

**International approaches to
research policy and funding:
university research policy in
different national contexts**

Final report

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Executive summary

This report summarises international approaches to research policy and funding in five countries: France, Germany, Japan, the United Kingdom and the United States. Our principal findings are as follows:

Patterns of funding

- Growing significance of university research within national research budgets.
- Prevalence of the dual support system as a mechanism for distributing research funds among universities.
- Development of new approaches to the allocation of project-based research funds to ensure a better match between resources and objectives.
- Implementation of initiatives to refurbish the research infrastructure (including laboratories and equipment).
- Increasing variety of funding sources and stakeholders in research.
- Use of ‘mix and match’ approaches to combine different funding streams for research.

Recent reforms (to funding allocations and evaluation)

- Attempts to better co-ordinate the implementation of research policies.
- Growing interest in methods to link performance to the allocation of core funds.
- Increasing focus on the balance between excellence, efficiency (including public accountability) and equity.

Main issues and current initiatives

World class and applicable research are closely intertwined.

- Support for world class research also encourages applicable research.
- Growing appreciation of the synergistic relationship between basic and applied research.
- Increasing use of mechanisms to target funding to priority areas.
- Increasing focus on reward systems as a means to selectively stimulate behavioural change.
- Increasing recognition of interdisciplinarity – new research areas are typically interdisciplinary.
- Some recognition that a wider distribution of research funds can lead to the development of new areas of basic, world-class research. It also provides a channel for universities to undertake applicable research of use to small and medium-sized enterprises (SMEs) and firms in traditional sectors.
- Recognition, in almost all countries, that world class scientific research might be linked to an institute’s ability to select the best young scientists, provide them with secure research positions, stable funding and the freedom to choose their own research topics.

Recognition of research networks

- Increasing focus of commercially funded research in the universities is coupled with a focus on issues connected with intellectual property.
- Flexible deployment of networking to facilitate research collaboration and co-ordination and so serve the goals of science, the regions, sponsors and overall efficiency (for example, through sharing expensive pieces of research equipment).
- Efforts to revise and up date traditional methods for technology transfer.

Career development and training

- Increasing recognition of, and attempts to remedy, the poor professional status of university researchers.
- New approaches to attract exceptional young researchers to careers in universities.
- Tendency for non-implemented rhetoric about promoting the participation of minority groupings (women, ethnic minorities, and people with disabilities) in university research.
- Concern to raise (and measure) the quality of teaching practice.

Widening research

- Perceived widening of the number of universities involved in research as well as the research domains studied.
- Escalating use of mechanisms to identify and fund priority areas of research.
- The creation of new research facilities to facilitate interdisciplinarity and research co-operation.
- Increased recognition, for instance in Germany, of the need for structural reform of the universities to foster flexibility and responsiveness to change and the complementary requirements to build strong leadership capabilities at departmental and university administrative levels.

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Introduction

Economic prosperity is progressively tied to the creation, distribution and exploitation of knowledge. As national economies become increasingly knowledge-based, scientific and technological knowledge are recognised as being critical to industrial performance and international competitiveness (OECD, 1999a).

University research, taken here to be ‘original investigation undertaken to acquire new knowledge in the natural sciences, social sciences and humanities’ is recognised as the key to national prosperity. Furthermore, as individual nations become more and more integrated into a global world economy, the research policies that each puts in place can affect that nation’s capabilities to mobilise international knowledge assets for public welfare and sustainable economic development.

Government policies for university research critically determine the characteristics of national stocks of knowledge and expertise. Over the last two decades, governments in most leading industrial countries have been examining their levels and patterns of funding for research in order to maximise the benefits from investment.

Maintaining an international presence in research is increasingly expensive. OECD (Organisation for European Economic Co-operation) countries are intensifying their expenditure on knowledge production activities (R&D, software, public expenditure on education). Current investment across OECD countries on average represents 8 per cent of GDP (gross domestic product) (OECD, 1999a), this figure is higher in France (9-10 per cent) and lower in Japan (6-7 per cent). Expenditure on R&D alone, after several years of stagnation and, in some countries, decline, is once again starting to grow.

Recent economic decline and tightening of public budgets for research have led governments in almost all OECD countries to examine their levels and patterns of spending on university research. The rising costs of achieving university research excellence have challenged them to engage in activities that will enable them to enhance the efficiency, effectiveness and relevance of national research systems. As a result, many governments have made extensive structural modifications to their arrangements for university research (Geuna, 1999a). Changes include alterations to ministerial responsibilities for university research, to the organisations that distribute research funds, and to the mechanisms used for allocating funds between research areas.

Political history has had a strong effect on the development of university research in each country. Practices for the distribution of responsibilities for university research (between regions and states or between Ministries) also determine the way in which the system in each country evolves and its room for manoeuvre. Thus individual countries are adopting different responses to the international, national and regional challenges that confront their university research systems (Senker et al., 1999).

This Final Report examines, compares and contrasts approaches to university research policy and the challenges facing it in five countries: France, Germany, Japan, the UK and the US. It provides evidence about the organisation and management of government funding for university research in these countries and examines the effects of research policy and funding

on the performance of the university research system. Detailed information on each country is provided in five national reports in the Appendix. The national reports are primarily qualitative in nature and based on a review and analysis of relevant literature as well as interviews with national experts. Each national report provides data on expenditure on university research by main field and trends in relative expenditure priorities for university research by main field, to the extent that such information is available from national statistical agencies, the Research Councils and their foreign equivalents. Differing institutional arrangements for university research between countries make it extremely difficult to provide truly comparable data on trends in national expenditure on university research. We have therefore used OECD data to provide a comparative overview of gross expenditure on R&D in the higher education sector, focusing only on government funds (using million constant \$, 1990 prices and ppp¹s) for the period 1992 – 1998 (Table I).

Table I: GERD (government domestic expenditure on research and development only) in the higher education sector.

