Science System Assessment

Science systems compared: A first description of governance innovations in six science systems

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Rathenau Instituut

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Preface

The quality of a nations' science system depends on the available resources. Therefore the level of overall funding is always at the center of the debate. However, how the system is organized is an important factor as well: are the resources allocated and spent in an optimal way? Learning from other countries can be very useful in this context. Comparing the way the science systems in different countries are governed may improve our understanding of the subtle dynamics of science. And it may help to improve the system and its performance.
Models from elsewhere cannot be easily copied, as history and local specificities play an important role. However, when questions are asked or problems signaled, one can learn from experiences and solutions elsewhere, if we understand their local context.
In this report, we compare the organization of the research system in six European countries. We selected four of the large European countries (UK, Germany, France and Italy) and also included Denmark, as in the latter country interesting changes have taken place over the last few years. Finally, the Netherlands is included. The comparison covers the important aspects of the systems: its organization and government, agenda setting and priority selection mechanisms, the way funding is organized, and finally the mechanisms for quality control and evaluation. One important issue, the regulation of research careers, is excluded from the current study. About that topic, we will publish a separate study in the near future.
This report is written on request of the Ministry of Education, Culture and Science in response to a Parliamentary debate about the governance of the Dutch research system and possible lessons that can be drawn from recent changes in the governance of science system that were implemented abroad. The report is a based on an analysis of material available in a variety of sources, and we have conducted some original data collection where this seemed necessary.
The report starts with an extensive summary in which the countries are compared (part 1), followed by six more detailed chapters about the individual countries. The comparison in part 1 of this report was also published in Dutch as an edition of the science system assessment *Facts and Figures* series of the Rathenau Institute.

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Content

PART I

International comparison of science systems

Introduction

Scientific research is a key factor for the quality of society and the strength of the economy. As a result government and other stakeholders have a keen interest in the performance of scientific organisations, including those who fund and coordinate research. The Netherlands is no exception to this phenomenon. Though the Netherlands features well on many international rankings of scientific performance - but less well if specific organizations are ranked or expenditures - debates recur about the organization of the research system and the performance of the organizations. Are Dutch universities able to compete with other universities within the European Research Area, and for overseas students? Do research organizations pay sufficient attention to industry interests? Are they too often lured by industry funding and losing their independence? Is research excellence and creativity getting enough space? Is research funding too competitive? On most of these issues there is little systematic evidence to determine what the most appropriate structure and governance of the research system is. To overcome this deficiency, we selected five countries to compare and contrast with the Dutch experiences. Such a comparison indicates the specific characteristics of the Dutch research system and whether these characteristics are due to insufficient responses to challenges of the knowledge economy, globalization and new scientific developments or, on the contrary indicate that the Netherlands is one of the forerunners in science policy.

This report consists of two parts. The first part presents a thematic review of trends and developments in the governance research system with a specific focus on lessons that are of interest for the Dutch situation. Four themes have been chosen for the review. They are of specific relevance considering current science policy in the Netherlands, and they are also frequently listed as key issues in international studies on the governance of research systems. (OECD 2003; High Level Expert Group 2005)

- The organisational structure of the research system and the governance of research and research organisations;
- Methods of priority setting and implementation;
- New funding mechanisms for scientific research;
- The development of quality control and evaluation systems for scientific research.

A Dutch language version of this part has also been published as a separate publication for the Dutch Parliament.(Meulen, Dawson et al. 2009) Part one concludes by listing particularities of the Dutch research system that are of interest for Dutch science policy as well as others who are interested in the Dutch research system.

The second part consists of the country studies that have been used for the thematic review. We analysed the four themes for the Netherlands and five other countries. The five other countries are:

- Denmark, where the GERD expenditures have increased significantly in recent years and which has implemented several structural reforms;
- France, which has tried to enforce the research position of its universities in the past few years;
- Germany, which scores traditionally quite well in comparisons of scientific performances and has a large institute sector;
- Italy, which has a considerably lower R&D intensity than the other countries and which tries to improve the quality of research through implementation of quality control.

- UK, where the importance of returns on investments in scientific research (value for money) has been emphasised since the early 90s and where the competition between universities and between researchers is strong.

The country reviews are predominantly based on international country reports published as part of the European research policy of Open Method of Coordination (OMC). OMC has been implemented in European R&D policy as part of the Lisbon Strategy and the development of a European Research Area.(Gornitzka 2005) The idea of OMC is that countries and their organizations exchange practices and experiences in order to improve mutual learning and enable collaboration in science and innovation policies. Parts of OMC are initiatives like CREST ERAwatch and PROinno.[1] The quantitative information is based on EUROSTAT, OECD statistics on R&D and on the Netherlands Statistics Report on Science and Technology NOWT report.[2] The information of these services has been checked and updated through information from the policy organizations in those countries as well as supplemented by background studies and analyses. Some of these studies come from the Network of Excellence PRIME, in which the Rathenau Institute participates.[3]

1 For CREST see: http://ec.europa.eu/invest-in-research/coordination/coordination01_en.htm;
For ERAwatch see: http://cordis.europa.eu/erawatch/index.cfm; For PROinno see: http://www.proinno-europe.eu

2 EUROSTAT: NewCronos database; OECD statistics: Main Science and Technology Indicators 2008/2; NOWT Wetenschaps en Technologie Indicatoren 2008, Ministerie van Onderwijs, Cultuur en Wetenschappen, www.nowt.nl

3 See www.prime-noe.org

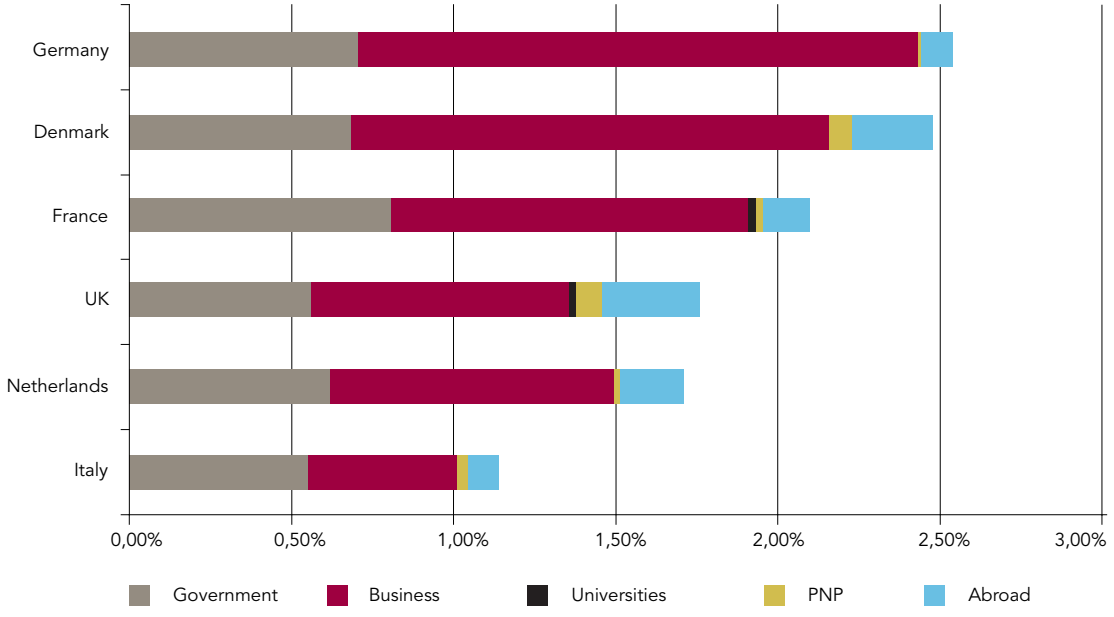
1 Input and output, benchmark

A simple way to compare national research systems is to look at the funding of R&D and to performance. In 2006, the Netherlands spent 1.71% of GDP on research, comparable to the expenditures in the UK, more than the expenditures in Italy and less than in France, Germany and Denmark. The trend in the expenditures is also similar for the Netherlands and the UK. In both countries the percentage of GDP spent on research decreased from around 2% in 1991 to 1.7% in 2006. Of the other countries, Denmark displays the most remarkable trend: in 15 years the expenditures grew from 1.61% in 1991 to 2.48% in 2006. (Figure 1)

This increase is mainly due to an increase of R&D expenditures by firms. Danish industry expenditures rose by 25%, in the service sector the increase was 153%. The service sector now represents 40% of the total business R&D expenditure.[4] Differences in expenditure between the Netherlands and the other countries are mainly due to differences in business expenditures. German enterprises invest 1.7% of GDP in R&D, Italian enterprises spend less than 0.5%. The Dutch are in between. In 2006 they spent 0.87% of GDP on R&D, which places the Netherlands fourth in the rankings.

In terms of government expenditures, the Netherlands also ranks fourth, but differences are much smaller. The French government spends the most on R&D, 0.81%, the Italian government spends the least with 0.55% of GDP. Though Germany in total spends 0.73% more than the Netherlands, the difference in government expenditures is much smaller: 0.71% vs. 0.62% of GDP.

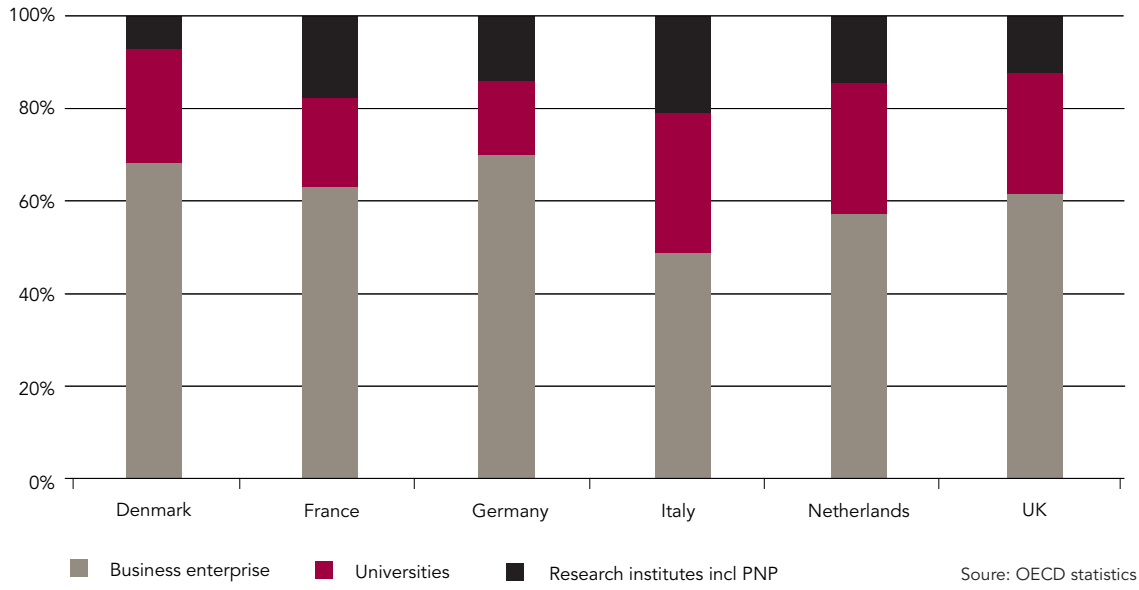
Figure 1 R&D expenditures in % GDP, 2006



4 See: Forskningsstatistik 2006, www.forskningsanalyse.dk.

Expenditures on research cannot only compared by the funding source, but also by the kind of organisation that performs the research: firm, university or research institute. (Figure 2) Again, we find that the Dutch private sector lags behind compared to the other countries, except Italy. The size of the academic research is comparable to other countries. Of all research in the Netherlands, 28% is performed at universities, comparable to Denmark (27.5%), Italy (30%) and the UK (26%). In Germany and France these figures are considerably lower: 16% and 19.2% respectively. In the Netherlands, 15% of all research is performed in institutes. Considerably more than in Denmark, where the institute sector has shrunk to just 7%, after a considerable number of institutes were merged with universities. These figures are both lower than in Italy (21%) and France (16.5%) where a considerable proportion of the scientific research is performed at institutes.

Figure 2 R&D-expenditures to performing sector, in % of total, 2006

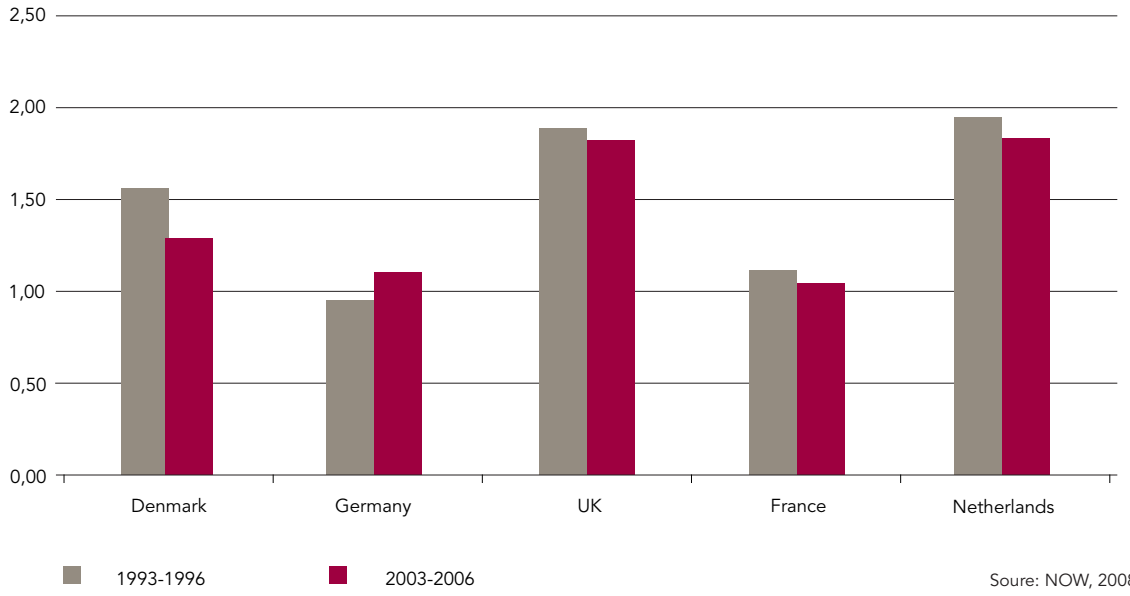


The scientific performance of countries is usually measured in terms of publications and their impact in terms of citations. According to these indicators, the Netherlands scores well, not just compared to the five countries in this study, but also internationally.[5] If we look at the number of publications, we see that in all countries this number has increased. Measured over 1993-1996 and 2003-2006, the countries show an increase from 22% (UK) to 42% (Denmark).[6] The Dutch scientific production rose with 39.5%. If we control for the number of researchers in a country (for Italy we didn't find the figures in the OECD database), we find that there is hardly any increase in production and for some countries even a slight decrease. (Figure 3) Researchers in the Netherlands and the UK produce the most: 1.83 and 1.82 publication per researcher in 2003-2006. Germany and France score considerably lower in this respect: 1.10 and 1.04 publications per researcher for these three years. Remarkably, the impact of the Dutch and UK publications is also considerably higher. This relative citation impact increases in all of the five countries, especially Denmark. (Figure 4)

5 Nederlands Observatorium van Wetenschap en Technologie, 2008, Wetenschaps- en Technologie- Indicatoren 2008, Den Haag: Ministerie van OC&W, OCW38.022/750

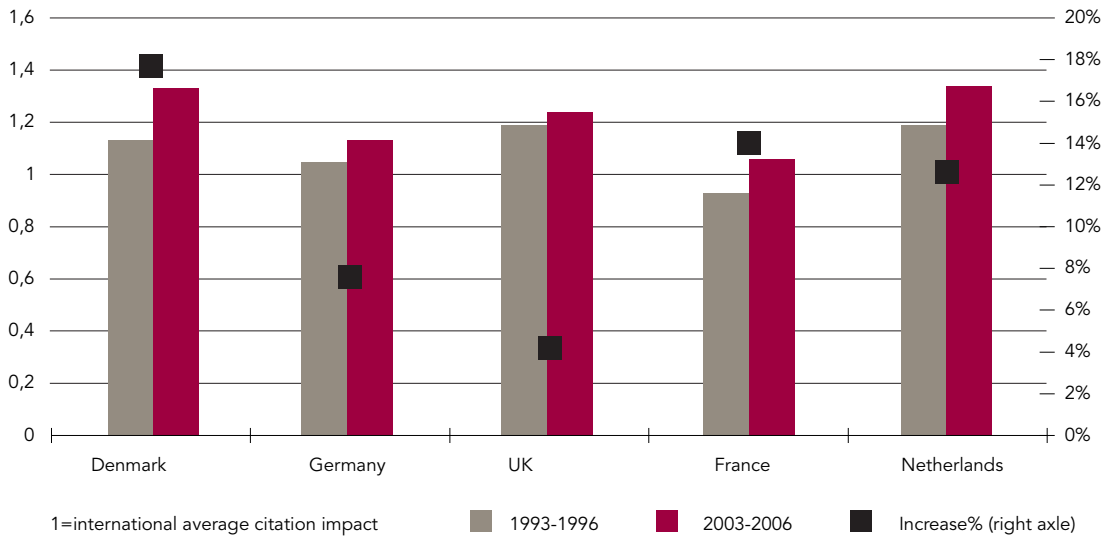
6 The figures for Italy are unknown.

Figure 3 Number of publications per researcher, 1993-1996 en 2003-2006



Soure: NOW, 2008

Figure 4 Relative citation impact of publications, 1993-1996 en 2003-2006



Soure: NOW, 2008

2 Structure of research systems and research funding

Most national systems have comparable organisations for science policy advice, research funding and performers of scientific research. However, they differ in the relative importance of these organisations, the way they perform tasks, and their governance relationships. These differences can have considerable effects on the functioning of the research system. In most countries, reforms have been implemented to improve the structure of the research system and to enable the key organisations to exploit their strategic opportunities. The changes can be summarized in seven points:

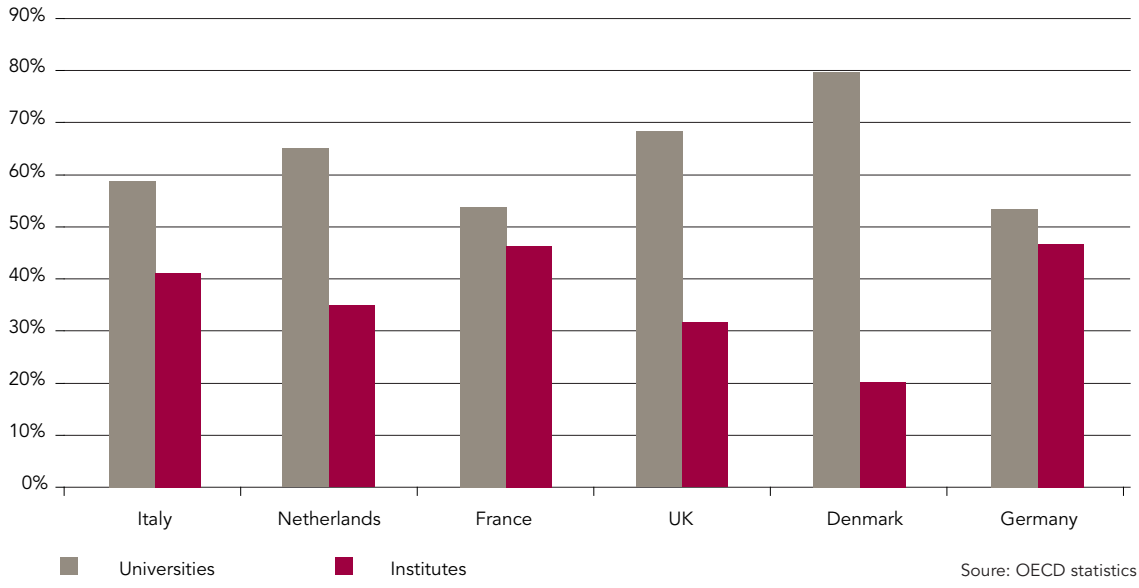
- Improvement in the coordination between different actors, policy objectives and instruments of science policy.
- Improvement of strategic planning.
- Increasing the autonomy of research performing organisations (universities, institutes).
- Enabling the participation of firms and societal actors in knowledge production.
- Strengthening the role of the intermediary level between government and the research performing level.
- Strengthening the research function of universities.
- Structural collaborations between different research organisations, like universities, government institutes and industrial laboratories.

