saarbrücken

A-4.1.2 Fraunhofer (Fraunhofer-Gesellschaft)

http://www.fraunhofer.de/en.html:

“Fraunhofer is Europe’s largest application-oriented research organization. Our research efforts are geared entirely to people’s needs: health, security, communication, energy and the environment. As a result, the work undertaken by our researchers and developers has a significant impact on people’s lives. We are creative. We shape technology. We design products. We improve methods and techniques. We open up new vistas. In short, we forge the future.”

Established in 1949
Ownership: Non-profit organization (membership?)
Key figures (2013):57
• Budget: about €2 billion (about NOK 17.9 billion)
  o Public service subsidiary as basic funds from federal and Länder (90:10 ratio) authorities: 28%
  o 23,000 staff members, 16,000 permanent staff members
  o
• Structure:
  o 67 institutes and research units

ICT-relevant research:
Research activities organized into seven groups:
- Information and communications technology
- Life sciences
- Light and surfaces
- Materials and components
- Microelectronics
- Production
- Defense and security VVS

Information and communications technology:
  o €235 million, third largest
  o 17 research institutions
  o Project revenue €168, project coverage 77%
  o Example: Fraunhofer Institut für Experimentelles Software Engineering in Kaiserslautern (www.iese.fraunhofer.de):

- Budget plan 2014: €13.6 million, 20% base funding, 45% public projects
- 248 staff members
- 110 scientists

A-4.1.3 Zuse Institute Berlin (ZIB)
http://www.zib.de/
ZIB “is an interdisciplinary research institute for applied mathematics and data-intensive high-performance computing. Its research focuses on modeling, simulation and optimization with scientific cooperation partners from academia and industry.”

Established in 1984

Key figures:
- Budget: ~€8 million (about 68 million NOK)
  - Public service subsidiary: about €6 million
- 218 persons employed
  - 151 financed by third-party funds
  - 99 scientists

ICT-relevant research:
- ZIB was founded by law as a statutory establishment and as a non-university research institute of the state of Berlin in 1984. In close interdisciplinary cooperation with the Berlin universities and scientific institutions, ZIB implements research and development in the field of information technology, with a particular focus on application-oriented algorithmic mathematics and practical computer science. ZIB also provides high-performance computer capacity as an accompanying service as part of the network of high-performance computers in Northern Germany (Norddeutscher Verbund von Hoch- und Höchstleistungsrechnern).

A-4.2 France

A-4.2.1 Inria, inventors for the digital world
http://www.inria.fr/en/
“Inria is the only public research body fully dedicated to computational sciences. Combining computer sciences with mathematics, researchers strive to invent the digital technologies of the future.”

Established in 1967

Key figures (2013):
- Budget: €270.2 million (almost 2.0 billion NOK)
- Self-financed proportion: 37%
  - Public service subsidy: €170.8 (basic funding €167.9)
- 4,471 staff members (60% paid by Inria)
- 3,449 scientists
- Structure:
  - Eight research centers located throughout France (Rocquencourt, Rennes, Sophia Antipolis, Grenoble, Nancy, Bordeaux, Lille, and Saclay) and a head office in Rocquencourt, near Paris
- Scientific activities:
  - 172 Inria project teams

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59 See http://www.zib.de/reports
ICT-relevant research:
All research areas of Inria seem to be ICT relevant:
- Applied mathematics, computation, and simulation
- Algorithmics, programming, software, and architecture
- Networks, systems, and services; distributed computing
- Perception, cognition, and interaction
- Digital health, biology, and earth (now computation, life, and environmental sciences).

A-4.2.2 CEA LIST
(French Alternative Energies and Atomic Energy Commission, or Commissariat à l’Énergie Atomique et aux Énergies Alternatives, Technology Systems Integration Laboratory)

(http://www-list.cea.fr/index.php/en/)
Based in Saclay (near Paris), CEA LIST is a public research institute specialized in digital systems design. Its main mission is based on achieving excellence technological development on behalf of industrial partners for value creation. CEA LIST is one of the three research institutes that make up CEA Tech, the CEA’s Technological Research Division.