Country	Year	1992	1993	1994	1995	1996	1997	1998
France	DGF	1 743.5	1 776.7	1 820.0	1 867.0	1 861.6	1 882.2	..
	GUF	1 690.9	1 772.4	1 762.7	1 806.9	1 839.7	1 888.4	..
	Total	3 434.4	3 549.1	3 582.7	3 673.9	3 701.2	3 770.7	..
	Govt.							
Germany	DGF	..	1 210.1 ^a	..	1 159.4	1 259.6	1 269.1 ^c	1 281.1 ^b
	GUF	..	4 028.9 ^a	..	4 047.5	4 001.3	3 930.4 ^c	3 967.2 ^b
	Total	5 232.1 ^{a,c,o}	5 239.0 ^o	5 332.4 ^o	5 206.9 ^{a,o}	5 260.9 ^o	5 199.6 ^{c,o}	5 248.3 ^{b,o}
	Govt.							
Japan	DGF	1 165.2 ^e	1 254.3 ^e	1 272.7 ^e	1 517.7 ^e	750.7 ^a	823.2	..
	GUF	5 102.4 ^{e,l}	5 563.4 ^{e,l}	5 476.3 ^{e,l}	6 135.9 ^{e,l}	4 350.4 ^{a,b}	4 360.5 ^b	..
	Total	6 267.6 ^{e,l}	6 817.8 ^{e,l}	6 749.0 ^{e,l}	7 653.6 ^{e,l}	5 101.1 ^{a,b}	5 183.7 ^b	..
	Govt.							
UK	DGF	789.9	915.2	1 113.9	1 126.8	1 115.7	1 119.7	..
	GUF	1 435.3	1 398.8 ^a	1 445.6	1 412.1	1 384.2	1 357.2	..
	Total	2 225.2	2 314.1 ^a	2 559.5	2 539.0	2 500.0	2 476.8	..
	Govt.							
US	DGF	16 950.1 ^{a,j}	17 480.0 ^j	17 806.6 ^j	18 187.4 ^j	18 601.4 ^j	19 237.6 ^j	19 806.5 ^{b,j,p}
	GUF	..	..	..	..	..	..	..
	Total	16 950.1 ^{a,j}	17 480.0 ^j	17 806.6 ^j	18 187.4 ^j	18 601.4 ^j	19 237.6 ^j	19 806.5 ^{b,j,p}
	Govt.							

Source: OECD, 2000. Million constant \$, 1990 prices and ppps.

DGF Direct government funds.

GUF General university funds.

a Break in series for which previous data are available.

b Secretariat estimate or projection based on national sources.

c National projection or estimate adjusted, if necessary, by the Secretariat to meet OECD norms.

e National results adjusted to meet OECD norms.

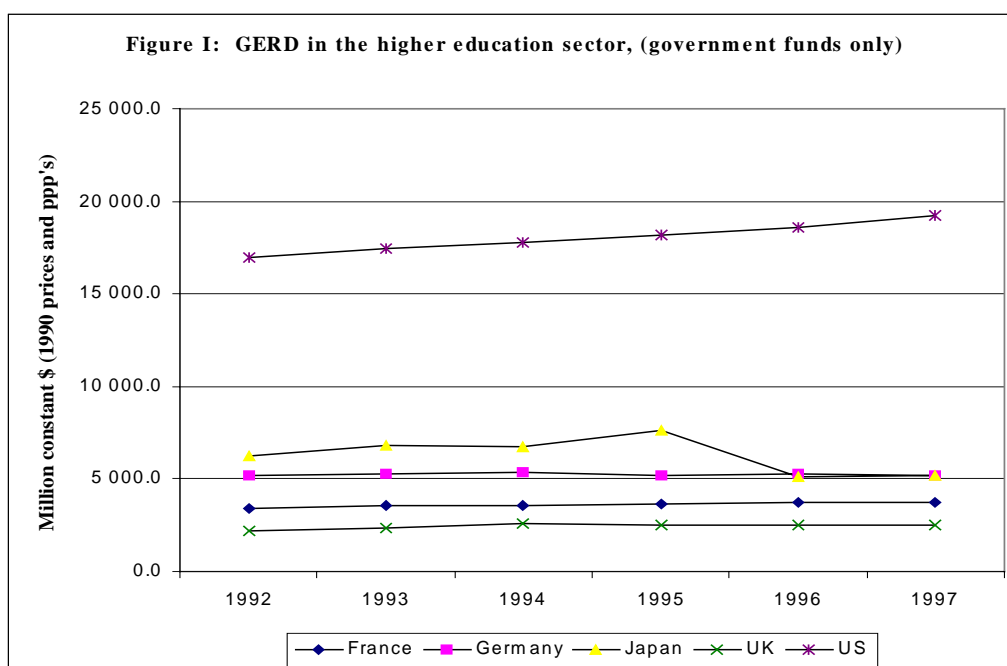
j Excludes most, or all, capital expenditure.

l Overestimated or based on overestimated data.

o Includes other classes.

¹ Purchasing power parity.

These data give rise to the following chart of government expenditure on R&D in the higher education sector in the various countries between 1992 and 1997, for which most complete data are available (Figure I).



Source: OECD, 2000.

Although these data do not account for size or number of higher educational institutions, the sheer volume of, and upward trend in, government expenditure in the US are noteworthy. Table II provides more detail on expenditures on R&D in 1996. In particular, regarding the five countries that are the focus of this report, the table shows the high levels of per capita gross expenditure on R&D and the high percentages of GDP that was spent, gross, on R&D in both Japan and the US.

The five national reports have been analysed to provide an understanding of the pattern of funding for university research in the countries studied, and this is presented in Section 1. Analysis has also focused on comparing international approaches to five other significant issues. Section 2 focuses on the provision of support for world class research, and Section 3 considers approaches to encourage applicable research. There are strong links between world class science and research application, with leading research groups often benefiting from industrial contracts. There are therefore many overlaps between these two sections. Recognition given to the formation of research networks is discussed in Section 4. An overview of international approaches to career development and training is given in Section 5. Finally, in Section 6, the extent to which research has widened, both in terms of the number of universities involved and the research domains that are being addressed, is examined.