In this chapter we review policy issues at the three main levels of research systems: the research performing level, the intermediary level and governmental level to see how these seven issues have been addressed in the six countries. In the fourth section we assess the Dutch situation from an international perspective.

2.1 Universities and institutes

In most countries, publicly funded research is performed within universities and public research institutes. These research institutes often comprise a heterogeneous set of actors and vary from

Figure 5 The relative size of public research sectors



Soure: OECD statistics

institutes for basic research to research institutes supporting government policies and technology institutes. The role of the universities in Denmark, England, Italy and the Netherlands is stronger than in Germany and France. Germany has two umbrella organisations for basic research institutes with excellent research infrastructures: the Max Planck Gesellschaft and the Helmholtz Gemeinschaft. There are also two umbrella organisations for strategic and applied research institutes, the Fraunhofer Gesellschaft and the Leibnitz Gemeinschaft. In France, the institutes of the CNRS, Centre National de la Recherche Scientifique, have a key role at the research performing level. For specific areas like health, agriculture and energy, there are dedicated research institute organisations. The institute sector in the UK and in Denmark is relatively small. In the UK a considerable number of the government institutes were privatised in the nineties, while in Denmark institutes have been merged within the universities. In Italy and the Netherlands, a strong role of the universities co-exists with a strong role of the institutes, due to the relatively small amount of privately funded and performed R&D.

In most European countries, universities are considered equal in terms of government policies. Only in the UK is there a hierarchy among universities, not just in terms of reputations, but this is also reflected in institutional funding.[7] There are not only differences between the research universities and new universities/former polytechnics. There are also differences between the research universities themselves in terms of status, quality and reputation. In Germany, federal and state governments aim to create such a hierarchy through the Excellenz Initiative, a 1.9 Billion Euro funding scheme for 2006-2011. In the first two rounds, 9 universities, 39 graduate schools and 37 university clusters have been selected. Graduate schools and clusters are located within a university, but there can be collaboration with non-university research institutes, often in the same region. As references, Harvard, Stanford and MIT are mentioned, but critics have noted that the scheme is far too small to create such elite universities. (Weingart and Maasen 2007)

Public research institutes have been under pressure in many countries, probably even more so than universities. Institutional funding for applied research institutes decreased and institutes were forced to compensate by increasing their share of the competitive and private funding. (Cox, Gummett et al. 2001) Institutes for basic research are pushed to improve their relationships with universities, to the benefit of university research and university research training. Germany is a prime example of this. In response to system evaluations of the large organisations and the national innovation strategy of the government, the Max Planck Gesellschaft has improved its interaction with the universities considerably. But, organisationally and strategically the universities and research institutes are clearly distinguishable entities. In France, the reform of the CNRS is more radical. French universities tended to be foremost and predominantly institutes for higher education while basic research was organised by the CNRS. This has changed considerably in recent years, and 90% of the CNRS research groups are now integrated in universities (or industry labs). The allocation of CNRS research capacity to universities can be compared to the way in which a research council such as the NWO allocates competitive research funding, or the HEFCE (Higher Education Funding Council for England) allocates institutional funding to the UK universities: in all cases the allocation is based on a form of peer assessment of the research (proposals) as part of an organised competition. (Thèves, Lepori et al. 2007)

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7 France has a stratified higher education system as well, but this refers much more to the higher education function of the universities and Grande Ecoles and related career prospects then to quality and reputation of scientific performances.

In Denmark, the proportion of research performed at universities has increased considerably because institutes have been integrated within universities. As a result universities now have a more articulated strategic mission. For example, institutes for environmental research and agricultural institutes became part of the University of Aarhus. The Technical University Denmark has been strengthened with institutes for fisheries, the energy and environment research institute Risø, its Danish Space Institute and the national institute for food research. The Danish veterinary institute and the University for Pharmacy were merged into the University of Copenhagen.

A third issue at the research performance level is the governance autonomy of the universities. Autonomy is considered to be crucial for the modernisation of universities and their ability to respond strategically to contextual changes and pressures. In the UK, universities have always had a large degree of autonomy and they make their own decisions in terms of human resource policy, funding and strategy. In many European countries though, universities are still part of the government and researchers have a civil servant status. In Germany there is an ongoing debate to change this and increase university autonomy. Since 2003, the Georg August Universität Göttingen is an independent university, but it is still an exception in Germany. In France and Denmark the universities became autonomous only very recently. In the Netherlands university autonomy was already increased at the end of the 80s, and established by law since the 90s. (Kehm and Lanzendorf 2006)

Denmark: Contract with the universities

Several countries have tried to implement increased governance autonomy of universities together with contract-related institutional funding. Denmark has actually developed such contracts. An example is the contract with the University of Arhus for the period 2007-2010. The contract describes the development of the university and on four areas performance indicators are specified: research, education, knowledge dissemination and consultancy. For each indicator the ambitions per year are specified in the contract. For research and knowledge dissemination, the performance indicators are:

Objectives research	**Indicator**
Production	Number of publications
Internationalisation	Number of new international researchers employed
Acquisition of external funding	Amount of EU funding
	Amount of funding from business and funds from abroad
PhD activities	Number of Graduate Schools
	Number of new PhD students
	Number of PhDs granted
Objectives knowledge dissemination	
Education and Post graduate courses	Collaboration with polytechnics
	Number of paying participants of post graduate courses
	Amount of income of post graduate courses
Participation in public debates	Number of contributions to newspapers and magazines
	Public lectures
	Participation in committees, councils and boards.
Collaboration of business enterprises	Number of collaborative agreements
	Number of patents
	Income from patents and licenses

Increase of governance autonomy is not only perceived as an increase of autonomy by the researchers and often the reforms go with protests that academic freedom is endangered. The point is that governance autonomy of universities implies a change in the relation between government and universities. Through a Board of Trustees, new funding mechanisms or performance contracts, governments maintain the ability to influence the universities and ensure suitable use of public funding. Due to the new governance relationship, governments become more of a customer and spell out their expectations about the university performance. As a main "customer" their actual influence can be larger than before, even if the formal strategic autonomy of the university has increased. Articulation of the expectation is not an easy task, though. Denmark is one of the few countries in which the government has been able to develop a contract relation with the universities and relate institutional funding to contractual agreed performances.

2.2 Intermediary organisations

Every research system has a level of intermediary bodies that, on the one hand, functions as the community of and representative of researchers and, on the other hand, allocates funding for the government, develops research programs, organises evaluations, and implements science policies. The most recognisable task of the intermediary organisations is to organise competitive funding mechanisms, in which research proposals are selected after peer review. Germany (Deutsche Forschungsgemeinschaft), the UK (the research councils), and Denmark (Det Frie Forskningsraad) all have intermediary organisations with a long and well established position in the research system. France and Italy had their national research organisations, CNRS and CNR.. Recently however, these two countries have established organisations for competitive funding. As a result, like Germany they have both a council for competitive funding and an institute organisation for basic research. The Dutch NWO is one of the few organisations that has both functions; organisation of competitive funding and the ownership of institutes for basic research.

Though good practices exist for the peer review based selection processes, the research councils are often criticized, especially in those countries where researchers are pushed by their own organisations to attract external funding and the research councils face increasing numbers of proposals. (Langfeldt 2001; Langfeldt 2006) Table 1 compares acceptance rates of the research councils. The DFG in Germany still has quite a high acceptance rate compared to its sister organisations. Still 50-60 % of the proposals are granted. In Denmark and the Netherlands acceptance rate is around 30% on average, with some considerable differences between areas. In the UK the acceptance rate is only 25%, which indicates the financial pressures within the system. The question is of course whether, at a system level with low acceptance rates, the benefits of competition (increasing quality and establishing reputation) outweigh the costs of the proposals and their selection.

At the intermediary level, organisations also face the pressures and changes that come with a more central role of scientific research for government, society and economy. This has led to considerable reforms, except in the UK where the role of the research councils is still limited to the competitive allocation of resources. In France, the role of the CNRS has changed significantly. In addition to the integration of CNRS research groups within the universities, the CNRS is also expected to increase its strategic role and coordinate scientific research in a broad range of scientific fields. Specific national bodies will also have a coordinating role for the life sciences (INSERM), nuclear research (CEA), agricultural research (INRA) and ICT (INRIA).

Denmark has also reorganised its intermediary level and established a range of different funding organisations within one agency. Next to a traditional research council, which funds projects initiated by researchers, the agency oversees a council concerned with funding Centres of Excellence, one for strategic research programs and innovation oriented research. In the Netherlands a number of research consortia and coordinating bodies have been established in a range of strategic research areas (genomics, ICT, nanotechnology, catalysis, climate research, water-management related science, etc.) which develop national programs for research and in most cases also select proposals and fund research. Some of them are located within the research council, NWO, while others are organised as consortia of participating universities, institutes and firms.

Table 1 Acceptance Rates of Open Competition funding schemes, 2007

			2007	2007*	
Denmark	Det Frie Forskningsraad		31		
		DFF- Social Science		19	
		DFF- Engineering		23	
		DFF- Natural Sciences		29	
		DFF- Medical		35	
		DFF- Humanities		35	
Germany	Deutsche ForschungsGemeinschaft		52,5		
		DFG- Geistes- und Sozialwissenschaften		47	
		DFG- Lebenswissenschaften		51,9	
		DFG- Ingenieurwissenschaften		54,1	
		DFG- Naturwissenschaften		57,2	
UK	Average of the councils		25		
		Nature and Environment Research Cnl - NERC		20	
		Economic and Social Research Council - ESRC		24	
		Biotechnology and Biological Sciences - BBSRC		25	
		Medical Research Council - MRC		26	
		Engineering and Physical Sciences RC - EPSRC		30	
Netherlands	Nederlandse Org. voor Wetenschappelijk Onderzoek		31		
		NWO - Maatschappij- en Gedragswetenschappen		24,8	17,0
		NWO- Medische Wetenschappen		26,4	21,4
		NWO - Exacte Wetenschappen		29,6	28,6
		NWO- Technische wetenschappen		31	27,2
		NWO - Aard- en Levenswetenschappen		35,0	21,2
		NWO - Geesteswetenschappen		39,4	24,1
		NWO - Natuurkunde		30,3	27.7
		NWO - Chemische Wetenschappen		40,2	29,2

*per scientific area; NWO areas:: % Total 2006, % "Vernieuwingsimpuls" (Career grants) 2006 Source: Annual reports.

2.3 Government role

In all research systems, governments have a major role in funding public research. Most of this funding is based on three related rationales.

- Knowledge production and support of scientific research as common good. Responsibility for funding related to this rationale usually lies with a Ministry for higher education and science. In some countries the science part is linked to innovation policy and moved to a Ministry responsible for industry.
- Knowledge production to support specific societal sectors. Ministries for Public Health and for Agriculture traditionally have quite a large budget for research. In the 80s and 90s innovation policy emerged with specific research budgets to support national industries.
- Research to support government policy and implementation, like defence research, environmental research and civil engineering research.

The rationales are not exclusive and responsibilities can be shared by Ministries, as is often the case for environmental studies. General objectives are also often linked to more specific objectives, like quality improvement, priority setting, creating critical mass, mobility of researchers etc. As a result, governments are challenged to improve the coordination. One way in which this is done is to bring, as far as is possible, the responsibilities for R&D policy into one Ministry. Denmark has brought innovation and science policy together into the Ministry for Science, Technology and Innovation.(Koch 2008) In 2007, the UK government established the Department of Innovation, Universities and Science (DIUS), which combines the responsibilities for science policy with those for innovation policy and higher education. In Germany the Bundes Ministerium für Bildung Wissenschaft, Forschung und Technologie (Education, Science, Research and Technology) was created in 1994, but four years later technology policy was moved to the Ministry for Economy. The current Federal Ministry for Education and Research (BMBF) has a broad range of science policy responsibilities from funding basic research to development of targeted research programs for innovation and societal priorities. In the Netherlands, the Ministry for Education, Culture and Science is responsible for the universities and science policy. Since the early nineties, the ministry governs "at an arm length", which de facto implies that it formulates policy objectives, but leaves the implementation to intermediary bodies and universities. The role of the Ministry of Economic Affairs has increased, though, and recently the two ministries have established a joint department for knowledge and innovation.

As part of the coordination, governments increasingly try to improve strategic planning, which includes the capacity to develop strategies and their implementation. In Germany the BMBF has its own budget and the strategic capacities to develop research programs and implement them. In the UK new forms of public management has been developed in which funding was linked to accountability mechanisms, competition between research councils and government formulated policy objectives. In Denmark we find, as mentioned before, within one agency for science and innovation, a number of specific funding bodies with separate missions. Such an organisation enables the development of a long term strategy and indeed implementation of it.

3 Strategic priorities

Since the early nineties there has been a tendency to set priorities for science and innovation policy at the national level.(Hackmann 2003) Countries have different rationales for priority setting:

- Budget restrictions and increasing costs of scientific research (especially for research related to infrastructure and facilities) necessitates priority setting. Without priorities, choices are made implicit and depend on contingencies. Priority setting mechanisms should optimize the choices and ensure that stakeholders (scientists as well as societal actors) are involved in the decision making process.
- Allocating additional funds for research to strategic goals. Priority setting should prevent additional funds, such as funds from extra gas revenues in the Netherlands, from "vanishing" in ongoing research programs, but instead ensure that they are invested in new areas and contribute to specific (societal) goals.
- Concentration of resources and focussing of strategies on scientific and economic strengths. Strategies at system level are the aggregate result of multiple actors. Priority setting should induce actors to align their strategies and enable the creation of clusters and networks.

In the early nineties, the UK and the Netherlands were forerunners in experimenting with new priority setting mechanisms. In the UK the then Department of Trade and Industry, which was also responsible for the research councils, introduced the Technology Foresight exercise. The aim of this exercise was to link scientific research more closely to future technological opportunities. The assumption was that the results of Technology Foresight could guide the strategies of universities, research councils *and* industry. This has not happened. Though symbolic references were made in organisational strategies, new initiatives and collaborations emerged in response to additional funds, not to the results of the Foresight exercise. (Keenan 2000) In the Netherlands, a foresight coordination committee was established in 1992, with the aim of developing priorities for science policy. Its activities did result in ten priorities for science policy, but only a few were reflected in NWO''s priorities and actually received any additional funding .

The review of the six countries shows three modes of priority setting, with related modes of implementation. The first mode is priority setting without implementation mechanisms. Priorities are often set as national priorities aimed to steer actor strategies in the research system. The Dutch and UK exercises mentioned above are early example of this. A more recent example is the Forsk 2015 exercise by the Danish Ministry of Science, Technology and Innovation. A list of 21 strategic research priorities was published after broad consultation of research organisations, firms, governments and NGOs. Forsk 2015 aim is to guide the future development of the Danish research system. A similar initiative is FUTUR in Germany, which the BMBF initiated in 2007 to develop new priorities for science and technology policy. Through a range of analytical tools (bibliometrics, stakeholder analysis, expert surveys) and interactive methods, themes from an international review were explored and elaborated into strategic options for Germany.

The second mode of priority setting is dedicated priority setting, done for specific funds or policy sectors. Examples can be found in funding organisations and within innovation policies. In the UK the current foresight process focuses on specific areas and there are no overarching

national priorities anymore. The research councils have their own strategic responsibility. As an example, the BBSRC, the research council for biotechnology and biological sciences (including agriculture) identifies ten priorities, as decided by its own Strategic Advisory Board. In Denmark the council for strategic research initiatives has identified ten research areas ("platforms") in which Denmark has a strong position internationally and wishes to maintain that position. The aim of identifying such platforms is to invite ministries co-fund research programs in these areas. Interestingly, there seems to be little relation between these platforms and the results of Forsk 2015.

Comparable to the priorities of specific organizations is priority setting for specific policies. Italian innovation policy is guided by 12 thematic innovation programs for industrial sectors. This applies from research for knowledge intensive sectors like ICT and pharmacy to research for the transport sector and for the ceramic industry. In the UK the Technology Strategy Board has listed six technology areas and eight application sectors for focusing the innovation policy.

Priority setting would actually be the wrong word for the third mode, which is a mode were priorities emerge as a result of different funding mechanisms. Even though there is limited additional funding to allow new priorities to emerge quickly, the UK has just such a policy. The extent to which new and strategic areas are funded depends on researchers persuading their own organisations and funding bodies into these areas. In the Netherlands we find this mode as well, but with additional funds to support the emergence of new areas. Catalysis is a good example, which was selected to be funded in the 90s through several subsequent funding instruments and which now has its own national coordination body within NWO, ACTS. Currently, it manages five research programs, initiated at national and European level. Other examples of such priorities include genomics, ICT and water.

4 Research quality and evaluation

In all countries, quality of research is an important policy theme, and in most countries one finds institutionalised mechanisms for the assessment of publicly funded research at universities and research institutes. The oldest approaches, again, are running in the UK and the Netherlands. Since 1986, the UK the Higher Education Funding Council for England and its sister bodies for Scotland and Wales, have organised a Research Assessment Exercise every 4 years. The results are used to allocate institutional funding to the universities. The main idea behind the RAE is that universities submit units of research for assessment. The allocated budget is related to the size and quality of the submitted research. Universities are not required to submit all research, but may try to optimize size and quality. Units of assessment do not represent the organisational structures of the university, nor its research programs, but can be constructed purely for the assessment exercise. The most recent RAE was in 2008, in which research outputs were assessed on 5 point scale. Table 2 gives scores and HEFCE allocation decisions for some universities, including their rank at the THE ranking of universities.

Table 2 RAE results and allocation decisions, 2008

	Totals (%)	University of Cambridge	University of Oxford	University of York	University of Surrey	University of Sunderland
Ranking THE		2	3	74	190	--
Size (fte)	52409	2040	2246	654	425	181
score 4*	17,4	32	31,8	22,6	15,6	4,2
score 3*	37,2	39,2	38,6	39,5	38,5	22,9
score 2*	32,7	23,9	24,1	31,5	34,4	33,8
score 1*	11,3	4,1	5	6,3	10,9	32,9
Unclass.	1,4	0,8	0,6	0,2	0,6	11,2
Allocation (k£)	1.073.968	74.297	74.533	18.549	11.841	2.077
Per fte submitted (£)	20.492	36.420	33.185	28.362	27.861	11.475

The Dutch evaluative approach has evolved from the government led assessments of the eighties towards the current system, in which universities and research institutes themselves organize evaluations according to the Standard Evaluation Protocol. (Van der Meulen 2008) The Standard Evaluation Protocol is a joint product of the Association of Universities (VSNU), NWO and the Academy (KNAW). Assessments are based on self assessments and peer review by an external panel. As a rule all research should be evaluated every six years, with an intermediate evaluation after three years. Assessment units are usually similar to those of the departments of universities and institutes or research programs. The panel is expected to score the research performance on four criteria: productivity, quality, viability and relevance. Assessment reports are mainly used within the university as an accountability instrument towards the University Board. There is no direct relation between the results and research funding within the university or between government and university.

Part of the Danish system reform is a uniform approach to the assessment of research quality and relevance. Three year evaluation plans are established by the Minister, and implemented

by the Agency for science, technology and innovation. The action plan includes evaluation of funding instruments, evaluation of policies like researchers' mobility and gender equality, and the assessment of disciplines and research areas. As in the Netherlands, assessments are based on a combination of self-assessment reports and expert panels. The assessment results are summarized in six criteria: publications, citations, external funding, international collaborations, industry related research and societal relevance.

In Italy and France specific agencies for the evaluation of research and research programs have recently been established. In Italy, researchers are asked to submit their main publication to be assessed; the aggregated results are published as an assessment of disciplines. In France evaluation is focussed on research programs. There is no standard protocol to guide such evaluations.