The Commission for Atomic Energy, CEA, was created in 1945, changing its name to the French Alternative Energies and Atomic Energy Commission in 2009. The missions of the CEA are equivalent to those of the US Department of Energy. Its yearly budget amounts to €4.7 billion and its permanent staff consists of slightly under 16,000 persons (as of 201060).

CEA:
Established in 1945
Key figures (2013):
- Budget: €4.3 billion (almost 24 billion NOK)
- Self-financed proportion: 25%
  - 75% of external resources from incentive funds (31%), industrial partners (25%), and grants (19%).
- 15,838 staff members
- 508 permanent staff members, 1,556 PhDs, and 293 post-doctoral students
- Structure:
  - 10 centers and four regional technology transfer platforms
  - 54 research units (43 of them mixed research units, UMRs)
- Scientific activities:
  - 4,735 scientific publications in reviewed journals (2012)

ICT-relevant research:
Research projects in four main topics:
- Advanced manufacturing
- Embedded systems
- Ambient intelligence
- Health ionizing radiation

60 See http://en.wikipedia.org/wiki/Commissariat_%C3%A0_l%27%C3%A9nergie_atomique_et_aux_%C3%A9nergies_alternatives.
CEA LIST
Key figures (2013):
- Self-financed proportion: 25%
  - 75% of external resources coming from incentive funds (31%), industrial partners (25%), and grants (19%)
- 710 staff members
- 508 permanent staff members, 160 PhDs and post-doctoral students
- Structure:
  - One out of three centers belonging to the CEA Tech
- Scientific activities:
  - 300 scientific publications

A-4.2.3 Institut de Recherche en Informatique et Systèmes Aléatoires (IRISA)

IRISA (Institute for Research in IT and Random Systems), established in 1975, is a mixed research center (UMR) that unites within a single laboratory the personnel and resources belonging to seven trustees (CNRS, ENS Rennes, Inria, INS.A de Rennes, Institut-Mines-Télécom, Université de Bretagne Sud (UBS), Université de Rennes 1) and one partner (Supélec). IRISA forms a research cluster for excellence within the ICTS, with scientific priorities that include bioinformatics, system security, new software architecture (manycore processing, cloud computing), and virtual reality.

ICT-relevant research:
The UMR is home to seven different departments:
- D1: Large-Scale Systems
- D2: Networks, Telecommunication and Services
- D3: Architecture
- D4: Language and Software Engineering
- D5: Digital Signals and Images, Robotics
- D6: Media and Interactions
- D7: Data and Knowledge Management

A-4.3 US

A-4.3.1 Governmental research labs in the US

1. Federally Funded Research and Development Centers (FFRDCs)\(^1\)
   - Public–private partnerships that conduct research for the US government. Currently 41 recognized FFRDCs are sponsored by the US government.
   - Annual federal obligations to FFRDCs were approximately US$9.5 billion in fiscal year 2009.\(^2\)
   - Example: Lawrence Livermore National Laboratory
     - Established 1952
     - “A premier research and development institution for science and technology applied to national security.”
     - Home of Sequoia, the third fastest supercomputer in the world (after Tianhe-2 and Titan).

Employees:
- About 6,300 employees (including term employees and post-doctoral students)
- 2,700 scientists and engineers (more than 40% of whom are PhDs)
- 700 facility users, visiting scientists, teachers, and students

Budget: US$1.497 billion (11.5 billion NOK)
- National Ignition Facility, US$301.1 million
- Nuclear Weapon Deterrent (Safety/Security/Reliability), US$227.2 million
- Advance Simulation and Computing, US$221.9 million
- Nonproliferation, US$152.2 million
- Department of Defense, US$125.9 million
- Basic and Applied Science, US$86.6 million
- Homeland Security, US$83.9 million
- Energy, US$22.4 million
- Computation (one of five research areas), about 1,000 people.