Table II: Research and Development,¹ 1996

	GERD appropriations for R&D ³				BERD (business enterprise intramural expenditure)				Govt. budget	
	%GDP	% financed by		Per capita at	% GERD	% of domestic	% financed by		% GDP	of which Defence R&D %
		Govt.	Industry	current USD ²		product of industry	Govt.	Industry		
Australia	1.68	46.4	47.0	355	47.4	0.84	2.6	92.6	0.62 ^{g,h}	7.8 ^{g,h}
Austria	1.52	46.7	49.0	325	55.9 ^c	1.11 ^c	9.8 ^c	86.0 ^c	0.62 ^h	0.0 ^h
Belgium	1.59 ^a	26.4 ^a	64.2 ^a	335 ^a	67.4 ^a	1.35 ^a	4.4 ^a	90.2 ^a	0.64	0.5
Canada	1.64 ^b	32.3 ^b	48.9 ^b	352	63.4 ^b	1.40 ^b	7.0 ^b	72.3 ^b	0.37 ^h	6.5 ^h
Czech Republic	1.07	35.5 ^c	59.6	135	59.9	0.75	7.3	90.7	0.45	0.0
Denmark	2.01	34.4	50.2	451	62.0	1.89	5.4	79.3	0.70	0.5
Finland	2.58	35.1 ^a	59.5 ^a	489	66.2	2.49	5.6 ^a	89.1 ^a	1.14	1.5
France	2.32	41.5	48.5	477	61.5	1.91	13.1	75.6	1.06	27.7
Germany	2.29	37.2	60.7	485	66.2	1.92	9.0	88.7	0.85	9.6
Greece	0.48 ^c	46.9 ^c	20.2 ^c	53 ^c	26.8 ^c	0.21 ^c	4.6 ^c	67.9 ^c	0.31 ^j	1.2 ^j
Hungary	0.66	50.0 ^c	38.9 ^c	61	43.2 ^c	0.35	13.7	78.3	..	..
Iceland	1.51	62.9	31.6	350	31.1	0.75	14.4	83.8	0.83	0.0
Ireland	1.39 ^a	21.6 ^a	68.5 ^a	238 ^a	71.2 ^a	1.28 ^a	4.5 ^a	91.5 ^a	0.32	0.0
Italy	1.03	48.8	45.7	205	54.4	0.69	10.9	81.2	0.58 ^a	4.7 ^a
Japan	2.83	18.7	73.4	658	71.1	2.24	1.1	98.6	0.59 ^k	5.8 ^k
Korea	2.79	20.3	77.8	379	73.2	2.39	4.4	94.7	..	..
Luxembourg	..	..	..	..	..	..	..	..	..	..
Mexico	0.31 ^a	66.2 ^a	17.6 ^a	23 ^a	20.8 ^a	0.07 ^a	2.8 ^a	76.2 ^a	0.21 ^{h,j}	0.0 ^{h,j}
Netherlands	2.09	41.5	48.5	439	52.7	1.37	5.6	84.5	0.89	3.1
New Zealand	0.97 ^a	52.3 ^a	33.7 ^a	164 ^a	27.0 ^a	0.32 ^a	6.9 ^a	86.4 ^a	0.49 ^a	1.2 ^a
Norway	1.71 ^a	44.0 ^a	49.9 ^a	390 ^a	56.7 ^a	1.38 ^a	11.9 ^a	82.5 ^a	0.76	5.5
Poland	0.76	57.8	38.9	53	40.9	0.43	28.2	70.7	0.47 ^a	..
Portugal	0.58 ^a	65.2 ^a	18.9 ^a	76 ^a	19.8 ^a	0.15 ^a	5.2 ^a	80.1 ^a	0.48 ^j	1.3 ^j
Spain	0.87	43.9	45.5	129	48.3	0.52	7.9	86.7	0.52	19.6
Sweden	3.59 ^a	28.8 ^a	65.6 ^a	672 ^a	74.3 ^a	3.92 ^a	9.5 ^a	86.8 ^{a,f}	1.16 ^j	20.9 ^j
Switzerland	2.74	26.9	67.5	700	70.7	2.32	2.4	92.5	0.80 ^j	1.9 ^{a,j}
Turkey	0.45	58.5	34.9	28	26.0	0.13	1.9	97.5	..	..
UK	1.94	31.8	47.3	362	64.9	1.68	9.5	68.8	0.74	37.7
US	2.62 ^d	33.6 ^d	62.5 ^d	730 ^d	73.2 ^d	2.15 ^d	16.4 ^d	83.6 ^d	0.91 ^{d,h}	55.0 ^{d,h}
G7	2.40	31.7	61.9	572	69.8	1.97	11.4	85.8	0.80 ^d	36.3 ^d
EU-15	1.84	38.2	53.1	355	62.4	1.49	9.6	81.4	0.81	15.9
OECD total	2.17	32.3	61.3	420	68.2	1.76	10.7	86.3	0.70	32.0

Source: OECD, 1999b

Figures in italics are provisional.

.. not available

1. Some national or OECD estimates
2. Converted using Purchasing Power Parities
3. 1997

a 1995

b 1997

c 1993

d Excluding most or all capital expenditures

e Underestimated

f Overestimated

g 1994

j 1996

k Excluding R&D in the social sciences and humanities

1 Funding patterns

In all of the countries included in this study, university research is awarded a growing share of the national research budget. Most of the countries investigated operate some form of dual support system for distributing this money to the universities (Table III). In this report, a dual support system is taken to be a split system in which core university funding and funding for research projects are allocated by separate institutions, as they are in Germany, the United Kingdom and the United States, and/or by the same institution using different methods, as for example in Japan.

Table III: Funding patterns in the five countries

Feature	France	Germany	Japan	UK	US
Dual support system		✓	✓	✓	✓
Mixed support system	✓				

France, which has a mixed support system, is the main exception to the dual support system model. In France, government funding for university research is administered through the Ministry of National Education, Research and Technology (MNERT). Core university funds include some funding for research but only cover 25-50 per cent of the amount required. The remainder comes from a multiplicity of sources. The units of two public research organisations – Centre National de Recherche Scientifique (CNRS) and Institut National de la Santé et de la Recherche Médicale (INSERM) – play a significant role in supporting research in higher education by locating a large proportion of its researchers and resources within the universities.