Germany is only country in our review which has no national evaluation system, though the issue is much debated. The Wissenschaftsrat, a joint advisory body of the federal government and the states, assesses research institutes on request. Usually, these are research institutes that do not (yet) belong to one of the institute organisations. The main principle however, is that quality of research is not a government responsibility, but one of the research organisation, and can be guaranteed best through peer review of grant proposals and scientific manuscripts.

5 The Netherlands in comparison

Most of the recent reforms we found in our reviews were implemented with the idea that countries were lagging behind international best practice. In many respects, the Netherlands has been an early starter, considering the implementation of the Autonomy and Quality principle in the eighties for the government-university relationships, the reform of the then traditional research council into the current NWO in the early nineties. Most institutes for basic science, currently governed by NWO or the Academy, KNAW, are through part time professorships, participation in graduate schools and other collaborative programs, joint facilities closely related with university research. The technical institutes also cooperate with universities for example in what is called the Water Cluster at Delft or in Brainport in Eindhoven. In contrast with countries abroad, in the last decade there has not been much pressure to catch up with international practice and implement structural reforms. In international rankings of publication and citation numbers, the Netherlands has been doing well, and is *still* doing well, some critics say, as the R&D investments in the Netherlands are relatively low.

Some of the reforms made in the nineties have continued to evolve to their current state, such as the evaluation system and the research council, as a result of strategic responses towards new scientific developments, governance interactions between government and research organisations, political choices and contingencies. Compared to the recent reforms in other countries, the Dutch research system has some remarkable characteristics.

- The role of the government and more specifically of the Ministry of Education, Culture and Science in strategy and planning is weak compared to other countries. In other countries we find a tendency to strengthen coordination at the national level, while in the Netherlands there is no national strategy. The idea of "governance at arm's length" is to some extent possible because reforms have been implemented much earlier. As a result actors in the research system have comparatively more freedom regarding strategy. The flip side is that when actors expect the government to intervene, it has few instruments to do so, though some actors maintain high expectations of the government.
- Compared to its sister organisations abroad, NWO has developed in an intermediary body with a range of different responsibilities and organisational divisions. It owns research institutes, has disciplinary boards and foundations to allocate competitive funding and manage research programs and some of the national coordinating bodies for strategic funding. In most countries such tasks are divided among different organisations. In a recent evaluation of NWO the evaluation committee made proposals for organisational change.
- The competition for funding through open competition is relatively strong in the Netherlands, in some field like the social sciences it seems to be too strong. The results of the review suggests that there might be inversed U curved relationship between competition and scientific performance. In the Netherlands, and more recently in Denmark, scientific performance improved together with an increase in competition. The figures suggest also that competition in the UK has become too high, and the costs of competition exceed the benefits.
- There is hardly any reputational and quality differentiation between the universities in the Netherlands. Dutch universities have a good reputation, but none of the Dutch universities belong to the international elite or rank at the top of international ranking lists. Compared to other European countries, currently this is only in contrast with the

UK, but other countries are also trying to achieve such differentiation to create one or two elite universities within their country. In the Netherlands, policy instruments have been implemented which could have led to quality and reputational differences, like the systematic evaluation of research, funding of top graduate schools and the 'Vernieuwingsimpuls', but this has not happened. Instead, some of these instruments have led to another remarkable system characteristic: the strong networking of university research into inter-organisational graduate schools, virtual institutes, research consortia and the like. These inter-organisational constructions seem to prevent the differentiation of universities instead of induce it.

- Quality control of scientific research at Dutch universities and research institutes is standardised through a joint protocol, which delegates quite some responsibilities for the actual assessments to the research organisations. As a result, it is unclear whether the different committees use comparable standards. The results of the assessments do not have any direct effect on resource allocation and limited effects on the research policies of universities and other research organisations.
- The Netherlands has no initiatives for explicit priority setting to be implemented. Some of the organisations in the research system have set their own priorities and as part of innovation policy, priorities have been set. More significant are those priorities that have been set *de facto* or emerged as a result of several policy instruments to create strengths, clusters and collaborations. Such an approach of incremental priority setting needs a regular impulse to promote research quality as well as additional funds. Currently, the approach is not institutionally settled and depends on *ad hoc* policy.

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PART 2

Country Studies

1 Denmark

Denmark has caught up to the research and innovation leaders quite remarkably in recent years. R&D expenditure has grown significantly, both in volume and as a percentage of GDP, the number of researchers has increased as a percentage of total R&D personnel, as well as relative to the total labour force. Denmark also performs well in terms of research output showing a large increase in publication output in international, peer-reviewed journals, as well as a large increase in citation impact score.

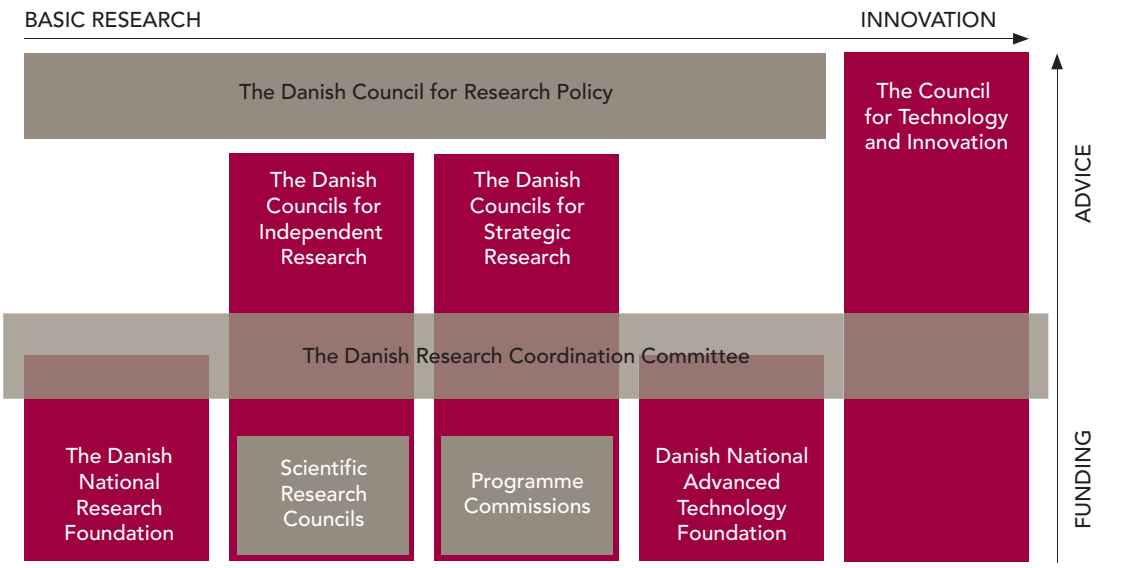
This catch up can be seen as the result of addressing a number of issues in Danish research policy which was seen to be too fragmented, public research effort was seen to suffer from lack of integration between the sectors of the various funding ministries, and cooperation, mobility and competition between researchers, research units and institutions was lacking. Universities were seen to be too introverted in relation to the policy relevant to research and economic development in the private sector. The research councils were considered to contribute to the fragmentation problem in the sense that they were closely connected to university research and its disciplinary organisational structure. All this has led to a number of structural changes in Denmark's research system since 2000 in the context of a clear strategy.

1.1 Characteristics of the Danish research system

Structure

The Ministry of Science, Technology and Innovation coordinates all research and innovation policies and most of research funding. Danish Ministries use the terms 'agencies' to denote ministerial subdivisions and 'bodies' for intermediary level organisations. The Ministry of Science, Technology and Innovation thus contains as a department the Danish Agency for Science, Technology and Innovation, which was established in May 2006 with the objective of promoting research and innovation of high international standard, financially, culturally and socially beneficial to the development of Danish society.

Figure 2.1 Advisory and Funding system for research and innovation in Denmark



Fact Sheet

Denmark's R&D expenditure as a percentage of GDP rose gradually from 1.61 in 1991 to 2.55 in 2007, mainly because of increasing private R&D. Denmark and Germany follow the Scandinavian countries with more or less the same GERD. The Danish government finances almost 30% (a decrease from 1991 when it was almost 40%), while the private sector is responsible for 2/3 of total R&D expenditure. The main financier of university R&D is the government which provides 83% of the total funds. Companies only account for 2% of university funding. The same applies for the funding of the research institutes.

Table 2.1 Basic R&D figures Denmark

	1991	1996	2001	2005	2006	2007
R&D expenditure						
R&D-expenditure (M€)	1783	2671	4278	5094	5420	5779
R&D expenditure by inhabitant (€)	346	509	800	941	999	1061
Total R&D expenditure as a % of GDP	1,61	1,84	2,39	2,46	2,48	2,55
% GERD financed by government	39,7	35,7	28,2	27,6	--	--
% GERD financed by industry	51,4	50,5	61,4	59,5	--	--
GERD performed in HE sector	22,6	21,6	18,9	24,6	25,9	27,5
GERD performed in GOV sector	17,7	16,3	11,8	6,5	6,6	7,0
R&D personnel						
Total R&D personnel	25756	32148	39892	43499	44878	46029
% researchers of total R&D personnel	46,8	51,9	48,8	64,8	64,3	64,2
R&D personnel by labour force	8,8	11,4	13,9	15,1	15,5	15,9
Researchers by labour force	4,1	5,9	6,8	9,8	9,9	10,2
R&D output	**1993-1996**				**2003-2006**	**Δ**
Publication output	26037				37121	42,6
Citation impactscore	1,13				1,33	17,9

Sources
EUROSTAT (NewCronos database): R&D expnditure in €:
OECD/MSTI (2008/2): R&D personnel and other R&D expenditure data
NOWT 2008: R&D output

Under the Agency there are a number of councils and committees to implement parts of the research and innovation policy. The Agency functions as secretariat to the Danish Research Coordination Committee, the Danish Council for Independent Research, the Danish Council for Strategic Research, the Danish Council for Technology and Innovation, the Danish Research Policy Council, and the Danish Committees on Scientific Dishonesty. There are also two separate foundations, established by law with capital provided by the Danish government, concerned with basic science. These are The Danish National Research Foundation (with a budget of approx. €40m) and The Danish National Advanced Technology Foundation.

The Council for Technology and Innovation advises the Minister of Science, Technology and Innovation and makes decisions regarding grants (amounting to €70m in 2004). Established in 2004, the Danish Council for Research Policy consists of recognised researchers and advises the minister on research policy. The Danish Council for Independent Research is an umbrella organisation for five research funding councils and supports research project ideas based on initiatives and priorities set by researchers. The other major funding council is the Council for Strategic Research which supports strategic and policy-oriented research. Together these two councils fund a total of 10% of the public R&D.

The Coordination Committee oversees the advisory and funding organisations of the research system and is responsible for the promotion of co-ordination and co-operation amongst the research councils, and between the research councils and the rest of the research and innovation system. The Coordination Committee is more of a consensus organ however, that has no authoritative role within the research system. The committee is composed of the chairmen of the Council for Independent Research, the Council for Strategic Research, and the Danish National Research Foundation. A further two members of the committee are nominated by the Danish Rectors' Conference, one member is nominated by the Assembly of Director Generals of the Danish Government Research Institutes (SEDIRK), and one member by the Council for Technology and Innovation. In Parliament, research policy is covered by the Committee for Science and Technology.

The main actors on a *research performing level* are the universities and government research institutes (ministry owned and the independent, GTS institutes), and R&D performing private companies. 80% of the publicly funded R&D (HERD + GOVERD) takes place in the universities. As a result of the 2007 reform of the public research organisations, there are now six main universities, combining existing universities and most of the public research institutes.

Governance

Denmark has an essentially centralised research system. The current Ministry of Science, Technology and Innovation, formed in 2001, coordinates all research and innovation policies and allocates approximately 75% of governmental grants to research and innovation. The second most important ministry in terms of R&D financing (roughly 5%) is the Ministry of Food, Agriculture and Fisheries. The Ministry of Economic and Business Affairs also has some influence over innovation policies. The Danish Energy Authority, from within the Ministry for Transport and Energy, has special influence over the research policy relating to energy in terms of funding, political instruments and agenda setting. Co-ordination between sectoral ministries is done on an informal basis through an initiative of the Ministry of Science, Technology and Innovation.

There have been several new initiatives from both the Government and Universities, including the University Act of 2003, which make the universities more autonomous. The reforms also entailed a change in institutional management such that the universities are now governed by a board with an external majority. The principal of the university is appointed by this board, rather than by the university staff. The universities now also have the new mission of 'knowledge exchange'. The universities are given more freedom through so-called development contracts with the Ministry of Science, Technology and Innovation. Within the framework of these four-year-long contracts, universities have greater freedom to select their own strategies. Future funding however, will be based on an evaluation of the institution's ability to reach the objectives stated in their contract. An example is the contract with the University of Arhus for the period 2007-2010. The contract describes the development of the university and on four areas performance indicators are specified: research, education, knowledge dissemination and consultancy. For each indicator the ambitions per year are specified in the contract.

Resource allocation
A significant proportion of the government budget allocated to the universities (approx. 45%) comes from the "General University Funds" and is received in the form of institutional funding. The research councils receive roughly 10%, other research institutes receive 15%, and roughly 5% goes abroad. The Council for Strategic Research and the Council for Independent Research also have budgets for funding research.

An agreement was signed in November 2008 between the ruling party and several opposition parties in the Danish government to distribute 4 billion DKK (roughly €540M) between 2009 and 2012 through the "globalisation fund". This agreement further augments basic university funding, from roughly €800M 2007 to roughly €900M in 2009, but also contributes to the strengthening of strategic research and independent research.

The allocation of funds to university education is currently under review. Universities, government research institutions and hospitals obtain funds from the Ministry of Science, Technology and Innovation distributed on both a basic funding and a program funding basis. The government has already announced that a significantly greater proportion of the university funds will in future be allocated through competitive schemes rather than as basic funds. Government research institutes receive about 60% of their funding through non-competitive funds and about 20% through mission-oriented government funds.

Priority setting
The three agencies within the Ministry of Science, Technology and Innovation are the Danish Agency for Science, Technology and Innovation, the Danish University and Property Agency and the National IT and Telecom agency. Only the first is involved in strategy and policy development regarding science and technology while the other two are more concerned with administration of their respective areas than research. Besides the Ministry of Science, Technology and Innovation however, other ministries are also significantly involved in priority-setting and funding of strategic thematic areas.

The establishment of the Danish National Advanced Technology Foundation is just one product of the strategy to focus on the frontier research areas of nanotechnology, biotechnology and

ICT. The intention is that traditional priority fields are not to be ignored but rather strengthened through the application of new methods - such as biotech in the food-related research, or nanotech and ICT in energy research. The Energy Authority, under the Ministry of Transport and Energy, contains its own advisory body on energy research, and has developed special strategies for different fields of energy research. Ideally research projects should relate to these strategies, but prioritisation amongst the strategies is not clear. Strengthening multidisciplinary research efforts is also seen as important.

The Danish Council for Strategic Research has identified 10 Innovation Accelerating Research Platforms based on areas where Denmark has internationally recognised researchers, competitive business clusters and/or a need for research-based solutions:

- water as a strategic resource of the future
- health care investments focusing on biological defence mechanisms
- user-driven innovation and business development in the knowledge economy
- biological manufacturing - useful products from renewable resources
- global design-oriented manufacturing platforms
- systematised sustainable energy
- from nanoscience to nano products
- health and safe food
- high tech instrument development
- the individual perspective in health-care services of the future

General policy documents do not however, give a clear indication of which research areas are prioritised within the Danish research system. This is partly because research policy focuses on universities and high technology, but also as much of the R&D funding is allotted directly to the universities or via the Council for Independent Research, the Danish National Research Foundation and the Danish National Advanced Technology Foundation. The "Forsk 2015" report however, published by the Ministry of Science, Technology and Innovation in May 2008 represents a move away from this situation. The report lists 21 strategic research priorities and is the result of a broad consultation process involving universities, research councils, public research organisations, private companies, national authorities and non-governmental organisations. The "Forsk 2015" report is intended to be used for guiding strategic research priorities.

Quality of research

Research evaluation, including the evaluations commissioned by Parliament, governmental agencies and the research councils including the Danish Council for Research Policy, became common practice as early as the 1990s. The Danish government is striving towards a more systematic evaluation of all research programmes, to ensure allocation of funds is closely related to quality.

The Danish Council for Research Policy developed a tool for assessing research quality and relevance (December 2006), based on internationally comparable criteria across research areas and institutions. The tool is used for allocation of both basic and competitive funding to institutions. The Danish Agency for Science, Technology and Innovation recently published guidelines for research evaluation in which it emphasised that increased investment in research increases the need for evaluation. These guidelines are based on a framework set out by the Ministry of Science, Technology and Innovation and applied to evaluations. The four aspects of evaluation are: funding instruments, research areas, research programmes and the research

system. Relevant stakeholders, such as the contracting authority, a panel of experts, users and the parties evaluated, should be involved in the process.
Making the Danish universities more competitive has been an important aspect of Danish research policy in recent years. Part of this has involved identifying the specific strengths of each Danish knowledge institution. To do this, the Danish Council for Research Policy mapped in November 2004 the particularly promising areas of Danish research institutions. All Danish research institutions with more than 15 publicly funded researchers were asked to report current as well as developing core areas. Based on this, the Council's Annual report concluded that the political allocation of research funding should be prioritised according to these three factors:

- strengthening Danish research, both quantitatively and qualitatively
- aligning national research efforts more closely with international efforts
- increasing social relevance of research efforts, also in terms of economic growth and employment creation

This report was followed up in December 2006 by the development of a tool for comparing research relevance and quality across fields and institutions, based on comparable indicators and self-evaluation of the institutions ("A Tool for Assessing Research Quality and Relevance"). The tool is intended to be used for future relevance- and quality-assessments, and for future allocation of basic and competitive funding to institutions.

The Danish Council for Research Policy recommends that the common reference for quality and relevance assessment should[8]:

- be based on open, publicly accessible self-evaluation by the research unit in question. These self-evaluations should be combined with and validated by external (national as well as international) independent evaluations
- comprise six indicators on a five-level scale, four for quality (1-4) and two for relevance (5-6):
  - Publications
  - Citations
  - External research funding/income
  - Formalised international research collaborations
  - Business-related relevance
  - Overall societal relevance
- be expressed graphically in a diagram
- be publicly accessible.

1.2 Recent policy changes: learning from Denmark

The Danish research system displays strong centrally oriented tendencies. This appears to be quite effective as seen from different kinds of input and output/effect data. The Ministry of Science, Technology and Innovation has a strong coordinating role, through, amongst other mechanisms, funding approximately 75% of the governmental budget for research and innovation. It is likely that this centralisation made the introduction of some major changes in the research system possible at the beginning of this decade (restructuring the universities and research institutes and significant growth and reorganisation of the Ministry itself).

8 http://en.fi.dk/publications/2006/a-tool-for-assessing-research-quality-and-relevance/a-tool-for-assessing-research-quality-and-relevance.pdf

Government has also defined objectives quite clearly (such as the objective to increase the relative amount of competitive funding), not only with regard to R&D funding in general, but also with respect to the research councils, the universities, and the research institutes. Although government has given the universities more autonomy and self governance, this is clearly defined within the boundaries of contracts between the universities and the Ministry of STI, with explicit indicators and a relation to basic funding from the Ministry. It would be interesting to see evaluative studies of how these contracts work.

Formation of a 'superministry', the Ministry of Science, Technology and Innovation

Initial situation

Danish research, innovation, education and technological development have become increasingly integrated and coordinated over the last 15 years. The formation of a so-called 'superministry', the Ministry of Science, Technology and Innovation, in 2001 is a major feature of this process. During the first years, the Ministry of Science had a marginal position with an initial focus on science consultancy and technological change. In 1994 the policy fields of IT and telecommunications were transferred to it, Innovation was transferred in 1998 from the Ministry of Business Affairs and the administration and research of universities was transferred from the Ministry of Education. In 2000, however, the administration and research of universities was transferred back to the Ministry of Education due to concerns of the Cabinet; and the concept of development contracts was developed at this time. The Ministry then went through a major reorganisation and expansion in 2001 when the current government was elected for the first time, once again including universities, research, innovation, IT and telecommunications.