2. University Affiliated Research Center (UARC)\(^63\)
- Strategic US Department of Defense research center associated with a university. There are currently 15 UARCs.
- Although UARCs receive sole source funding under the authority of 10 USC Section 2304(c)(3)(B), they may also compete for science and technology work unless precluded from doing so by their Department of Defense UARC contracts.
- Example: Institute for Creative Technologies (ICT)
  - A research institute of the University of Southern California located in Playa Vista, California.
  - ICT was created to combine the assets of a major research university with the creative resources of Hollywood and the game industry to advance the state of the art in training and simulation. The institute’s research has also led to applications in education, entertainment, and rehabilitation, including virtual patients, virtual museum guides, and Academy Award-winning visual effects technologies. Core areas include virtual humans, graphics, mixed reality, learning sciences, games, storytelling, and medical virtual reality.
  - Established 1999 (US Army)

A-4.3.2 California Institute for Telecommunications and Information Technology (Calit2\(^64\)) (http://www.calit2.net/)

“As a multidisciplinary research institution, it is devoted to conducting cutting-edge research discovering new ways in which emerging technologies can improve the state’s economy and citizens’ quality of life.”

Established in 2000 as one of four Governor Gray Davis Institutes for Science and Innovation with a budget of US$400 million\(^65\) (about 3 billion NOK).

Structure: Two buildings, one at the University of California, San Diego and one at the University of California, Irvine

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\(^64\) Previously “Cal (IT).”

\(^65\) See [http://en.wikipedia.org/wiki/California_Institute_for_Telecommunications_and_Information_Technology#cite_ref-Calit2_3-0](http://en.wikipedia.org/wiki/California_Institute_for_Telecommunications_and_Information_Technology#cite_ref-Calit2_3-0).
A-4.4 Netherlands

The Netherlands Organisation for Scientific Research (NWO) is an intermediary organization acting as a granting organization but is also an organization with institutes that carry out research. The Royal Netherlands Academy of Arts and Sciences (KNAW) is an intermediary organization, an advisory body, and an organization with institutes that carry out research.

Basic research is carried out primarily by universities and the para-university institutes that fall within the remit of the NWO and KNAW. Funding allocations of the Dutch research system are given in the table below.

Table: R&D expenditure by type of research organization, 2009

<table>
<thead>
<tr>
<th>Sources of funds</th>
<th>Higher education *</th>
<th>Research institutes</th>
<th>Companies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>€ 4.2 billion = 40%</td>
<td>Government</td>
<td>Government</td>
</tr>
<tr>
<td>Companies</td>
<td>78%</td>
<td>Companies</td>
<td>Companies</td>
</tr>
<tr>
<td>Private Non-Profit</td>
<td>8%</td>
<td>PNP</td>
<td>Companies</td>
</tr>
<tr>
<td>Foreign</td>
<td>9%</td>
<td>Foreign</td>
<td>PNP</td>
</tr>
<tr>
<td>Total</td>
<td>€ 10.4 billion</td>
<td>Total</td>
<td>Foreign</td>
</tr>
<tr>
<td>Sources of funds</td>
<td>€ 1.3 billion = 13%</td>
<td>Sources of funds</td>
<td>Sources of funds</td>
</tr>
<tr>
<td>Government</td>
<td>78%</td>
<td>Government</td>
<td>Government</td>
</tr>
<tr>
<td>Companies</td>
<td>8%</td>
<td>Companies</td>
<td>Companies</td>
</tr>
<tr>
<td>Private Non-Profit</td>
<td>9%</td>
<td>PNP</td>
<td>PNP</td>
</tr>
<tr>
<td>Foreign</td>
<td>5%</td>
<td>Foreign</td>
<td>Foreign</td>
</tr>
</tbody>
</table>

- 14 universities
- Eight university medical centers (UMCs)
- 41 universities of applied science (hogeschool)
- Research institutes

The research institutes group consists of a mix of institutes, subdivided into seven smaller groupings:

- The para-university institutes that fall within the remit of the NWO and KNAW and which carry out basic research in a variety of scientific disciplines
- The Netherlands Organisation for Applied Scientific Research (TNO), the Dutch organization for applied research serving government and businesses
- The Large Technological Institutes, which carry out research with a more application-directed focus in specific fields
- The institutes that carry out agricultural research under the flag of the Wageningen University and Research Centre
- Institutes that are part of a ministry
- Leading institutes (technological and societal)
- Other institutes

A-4.4.1 NWO and its institutes

The Netherlands Organisation for Scientific Research (NWO), or the national research council:

- Has the task of promoting quality and innovation in scientific research and initiating and promoting new developments in scientific research
- Carries out its task by allocating funds
- Promotes the dissemination of research results
- Focuses primarily on university research

Established in 1950

Key figures:

- Budget (2010): €727.4 million (about 6 billion NOK)
  - Government funding from the Ministry of Education, Culture and Science: €521.3 million (71.7%)

Specific subsidies from Ministry of Education, Culture and Science: €104.0 million (14.3%)
- Subsidy from Ministry of Economic Affairs: €27.9 million (3.8%)
- Subsidies and contributions from other ministries: €15.9 million (2.2%)
- Income from companies: €11.1 million (1.5%)
- Subsidies and contributions from other third parties: €39.1 million (5.4%)
- Other income: €8.0 million (1.1%)

- Spending: €165 million spent on seven NWO institutes (22.3% of spending)
- Persons employed
  - Almost 7,000 researchers (scientific and non-scientific) at Dutch universities, institutes, and research centers carry out their work with financial support from the NWO.

ICT-relevant research:
- Eight divisions, including Technical Sciences (via the STW Technology Foundation)
- Three foundations (including the Netherlands National Computing Facilities Foundation, or NCF) and three Temporary Task Forces, which direct and finance research in scientific areas that are important from the point of view of government policy
- Nine research institutes, including the following:
  - Centre for Mathematics and Computer Science/National Research Institute for Mathematics and Computer Science (CWI: http://www.cwi.nl/): Developed python!
    - Employees: 197.8 FTE
    - Scientific employees: 154.6, with 55 permanent, 40 post-doctoral students, and 70 PhDs
    - Expenditure (2010) from the NWO: €21 million (about 180 million NOK) + 8.9% contract research.
    - Research groups:
      ✓ Algorithms and complexity
      ✓ Cryptology
      ✓ Database architectures
      ✓ Distributed and interactive systems
      ✓ Formal methods
      ✓ Information access
      ✓ Intelligent systems
      ✓ Life sciences
      ✓ Multiscale dynamics
      ✓ Networks and optimization
      ✓ Scientific computing
      ✓ Software analysis and transformation
      ✓ Stochastics

### A-4.4.2 KNAW and its institutes
(http://www.knaw.nl/en)
The Royal Netherlands Academy of Arts and Sciences operates in the field of scientific research. It carries out the following:
- Promotes the exchange of ideas and information between its members and others engaged in scientific endeavor and scientific organizations
- Advises the government, either on request or at its own initiative, on matters in the field of scientific endeavor
- Promotes scientific endeavor by carrying out activities in that field or causing such activities to be carried out
Established in 1808

Key figures:
- Budget (2010): €150 million (about 1.3 billion NOK)
  - Government funding from the Ministry of Education, Culture and Science 93.3 (62.2%)
  - Work for third parties and other income
- Spending: €121.5 million spent on 17 KNAW institutes (87.1% of spending)
- 1160 FTEs employed in the institutes

ICT-relevant research:
- 17 research institutes:
  - Humanities and social sciences: 11 institutes (440 staff members, €41.4 million)
  - Other: Two institutes (52 staff members, €6.4 million):
    - Rathenau Instituut:67 studies developments in science and technology, interprets their potential impact on society and policy, and fosters dialog and debate in support of decision making on science and technology.
      - Budget (2014): €5.3 million (about 45 million NOK)
      - 43.75 full-time equivalents (2014), 62% permanent
    - “To guarantee its independence, the institute obtains no more than 25% of its budget from external clients.”
  - Life science: Five institutes (668 staff members, €61.1 million), among them
    - Interuniversity Cardiology Institute of the Netherlands (ICIN), Cardiovascular system (76.9 staff members)
    - Netherlands Institute for Neuroscience (NIN), Neurosciences (156.6 staff members)
  - Spinoza Centre for Neuro-imaging, Brain Research

A-4.4.3 Netherlands Organisation for Applied Scientific Research (TNO)

TNO’s mission is to apply scientific knowledge with the aim of strengthening the innovative power of industry and government. TNO is an independent organization for contract research.

Established in 1932

Key figures:
- Revenue (2013): €526 million (about 4.8 billion NOK)
  - Government funding €171 million (about 1.4 billion NOK)
- 3,009 persons employed, 92.3% permanent staff.

ICT-relevant research:
- Seven themes and 19 innovative areas, among them defense, security, and safety and information society (spending of €41.4 million)

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