In the four countries included in this study that use the dual support system, it is considered to have functioned well. Perhaps its main advantage is that it gives universities a certain level of support and independence that enables them to take part in basic research activities that are not funded by project-specific grants. The existence of two channels for allocating funds also allows resources to be targeted to particular elements of the research system.

However, in most countries, government budgets for research are considered to be inadequate to meet the goal of supporting international research excellence. They are highly constrained by the need to cover the expanding waterfront of research activities that are being undertaken in a growing range of higher education institutions.

There are three main consequences of this. First, for example, in Japan, Germany and the UK, there has been an expansion in competitive research funds relative to core funds. Germany and the UK have experienced shrinking core funding combined with growing student numbers. This can lead to inadequate provision for the indirect overhead costs of basic research projects, impair the research environment and reduce the level of research achievement. Lack of adequate core funds (together with the need for flexibility, for instance in those countries that have traditionally employed tenured staff such as the US) has also resulted in an increase in the numbers of researchers employed on short-term contracts.

Second, there is considerable pluralism in the types of funding that are being made available for university research, the institutions involved in funding research and the arrangements

under which university research is being performed. Universities are forced to exercise creativity in the way that they combine and deploy the various resources that are available to them. For example, in the United States, an institution's own funds (including monies accruing from investments and endowments) may be used to undertake research, fund staff salaries or improve the research infrastructure. The dual support system, as it is defined here, is premised on a conceptual distinction between teaching and research that, to a greater or lesser extent, is often departed from in practice.

Finally, the system has come under strong pressure to promote the efficient and effective use of funds. In all of the countries studied, there is a growing tendency to use evaluation, particularly peer review, to link core funding to teaching and research performance in order to enable governments to prioritise and select between the recipients of core funds. In addition, governments face an increasing need to be publicly accountable for their use of public money. This has contributed to the development of two emerging trends. First, universities are being pressed by governments to formally account for their investments in research and to increase their levels of public dissemination of research results. Second, governments are trying to assure, at least in their public rhetoric, that amid the drive for excellence, equity also has priority.

There is some concern that the increasing variety of stakeholders, funding initiatives and so on in the system, together with its inherent competitiveness will militate against the cohesion and complementarity required for the pursuit of longer term national strategic research goals. This has led some countries, Japan and the UK for example, to establish a central co-ordination function to oversee and control the implementation of university research policy. For example, in Japan, the Council for Science and Technology (CST) is responsible for the overall co-ordination of government policies for university research on science and technology. The Science and Technology Agency (STA) is responsible for implementing co-ordination policies and promoting R&D in a variety of different fields across different ministries and agencies. However, although the institutional framework for co-ordination has been established in Japan, its operation has not been entirely successful, and remedial measures are being taken. In France, the public funding of research in French universities has been subject to contractual agreements between each university, MNERT and CNRS since 1995. One of these aims of these contracts is to improve research policy co-ordination between MNERT and CNRS.

2 *Supporting world class research*

The provision of support for world class research in all of the countries included in this study has involved influencing the balance that is struck between and within a set of competing requirements. These include, for example, that researchers focus on: research and teaching; being competitive but also collaborating; developing skills for self-direction but also for governance and leadership; striving simultaneously for excellence, efficiency and equity. The particular policy decisions that are made and their implementation in each of the different socio-economic contexts have led to a series of individual country profiles that share common characteristics but also have unique attributes. Combination of these elements leads to great diversity in international approaches to university research policy and funding.

2.1 Supporting world class research in France

The mixed support system in France has a rather complicated form of organisation. The core funds provided to French universities by MNERT are intended to provide faculty with the time and resources to carry out research. In reality, core funds only provide 25-50 per cent of the amount required to do research. France does not have research councils that fund research projects, as is the case in most other countries. Therefore, university teachers/researchers raise funds, generally for short-term contracts, from a variety of funders at the national and international level, but these activities do not support world-class research. Basic academic research in universities is primarily supported by two research organisations:

- the CNRS, under the responsibility of MNERT, and
- the INSERM, under the joint responsibility of MNERT and the Ministry of Health.

Both support basic research not by allocating project grants but by supporting the researchers they recruit to work in CNRS units. They have policies to locate a large proportion of their researchers and resources inside universities so as to facilitate interaction between teaching and research activities. University teachers/researchers can do research in the mixed units, and CNRS researchers are able to contribute to teaching. World class research is thought to be linked to these ‘mixed’² CNRS/university research units, where both university and CNRS staff have job security based on their being civil servants. For this reason, these ‘mixed’ units will provide the focus for this section.

Mixed units are established on the basis of applications made by groups of CNRS and university researchers. Those that are successful have a limited life of 10 years. Mixed units that wish to continue to receive CNRS accreditation have to re-apply, which indicates that research units need to have the capability to evolve their strategy/research mission or they will be discontinued. There is dynamism in the system as CNRS researchers who wish to develop new research areas are able to submit proposals at any time for the establishment of new mixed units. CNRS researchers are recruited by a highly competitive system that seeks to identify promising young researchers (applicants must be less than 30 years old) who receive lifetime employment as civil servants. Once recruited, CNRS researchers can choose the laboratories where they wish to work and are free to select the research they wish to do. World class science is promoted by the system because the CNRS system makes research careers extremely attractive. CNRS is able to recruit the best people, even though salaries are relatively low, because researchers are offered good working conditions, high status and a good quality environment.

Mixed units exist in many universities, but only cover one or a few disciplines in most. Their main objective is to add to knowledge. The pattern of funding is especially important for encouraging world class research. Long-term core funding for these units represents only 40 per cent of their income. The remaining 60 per cent comes from the EC, national programmes, industry, the regions and foundations. The fact that funds are provided by numerous sources gives the units stability. The attractiveness of these units to external funding bodies derives from the ‘stamp of approval’ provided by CNRS ‘labeling’, the evaluation on which the accreditation is based and the core funds provided to these units.