Danish Ministries use the term 'agencies' to denote ministerial subdivisions and 'bodies' for intermediary level organisations. The three agencies within the Ministry are the National IT and Telecom Agency, the Danish Agency for Science, Technology and Innovation and the Danish University and Property Agency. In 2006 the Ministry underwent an internal reorganisation to create a clear division between the work of the department, with a significantly reduced workforce, and the agencies, reorganised to receive staff from the department. Research and innovation received extra attention and strategic positioning from the VK Regeringen II (2005-2007) and the Globalisation Council (2005-2006) leading to a number of reforms.

Policy objectives

The Danish Agency for Science, Technology and Innovation, with its embedded councils, is the only agency involved in the promotion of research and innovation and policy development. The Danish University and Property Agency has the responsibility of administering education policy for the universities and education policy relating to research, and of administering all university real estate and other property. The research advisory subsystem consists of four councils which are responsible for overall coordination of public research, policy advice and in the case of two of these councils, funding of research at the universities.

The 4 main strategic goals of Danish research and innovation policy are:

- To become a leading knowledge society. GERD to reach 3% by 2010 (Lisbon agenda)
- To become a leading entrepreneurial society. Produce most new enterprises.
- World class education. Increase proportion of future generation higher education graduates.
- To be the most competitive society in 2015

The Globalisation Council was appointed in 2005 with broad representation from relevant sectors of society, chaired by the prime minister, in order to formulating a precise globalisation strategy. The globalisation strategy focuses on education, research, entrepreneurship and innovation, turning R&D into one of the main pillars of government policy. The document repeats the Lisbon 3% objective, arguing that public R&D expenditure should reach 1% of GDP by 2010.
Policy objectives with regard to R&D are:

- increased public funding for strategic research of importance for the development of society, e.g. environment, energy and health - private co-funding is encouraged
- as much as half of public R&D funding is to be competitive by 2010 (compared to one third currently) - funding should cover all costs, including overheads
- applied, target-oriented research in government institutes is to be integrated into the universities
- financing of collaboration between research institutions and industry is to be consolidated into a single fund

R&D collaboration at the operational level, i.e. between research institutes and industry has traditionally been a weak point in Denmark. A new program of user-driven innovation was created in 2006 in response to the recognised need for policy concerned with the interaction between industrial suppliers, users and clients. The long term trend regarding policy on research, innovation, education and technological development since the formation of the Ministry of Science, Technology and Innovation is towards a more research and utilitarian orientation through paying more attention to research in areas open for business opportunities.

Effects
According to the OECD, the Danish economy is probably the strongest in Europe (2006). Denmark held the 8th place of the best performing countries in terms of research and development according to a 2003 study carried out by the Danish Ministry of Business and Economics. Public and private spending on R&D has increased significantly over the last 10 years especially when compared to other OECD countries. Public spending reached is reported to be up to 0.8% of GDP but private sector spending still accounts for most of the increase in GERD.

Even with the classical management tools for centralised coordination and organisation, many of the internal tasks of the Ministry of Science, Technology and Innovation are quite diverse. The Ministry was born with an emphasis on research with weak initial (political) objectives and means of evaluation and this initial became embedded in the internal culture of administration. Agencies which were previously part of different ministries still have a tendency to operate relatively independently. The cultural split between the research policy administrators with political science backgrounds and the people taking care of technology innovation from engineering and business backgrounds is a drawback of the superministry approach.

It is argued that small and medium size enterprises suffer due to the shift away from traditional sector-orientated business policy and instead there is an overinvestment in research. When it comes to business-orientated innovation policy, traditional sector-orientated innovation strategies suffer due to an overinvestment in high technology and entrepreneurship. It has been suggested that the government should be more active in developing general strategy for integration of innovation and research.

The advisory and funding system for research was recently evaluated by an Nordic panel of experts, to assess whether the organisation of the councils and their division of tasks was appropriate with regard to its aims. The main conclusion of this evaluation was that, though the councils operate under one umbrella, the Agency of Science, Technology and Innovation, their actual operation is fragmented and uncoordinated, and the divisions of tasks are unclear. As a result it is not fit to develop and manage large research programmes and stimulate interdisciplinary research. The expert panel recommends that the purposes of the respective bodies be more clearly defined.

University reforms and development contracts

Initial situation

The university sector has undergone fundamental reforms regarding governance, R&D quality and its relationship to industry. The universities are considered to be cost effective and the quality of university research is considered to be high. The number of Danish PhDs doubled during the 1990s, and the government now plans to double it again.

An OECD expert panel gave the following recommendations in 2002 based on an evaluation of Danish Universities:

- A national strategy should be set for the universities considering objectives of individual universities
- The government should consider whether the status of the universities should be changed from special administrative entities to foundations under private law, to enable them to operate as private sector bodies, while continuing to receive public funds
- The government should consider relinquishing central control over universities
- In addition, excellent teaching should be recognised and rewarded. All universities should establish programmes promoting high quality teaching and learning, and introducing innovative teaching methods. Universities should carry out program reviews periodically.

In part, to strengthen the link between research, innovation and entrepreneurship, the Globalisation Council initiated institutional reform came in the form of a merger of universities and research institutes reducing the number from 12 to 7 larger units. The aim of a concentration in a few universities is to promote/create more competitive universities. The establishment of three large universities - Copenhagen University, Aarhus University and Denmark's Technical University - in particular should strengthen the research system. These three universities will have clear research profiles and will concentrate the main R&D actors in their respective fields:

- Copenhagen University will house the main chemical and biological research performers
- Aarhus University will cover a broad range of fields with a specialisation in sciences covering environmental issues and natural resources, nanoscience, economics and social sciences
- Denmark's Technical University has merged with five sector research institutes, e.g. the Research Centre Risø, with the goal of becoming a leading international university for the development and application of research-based technology

The other universities are the University of Southern Denmark, Aalborg University and Roskilde University.

Policy objectives
The objectives of the Globalisation Strategy developed by the Globalisation Council in 2006 with respect to research performers are:

- university funding to be more closely linked to quality of research
- basic funding of universities is to be based on an evaluation of the institution's ability to reach the objectives stated in the development contract from 1 January 2008
- evaluation of university education and research is to be carried out, based on internationally-acknowledged indicators by international, independent, expert panels
- number of PhD scholarships to be doubled, especially within areas of natural science, technical development, ICT and health studies and elite candidate bachelor courses to be established
- university teachers will be offered opportunities to develop their teaching skills. PhD students will follow courses in education. Good teachers will be rewarded financially
- universities to be given more flexibility in the recruitment of researchers regarding salaries, the number of professors and the possibility of recruiting "super professors" with their own budget
- universities to develop concrete goals for the societal relevance of R&D and compete annually for large, long-term, research projects
- research councils to give priority to large investments in infrastructure, especially facilities used by more than one institution
- the research councils will be allowed to fund international R&D co-operation, including support for industry and research institution participation in the EU Framework Programme
- the funding for the technical service institutes (GTS) is to be more competitive, i.e. other institutions may compete for the same funding
- the government will establish a new centre for e-business within the GTS system

The use of performance contracts in Denmark is widespread in public administration, but these performance contracts do not replace traditional coordination tools such as laws and budgets. The contracts aim to coordinate at least three relationships with respect to the Ministry of Science, Technology and Innovation. Firstly, internally between the department and the agencies of the Ministry balancing long term policies with the need for change. Secondly between the Ministry and universities regarding the independance of the universities and the board of directors. Third, between the Ministry and the approved (GTS) technological service institutes. These performance contracts are intended to promote transparency by forcing institutions to develop a clear set of goals. The first generation of contracts signed in 2001 represent only a brief outline of activities and goals while the second generation of contracts (mostly 2006-2008) contains more quantitative goals with mandatory yearly evaluations.

Effects
Two central objectives of the Globalisation Council reforms were the strengthening of the quality, and the more careful orientation and application of research and education.
The merger process where by the 12 large universities were merged to reduce their number to 7 and combined with research institutes will be evaluated in 2009.

One of the effects common amongst all the universities is a more international outlook. The Technical University of Denmark for example is obliged, according to its second generation

contract, to form strategic alliances with foreign universities and be evaluated according to international standards. Aarhus University signed a development contract for the period 2008-2010, based on 40 indicators, almost all of which are quantitative. This gives an indication of the ambitions of Aarhus University regarding research, education, the dissemination of knowledge and research-based advice to authorities.

Table 2.2 Overview of development contract indicators of the Aarhus University, 2008-2010

Area	Indicators
Research	Number of research publications
	Number of foreign researchers attracted
	Amount of EU funds commissioned
	Amount of private Danish and foreign funds
	Number of graduate schools
	Newly enrolled PhD students
	Number of PhD degrees conferred
Degree programmes	Number of newly enrolled students
	Drop-out percentage
	Percentage of students completing their studies in the prescribed time or prescribed time + 1 year (bachelor, master)
	Unemployment figures for Master's degree graduates
	Number of entrepreneurship courses offered
	Number of incoming and outgoing students
	Number of courses taught in English
	Number of complete degree programmes taught in English
	Degree programme quality
	Number of completed degree programmes for which the evaluation of the teaching is published on the Internet
	Strategy for new methods of teaching/continuing teacher education
	Study guidance activities
	Strategy for study environment
Dissemination of knowledge	Collaboration with university colleges
	Number of course participants
	Study fees
	Number of written contributions to popular media
	Number of lectures open to the public
	Participation in councils, committees and boards
	Number of collaboration agreements
	Number of reported inventions
	Number and revenue from sold patents and licences
Research-based advice	Number of conferred PhD degrees
	Income from advice to the authorities

Source: http://www.au.dk/en/policy/developmentcontract

2 France

The French research system was created after the World War II and has long been characterised by the organisation of fundamental research within the CNRS and outside the universities, and the use large scale scientific and technological research programs to pursue national objectives. These characteristics have been criticized frequently, along with the special position of the Grand Ecoles - pulling the best students out of the academic system, and the gap between public research and industry - obstructing the innovativeness of French industry. Since the 1980s French government has tried to remedy weaknesses of the French system, changing the governance of the research system at governance level, as well as trying to improve institutional conditions at the research performance level. Recently the ambitions of the government have got a new impetus, legitimized by the Lisbon agreement and the observation that the French research system is structurally not ready yet for the knowledge economy. The 2006 Law for Research aims to allow the French research system to adapt to scientific developments, to society's expectations (e.g. sustainable development), and to the European and international context. Some major accomplishments of the subsequent reforms are the integration of CNRS laboratories and the universities and the development of a stronger intermediary layer.

2.1 Characteristics of the France research system

Structure
At the policy level, the Ministry of Higher Education and Research co-ordinates the governments decisions regarding research. The following ministries are involves in the Mission of Research and Higher Education (MIRES), the French public research budget:

- the Ministry of Higher Education and Research
- the Ministry of Ecology, Energy and Sustainable Development (MEDAD)
- the Ministry of Economy, Finances and Employment
- the Ministry of Defence
- the Ministry of Culture and Communication
- the Ministry of Agriculture and Fisheries

The Ministry of Higher Education and Research coordinates governmental decisions and research actions relevant to research performers as well as the intermediary bodies in the research system. In practise however, as pointed out by the Court of Auditors (*Cour des Comptes*) in its 2003 annual report to the president of the Republic, the capacity of the Ministry of Higher Education and Research to efficiently orient research policy is weak.

Governmental policy strategies regarding research and technology have been defined but not coordinated, since 1998, by the Inter-Ministerial Committee of Scientific and Technological Research (*Comité interministériel de la recherche scientifique et technologique - CIRST*), chaired by the prime minister. The Ministry of Higher Education and Research is responsible for preparing regular meetings as well as carrying out the administrative secretariat tasks of the CIRST.

The High Council for Science and Technology (*Haut Conseil de la Science et de la Technologie - HCST*) was created in 2006 to offer recommendations regarding national research and innovation strategies. It shares this scientific advice activity with the CSRT, which is mainly oriented towards research issues. The High Council for Research and Technology (*Conseil*

Fact Sheet

Despite ambitions to meet the Lisbon target of 3%, French R&D expenditures have been decreasing from around 2.27% of GDP in 1996 towards 2.08% in 2007. This decrease seems to be mainly due to a decrease in government spending. Its share in the R&D expenditures decreased to 38.4% of the total, while that of industry rose to 52.4%.

Universities seem to have suffered from the decrease though. 19.2% of R&D is now spent in the higher education sector. The decrease has mainly affected the government institutes of which the contribution to R&D performance has decreased from 22% to 16.5%. Like other countries in our review, France also shows an increase in scientific output, and an increase in the relative scientific impact of these publications.

Although France consists of a large number of regions and local communities with budgets for R&D, they still play a small role in total R&D with approx. 3 percent of total public funding of R&D (despite an increase in budgets since 2000). Historically, local governments - communes (36,778), départements (100) and regions (26) -support science and technology activities by financing universities' and engineering schools' buildings.

France is a large actor in the European context: the French share of R&D expenditure of EU-27 total was 17% in 2006 (20 percent in 1996). French R&D intensity has declined since the nineties, although it now seems stable at a level of 2.1%. French R&D has a strong orientation towards defence: almost 30 percent of the budget of the government is spent here.

Table 2.3 Basic R&D figures for France

	1991	1996	2001	2005	2006	2007
R&D expenditure						
R&D-expenditure (M€)	23388	28119	32887	36228	37909	39369
R&D expenditure by inhabitant (€)	401	472	540	578	602	621
Total R&D expenditure as a % of GDP	2,32	2,27	2,20	2,10	2,10	2,08
% GERD financed by government	48,8	41,5	36,9	38,6	38,4	..
% GERD financed by industry	42,5	48,5	54,2	51,9	52,4	..
GERD performed in HE sector	15,1	16,8	18,9	18,8	19,2	19,2
GERD performed in GOV sector	22,7	20,3	16,5	17,8	16,5	16,5
R&D personnel						
Total R&D personnel	299201	320805	333518	353554	363867	..
% researchers of total R&D personnel	43,4	48,3	53,2	57,8	58,0	..
R&D personnel by labour force	12,0	12,5	12,4	12,8	13,2	..
Researchers by labour force	5,2	6,1	6,6	7,4	7,7	..
R&D output	**1993-1996**				**2003-2006**	**Δ**
Publication output	172364				220528	27,9
Citation impactscore	0,93				1,06	13,5

Sources
EUROSTAT (NewCronos database): R&D expnditure in €:
OECD/MSTI (2008/2): R&D personnel and other R&D expenditure data
NOWT 2008: R&D output

supérieur de la recherche et de la technologie - CSRT) was created in 1982 and has a consultative role on research policy to the President regarding, amongst other issues, the civil budget for R&D and the creation of scientific and technological public institutes. A more informal science policy adviser, mainly through the FutuRIS project, is the National Association for Technical Research (ANRT). The FutuRIS project proposes a wide review of the many different aspects of the research and innovation system.

The National Agency for Research (ANR), mainly oriented towards public research performers and the OSEO Group, mainly oriented towards private research performers are the major French funding agencies. The National Agency for Research was created in 2005 to provide support to basic and strategic research, innovation, partnership between public and private sectors and contributes to the technological transfer of public research results towards the economic sector. Like national research councils in other countries, it funds projects, that are selected according to scientific and technical excellence criteria. ANR works according to a competitive funding schemes through calls for projects on various themes. From an institutional point of view, the ANR is under the aegis of the Ministry of Higher Education and Research, but the Ministry of Education, the Ministry of Health, the Ministry of Budget and the Ministry of Industry are also represented in its executive board.

The most important actors at the research performing level, in terms of funds, are the 162 higher education institutions of which 86 are universities (as counted by the Mission of Research and Higher Education) and "grandes écoles". The French university system is characterised by a large concentration of resources and a large number of small universities. Thirty-three higher education institutions receive two thirds of the total resources with nine of these receiving one third. The remaining resources are spread thinly across the regions mainly due to historical spatial planning logic. 19.2% of total R&D in France is performed in the higher education sector. Research is also performed by the National Centre for Scientific Research (CNRS) and the other public research organisations (PROs), accounting for 16.5% of total R&D.

The CNRS, active regionally, nationally and internationally has recently undergone significant reforms and is now composed of 9 institutes. With more than 25000 staff in 2007, the CNRS, through its 19 regional offices and several international offices, has research performing, funding and overseeing functions. The PROs are under the supervision of one ministry, in accordance with the research area for which it is in charge of applying its strategy in. Employees of publicly-funded research institutes have the status of civil servants.

Governance

The Ministry of Higher Education and Research (*Ministère de l''enseignement supérieur et de la recherche*) governs the Directorate General of Higher Education, the Directorate General of Research and Innovation (*Direction générale de la recherche et de l'innovation*). The Ministry is responsible for defining and implementing policies in the fields of education, research, innovation, new ICT and space research. The Ministry is represented at the local level by 28 regional delegations which are in charge of implementation of central policy at a regional level. Almost all headquarters of public research organisations and large R&D performing companies and almost half of all national R&D expenditure is concentrated in the Ile-de-France region. The relationship between the regions and the national government are set out in the seven year contracts (CPER). The CPER defines the financial aid provided by the central government in accordance with the regional objectives. Research represents an explicit chapter in these contracts.

In August 2007, the government introduced a plan, to be implemented by the universities within five years, to restructure universities in terms of the responsibilities and freedom: the Law on University Reform. The law aims to redefine university governance, giving the universities greater freedom and responsibility regarding human resource management and easing access to private funding. Human resource management should be improved in the sense that it will be easier and quicker to recruit in accordance with the university's needs and strategy. Bonuses and annual premiums for staff, at the initiative of the university president, are now also allowed.

Resource allocation

From 1982 to 2005, the main resource allocation instrument of the Ministry of Higher Education and Research (along with other government ministries) was the Civil Budget for R&D (Budget Civil de R&D). The Civil Budget for R&D included the resources devoted to R&D by all Ministries involved in distributing them. In practise, however, each ministry was responsible for the execution (or the non-execution) of its R&D budget, and the Ministry of Higher Education and Research did not really have an effect on the overall orientation of R&D. On top of this, public expenditures on R&D amounting to around half of the Civil Budget for R&D were not collected in the civil budget for R&D. Since 2006, the Ministry of Higher Education and Research has more control over the orientation of overall research policy. The state budget is now defined according this new law. As far as research policies are concerned, the law identifies one inter-ministerial mission (Mission of Research and Higher Education), which replaces the former civil budget for R&D, and involves 12 programmes and seven ministries.

Table 2.4 State funding France to different sectors

Sector	Budget 2008 (M€)
mathematics, ICT, micro and nanotechnologies	879
food and agriculture	111
Physics, chemistry, engineering sciences	952
life sciences, biotechnologies and health	1,915
energy (incl. nuclear physics)	963
Security and space	1,434
Transport/mobility, housing	400
earth, universe and environment sciences	1,377
socio-economic sciences and humanities (incl. cultural research)	1,393
multidisciplinary and transversal research	454
industrial research	477

Source: 2008 Finance Bill

Since the Constitutional Bylaw on Budget Acts, the general budget is divided into missions (34) representing the main areas of the state policy which are in turn divided into programs (132), which are in turn divided into actions. Each program defines a strategy, with objectives and indicators and a co-ordinator accountable to Parliament for the results of the program. Actions are identified with a corresponding budget. The success of each programme is evaluated according to, amongst others, the socio-economic benefits from an environmental, cultural and medical point of view and the cost to the benefit of the program. The Constitutional Bylaw on Budget Acts still faces implementation difficulties and as it is a recent development, it is difficult to assess its efficiency.

In 2004, roughly 75% of public funding went to organisations in the public sector (80% of this in the form of block grants), some 15% to private enterprises and some 10% went abroad. In 2005, however, the funding structure changed, as a result of the establishment of the National Agency for Research. There has been a slight decrease in the proportion of public funding in the form of block grants, from 81% in 2000 to 75% in 2008, and project-based funding has increased from 15.2% in 2000 to 22.3% in 2008.

The move to increase the proportion of public funding allocated on a project basis is implementated through instruments such as the National Agency for Research and the Competitiveness Clusters. Competitiveness clusters are a form of public private partnership, aimed at increasing a territories' attractiveness, linking public research units, training centres and enterprises on projects whether on emerging or more mature themes. From 2005 to August 2006, €540m of public funding was distributed over 165 projects. Over €230m came from the state budget, €80m from the Agency for Industrial Innovation, €200m from the National Agency for Research and €30m from OSEO Innovation. In total, the R&D budget of the 165 projects has reached a level of €1800m.