²Comments about CNRS also apply to INSERM.

CNRS and INRA³ are currently experimenting with new forms of collective evaluation in about one-third of their units based on an audit of capabilities, investments, personnel, the outcomes of research, and also future plans. These new evaluations may transform the relationship between these public research organisations and the units.

In an attempt to foster world class research by university teachers/researchers, MNERT rewards some non-CNRS research groups that are evaluated as being ‘good labs’. These groups are accredited as ‘laboratoire recommandé’, and are given extra resources. MNERT has also introduced a scheme to allow about one hundred of the most promising young scientists recruited each year to spend 3 years solely on original research at the interface of more than one discipline.

To sum up then, the main benefits of this mixed system are that:

- Interactions between CNRS researchers and university staff have proved beneficial to research.
- Researchers have job security, adequate financial resources to undertake research, and freedom to choose where they work and the type of work that they wish to do.
- Researchers are provided with good working conditions, and they have high status allowing the recruitment and retention of the best researchers at relatively reasonable salaries.

Less beneficial aspects of the system are that:

- University teachers/researchers not associated to CNRS ‘mixed’ units are required to undertake a lot of short-term contracts that do not help promote world class research.
- There are few opportunities or incentives for university or CNRS teachers/researchers to change their organisational affiliations. Nor is there any way for CNRS researchers who fail to realise their potential to be redirected to civil service positions more suited to their capabilities.

2.2 Supporting world class research in Germany

Germany has also been revising its research policy to facilitate the growth of university research. In the 1980s, public spending increased faster on non-university research than on university research, and non-university institutes often provided a better research infrastructure and more favourable research conditions. Since the late 1980s, several initiatives have been introduced to re-direct university research in Germany. A jointly funded Federal and Länder programme has been set up to achieve this by:

- Creating growing roles for competition and autonomy in the research system.
- Expanding the Fachhochschulen (universities of applied sciences).
- Increasing funds available for project-based funding.
- Giving additional funds to build R&D capabilities among higher education institutions in the new Länder.

³ Institut National de la Recherche Agronomique.

- Increasing funding for the construction and modernisation of buildings and equipment in the higher education sector – particularly in the new Länder.
- Updating personnel structures and employment law.
- Eliminating barriers between public research and private enterprise.

In Germany, research is mainly carried out in two sectors of the higher education system: the ‘scientific universities’ (wissenschaftliche Hochschulen) that focus on fundamental research and research training and the ‘universities of applied science’ (Fachhochschulen) that are responsible for education but also undertake research projects, e.g. for local industry. World-class research is therefore typically associated with the scientific universities, and its identification and pursuit have been the result of generative (‘bottom-up’) processes, driven by the high quality research ideas of individuals and groups within the research system.

This lack of strategic direction for research funding is under considerable pressure for change. Increasingly, competitive research programmes in target areas are being used to direct funding towards identified priority areas. Most strategically oriented research is funded by the Federal Government’s Bundesministerium für Bildung und Forschung (BMBF) that aims to support the best research and to distribute available funds as widely as possible in priority areas.

It is particularly difficult in Germany to establish new and interdisciplinary research areas because of historical terms and conditions of employment, rigidity in departmental structures and patterns of interaction between them and general lack of departmental and administrative-level leadership in the universities.

2.3 Supporting world class research in Japan

Until recently, the main function of Japanese universities was to educate large numbers of people, particularly engineers, for local industry. In global terms, the Japanese research system was considered uncompetitive. In 1995, government policy revised its focus and goals towards attaining world class excellence in science and technology. Fundamental to this was the need to reinforce basic research and development activities, particularly in the national universities.

A range of priority initiatives has been put into place to stimulate basic research. Most notable are:

- the Centre of Excellence programme that was created in 1997 to stimulate new advances in scientific research in preparation for the 21st century and upgrade the infrastructure for research, and
- the Research for the Future Programme, which provides for the Grants-in-aid for Scientific Research initiative. The aim of this initiative is to stimulate creative and pioneering basic research in all fields where the research is in keeping with current trends. Politically, the initiative has high priority; between 1989 and 1998, its budget increased by 150 per cent.

2.4 Supporting world class research in the United Kingdom

The main historical strengths of the UK research system are in the biosciences, some of the physical sciences and, to a lesser extent, in some areas of engineering. The keys to these strengths are the competitiveness of the system⁴ and its strong reliance on the peer review system (by the Research Councils) and research assessment exercise (RAE) (by the funding councils).

Continuing to support a university system that is capable of producing world class research, is perceived to require focus on two main (and inseparable) needs:

- to provide sufficient core funding to ensure the continued health of the university research system, and
- for attention to be directed towards the allocation mechanisms that are used to direct available funds to the universities.

This is likely to involve development of the RAE as a mechanism for assessing university research performance so that it can:

- reflect equally on the excellence and variety of research carried out in the old and new universities, and
- stimulate (and reward) the generation of diversity (in research as well as approaches to research).

In addition, while the mechanisms that have been put in place to fund instrumentation and the infrastructure for research are recognised and appreciated, there are concerns that the more mundane requirements for funds for renovation and running repair are not being met. A continued and progressive decline in established research facilities may threaten the ability of these institutions to maintain high standards of research and continue to support the breadth of their research portfolio.

2.5 Supporting world class research in the United States

Research in the higher education sector in the United States is concentrated in only a few of its 3,600 universities and colleges. These are mainly universities that offer graduate degree courses, and particularly those that award doctoral degrees.

University research in the United States is conducted in a merit-based and competitive environment that secures a tight relationship between world-class and applicable research. Industry has played an increasingly important role in providing funds for university research. However, there is growing anxiety over the extent of industrial sponsorship for research and its influence on university departments and the behaviour of researchers within them.

In recent years, Federal funds for R&D had been declining, largely because of reductions in defence spending. Increased industrial support for research had gone some way towards compensating for the shortfall in funds and Federal programmes to promote university-

⁴ In many areas, this has been nurtured through strong linkages and active working with modern industry.

industry research collaboration have encouraged this trend. Investment in the science and technology base, the construction of new academic R&D facilities, as well as the repair and renovation of academic R&D facilities, have been increasing. Most of this has come from state and local governments together with contributions from institutional funds.

Federally funded university research in the US takes place in a highly, and increasingly, politicised context and is guided by political, rather than scientific, rationality. This is a strength, in that there is an assumed linkage between spending and the wishes of the electorate, and a source of weakness that may distort the allocation of funds for research.

The entrepreneurial character of the university research system in the United States is one of its core strengths. World-class research is fundamentally linked to a range of factors including the calibre of researchers in the system, the quality of instrumentation, the existence of a funding system that matches resources for research to expectations from research, strong multi-directional interaction and communication and high quality administrative support.

3 *Encouraging applicable research*

Government initiatives to encourage applicable research in the various countries need to be understood in their national and international contexts. Nationally, they reflect individual government responses to local challenges. Internationally, policy in all countries is directed towards attaining globally competitive and excellent research. However, there is growing recognition in all of the countries studied, and most notably in the US, that world class science is very closely intertwined with application. Therefore, promoting world class science also helps to encourage applicable research.

In France, there is increased linkage between industry and university research. The ‘mixed’ CNRS units have proved to be very successful in attracting funds from industry; for instance, between 1980 and 1994, they saw a ten fold increase in the number of industrial contracts. This trend may arise partially from recent demands that CNRS units undertake relevant research as well as adding to knowledge. This new demand for relevance reflects increasing recognition of the overlap between basic and applied research and a belief that the best researchers are driven not only by the need to do good research, but to ensure that the results are applied.

The teachers/researchers in universities that do not belong to CNRS ‘mixed’ units benefit from resources provided by the regions for research directed towards local economic needs. These resources allow them to undertake research relevant to SMEs, firms in traditional sectors and other economic activities (e.g. tourism). Local firms may also fund these activities. The MNERT also has a new fund for collaborations between SMEs and teachers/researchers to undertake applied research, especially in new technologies.

In the United Kingdom, economic pressures on the universities require them to seek funds from a range of available sources, including industry. This forces them to show the relevance and appropriateness of their research profile to industry. This pressure is aggravated by an historical gap in funding for technology transfer activities (i.e. to bridge between research and commercial demonstration and development).

Recent UK research policy has encouraged the relevance, particularly to industry, of university research. Technology Foresight, has been introduced to assist in the identification and selection of priorities for research that will impact on economic competitiveness, and the results of this initiative are integrated with a range of schemes to support academic and industrial research collaboration. In general, industry provides a proportion of the costs of these, and government supplies the remainder. Technology Foresight also has some influence on the funding policies of the Research Councils, which provide grants for research projects.

In the United States, universities are organised into disciplinary departments in which university faculty carry out both teaching and research. Priorities for university research are influenced by a multi-layered and highly interactive system⁵ that operates top-down (directed by the Federal funding agencies) and bottom-up (driven by the ideas of researchers themselves) simultaneously. The absence of central control has advantages in that it supports variety in the system. Its main disadvantage is that change, for example in historical patterns of research spending, can be slow.

4 *Recognising Research Networks*

In all countries, policy has encouraged collaborative research and the formation of research networks. Collaboration is now becoming necessary to build the critical mass needed for research at the EU level. Calls for proposals by the EC now demand a variety of competencies that can only be achieved through joining forces with other departments, other universities or firms.

Leading firms are aware of where world-class science is being performed, and make efforts to link up with it. Hence, the majority of industrial funding for research focuses on a few universities like Harvard and Stanford in the US and Imperial College and Oxbridge in the UK. Other universities, for example the ‘new’ universities in the UK, target small, often local firms and/or those in traditional sectors for collaboration. In some countries, for instance the UK and Germany, industrial collaboration includes joint schemes for doctoral research training.

In the US, there has been growing anxiety over the extent of industrial sponsorship for research and its influence over the missions and goals of universities and the normative behaviour of scientists. Concerns include the fear that industrial interests can threaten the pursuit of disinterested enquiry,⁶ can render scientists unable to disclose the results of their research for agreed periods, can intervene in the interpretation of research results and, coupled with diminishing public support, may skew the field mix of academically related R&D.

⁵ Internally as well as having links to the political side of the administration in the White House.

⁶ The US\$25 million agreement, in November 1998, between Berkeley and Novartis, a Swiss pharmaceutical giant and producer of genetically engineered crops, whereby Novartis funded a substantial proportion of basic research in the department of Plant and Microbial Biology in return for five seats on the department’s research committee and the right to negotiate licences on about one third of the department’s findings, caused uproar (Press and Washburn, 2000).

In Japan, where industry has traditionally dominated research, the promotion of co-operation and interaction between industry, academia, and the government is identified as a pillar of the 1996 Science and Technology Basic Plan. The MESSC has implemented support for a comprehensive range of measures to stimulate research co-operation, including joint research initiatives, private sector commissions for research, commercial endowments and the formation of joint research centres.

In all countries, the rise in the number of collaborative research projects has led to the identification of methods to further facilitate universities and industries working together. Mechanisms for technology transfer, often accomplished by the physical movement of researchers between university and industrial sites, need to be strengthened. Attention is increasingly being given to the protection and promotion of intellectual property arising from the results of research, and revisions have been made to the practices and procedures relating to the issue and use of intellectual property rights, licences and patents.

Intra- and inter-university collaborations are also widely encouraged and are being used to serve regional, as well as scientific, objectives. For example, in France, where most regions have between three to five universities, there is strong local effort to use collaboration to ensure that these universities cover all disciplinary fields. Most regions have clear priorities that depend on their particular economic background. They try to establish 'poles' and networks around these priority activities to foster the research co-operation that is required to meet regional objectives. Often, this is accomplished by pushing researchers together around a technical resource. Regional policy actors are becoming very powerful in research and innovation because they concentrate on building links between university research and local economic development.