The budget of the National Agency for Research, ANR, is allocated to six themes and an open competition. Public research institutes and higher education institutions are the main beneficiaries. In 2007, they received 81.1% of ANR funding, of which 24.6% went to the universities. The percentage allocated to major research organisations rose from 38% in 2006 to 40% in 2007. Universities are very active in the non-thematic sector (34.1%). Of the remaining 18.9%, 15% was allocated to enterprises.

Table 2.5 Budget and selection rate per theme ANR 2007

Theme	Budget %	Selection rate
Sustainable Energy and Environment	14.5	26.7
Information and Communication Sciences and Technologies	20.9	31.1
Engineering, Processes and Security	7.1	27.2
Biology and Health	22.1	21.2
Ecosystems and Sustainable Development	7.3	28.8
Humanities and Social Sciences	3	24.7
Non thematic and cruss cutting actions	25.1	25.9

Source: ANR annual report 2007

Roughly 90% of the State funding for research in universities is channelled through the Quadrennial contracts between the State and the higher education institutes or public research organisations. The contracts are based on a project based approach, using targets and indicators for evaluation purposes.

Before the recent Law on University responsibilities and freedom of August 2007, universities only directly managed 20% of the total state funding dedicated to universities in the annual budget law. Most of the budget was spend on human resources, social actions for students, central administration, which were managed by the Ministry because of the universities' public status and the status of researchers as civil servants. With the reform, universities that have changed status are able to manage a global budget, including staff costs. By now, block grants account for almost 90% of resources of universities and of the National Centre for Scientific Research.

Priority setting
The National Agency for Research was created in 2005 to support fundamental research on a project basis. Its mission is to fund research projects relevant to the priorities set by the government. The National Agency for Research's call for projects is organised around the following seven themes:

- biology and health
- ecosystems and sustainable development
- sustainable energy and environment
- materials and information
- human and social sciences
- non-thematic or transversal programmes and
- partnerships and competitiveness

The French System of Research and Innovation (FutuRIS) initiative is integrated in the activities of the National Association for Technical Research. Unlike traditional foresight exercises which often deal with specific sectoral technologies, FutuRIS provides a review of a wide range of aspects of the research and innovation system. The general objectives of FutuRIS are to identify the strengths, weaknesses and structural tendencies of the French system of research and innovation, to propose ways to improve it, and suggest how the system could evolve by 2015-2020. It does this in the form of a synthesis document listing thematic priorities mainly addressed towards the government. This is in keeping with the general form of French research priority setting which is more thematic and general than specific.

Quality of research / evaluation
The implementation in 2006 of the Constitutional Bylaw on Budget Acts (LOLF) represents a significant shift in the French approach to accountability, from a resource-based to a results-based approach. In fact, the French culture of evaluation has changed considerably since the mid-1990s. It was previously mainly concerned with the control of financial flows and the responsibility of the Court of Auditors (*Cour des Comptes*). The Court of Auditors is mainly responsible for performing audits of the accounts of public organisations, making for example, reports focussing on how resources made available by the previous year's finance law have been used. Any public research organisation can be subject to an audit by the Court of Auditors.

More recently however, focus of evaluation has since shifted towards a series of more strategic policy evaluations. Several research and innovation programs have been evaluated by external experts, and the national networks for research and technical innovation have undergone systematic external ex-post evaluation. Some programs are also subject to a mid-term evaluation. In the majority of cases currently, however, no evaluation plan is established, and evaluations, if any, are carried out on an ad hoc basis.

The Agency for the Evaluation of Research and Higher Education (AERES), created in April 2006 by the Law for Research, is responsible for evaluating research programs in the domains of research and higher education. The agency takes over missions previously the responsibility of the National Committee for Research Evaluation (CNER) and the National Committee for the Evaluation of Higher Education Institutes (CNE) which also covered issues such as the commercialisation of research results. Under the supervision of the Ministry of Education, *L'Inspection générale de l'administration, de l'éducation et de la recherche*, the department responsible for auditing education and research administrations, performs evaluations of

research policy and provides advice to policy-makers in the field of research. The Centre for Strategic Analysis, which replaced the Commissariat Général du Plan in 2006, carries out policy evaluations, some of which relate to research and innovation, and reports to the prime minister.

2.2 Recent policy changes: learning from France

Pact for Research / Law for Research

Initial situation

An important step in the reform of the French research system was taken in July 1999 with the Law for Innovation and Research. The main objectives of the law were to create innovative companies and to promote application of public research. The cornerstone of current research policies was put into place in 2003 when the Ministry of Higher Education and Research defined guidelines for government research policies in the Innovation Plan. The priorities were defined as follows:

- Improve overall public research governance. From definition of clearer priorities, methods and quantitative as well as qualitative objectives by the state to simplified administrative organisation of universities and public research laboratories.
- More competitive distribution of public funds.
- Focus on recruitment of young researchers and mobility of public researchers into private companies.
- Increase co-operation and move towards more strategic, durable and global relations between public research organisations and companies.

France is committed to reaching the goals of the Lisbon Agenda, however unlikely this may be. According to the Ministry of Higher Education and Research, this would require the government to promote an environment favourable to research and innovation, target actions in fields recognised as promising, identify successful projects and improve the leverage of public research. In other words:

- raise the GERD to 3% of GDP by 2010
- increase the evaluation and strategic culture
- improving co-operation between public and private sectors
- improve environment for young innovative firms
- renew the status of research foundations
- valorise intellectual property

In accordance with this, research policies were set out in 2005 in the Pact for Research. The pact stresses several objectives and measures, some of which have already been implemented and others soon to be implemented. The three broad objectives are to strengthen public research, to reinforce the relationship between science and society, and to facilitate the transfer of knowledge from research to innovation. Innovation policy is especially concerned with the innovative behaviour of companies, especially SMEs. Traditionally, French innovation policy was oriented towards large companies, but significant efforts have been made in the last few years to shift things in favour of SMEs. These include the Young Innovative Company scheme and the reform of the Research Tax Credit with the introduction of a volume-based scheme.

Policies

The Law for Research is a policy document published in 2006 based on the Pact for Research from the previous year. This law sets the objective of a research budget of €24 billion in 2010 (3% of the GDP in 2010) and states the objective of the €6 billion financial increase granted to

research in the following three years. This document addresses several issues with a middle-term approach (until 2010) providing the following measures:

- to enforce strategic orientation abilities through the creation of a High Council for Science and Technology
- to support research projects by the reinforcement of power of the existing National Agency for Research and of OSEO innovation
- to encourage co-operation between institutions of research and between higher education institutes
- to renew research evaluation procedures by means of the creation of the Agency for Evaluation of Research and Higher Education (*Agence d'évaluation de la recherche et de l'enseignement supérieur-AERES*) as an independent administrative authority

In order to redefine the overall research structure according to the 2003 Innovation Plan, the minister highlighted the need to improve public research governance. For the state this involves defining priorities, and quantitative as well as qualitative objectives for research governance, while for public institutes, the administrative organisation should be simplified to allow for better co-ordination of the different types of institutes, i.e. between universities and public research laboratories. The High Council for Science and Technology (*Haut conseil de la science et de la technologie*) was created in June 2006 as stipulated in the Pact for Research and provides recommendations on national research and innovation strategies.

The following are the four main foci of resulting research policy:

1. A shift in the balance from institutional to competitive funding for public research. Funding based on projects will continue to grow. This policy trend is confirmed in the Law for Research and the Law on the Autonomy of Universities, which both allocate larger budgets to the National Agency for Research and OSEO Innovation.
2. A greater emphasis on support for collaborative research. In order to increase visibility of French research actors at national, European and international level, the government aims to strengthen collaborative projects as well as to reinforce relations between scientific disciplines. The Pact for Research and the Law on the Autonomy of Universities both emphasise the need to encourage public research actors to strengthen partnerships with socio-economic actors.
3. A greater autonomy given to universities. The August 2007 Law on the Autonomy of Universities aims to renew universities' governance, giving them greater responsibility in human resource management and easing access to private funding.
4. A number of thematic priorities as specified by the ANR(see item 2.4 on priority setting).

Effects

The Pact for Research and the resulting Law for Research are relatively recent developments which do not completely change the statuses of higher education and research organisations, but they go a long way towards blurring the boundaries between them. Strong legal and financial incentives have been developed to stimulate research excellence and clustering of relevant institutions.

Research organisations are particularly challenged through the creation of the National Research Agency and the Agency for the Evaluation of Research and Higher Education. The National Research Agency effectively deprives research organisations (such as CNRS) of guaranteed financial resources and the Agency for the Evaluation of Research and Higher Education destroys their monopoly on evaluation and accreditation.

Restructuring of the CNRS

Initial situation

Historically, the French research system is based on a dualism between universities and public research organisations, and since the end of the Second World War, basic research has been the domain of the national research organisations. However, in the 1980s the border between these two types of actors started to become increasingly blurred. Currently more than 80% of the research laboratories of the CNRS are joint research units with universities. This tendency to link with other public research actors is strongly encouraged by the government, and the Pact for Research aims at reinforcing these links. Universities are given a central role in this transition.

Policy Objectives

The CNRS itself has recently undergone a restructuring. The board of directors of the CNRS adopted the *Plan stratégique Horizon 2020* on 1 July 2008. The plan affirms the reorganisation of the CNRS into disciplinary institutes charged to oversee the laboratories. The reorganisation of the CNRS gave rise to the mobilisation of thousands of concerned researchers in protest who prevented the CNRS board of directors from being held on 19 June 2008. Researchers were specifically concerned about the future of the life sciences (which represent about 25% of the activities of the CNRS) and data processing, as the minister of research considered that these fields should be coordinated by the National Institute for Health and Medical Research (INSERM) and the National Research Institute in Data processing and Automatic (INRIA) respectively. The National Institute for Health and Medical Research (INSERM) was also restructured into thematic institutes. The objective of these restructurings is to distinguish between the research-performing and the research-funding roles of these organisations. The restructuring into thematic institutes is intended to improve coordination and simplify collaboration with external partners.

The adopted reorganisation plan reaffirms that all the disciplines currently represented by the CNRS shall remain part of the organisation and be structured into institutes. In future, institutes will not only manage laboratories, they will also function as financing agencies for laboratories of various organisations and universities. Moreover, the institutes will aim to carry out the national missions set by the government.

Effects

The net contribution of universities to joint ventures with the CNRS is now greater than that of the CNRS. For professors in most scientific disciplines, being part of a joint research centre (with CNRS or one of the other national research institutes) has become an academic norm. There has been a growth in number of research groups that are joint ventures between universities and the CNRS, however, difficulties have been noted in matching CNRS national and sectoral policies with emerging, localised university policies. In response to this shift in power in favour of universities in joint ventures, it has been noted that evaluation and accreditation processes of joint ventures should be more inclusive of and appropriate for the CNRS.
The number of 100% CNRS research units has decreased significantly in recent years as the number of joint ventures has increased. There have been intrinsic difficulties in matching the priorities of the univeristies and the CNRS in joint ventures, with the balance of power shifting towards the universities, which led to the CNRS focusing on two approaches to fit with its strategic agenda. Reducing the overall number of research units through mergers, and reduction of joint ventures increasing the number of 100% CNRS units in strategic areas. It has been noted that units in fields such as the social sciences and the humanities, which account for a large number of the small-size units that often contribute little to the strategic research programs of the CNRS, are being placed in universities due to their strategic irrelevance.

3 Germany

Germany has traditionally been one of the EU's top performers in science, technology and innovation with a mature national innovation system including a number of large, well established research institutes and firms. As productivity performance has been slipping relative to other leading OECD countries, extracting greater benefits from existing innovation capabilities is seen as essential in boosting this. Germany aims to reach the EU Lisbon strategy of 3% of GDP invested in R&D by 2010 with the 2006 figure reaching 2.53% of GDP. Although a higher than average number of PhDs are awarded in science and engineering, the German tertiary graduation rate is amongst the lowest in the OECD area, potentially narrowing the skills base for future innovative activities. Germany has a wide range of policies to support innovation and stimulate the internationalisation of its R&D system.

3.1 Characteristics of the German research system

Structure

The policy level of the German system consists of the 16 Länder Governments with their 16 respective Ministries of Science and Ministries of Education alongside the Federal Government. The Federal Ministry of Economics and Technology (BMWi) is responsible for all federal innovation policy and industry related research. It supervises not only specific innovation programmes, mainly geared towards SMEs, but also several industry-oriented research institutes. The Federal Ministry of Education and Research (BMBF) on the other hand, mainly responsible for federal science and research policy, administers most federal research institutes, co-finances many institutes jointly with the Länder and is responsible for all kinds of research and science support schemes. All German Länder have a science and technology policy of their own, often shared between two ministries, similar to the structure at the national level. Based on the German Basic Constitutional Law, the Länder have the main competence for the organisation of public universities.

The *Deutsche Forschungsgemeindschaft (DFG)* is the main competitive research funding organisation, responsible for funding researchers initiated research. It funds research projects in all fields of science and the humanities. This includes support for individual projects and research collaboration, awards for outstanding research achievements, and funding for scientific infrastructure and scientific cooperation. The *German Federation of Industrial Research Associations* "Otto von Guericke" (AiF: Arbeitsgemeinschaft industrieller Forschungsvereinigungen "Otto von Guericke") is a registered non-profit association. The task of the AiF is the promotion of applied R&D for the benefit of SMEs. Organised by industry and partly government funded, the AiF supports the efficient usage and advancement of R&D programmes in order to increase the competitive strength of SMEs.

The operational level of the German research system is composed of private companies (responsible for majority of expenditure), universities, and non-university institutes. Traditionally, universities form the backbone of the German research system with a variety of project arrangements ranging from basic to contract research. Universities of applied sciences (Fachhochschulen) function as a link between the sciences and, most importantly, the region's industry. At the moment, there are 345 universities in Germany, of which 183 are universities of applied sciences. Institutional financing for the universities is provided by the German Länder.

Fact Sheet

The German GERD as a % of GDP has remained relatively constant for the past 5 years at around 2.5% (compared to 1.7% in the Netherlands). The % researchers of total R&D personnel has grown by 10% since 1991 to 57.4% in 2007(comparable to France, only higher in Denmark).

The policy level of the system is characterised by the shared responsibilities of the 16 State(Länder) Governments (~45% of GBAORD), responsible for financing research and teaching at public universities in their Länder, and the Federal Government(~55% of GBAORD), involved in co-funding of non-university research institutes nationally and more recently financing of universities.

At the intermediary level, the Federal Ministry of Economics and Technology(BMWi) is responsible for all federal innovation policy and industry related research, while the Federal Ministry of Education and Research(BMBF), mainly responsible for federal science and research policy, administers most federal research institutes, co-finances many institutes jointly with the Länder and is responsible for all kinds of research and science support schemes. All 16 Länder have a science and technology policy of their own, often shared between the ministries of Science/ Education and Economy/Finance, similar in structure to the national level.

Private companies account for the majority of R&D expenditure(68.1% in 2006), while universities (16.3% in 2006) account for the majority of public expenditure. A unique feature of the German system is that a large share of basic research is performed by non-university public research institutes, mostly the Max Planck Society and the Helmholtz Association. Other major research institute organizations are the Fraunhofer Society and the Leibniz Association.

A Hightech Strategy was initiated in 2006 to promote the link between academic research and industrial application, a significant result of this is the Top Cluster Competition which funds 5 top clusters of excellence with €200m for 5 years.

Table 2.6 Basic R&D figures for Germany

	1991	1996	2001	2005	2006	2007
R&D expenditure						
R&D-expenditure (M€)	36097	42168	52002	55739	58872	61240
R&D expenditure by inhabitant (€)	453	515	632	676	714	744
Total R&D expenditure as a % of GDP	2,47	2,19	2,46	2,48	2,54	2,53
% GERD financed by government	35,9	38,1	31,4	28,4	27,8	..
% GERD financed by industry	61,7	59,6	65,7	67,6	68,1	..
GERD performed in HE sector	16,2	18,6	16,4	16,5	16,3	16,3
GERD performed in GOV sector	14,4	15,3	13,7	14,1	13,9	13,7
R&D personnel						
Total R&D personnel	516331	453679	480606	475278	487260	498000
% researchers of total R&D personnel	46,8	50,7	55,0	57,3	57,4	57,4
R&D personnel by labour force	13,1	11,5	12,1	11,6	11,7	12,0
Researchers by labour force	6,1	5,8	6,7	6,6	6,7	6,9
R&D output	**1993-1996**				**2003-2006**	**Δ**
Publication output	218952				307823	40,6
Citation impactscore	1,05				1,13	8,4

Sources
EUROSTAT (NewCronos database): R&D expndiure in €:
OECD/MSTI (2008/2): R&D personnel and other R&D expenditure data
NOWT 2008: R&D output

Most of the non-university public research organisations are organised under the umbrella of the following four main organisations:

- the Max Planck Society currently maintains 80 institutes, research units and working groups (with a staff of more than 20,000 persons) addressing a wide range of promising areas of basic research
- the Fraunhofer Society (60 institutes; staff of 16,000) promotes and undertakes applied research of direct utility to private and public enterprise and of wide benefit to society as a whole
- the Helmholtz Association (16 institutes; staff of 25,000) is Germany's largest scientific research community focusing on research which requires large scale installations in the interest of science, society and industry
- the Leibniz Society (86 institutes; staff of 14,000) operates at the interface of problem-oriented basic research and applied research, covering the whole range from social to natural sciences. Its purpose is to provide private companies with R&D services, particularly in Eastern Germany

The Max Planck and Fraunhofer Societies, both created just after WWII, are relatively more integrated organisations with a strong headquarters, while the Helmholtz Association and Leibniz Society, formally established in 1995 and 1997 resp., are comparatively loose umbrella organisations of legally independent institutes.

Governance

Federal R&D policy is mainly implemented by the Federal Ministry of Education and Research (BMBF) through various instruments. The Federal Ministry of Economics and Technology (BMWi) also has a range of innovation and transfer-oriented schemes. Since 1999, the BMWi has been responsible for energy and aerospace research, SME-oriented indirect measures and the support of technology-based start-up companies. While the BMWi allocates a large proportion of its research budget to support for the industrial sector (roughly two-thirds in 2002) the BMBF is still, through its thematic programmes, the largest public source of funding for the support of industrial R&D.

The Joint Conference on Science (GWK) replaces (September 2007) the Bund-Länder Commission for Educational Planning and Research Promotion (BLK). The BLK was established as a permanent forum for the discussion of all questions of education and research promotion which are of common interest to the Federal and Länder governments. The mission of the GWK is the coordination of national, European and international R&D policies with the aim of enhancing Germany's performance and competitiveness. The members (Länder Ministers for research, science and finance as well as the respective Ministries of the Federal Government) cooperate in cases of funding of supraregional importance. These include the non-university R&D institutions, R&D related matters in universities and scientific infrastructure in the higher education sector. The heads of both Federal and Länder governments are assigned to delegate further tasks to the GWK.

Resource allocation

Taking into account R&D expenses only, the BMBF spent roughly €5.845b in 2007, followed by the BMWi (€2.040b) and the Federal Ministry of Defence (€1.168b). These three big players are followed by the Ministry of Agriculture and Consumer Protection (€275m), the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (€180m), the Federal Ministry of Transport, Building and Urban Affairs (€175m) and the Foreign Office (€145m). All other

ministries spent less than approximately €100m in 2007. Basic federal funding amounted to €3.678b in 2007, while all German Länder combined contributed €1.778b to institutional funding.

This basic funding for the main research institute organisations is divided as follows for 2007: Max Planck Society €1.054b, Fraunhofer Society €468m, Helmholtz Association €1.7b, Leibniz Association €773.6m. The German Research Foundation (DFG) received €1.4b. Its mission is to promote, through funding, all fields of science and the humanities. Funding is awarded on the bottom-up principle based on peer review and mainly allocated to the universities. These five main scientific organisations receive their funding from both the Federal government and the Lander government. Three organisations, Max Planck Society, Leibnitz Association and the DFG are funded 50-50 by federal government and Länder governments. The other two receive 90% of their funding from the federal government and 10% from the Länder governments. The contribution of each of the Länder to the budgets of the institute organisations is calculated annually by the Köningsteiner Schlüssel, which is based upon tax income and population size.