MNERT's new genome programme is an example of a high-level response to the demands of an important research domain that requires expensive equipment and large-scale research. A network of genome centres is being funded to develop platform technologies. The centres will be based in six areas, and each will develop a specific platform technology and employ around 100 researchers working on large-scale projects. The teams will develop knowledge either about the relationship between the genome and pathology or the genome and function. Each centre has a bio-incubator, and all are linked by information and communication technologies (ICTs) to facilitate knowledge sharing. There is also an intention that the knowledge and equipment in each centre should be shared with other universities in the region.

The ability to attract research funding in Germany increasingly depends on collaboration across departments within particular universities or between the university and its neighbouring institutions. In addition, a programme that aims to strengthen particular research areas funds long-term (about 6 years) collaborative research that may involve between 15 and 45 teams of researchers across the country.

In Japan, intra- and inter- university research collaborations are encouraged particularly through the formation of Centres of Excellence (COEs) for advanced scientific research. Depending on the research field and the nature of research activities, a COE might include a chair and research section, a special course, a major field, a discipline, a research department, a research facility or centre, or a network of related research organisations. These can be broadly divided into the following categories:

- Relatively large research organisations with clearly defined organisational structures.
- Groups of loosely linked research organisations.
- Groups of researchers working together under a pre-eminent researcher.
- Joint-use groups established primarily to share facilities and equipment.

Efforts to reform the university sector and stimulate global competitiveness have led to the creation of a variety of frameworks for international co-operation and exchange. In addition, university researchers are encouraged to collaborate with government laboratories or institutions in areas where:

- R&D is irrelevant to the working of the market mechanism, such as public welfare and in areas necessary for the implementation of public policy, such as securing natural resources.
- High risks and costs deter company investments.
- The aim is to create new technological ideas or undertake basic research to solve complex technological problems.
- A local response is required in relation to international standards and norms.

In the UK, the Research Councils and the DTI place a premium on collaborative research and do a lot to encourage and support it. LINK, the main mechanism for supporting university-industry research collaboration, supports long-term enabling or generic research. The Teaching Company Scheme (jointly funded by the Research Councils, the DTI and corporate investment) enables young graduates to conduct research and development in a directly applied or commercial area. Some Research Councils favour research proposals containing an expression of interest and/or involvement by the user community, and the Medical Research Council has replaced standard project funding with collaborative grants.

The HEFCE is also concerned to promote collaborative research both directly and indirectly. Direct measures include the provision of support for generic research (GR)⁷ that is developed in collaboration with its user communities, funds for inter-institutional research collaboration (for example the £17 million CollR initiative) and other special initiative programmes. Indirectly, the HEFCE encourages collaboration where it is appropriate for world class research by providing funds for quality-related (QR) research⁸.

In the US, inter- and intra-university collaborations are increasingly being supported by the formation of research consortia that may be either physically resident in Research Centres, or virtual consortia supported by information and communication technologies.

⁷ In 1998-99, GR funds amounted to £20 million.

⁸ In 1998-99, the HEFCE provided £804 million in QR funds across 69 subject areas.

5 Career development and research training

In most of the countries studied, low levels of security, status and pay combined with deteriorating working conditions among university research professionals have led to concern for the sustainable growth of globally competitive and excellent research. Concerted efforts are beginning to be made to develop, attract and retain quality professional researchers in universities. There is widespread recognition that comprehensive changes are required to existing practices including research training, the career structure, and the terms and conditions of university work, if young and promising researchers are to be attracted to careers within the university sector and contribute towards the attainment of national research priorities.

In France, for example, the CNRS has created a shared vision of science that is linked to strategy, career management and career training. One initiative now being implemented when new CNRS 'mixed' research units are created is for the Director to go on a training course that covers strategic development as well as approaches to developing and nurturing team leaders to be able to manage research teams. The CNRS runs many short courses to help develop the capabilities of their researchers. Four-yearly site evaluations of research units may lead to recommendations for specific researchers to attend courses to improve their skills, but the CNRS is unable to enforce attendance.

The Comité Nationale of the CNRS uses rigorous evaluation procedures to recruit the best young researchers. However, ongoing evaluation of individual researchers that might be used as a basis for developing and shaping human resources is limited. Not all researchers can rise to become head of a research unit. The creation of an explicit career path through which researchers can move as they develop their expertise is essential to the attraction and retention of high quality recruits. In addition, there is a need for better human resource management to ensure that what researchers do is best suited to their capabilities, gains their commitment to research goals and stimulates the delivery of results. A major weakness of the system is that CNRS has no method for dealing with researchers (civil servants with tenure) who fail to achieve excellence in research. There is no political will to re-assign poor researchers to civil service posts more suited to their capabilities.

Problems particular to the French system in general include that:

- University teachers/researchers within universities get tenure at a very young age, have low mobility and less time to do research than their CNRS colleagues, although promotion is based solely on research performance.
- The human resource development function is inadequate to the needs of CNRS staff.
- There is no capability in the universities to develop a research strategy, aside from the training of Directors of CNRS 'mixed' units.

Germany has confronted similar problems. During the 1980s, a slow growth in core funds and rise in student numbers impaired the environment for research in universities. A jointly funded Federal and Länder programme was set up to improve the infrastructure of universities and the conditions for personnel, including schemes to promote young scientists.

All doctoral students in Germany hold temporary university positions that are funded out of the resources provided to professors by the Länder, or from research grants. They spend a

relatively large part of their time on teaching, administration or other research projects.⁹ In response to criticisms in the 1980s about the lack of structured and consistent doctoral training, almost 300 graduate colleges were established. These provide for almost 6,000 doctoral candidates in different topics at different universities, and the training includes a taught component. Grants for doctoral research come from the DFG and public foundations that are mainly connected with political parties, church, or trade unions.¹⁰

Young scientists in Germany take a considerable amount of time to reach professional independence compared to their counterparts in other countries. Efforts have been made to shorten the required time to professional independence, but so far, these have failed to change the research culture. This makes research unattractive as a career option and has led to the development of a range of initiatives to attract and retain the brightest and the best young students. For example, the Gerhard Hess Programme rewards the excellent scientific achievements of junior scientists (under 33 years of age) with a five-year grant of up to DM200,000 per year to establish an independent research team. Another programme is being developed to provide support for 100 young scientists each year, who are under 30 years old, to spend a post-doctoral period abroad and, upon their return, fund the establishment of a junior research group within a university.