R&D expenditures in the higher education sector amounted to €9.1b in 2007, of which €3.5b was third-party funding. The DFG complements institutional funding for basic research with project based funding, career grants, and funding for research infrastructures, in 2007 for about €2b.

For the administration of the government research programs, project administering agencies (Projektträger) have developed within research institutions or other research policy related bodies. Typical examples are the German Aerospace Centre which is responsible for the IT Research 2006 program, VDI/VDE, a consultancy spin off of two engineering associations, responsible for the Microsystems Program and Forschungszentrum Jülich, a research centre for health, energy and environment, which is responsible for biotechnology and material research programs. The task of these agencies is to evaluate incoming applications for funding according to the guidelines provided by the specific funding agency. The final decision regarding the funding of a R&D, however, remains with the funding agency. If the guidelines include mid-term or other fixed evaluations of already funded projects (e.g. to decide whether or not a project will still be included in a second or third phase of a research programme) these are usually also carried out by the project administering agency.

Private companies account for approximately two-thirds of overall R&D expenditure. Funding for R&D performed is provided by firms themselves as well as for contract research conducted by private and public research organisations and institutes (including universities).

Priority setting

Communication between the Federal Ministry of Education and Research (BMBF) and the umbrella organisations of the public research institutes is well established, including regular opportunities for stakeholder discourses. Another, different approach was taken with foresight project, 'FUTUR', which was initiated in 2001 in attempt to integrate some extremely diverse interests. Since the results of this foresight process have not been directly implemented in national R&D policy, it is still not clear how successful this sort of approach has been and, therefore, whether there will be any policy shifts with respect to access opportunities for the various societal groups concerned.

In 2006 the Chancellor set up the "Council for Innovation and Growth" (*Rat für Innovation und Wachstum*), succeeding the "Partner for Innovation" (Partner für Innovation) advisory body set

up by the previous government. The "Council for Innovation and Growth" brings together representatives from private firms, German research organisations and government. Lead by Heinrich von Pierer, the former CEO of Siemens, its task is to provide the Federal Government with advice on a wide range of innovation related issues.

A second advisory board, the Forschungsunion Wissenschaft-Wirtschaft (Research Union Science-Industry) was set up by the BMBF also in 2006. This body gives advice on how to strengthen Germany's position as a High-Tech location and, in particular, how to implement the High-Tech Strategy. Both boards are meant to further the involvement and incorporation of interests of stakeholders. The impact of the two bodies is yet to be evaluated. In 2007, a new foresight process was initiated by the BMBF involving scientists and experts from industry and other societal groups. This foresight process aims at methodically identifying and analysing potential long term developments in selected areas of research and technology. Results are expected to be published in 2009.

Quality of research

As in many other industrialised countries, peer review is central in the process of evaluation at the level of individual research performance. More recently, additional procedures (bibliometrics, etc.) have been introduced to measure the research performance of individual researchers and groups Peer review procedures are in widespread use, especially in the *ex ante* evaluation of projects in basic and long-term application-oriented research. Peer review is also the predominant evaluation instrument of the German Research Foundation (DFG), which promotes basic research in universities, principally by granting individual researchers funds on application. Applications for grants are assessed by peers, who are elected every four years by the entire scientific community. Experts are advised to judge the application on the basis of its scientific quality alone.

A second level of evaluation, arranged around a core of peer review procedures, consists of impact analyses of R&D policy programmes. Impact analyses have gained acceptance in Germany since the 1970s in many political fields with the spread of programme policy. These studies have developed into an instrument of policy advice used in many fields. This spread of evaluation is closely associated with the increasing use of strategic programmes (initiated by the EU Commission) to promote R&D. As a rule, independent research institutes act as evaluators on behalf of R&D policy administrators. Since the mid-1990s many R&D policy programmes have been launched as competitions, which aim to bring about structural changes in science and the economy: consortia of candidates (usually institutions) in a self-organised process are required to elaborate joint project plans and detailed goals. As a consequence, new evaluation designs have been required. More than two decades of programme evaluation resulted, in 1998, in a group of experts and institutes from the field of economics and social sciences, using a variety of methods and instruments, organised professionally within the "German Society for Evaluation" (DeGEval).

The performance of entire research institutions is also evaluated. The evaluations of by German Science Council (WR) have played an important role for a long time; even assuming a shaping role in the re-structuring of the research landscape of Eastern Germany after reunification. Since the 1990s, evaluations of institutions have been carried out with greater frequency. The latest system evaluation carried out by the WR concerned the governmental research agencies. The BMBF commissioned the WR to carry out this particular evaluation in 2004 with the aim of modernising the governmental research agencies. Evaluation reports are currently available for 13 governmental research agencies.

The government, including the Länder, is running the *Excellenzinitiative* (The Best Universities) program from 2006 to 2011 with a budget of €1.9 billion, solely for the university sector. The aim is to boost scientific excellence. It supports three universities, 18 schools within universities (*Graduiertenschulen*) and 17 special clusters (*Exzellenzcluster*). The *Excellenzinitiative* offers, amongst other things, money. However attractive this additional funding may be, the prestige that selection brings is equally important to the universities concerned. It significantly increases their ability to attract high profile international academics. It can also be put to good use in fundraising, another competitive academic discipline in which German universities are becoming increasingly active.

3.2 Recent policy changes: learning from Germany

High-Tech Strategy

Initial situation

Although German scientists are among the world leaders in many sectors, there is a general lack of corresponding transformation of knowledge into industrial applications, products etc. This is not a new issue and previous policies have attempted to address this, with unsatisfactory results. The suggested reasons for this are:

- lack of venture capital for innovative start-ups
- a general risk-aversion
- lack of effective links between science and industry
- lacking attractiveness of Germany for foreign top level researchers
- impending lack of highly qualified labour
- lack of sufficient resources for R&D.

Because of the division of labour amongst the different ministries involved in German research and innovation, the responsibilities for policy are fragmented. The presence of the political will, and indeed power, to deal with the challenge in overcoming this situation is linked to the so-called grand coalition that has been in office since autumn 2005. The grand coalition refers to the two major German political parties forming a coalition within the parliament and their additional majority in the Bundesrat (the representation of the Länder governments). The two main issues here are:

- the weak links between (basic) research and innovation / innovative companies and
- the lack of coordination in a political system of shared responsibilities and a strong division of labour.

To solve these problems, the High-Tech Strategy was formulated. It is a major part of the innovation policy of the Federal government. The strategy involves an additional €6 billion in financial resources in order to achieve the 3% goal of the EU. Although published by the BMBF, the High-Tech Strategy is developed in cooperation with the Federal Ministry of Economics and Technology (BMWi). In fact it can be seen more as a coordinated effort of the Federal government as a whole as it affects technology sectors under the responsibility of several Federal ministries.

Policy objectives

In line with the High-Tech Strategy, the central goal of German research policy is to increase to the competitiveness of the economy, and to use public money more efficiently in order to stimulate economic growth and employment via knowledge production and distribution. The High-Tech Strategy lists a number of activities and goals as priorities relating to both research

and education policies:

- new incentives for closer cooperation of science and industry
- improve conditions for high-tech spin-offs and SMEs in general
- to increase the share of SME performing innovative activities
- make private investments in R&D more attractive
- to improve (international) IPR protection
- to increase the use of standards for innovation
- to make use of public procurement for the support of innovation
- to introduce e-government
- to develop a national strategy for the internationalisation of R&D
- to increase German participation in European R&D policy
- to further develop the education system
- to introduce a number of technology-specific support mechanisms (including SWOT-analysis)

Effect

German federal policy has firmly embraced the notion that national competitiveness depends on localised assets. The increasing emphasis on excellence in the German research and science policy has led to the promotion of clusters. Following the first call for applications in August 2007, 38 regional projects were submitted by the closing date (December 2007). A dozen of those projects qualified for the final, and five winners of the first round were disclosed in September 2008. The top five clusters of excellence will receive about €200m for five years. At this stage it is difficult to identify any direct effects of this funding mechanism. The recipients and their share of the funding received, are also not disclosed.

Bund-Länder-Kommission für Bildungsplanung und Forschungsförderung (BLK)

Initial situation

The BLK is a permanent forum for discussion regarding the promotion of education and research of common interest to the Federal and Länder governments. It makes recommendations to the heads of the Federal and Länder governments on educational planning and research policy. The BLK was established in 1970 as Bund-Länder-Commission for Educational Planning (Bund-Länder-Kommission für Bildungsplanung) by an administrative agreement between the Federal and Länder governments. After the Commission was given additional functions in 1975 by the Skeleton Agreement on Research Promotion, its name was changed to "Bund-Länder-Commission for Educational Planning and Research Promotion" (Bund-Länder-Kommission für Bildungsplanung und Forschungsförderung) with effect from 5 April 1976. The BLK is an intergovernmental commission and cooperates closely with the various Conferences of Länder Ministers. With the reform of the German federal system in 2006, the role of the BLK has changed significantly and is expected to change further in the near future, leaving uncertain whether the BLK will remain responsible for its current but recently changed activities or even whether it might be dissolved.

The Commission takes its decisions with a majority of at least 25 of its members' votes. Members who have been outvoted may put down their dissenting opinion in a special vote. The Commission makes recommendations, which - including special votes, if taken - are submitted to the heads of the Federal and Länder governments for deliberation and decision-making. A decision requires approval by at least 13 heads of government; and it is binding only to those who have approved it. The Skeleton Agreement on Research Promotion provides for

simplified procedures for approval by the heads of government. Any results of the Commission's deliberations which are expected to be of interest to the community of experts are, as a rule, published in the BLK series "Materialien zur Bildungsplanung und zur Forschungsförderung". Representatives of the Science Council (Wissenschaftsrat), the Local Authorities' Associations (Kommunale Spitzenverbände) and the Central Committee of the Federal Institute of Vocational Training (Bundesinstitut für Berufsbildung) take part in the Commission's meetings in an advisory role. The procedure followed by the Commission is laid down in the BLK's rules of procedure.

The Commission has the following main tasks consistent with the Skeleton Agreement on Research Promotion and the reform of the German federal system:

- the BLK is the permanent forum for all matters of supporting science and R&D jointly by the Federal and the Länder governments
- coordination of different plans according to research policy and development of a common strategy
- giving recommendations and planning of central measures for the mutual briefing of Federal and Länder governments regarding research promotion
- development of joint basic principles for budgets and evaluations
- recommendation on the subsidy requirements of the jointly financed research organisations
- suggestion of institutes to be included in or excluded from the joint financing,
- decision on the funding of R&D infrastructure and large R&D facilities with investment needs above the threshhold of € 5 million and
- dealing with policy issues concerning specialized information systems.

The BLK has been facilitating the alignment of procedures and quality criteria etc. for science and education between the Federal and Länder governments for decades. The in-built need for production of consensus however, brought with it a tendency towards institutional conservatism, preventing for example the modernisation of the German university system.

Policy change
In the reforms of the German federal system in 2006, the Federal and Länder governments are no longer jointly involved in educational planning. The Constitution still allows the cooperation of the Federal and Länder governments concerning matters of the competitiveness of the whole educational system but not within the BLK. In September 2007, the Joint Conference on Science (GWK) replaced the BLK. The mission of the GWK is the coordination of national, European and international R&D policies with the aim of enhancing Germany's performance and competitiveness. The members (Länder ministers for research, science and finance as well as the respective ministries of the Federal Government) cooperate regarding funding of supraregional importance. This includes the non-university R&D institutions, R&D related matters in universities and scientific infrastructure in the higher education sector. The heads of both Federal and Länder governments are assigned to delegate further tasks to the GWK.

Effect
No evaluation has been made so far, whether the replacement of the BLK for the GWK has improved the flexibility and responsiveness of the German research system.

4 Italy

The most important event in the historical evolution of the Italian research system over the last 20 years was the creation of the Ministry of Education and Research in 1989. Before that, the National Research Council was the body, under the supervision of the Prime Minister, responsible for coordinating the public research system. The numerous public funds is one of the distinctive features of the Italian research system.

Economic stagnation, severe financial constraints and political instability persists with low growth as the key problem. Italy's performance has substantially lagged behind that of the other main EU economies since the start of the nineties. The last general elections were held in April 2008; the right-centre coalition obtained a large majority of the votes and members of Parliament. A new Government has been formed that is made up of fewer ministries than the former, left-centre government. As a consequence, the previous split of the Ministry of Education, University and Research into two separate ministries has been reversed, and only one ministry is again in charge of both education and research activities.

4.1 Characteristics of the Italian research system

Structure

The policy level of the Italian research system is occupied by two main bodies: the Council of Ministers and the Inter-Ministry Committee for the Economic Planning (CIPE). CIPE plans the allocation of financial resources to public research performers by approving the National Research Programme. The Ministry of University and Research (MIUR), mostly involved in basic research policy, and the Ministry for Economic Development, with a bias towards innovation-oriented research, manage research policy at a national level. Other relevant funding ministries in S&T policy include the Health Ministry and the Ministry for Agricultural Policies. The MIUR acts mainly by imposing regulations and by distributing financial resources through the use of block funding and various funds allocated on a competitive basis. The strategies and objectives of these ministries are coordinated by the MIUR within the framework represented by the National Research Programme.

Most Italian research policies are directly implemented by the government. MIUR manages a range of dedicated foundations. There are only a few intermediary organisations. The national research council, CNR, is like in some other European countries an institute organisation. CNR has more than 8200 employees of whom more than 4000 researchers active in almost 100 Institutes, working in the main fields of scientific and humanistic research. In addition to these there are more than 3000 junior scientists completing their training at CNR. The role of CNR in competitive project funding was ended in 2000.

Research is principally conducted in the public sector, with a primary role taken by universities (83 in total, of which 63 are public), followed by large research agencies. The Italian National Bureau of Statistics estimates that there are at least 3,400 firms currently doing R&D in Italy. In 2005, roughly 85% of total spending on private R&D was financed by companies, of which SME was only responsible for 18%. The largest private R&D performers are FIAT and Finmeccanica. Industry research associations jointly fund 19 research establishments with the state, each of which specialises in a different sector (such as: glass, fuels, leather and tanning materials, etc.). A number of service centres for innovation and technology transfer, funded by chambers of

Fact Sheet

The total Italian R&D expenditure is 1.7 times that of the Netherlands but the R&D intensity is lower at 1.14% (lowest in comparison set) of GDP compared to that of 1.71% in the Netherlands in 2006. The Italian R&D intensity has not increased significantly since 1991, in fact the % researchers of total R&D personnel has decreased by 6% to 46.1% in 2006 (only country in set to experience this).

At the policy level, the Inter Ministries Committee for the Economic Programming (CIPE), including a special section dedicated to research and education, examines the document of economic and financial policy (DPEF), which establishes strategic direction and priorities for scientific and technological research, financial resources and coordination among different public administrations, universities and research institutes and is submitted to Parliament each year.

The Ministry of University and Research (MIUR; established 1989; basic research policy, €2483m budget for 2008) and to a lesser extent, the Ministry for Economic Development (innovation-oriented research, €1.6m budget of 2006) are major actors at the national research level (the 20 regions have a degree of autonomy in certain fields). National Research Programme (PNR) 2005-2007 put in place to increase private effort in R&D and increase student numbers.

About half of the research at the operational level is conducted in the public sector with a primary role taken by universities (30.3%), followed by large research agencies(17.2%). The share of the private sector is the lowest within the comparison set (40.4% in terms of funding; in terms of performance is not available) primarily by a few large firms.

Table 2.7 Basic R&D figures for Italy

	1991	1996	2001	2005	2006	2007
R&D expenditure						
R&D-expenditure (M€)	11517	9779	13572	15599	16831	:
R&D expenditure by inhabitant (€)	203	172	238	267	287	:
Total R&D expenditure as a % of GDP	1,19	0,99	1,09	1,09	1,14	:
% GERD financed by government	49,6	50,8	..	50,7	48,3	..
% GERD financed by industry	44,4	43,0	..	39,7	40,4	..
GERD performed in HE sector	21,5	26,5	32,6	30,2	30,3	..
GERD performed in GOV sector	22,7	20,0	18,4	17,3	17,2	..
R&D personnel						
Total R&D personnel	143641	142288	153905	175248	192002	..
% researchers of total R&D personnel	52,4	53,7	43,3	47,1	46,1	
R&D personnel by labour force	5,8	6,2	6,4	7,2	7,8	..
Researchers by labour force	3,1	3,3	2,8	3,4	3,6	..
R&D output	**1993-1996**				**2003-2006**	**Δ**
Publication output	No data available					
Citation impactscore	No data available					

Sources
EUROSTAT (NewCronos database): R&D expnditure in €:
OECD/MSTI (2008/2): R&D personnel and other R&D expenditure data
NOWT 2008: R&D output

commerce and local authorities at a regional level, provide advanced solutions, mostly specialising in agriculture.

Governance
The policy of the Ministry of Education, University and Research (MIUR) was established in multiannual National Research Programme, the latest to our knowledge is 2005-2007, which has not been updated since.
Regions have acquired more responsibility through a change in the Italian Republic's Basic Law, enabling them, along with the state, to adopt autonomous STI policies. Each Italian region has its own research policy and innovation policy that runs concurrently with that of the state. In most regions however, the definition of governance structures for research policies is only starting. Regional research councils, for instance, do not yet exist. As to the division of competencies between the state and its regions, the 2004-2006 National Research Programme confirms that regional authorities can regulate aspects that have not previously been regulated by the state in relation to STI policy.

Interventions that are reserved for the state are:
- support of academic research and public research institutions
- mission oriented R&D programmes realised through the FIRB Fund
- the creation of large public-private laboratories
- the coordination of the national scientific system participation in European and international R&D programmes
- support of the research infrastructure

Institutions facilitating public-private research cooperation exist in each of the 24 technological districts that have arisen throughout the country. These can be seen as governance structures set up between public research centres and private firms. They channel both input and output of high-technology projects aiming for positive market results.

Resource allocation
The MIUR coordinates national and international scientific activities and distributes funds to universities and research agencies. MIUR also establishes the means for support of public and private RTDI funding. The Ministry for Economic Development supports industrial R&D by managing financial tools of intervention in industrial research.

The general funding of the MIUR can be divided into two main parts:
1. Higher education institutions: including the Ordinary Fund for Higher Education covering expenditures for both teaching and research activities;
2. The "Fondo ordinario per ricerca e sviluppo" (Ordinary Fund for R&D): This represents the core funding of the public non-university institutes. The Fund is a framework included in the yearly national financial law. Its aim is to plan R&D by areas, domains and themes.

General funding also includes financing the international cooperation programmes and European S&T infrastructures and organisations. Other ministries (Health Ministry, Agriculture, Cultural Heritage, etc.) are responsible for the general funding of the non-university public research institutes under their control (more than 70 organisations).
A second means of government funding is project funding. In this case, MIUR also plays a leading role. The instruments at MIUR's disposal are:

- COFIN Fund for the co-financing of research activities of universities, through nationally relevant research projects
- FIRB Basic Research Investment Fund
- FRA Fund for Applied Research
- FISR Special Integrative Fund for Research
- PON research programmes in the Southern regions, aiming at structural changes within the larger strategy of the Development Plan for the Mezzogiorno
- PUS Funds for the diffusion of scientific culture

MIUR shares the responsibility for innovation with Ministry for Economic Development. Together they finance:

- FIT, the Fund for Technological Innovation, to support pre-competitive development
- contributions for participation of firms in international programmes
- special interventions for aerospace and naval sectors

Since 1998 a legislative decree has transferred 37 industrial financial incentives (previously managed by the state) to the regions, including R&D measures. . A shift from discretionary instruments for the support of industrial R&D to automatic fiscal incentives started occurring as of the 2007 financial law.

Priority setting

Strategies and priorities for the national research system were set out in the triennial large National Research Programme (PNR). PNR is released every three years and updated yearly. It is built up on the basis of a large consultation process which includes representatives from the scientific community (universities and public research agencies), Ministries (especially MIUR), Regional and local authorities, association of firms (Confindustria, Airi) and other stakeholder representatives. Experts in the priority sectors identified by the PNR are also involved in the priority setting. MIUR and the Ministry for Economic Development use a variety of funds in policy implementation. The resources to implement public policies are chiefly distributed through the state's annual financial law approved by Parliament every December.

Despite formal statements to the contrary, in practice the balance between generic and thematic research policies in Italy lies towards a focus on general aims, illustrated by the emphasis on university funding. Nonetheless, some mild priority areas can be identified in the PNR 2005-2007 regarding the need to strengthen the scientific base of the country by:

- supporting excellence (Italian Institute of Technology created)
- promoting the internationalisation and growth of human capital
- improving the technological level of the economic system and sustaining participation in international research programmes

Several intermediate goals are also envisaged:

- increasing the number of PhDs and their internationalisation
- augmenting the number of students at scientific university faculties
- fostering the excellence of public research agencies through the mechanism for sharing the "Fondo Ordinario" funds
- fiscal incentives to export-oriented industrial sectors

The main objectives of public research policies are improvements in the quality of life, health, safety and environment. The main aims of innovation policy are the competitiveness of firms, pursued through twelve strategic programmes:

- health
- pharmaceutical
- biomedical
- manufacturing systems
- motor design and manufacture
- shipyard and aviation industry
- ceramics
- telecommunications
- agrofood
- advanced logistics and transportation
- information and communication technology and electronic components
- energy microgeneration.

Quality of research

A lack of formal and substantial evaluation of R&D in the public sector has always been considered a weak point of the Italian research sector. Over the last 6 years, this has been taken seriously by policy actors, and an ex-post research evaluation system is being developed. Evaluation of research is performed by the National Committee for the Evaluation of Research (CIVR). The latest large scale evaluation was done over the period 2001-2003, of which the results were published in 2006. There are currently no indications that similar exercises have been conducted recently or are in preparation.

The introduction of new regulations and procedures and the establishment of new supervising bodies is a result of the effort to spread the culture of evaluation. The role that centres of excellence can play in the fundamental research has also increasingly been emphasised through the creation of the Basic Research Investment Fund, leading to the creation of the Italian Institute of Technology in 2003

4.2 Recent policy changes: learning from Italy

Evaluation of research

Initial situation

The lack of formal and substantial evaluation of R&D in the public sector has always been considered a weak point of the Italian research sector.

Policy

The December 2003 decree of MIUR established the first national evaluation exercise covering the years 2001-2003. The National Committee for the Evaluation of Research, CIVR, was responsible for the implementation of this exercise. Its main objective was the evaluation of the scientific research performance of 102 research institutions. The publication of VTR2001-2003 is the outcome of a complex process which involved the research institutions themselves, panel members and other experts. The report is addressed to the scientific community, the general public, as well as political and institutional decision makers. This is reflected in the priorities of the evaluation exercise: to support political decision makers and the scientific community in carrying out their duties such as defining research priorities and deciding on the allocation of funds. It also aims to improve the quality of research carried out in the Italian research institutions.

For the evaluation, universities and research institutes had to submit information about human resources, research income, research productivity, training, and transfer activities. For every two fte researcher, research institutions submitted one piece of output to be assessed by expert panels. Outputs were assessed on quality, importance, originality and internationalisation. Results were published per university and research area.

Research is evaluated by discipline at each university or research institute. The evaluation involves a maximum of one publication per full-time researcher (scientists at universities only count as half as they only spend 50% of their time on research). Evaluation per area was overseen by a panel of 5-17 researchers. Each publication is rated by two external experts, organised by 20 panels, on the basis of quality, relevance, originality/innovation and internationalisation. In total over 17.000 products were evaluated by over 6500 experts in 15 areas. Feedback is given in the form of a rating in terms of Excellent, Good, or Within Acceptable Limits. A rating index of all organisations per discipline is drawn up using an aggregation of the rankings of all publications. The Excellence Index is the percentage of publications classified as "excellent" but this evaluation has no effect on funding.
The evaluation of research results involved universities, research institutions such as Agency for New technologies, Energy and Environment, and other public and private institutions.

The evaluation process included retrospective evaluations of research projects funded within the National Research Programme (PNR) 2005-2007 and those funded by other specific means. The evaluation process is applied to the fourteen scientific-disciplinary areas established by the National University Committee (CUN). Specific areas are chosen for the CIVR evaluation based on their value to Italy and their coherence with the Italian and European research plans. In this way, the evaluation exercise is the first step to a systematic comparison of procedures between Italian and international research structures. As a by-product, it supports education institutions and the government in their financial choices. The existing gap between financial support by the Public Administration and research costs is also analysed. Attention is directed towards the correct utilisation of financial resources, and scientific areas and research structures that should be supported in order to improve the development of the Italian research system are highlighted.

Effect
Unlike previous evaluations of the Italian public research sector, the results of the VTR exercise including a ranking of the ratings obtained for the universities in 20 regions and were posted publicly on the website of the CIVR. Within the VTR, some important discontinuities with the past research evaluation programs can be highlighted. Firstly, the ratings obtained by the research institutes and universities are the direct result of the assessment of individual research products. In fact, a great deal of attention has been given to the form and communication of the evaluation output. Press conferences have been held and the website where the results were published has received more than a million visits. Evaluation has thus become less of an issue between the universities and the national government, and more a way in which society requires universities to account for their quality levels and it holds government responsible for policies for stimulating and promoting research.

It is claimed that the evaluations have changed the relationships between universities and government and evaluations have become more accepted at universities. However, since the VTR evaluation for the period 2000-2003, there is no indication that a subsequent period will be assessed.

5 Netherlands

The Netherlands is a prosperous, relatively small country; in scientific terms among the better performing countries in the world. Dutch science policy making is characterised by its strong emphasis on mediation processes, which conforms to the consociational tradition of Dutch policy making in general. As a result none of the actors have a monopoly on policy making, many have veto positions and policy making is a result of interaction, mutual strategy-making and coalition-building.

Whether the characteristics of the Dutch research system and effects of past policies will remain, is difficult to assess. Firstly, there are some pressures on the Ministry of Education, Culture and Science to take up a stronger coordinating role, and especially to have a stronger role in quality control and evaluation. Secondly, in recent years the government has shifted institutional funding for the universities to the budget of NWO, the research council, making universities more dependent on NWO. A recent evaluation has indicated that NWO has developed into an organisation that is too complex to develop its mission properly. Thirdly, the current policy has very much been fuelled by extra funding from gas revenues and the ability to invest in new policy schemes for interorganisational collaborations. Whether these funds can be renewed is unsure in the current economic climate.

5.1 Characteristics of the Dutch research system

Structure
At governmental level, main responsibility for the research system lies with the Ministry for Education, Culture and Science (MOCW). Increasingly the Ministry of Economic Affairs is involved because of its responsibility for innovation. The two ministries have a joint Department Knowledge and Innovation. Significant advisory bodies at the policy level include the AWT, Royal Netherlands Academy of Arts and Sciences (KNAW) and the Innovation Platform. The Innovation Platform was established in 2003 based on the concept of the Finnish Council for Science and Technology Policy.

The main funding body is the research council NWO. In the nineties it was transformed from a traditional council for basic research into a research council with a broader mission funding also strategic research and policy related research programs. Altogether, in 2007, the NWO's website reported that it coordinated 161 different funding schemes. Organisationally it is comprised of 8 divisions, responsible for all the funding tasks of the NWO, each with a board of scientists. Two of the divisions are cofunded by Ministries: STW, the council for engineering sciences is cofunded by the Ministry of Economic Affairs. ZON/MW, the council for medical and health sciences is cofunded by the Ministry of Health. NWO also houses some temporary bodies for strategic research areas: genomics, ICT, nanotechnology and catalysis. In addition to being a funding agency, NWO is also an institute organisation, owning several institutes for basic research. In a recent evaluation of the council, it was suggested that the organisation had grown too complex.

Main public research performers are the 14 public funded universities, 18 KNAW research institutes, 9 NWO research institutes, the agricultural research institutes of the Wageningen University and Research Centre, TNO (Netherlands Organisation for Applied Scientific Research), the 4 Large Technological Institutes, various Leading Institutes (technological as well

Fact Sheet

- The Dutch R&D intensity (1.70% of GDP) is only higher than that of Italy (1.14% in 2006) and comparable to that of the UK (1.76% in 2006) within the comparison set. The % researchers (48.5% in 2007) has increased by almost 8% since 1991 but decreased by almost 3% since 2001. The Citation Impactscore 2003-2006 is the highest of the comparison set with the 3rd greatest improvement from the Impactscore 1993-1996.
- A characteristic of the Dutch research system is the three funding flows via which Universities receive their funding. The first flow of base funding (directly via the Ministry of Education, Culture and Science (MOCW) is approximately 63%, while the second flow is 12% and the third flow 25%. The MOCW is responsible for the "first flow" (lump sum) funding to universities. Recently this "first flow" funding was cut back some 6% (€50m) by the new cabinet. This money is added to the NWO budget to support excellent individual researchers through competition-based funding (second flow).
- Main funding organisations are the MOCW (basic research) and the ministry of Economic Affairs (EZ; technology and innovation).
- Main public research performers are the 14 universities, 18 KNAW research institutes, 9 NWO research institutes, the research institutes of the Wageningen University and Research Centre, TNO (Netherlands Organisation for Applied Scientific Research), the 4 Large Technological Institutes, various Leading Institutes (technological as well as societal), and several state-owned research and expertise centres. The eight largest R&D intensive companies are: Philips, ASML, AkzoNobel, NXP, Shell, DSM, Océ and Unilever (73% of the business expenditures on R&D).
- Significant advisory bodies at the policy level include the AWT, Innovation Platform (2007-2011) and the KNAW, while most specific R&D strategy is implemented by 2 key agencies, NWO (€500m budget in 2005) and SenterNovem (agency of EZ).

Table 2.8 Basic data for the Netherlands

	1991	1996	2001	2005	2006	2007
R&D expenditure						
R&D-expenditure (M€)	4810	6534	8075	8842	9256	9666
R&D expenditure by inhabitant (€)	320	422	505	542	567	591
Total R&D expenditure as a % of GDP	1,96	1,98	1,80	1,72	1,71	1,70
% GERD financed by government	48,6	41,5	35,8	..	..	..
% GERD financed by industry	47,8	48,5	51,9	..	..	..
GERD performed in HE sector	29,7	28,6	27,1	27,8	27,2	26,6
GERD performed in GOV sector	18,3	17,7	13,8	13,8	13,6	13,0
R&D personnel						
Total R&D personnel	72350*	80822	89206	89701	94734**	49233**
% researchers of total R&D personnel	40,7*	44,0	51,0	52,5**	55,7**	55,9**
R&D personnel by labour force	10,3*	10,8	10,8	10,5	11,0**	10,4
Researchers by labour force	4,2**	4,7	5,5	5,5**	6,1**	5,8**
R&D output	**1993-1996**				**2003-2006**	**Δ**
Publication output	69168				96476	39,5
Citation impactscore	1,19				1,34	12,1

Sources
EUROSTAT (NewCronos database): R&D expenditure in €:
OECD/MSTI (2008/2): R&D personnel and other R&D expenditure data
NOWT 2008: R&D output
* number of researchers in 1991 estimated on data for 1989 and 1993; researchers by labour force based on this figure;
** data based on CBS-corrections and estimates of Ministry of OCW

as societal), and several state-owned research and expertise centres. The eight largest R&D intensive companies are: Philips, ASML, AkzoNobel, NXP, Shell, DSM, Océ and Unilever (73% of the business expenditures on R&D)

Governance
Most public research performers have a relatively large degree of autonomy, and the MOCW tends to have a "governance at a distance" attitude towards the research performing sector. Even to the extent that it is criticized by the AWT for not being active enough. Intervention in the research system ranges from new funding instruments of NWO (like the 'Vernieuwingsimpuls', described below), to allocation of new resources from national gas revenues. Typical policy goals for the research sector include scientific excellence, creation of priority areas (focus and critical mass) and valorisation of research.

New de facto governance interventions have emerged in relation to the new funds from the national gas revenues and to cluster approach in innovation policies. For strategic areas like ICT, genomics, nanotechnology new quasi-funding bodies have been created to allocate additional budgets and develop national strategies (see below).

Resource allocation
Universities receive their funding via three flows. The *first funding flow* or institutional funding comes in the form of a lump sum, directly from the MOCW accounting for approximately 63% of the total. The *second funding flow* is administered and allocated by the NWO. This competition-based funding originates mainly with the MOCW, the Ministry of Economic Affairs (co funding for STW) and the Ministry of Health (co funding for ZON/MW). The second flow represents 12% of the total funding. Recently the first flow funding was cut by 7% (€50m) by the new cabinet. This money was added to the second flow as part of the NWO budget to support excellent individual researchers through competition-based funding. The *third funding flow*, 25% of total research funding, consists of all the money that universities acquire from outside the government, or indirectly from the government: contract research, international sources and industry This includes:

- regional, national and international governmental support for innovation improving subsidies, e.g. the surpluses of the income of the natural gas fields invested in innovation-driven research
- (joint-)funding by companies
- funding from charities (e.g. Cancer Foundation) as stimulator of primarily medical research

The private non-profit sector is an important funder for research performed at universities (€57m), and also for research performed at governmental institutes (€45m). Most of this research concerns health, and comes from so-called charities. Private non-profit organisations also perform research, and they received €5m in 2003 for research.

Government is also a major funder of the research institute sector, accounting for almost 70% of the total sector budget. This percentage differs per organisation type, the sector being quite heterogeneous.

The large companies are the main contributors to the Dutch R&D expenses. In 2005, companies with more than 250 employees represented 12% of all R&D companies. These companies however were responsible for 73% of the private R&D. Although the national

bureau for statistics, CBS, reported a small increase in the business expenditures of R&D in the period 2002-2005, they also point to a rather sharp decrease of 21% in the number of R&D performing companies (from 4,200 in 2002 to 3,300 in 2003).

Priority setting
The two most important intermediary organisations of the Dutch research landscape are the NWO and SenterNovem. In 2007, NWO listed 161 different funding schemes on its website, while SenterNovem listed 196 funds and 37 research related funding schemes. This number of schemes illustrates how the financing of Dutch research has evolved from a relatively simple management instrument to an extensive number of instruments, thereby creating a new level of coordinating organisations.

Research infrastructure in the Netherlands has evolved incrementally rather than in a centrally planned manner. There is no overall national strategy for the research system, nor explicit procedures for establishing priorities. Instead de facto priority areas emerge as a result of multiple funding initiatives. In the fields of four specific key technologies, catalysis, ICT, genomics, and nanotechnology, temporary coordination committees (*regieorganen*) have been set up to coordinate and execute programmes. They have a semi-permanent status and are accommodated by NWO.

Overall, however, steering relations that enable governance actors to implement policies are rather underdeveloped. As a result science policy is neither a result of top down policy making, nor a traditional bottom-up process in which research actors are mainly involved. Rather one can conceptualise it by processes of mediating and aggregating interests.

Quality of research
There are three main mechanisms to guarantee and stimulate quality of research within the Dutch research system:
1. In the mid eighties, a research evaluation system was developed in order to increase the accountability of university research. The government installed committees to provide it with advice on discipline oriented science policies, and as part of their work, these committees started to evaluate university research. The evaluation system has evolved through several stages from a loosely coordinated government exercise to a well established institutional practice. Under the standard evaluation protocol (SEP), introduced in the nineties, public research groups are evaluated every six years, with a mid term review organised internally every three years. Research performing organisations are themselves responsible for the evaluations. Some are organised nationally by discipline, others are locally organized by institute or university.

   Peer review remains the core evaluation technique; common evaluative scales have been introduced with increased formalisation and standardisation. To guarantee comparability of results there is a protocol agreed upon by the Association of Universities, NWO and KNAW. There is no direct connection between evaluation results and allocation of resources even though the scoring scheme would allow translation of evaluation results into funding decisions. Distribution of research funding among universities has changed very little over the last 15 years.

2. The second mode is through competitive funding schemes. In 2007, the NWO listed 161

different funding schemes on its website, ranging from small programmes of a few projects to the funding of the top-ranking graduate schools, and from "open programs" filled bottom up by university researchers to targeted programs on policy-related topics. The large number of new funding initiatives suggests an increase in competitive funding and a relative decrease of institutional funding, especially for university research. Analysing the patterns of governmental research funding since 1975 reveals a different picture however (Versleijen, A., 2007). The share of institutional funding decreases from almost 90% in 1975 to about 65% in 1990, and it has remained at that level ever since. Between 1990 and 2005 free institutional funding even increased from 53% to 58%. Most of this funding goes to universities and institutes for basic research. Competitive funding shows a different pattern. The proportion of funds allocated for open competition increased between 1974 and 1990, but has decreased since. New forms of competitive funds have emerged: thematic competitive funds and European funding from the 1980s onwards and consortium funding since the early 1990s. In 2005 about 30% of the competitive funding was allocated through open competitions, and 70% through the other three competitive funding mechanisms. Only 3% of the governmental research budget is allocated through contract research, and 5% goes to international organisations. Thus, in contrast to the impression that policy initiatives give, the relative amount of institutional funding and competitive funding is relatively stable since the last 15 years.

3. In the past fifteen years, through several interventions, centres for excellent research have developed and selected based upon the idea of increasing focus and critical mass within the research system. These include the Top Graduate Schools, Leading Technological Institutes and Leading Societal Institutes. Most of these centres are interorganisational bodies, organizing research, research acquisition and resource allocation within their specific area.

5.2 Recent policy changes: learning from the Netherlands

Incremental priority setting: Technological Top Institutes

Initial situation

The Consultative Committee on Foresight (Overleg Commissie Verkenningen) worked for over four years before it issued its final report in 1996 suggesting twelve priorities for Dutch science policy. The priorities were adopted as suggested in the Science Budget of that year. However, the priorities had to be implemented through two means: contractual agreements with universities and the national research programs of NWO, to be eventually co-funded by sector ministries. The contractual agreements were never realised. Universities resisted making such priorities part of the institutional funding scheme and successfully argued for their autonomy. Though NWO at that time was indeed developing into a council able to implement science policies, it did not really take up the priorities and relied in its strategy of internal priority-setting mechanisms rather than on government indications. Hence, top-down priority-setting in order to steer research funds to social and economic priorities failed. But the idea to improve relationships between scientific research and social and economic developments remained.

Policy objective

In the following years, a scheme was set up by the Ministry of Economic Affairs to create new industry-oriented research institutes, which would do excellent, internationally outstanding research of relevance to Dutch industry. Though the Ministry aimed at real "brick-institutes", this idea was soon abandoned. All applications suggested a collaborative institute based on

existing expertise within universities, research institutes and industry. In 1997 four "Leading Technological Institutes" (*Technologische Top Instituten*) were established: the Dutch Polymer Institute, the Netherlands Institute for Metals Research (now Materials Innovation Institute), the Telematica Institute and the Wageningen Centre for Food and Nutrition. In 2001, further Leading Technological Institutes were created in the areas of pharmaceuticals, translational molecular medicine, water technology, and agricultural genetics.

In response, in 2005, the Ministry of Education, Culture and Sciences in conjunction with the NWO created three Leading Societal Institutes on the Internationalization of Law, on Pensions, Aging and Retirement and on City Innovation. The growth in number of institutes is indicative of how selective measures dilute through ongoing politicking and strategising within the system.

Effects
The development of the first four institutes is indicative for how initiatives to create international outstanding institutes become embedded in the existing ecology of universities and research institutes. After eight years, three out of the four original institutes were still virtual structures, and only the Telematica Institute had developed to some extent into a real institute employing its own scientific staff. Rather than being institutes in the traditional sense, the Leading Technological Institutes had become program organisations responsible for managing collaborative programs co-funded by the government, partner industries and partner research organisations. The total income of the institutes varied in 2004 from 15 to 23 Million Euros. Two of the new institutes coordinated research done in five universities and research institutes, the other two new institutes allocated their budgets to fourteen and twenty-three research organisations respectively. Currently the Ministry of Economic Affairs, responsible for innovation policy, considers the Leading Technological Institutes as one of the funding instruments that will help to create the right policy mix for stimulating economic priority areas.

'Vernieuwingsimpuls' (Innovational Research Incentives Scheme)
Initial situation
The Innovational Research Incentives Scheme was set up jointly in 2000 by NWO, KNAW and universities with the aim of promoting innovation in the academic research field, and the development of the scientific careers of young excellent researchers.

Policy objective
The now €150m/year scheme, funded by MOCW via NWO, is directed at providing encouragement for individual researchers and gives top (best 10-20% per age group) researchers the opportunity to conduct independent research and promote talent retention in the scientific profession. There are three types of subsidy for individual researchers, which target different stages in a researcher's scientific career: Veni (for those who have recently gained doctorates), Vidi (experienced) and Vici (very experienced).

Initially, full professors were not entitled to apply for Vidi subsidies and they could only apply for a Vici subsidy if they had held a post as full professor for less than three years. The restriction for full professors will be abolished for Vidi and Vici. From now on very experienced researchers will only have to make agreements with an institute or a university once they have heard that they are to receive a Vici subsidy. Before this change a researcher had to arrange this 'embedding guarantee' in advance.

Up until 2008, the hosting institution was required to pay 33 percent of the subsidy and NWO 67 percent. From 2008 onwards, NWO will pay the entire subsidy, leading to a shift of power between the grantees and the research institution in favour of the former: the grantee brings in all the money and is no longer dependent on a research organization willing to pay its 33% matching. The scrapping of this institutional contribution coincides with the transfer of 50 million Euros from the universities to NWO and another 50 million from MOCW. More funds were made available to extend and expand the program after a positive evaluation in 2007.

Effect

Since 2000, about 1700 researchers have received a grant. This scheme indeed has an impact on the career of scientists. Those who are awarded a grant move faster towards higher university research positions than those whose application is turned down (Bongers, 2007). This effect may increase the longer the scheme is in operation, indicating that the scheme has become part of the reputational system of university research. However, there are no indications that the scheme also affects reputation and quality differentiation at the organisational level, that is between universities and between faculties. Finally, it is unclear whether this reputational effect is based on differences in performance (Van den Besselaar & Leydesdorff 2009).

6 United Kingdom

The UK has an essentially centralised research system, with the recently created Department for Innovation, Universities and Science as lead player, within which the Chief Scientific Adviser's Government Office for Science is located. Some aspects of innovation policy are, however, devolved to the regions of Scotland, Northern Ireland, Wales and England. Whilst the first three regions have separate arrangements for higher education funding, Scotland has further autonomy in some aspects of research, particularly environmental, agricultural and biological sciences.

UK research policy may be characterised by a strong policy linkage between research and innovation, with emphasis on research infrastructure. Recent years have seen major funding inputs from the Government in support of the national research system. Key spenders in the UK research system are the universities and public research institutes (including institutes of the UK Research Councils and government laboratories), and an extensive network of independent Research and Technology Organisations and industry. Regarding R&D expenditures, the business sector is the lead performer, followed by the Higher Education sector, Government Departments, Research Councils and finally the non-profit sector.

6.1 Characteristics of the UK research system

Structure
The key Government Department in terms of science and innovation is the Department for Innovation, Universities and Science (DIUS). In June 2007 the Department of Trade and Industry was disbanded to form two new Departments: DIUS, which included the Office of Science and Innovation and the Department for Business, Enterprise and Regulatory Reform including Better Regulation Executive from the Cabinet Office. DIUS contains the Government Office for Science and is responsible for the Higher Education Funding Council for England, the Research Councils, the Technology Strategy Board and oversight of the Regional Development Agencies in the area of science and innovation strategies. Other Government departments with significant research responsibilities are the Department of Health, Ministry of Defence, and the Department for Environment, Food and Rural Affairs.

The Director General of Science and Innovation (DGSI), contained within the DIUS, is responsible for the allocation of the UK Science Budget via the Research Councils and, to a lesser degree, the Royal Society and Royal Academy of Engineering. The Research Councils, who in turn support R&D and research training both in higher education institutions and their own institutions, provide research grants for programmes, projects and research centres. In addition, some of the councils maintain their own research facilities in the UK and abroad for university researchers. The Research Councils are:

- Arts and Humanities Research Council (AHRC)
- Biotechnology and Biological Sciences Research Council (BBSRC)
- Economic and Social Research Council (ESRC)
- Engineering and Physical Sciences Research Council (EPSRC)
- Medical Research Council (MRC)
- Natural Environment Research Council (NERC)
- Science and Technology Facilities Council (STFC)

Fact Sheet

The R&D expenditure was roughly 3.5 times that of the Netherlands in 2006 but the R&D intensity (1.76% in 2006 down from 2.03% in 1991) was comparable to that of the Netherlands (1.71%). The UK showed the lowest increase in publication output from 1993-1996 to 2003-2006 and also the lowest increase in citation impact score for the same periods, but the UK impact score was only lower than that of the Denmark and the Netherlands.

The UK has an essentially centralised research system, lead players being the recently (2007) created Department for Innovation, Universities and Science (DIUS) within which is located the Chief Scientific Adviser's (CSA) Government Office for Science (GO-Science). The Council for Science and Technology (chaired by the CSA) advises Parliament and the Prime Minister which provide policy for the DIUS. The DIUS in turn funds universities and higher education institutes through the 7 research councils (combined budget of €3.16b 2006-07) and private companies through the technology strategy board.

Key research performers are the Higher Education sector (26.1% of GERD performed), largely comprised of the UK's universities, the private sector (finances 45.2% of GERD), the Research and Technology organisations and the Government laboratories or Public Sector Research Establishments(10% of GERD performed).

The Higher Education Funding Council for England (€9.2b in 2005/06) has announced that the 22 year old Research Assessment Exercise (RAE) will be replaced after RAE 2008 with the Research Assessment Framework. making greater use of quantitative indicators (bibliometric) indicators.

Table 2.9 Basic data for the United Kingdom

	1991	1996	2001	2005	2006	2007
R&D expenditure						
R&D-expenditure (M€)	17307	17616	29403	31707	34037	:
R&D expenditure by inhabitant (€)	302	303	498	528	563	:
Total R&D expenditure as a % of GDP	2,03	1,83	1,79	1,73	1,76	:
% GERD financed by government	35,0	31,5	28,9	32,7	31,9	..
% GERD financed by industry	49,6	47,6	45,6	42,1	45,2	..
GERD performed in HE sector	16,7	19,5	22,7	25,7	26,1	..
GERD performed in GOV sector	14,5	14,4	10,0	10,6	10,0	..
R&D personnel						
Total R&D personnel	261000	271580	311982	321919	334686	..
% researchers of total R&D personnel	49,0	53,3	53,5	55,7	54,8	
R&D personnel by labour force	9,1	9,7	10,8	10,9	11,2	..
Researchers by labour force	4,5	5,1	5,8	6,1	6,1	..
R&D output	**1993-1996**				**2003-2006**	**Δ**
Publication output	273448				334541	22,3
Citation impactscore	1,19				1,24	3,9

Sources
EUROSTAT (NewCronos database): R&D expnditure in €:
OECD/MSTI (2008/2): R&D personnel and other R&D expenditure data
NOWT 2008: R&D output

The seven UK Research Councils had a combined budget of around £2.8 billion for 2006-07, most of which was received from the Government Science Budget. The Science Budget is administered through the DIUS. Some Research Councils also receive income from other Government Departments, commercialisation of research and other research funders.

The key research performers are the Higher Education sector, largely comprised of the UK's universities, the private sector, the Research and Technology organisations and the Government laboratories or public sector research establishments. Pharmaceuticals, aerospace and IT related research represent almost 50% of private sector activity.

Governance
The UK has an essentially centralised research system, the lead government department being the DIUS containing the Government Office for Science, which is chaired by the CSA. The Council for Science and Technology (also chaired by the CSA) advises Parliament and the Prime Minister which in turn provide policy for the DIUS. The DIUS funds universities and higher education institutes through intermediate councils and provides tax incentives for the private sector through the Technology Strategy Board.

Resource allocation
DIUS is the major provider of research funds for the public sector. The Director General of Science and Innovation, located within the DIUS, allocates the UK Science Budget via the Research Councils and, to a lesser degree, the Royal Society and Royal Academy of Engineering to universities and other higher education institutes. The Research Councils, who in turn support R&D and research training both in higher education institutions and their own institutions, provide research grants for programmes, projects and research centres. In addition, some of the councils maintain their own research facilities in the UK and abroad for university researchers. Substantial funds are also allocated in the form of block grants to UK universities from the Higher Education Funding Councils and their equivalents in the devolved administrations of the regions.

The UK Government also provides support to the private sector to help companies invest in R&D through a number of mechanisms, including tax credits administered via the Treasury, and the Technology Strategy Board (TSB), which also has responsibility for the formulation and delivery of a national technology strategy. Other Ministries and Departments, particularly the Department for Environment, Food and Rural Affairs, the Ministry of Defence and the Department of Health, also have significant research portfolios within their areas of responsibility. They commission R&D through their own laboratories and institutes (or, in many cases, their former institutes which are now privatised or have intermediate agency status) or other organisations, especially HEIs.

The UK Private Sector is both a major funder and performer of R&D. In 2004, the sector's total expenditure on R&D amounted to some €18.9 billion, including just under €3 billion on defence. Just over 10% (€1.97 billion) of this came from Governmental sources and 23% from overseas. However, the majority – 66% (€12.5 billion) – came from within the private sector.

Similar to the national level, research policy at the regional level is very much integrated with innovation policy issues. Regional authorities do not typically become involved with regional aspects of research. Thus, in the nine English regions, the Regional Development Agencies

have developed regional innovation strategies, in consultation with a broad range of regional and local actors. These focus on issues such as the development of regional networks to foster collaboration, and interactions between universities and research institutions and local/regional businesses, particularly SMEs.

The devolved administrations of Scotland, Wales and Northern Ireland have similar arrangements, but with greater autonomy in the development of policy and with some separate funding arrangements (such as separate Higher Education Funding Councils or their equivalents). Thus, the UK is characterised by a mix of centralised and decentralised arrangements – for example, all universities and other research performers in the devolved administrations are eligible to apply for Research Council funding.

Priority setting

The UK tends not to prioritise specific areas of research (themes), but rather applies horizontal (generic) support to maintain the overall performance of the research system, particularly in terms of ensuring the production of high quality, world-leading research, maintaining and developing research infrastructures (such as universities and public laboratories) and ensuring a constant supply of scientists, engineers and technologists. This is coupled to the objectives of making the science base responsive to the needs of the economy and both increasing the level of business investment in R&D and their engagement with universities. However, certain fields of research funded through government sources, by virtue of the scale of demand, tend to attract larger budgets than others. One example is health research, while defence R&D spending also represents a major recipient of government support.

Government has identified six broad scientific and technical areas for the provision of additional funding. These areas are:

- stem cell research
- sustainable energy economy
- rural economy and land use
- e-science
- post-genomics and proteomics
- basic science

There is no single 'formal' mechanism by which priorities are set. Government, at a range of levels, may commission reviews or inquiries into aspects of science, technology and innovation policy and such reviews may be conducted by individuals or groups drawn from any of the many bodies reviewed by the CSA, or from others with specific interests, or even independent consultants from the public or private sectors. Similarly, these bodies, notably but by no means exclusively, the Confederation of British Industry, the Royal Society and Universities UK, may undertake their own inquiries and reviews, or commission them from external sources. Ongoing initiatives, such as the Foresight Programme, also feed into this policy making process, although no single source of advice or information predominates.

The Foresight Programme, as part of the government office for science, acts as the government think tank on science and technology issues, drawing together experts from the natural and social sciences. With the aim of bridging the gap between short and long term policy making, the programme focuses on three to four areas at once, examining either key issues where science might provide solutions or a cutting-edge scientific topic where potential

applications and technologies are not yet fully realised. A high-level stakeholder group, comprising senior decision-makers and budget-holders from relevant departments, research councils and other organisations, oversees all projects. The group is chaired by the minister of the lead department, and is responsible for agreeing an action plan, which is usually published alongside the findings and reports of the project. Each project is led at a senior level by the government's chief scientific adviser. Projects usually last between 18 months and two years.

Quality of research

The Research Assessment Exercise (RAE) is the mechanism whereby the Higher Education Funding Councils allocate block funding for the support of research in UK universities. It is more than an evaluation mechanism, as it also deals with selection criteria whereby reallocation of grants between universities is possible. The RAE was introduced in 1985 because insufficient funds were available to maintain the existing research infrastructure; so selective block grant allocation was necessary. Block grants are allocated to the universities by the Higher Education Funding Council for England and equivalent bodies in the devolved administrations.

The RAE has been refined in a stepwise manner since its introduction. The major features that have remained constant are the centralised, comparative evaluations performed by the funding councils, the utilisation of peer review in these evaluations, and the use of evaluation outcomes to selectively allocate block grants. Any UK HEI that is eligible to receive research funding from one of these bodies can participate in the exercise. 'Quality profiles' are produced for each submission of research activity made by HEIs.

The mechanism by which the assessment is made has changed over time and has been the subject of protracted debate and a number of extensive reviews. One of the major criticisms of the process is the enormous amount of staff time and resources that HEIs have to devote to the process of preparing RAE submissions. Plans are underway to replace the RAE with a new Research Evaluation Framework, which seems to become more 'metrics-based' – possibly utilising bibliometric approaches and indicators of external research income generated.

Quality of science policy

Many government supported programmes and schemes are subject to review and assessment and such processes are built in at the programme design stages. Most innovation support schemes are evaluated by the DIUS, either by in-house or independent teams, although the outcomes of such evaluations are not always reported publicly. Similarly, other ministries, departments and agencies (notably the HEFCE) may also commission or undertake evaluations of the programmes they support. The outcome of such evaluations will feed into the general policy making process in a similar manner to that of other sources of advice.

In addition, at a higher level of aggregation, government (and stakeholders) regularly undertakes broader evaluations and reviews of policy or specific aspects of policy which again feeds into the policy making cycle. One example is the 2003 Lambert Review of business-university collaboration, which, together with a number of other targeted reviews, fed into the ten-year Science and Innovation Investment Framework. System evaluations, i.e. reviews of the entire innovation system or specific elements of it (such as industry-academic linkages), take place on a fairly frequent basis. Many have been conducted, or sponsored, by the former Department of Trade and Industry and often in conjunction with HM Treasury. A recent example is the Sainsbury Review of UK science and innovation. A further example of the role of such

reviews in policy formulation is provided by the consultation exercise and review conducted in advance of the presentation of the 2004 ten-year Science and Innovation Investment Strategy, which now forms the cornerstone of ongoing UK Government research and innovation policy.

6.2 Recent policy changes: learning from the UK

Research Assessment Exercise
The RAE is the mechanism whereby the Higher Education Funding Councils allocate block funding for the support of research (e.g. meeting infrastructural costs) in UK universities. The first Research Assessment Exercise (RAE) was undertaken in 1986. For the first time, an explicit and formalised assessment process of the quality of research was introduced. Further exercises held in 1989, 1992 and 1996 became gradually more transparent, comprehensive and systematic. The fifth exercise in 2001 considered the work of almost 50,000 researchers in 2,598 submissions from 173 HEIs. The RAE is the principal means by which institutions assure themselves of the quality of the research undertaken in the HE sector. The most recent RAE was RAE2008. The submission deadline for RAE2008 was 30 November 2007. 2,344 submissions were made by 159 HEIs, and the results were published on 18 December 2008.

Policy objective
The Research Assessment Exercise was implemented in the 1980s as an instrument to maintain and develop the strength and international competitiveness of the research base in UK institutions. It aims to identify high quality within institutions and reward the best research through allocation of larger grants. Its introduction was part of a general shift of the relationship between the government and scientific organisations towards a form of New Public Management where performances would be made more explicit, competition increased and the notion of 'value for money' emphasised by the government.

Effects
Although the RAE is one of the most investigated university evaluation systems, little reliable information is available regarding its negative or positive effects. There is much stakeholder literature available, however most of these studies provide anecdotal rather than systematic evidence about the RAE's effects. Little is known for instance about the RAE's impact on the content of research.

Introduction of the RAE's appears to have achieved an overall improvement in the UK's research quality. The UK has increased its share of world publications and citations, but this increase can not be causally attributed to the RAE. It is however accepted that the RAE has increased universities' attention to research, which resulted in improved support of research. A favourable rating in the RAE leads to an increase in funding for the department and to reduced teaching load for researchers.

Unintended effects
Universities selectively submit only the work of so called 'active academics' to the RAE. The research of 'inactive academics' is perceived by the university to be unlikely to perform well enough in the RAE. This classification has led to tensions within the universities and frustrations among academics.

In response to growing dissatisfaction with the former RAE and also to claims that it has now achieved its original purpose - to drive up the quality of research performed in UK universities, the Higher Education Funding Council for England (HEFCE) has announced that the RAE will be replaced with a Research Evaluation Framework (REF). In this REF, panels will focus on quality of outputs, impacts of research and the quality of the research environment.

Technology Strategy Board

Initial situation

The UK Government helps companies invest in R&D through a number of mechanisms, including tax credits administered via the Treasury, and the Technology Strategy Board (TSB), which also has responsibility for the formulation and delivery of a national technology strategy. The TSB was established with the aim of ensuring that the promotion of technology and innovation in business is led by business itself. Over 700 collaborative R&D projects have received investment since 2004, amounting to over £1 billion (about half from the TSB and half from the businesses involved). Unlike SenterNovem, which is an agency of the Dutch Ministry of Economic Affairs, the TSB is an executive non-departmental public body (NDPB), which is sponsored by the UK's Department for Innovation, Universities and Skills. TSB was established in October 2004 following the 2003 DTI Innovation Report. In 2007 it became an NDPB.

Policy objective

The TSB was originally established as part of the DTI to advise the Secretary of State for Trade and Industry on business research, technology and innovation priorities for the UK. In 2007 it was revitalised, changing both its status and focus, and it now operates at "arm's length" as a non-departmental public body. Its current focus is the translation of knowledge into innovation and new and improved products and services, complementing the government's significant investments in knowledge creation, across all important sectors of the economy. Largely through its Technology Programme, the TSB has a budget of £190 million (2007) to support technology and innovation, through collaborative work between businesses or between businesses and academia. Members of the TSB include leading figures in the fields of industry, research and innovation.

Regular competitions for TSB co-funding for collaborative R&D projects have been held since 2004, and by November 2007 over 700 projects had been supported, with a combined investment of over £1b. The £1bn figure was reached following the announcement of the results of the Technology Strategy Board's Spring 2007 competition, which approved investment of £101.5m in 76 new collaborative research and development projects, covering seven technology priority areas. This included £5.4m from the Research Councils and £3m from the Ministry of Defence. Taking into account contributions from business, this resulted in collaborative R&D expenditure of about £200m. The seven technology areas are:

- Design Engineering & Advanced Manufacturing
- Lightweight Materials and Structures
- Low Carbon Energy Technologies
- Networked Enterprise
- Oil & Gas Technologies
- Plastic Electronics, Materials Processing and Systems Integration
- Smart, Bioactive & Nanostructure Materials for Health

Effects

Many recent competitions for R&D funding have been heavily oversubscribed, implying that the competitions are being held in areas that were appropriate, where there was significant UK capability and where those with that capability thought they had innovative ideas. As grants awarded are mainly co-funding, proposals all contain a commitment by the companies involved to also invest their own money in the future success of their sector of the UK economy. The competition on grants for market advancement of electric and hybrid vehicles competition, for instance, with an allocated £10m of funding, received first round proposals totalling over £78m.

The unprecedented level of interest in the competitions has stretched the TSB processes. Companies making unsuccessful submissions seek more information on why they fail to pass certain hurdles and what they could do to make sure any future proposal was more effectively presented. In the past, TSB gave no full feedback at the first stage, informing those who were unsuccessful only of their percentile position in the rank ordered list. At the second stage, the technologist responsible for the area of work has extracted the important points raised by the assessors and provided more detailed feedback. The TSB does not currently have the resources available to give feedback to all unsuccessful candidates.

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