In Japan, only 50 per cent of universities provide doctoral training. In 1994, there were 39,000 students enrolled in these programmes; most pay their own fees. Attracting new recruits into the university system has been particularly difficult because of public perceptions of the university research experience. Two groups of researchers are explicitly targeted for priority: young researchers and women.

In order to stimulate the entry of young researchers into the university system, the MESSC developed a programme to support the recruitment and training of 10,000 outstanding and creative doctoral and post-doctoral researchers by the year 2000. The programme is administered by the Japanese Society for the Promotion of Science (JSPS).

By and large, the research infrastructure for female researchers has been less well developed in Japan compared to other advanced nations in Europe and America. In Japan, women represent only 7.3 per cent of the research workforce. According to the Science Council,¹¹ support for female researchers is imperative because of their relatively weak position compared to male researchers.¹² A range of measures has been identified to assist the entry of women researchers, including:

- Encouragement of female researchers to participate in research projects.
- A ban on sexual discrimination, especially in selection, promotion, decision making and the allocation of roles and responsibilities for research.
- Improvements to the research infrastructure and the terms and conditions of work to make them more favourable to women.

⁹This source of funds is mainly available to science students, and is less dominant in the humanities and social sciences.

¹⁰ Steffen Bayer, *pers. comm.*

¹¹ See Chapter 2, Section 1 (8) *Extension of research opportunities for female researchers* of the Science Council Report (1999b).

¹² In terms of sheer numbers, in 1999, there were 73,000 female and 659,600 male researchers (*Statistics Bureau and Statistics Centre*).

However, while the importance of creating a more favourable research environment for female researchers has been loudly acclaimed, no such measures have yet been implemented.

In the UK, while it is recognised that career development and research training have led to the considerable success of the university research system, there are now sincere doubts that they are being used efficiently and effectively. Growth in the number of part-time and short-term contracts has resulted in difficulties for young researchers who want to build secure research careers. As a result, some take university teaching positions that have more permanent contracts associated with them, whereas others leave the sector.

In the United States, the Federal Government is a significant source of funds for doctoral research. Additional support is provided by state and local government assistance, scholarships from foundations and corporations and from the personal resources of the students. Federal support for doctoral and postdoctoral training declined in the 1970s. Since that time, the principal Federal mechanism for supporting pre- and postdoctoral training has been through RAs for students on Federal research grants awarded to their mentors.¹³

The education and human resources part of the NSF budget for science and engineering provides financial resources and training support services to promote the early career development of scientists and engineers. It has recently been recognised that a lot of additional career and human resource development takes place in the context of research projects. In order to assist young researchers in their efforts to attract funding, several of the funding agencies have provided additional funding streams that are targeted to new faculty members.

There are also growing concerns about the rise in the number of ‘un-faculty’ or ‘perpetual postdoc’ positions, non-tenure track, fixed term, research appointments in academic institutions that depend solely on outside funding and typically involve no teaching. These are considered to be detrimental to the longer-term careers of researchers.

6 Widening research

Most countries have witnessed a widening of research both in terms of the range of research domains that are being addressed as well as the numbers of universities involved in the research effort. In all of the countries studied except France (where researchers have considerable autonomy), programmes to identify research priorities have been implemented. Even in France, CNRS now identifies important new areas for research and provides additional resources for CNRS research units with the interest and capability to move into these new fields. The new areas may also be privileged in the annual recruitment of new CNRS researchers.

In France, most research is concentrated in a few universities. The teaching load is about the same everywhere, but some universities in Paris are over-staffed, and this facilitates their continued involvement in research. Three main changes during the past 10 years have widened the number of institutions involved in research.

¹³ US Congress (1991).

- a) Grandes Écoles (specialists in engineering science) are now active in research, a move stimulated by EU programmes that have focused on the engineering sciences.
- b) The numbers of universities have increased. All employ teachers/researchers, and all are involved in research. MNERT creates about 3,000 new tenured posts for teachers/researchers in the universities each year. Some academic research groups have acquired additional funds for research from a variety of economic actors. Others show emerging research capabilities because of CNRS efforts to decentralise its 'mixed' units and support the development of research capabilities in the less privileged universities. This does not cover all disciplinary areas.
- c) Research activities in the less privileged universities have also been stimulated by teachers/researchers who train manpower to suit regional economic activities and carry out research to meet the needs of SMEs and traditional economic activities. Researchers work in small teams that are recognised at the regional or local level. The staff employed here are the most heterodox, those who create the new research areas that are the basis of new 'mixed' laboratories funded by CNRS or INSERM. For instance, staff working at a hospital in Nantes were pioneers in gene therapy, before it was considered a theoretical possibility. Now, a 'mixed' INSERM unit exists there.

In Japan, the MESSC has for some time been making systematic, prioritised efforts to bring Japan's research infrastructure up to international standards and to develop a scientific research system that is open to the world. This has included the creation of new research facilities, Centres of Excellence, as well as the identification and expansion of new and existing research areas.

In Germany, with the exception of the new Länder, there has been considerable stability in the number of universities in the research system over the past 25 years. Expansion instead has happened within the same institutional frame, for example through recruitment and the creation of new departments, leading to more research actors.

In the UK, 'new' universities are striving to become 'research active' in the traditional university sense (performing basic academic research) while maintaining their previous strengths in applied research and development. In addition, the net effect of efforts to set priorities for research, like the UK Foresight Programme, has been to widen the fields of research addressed by universities.

In the US, the range of universities that are involved in research has increased dramatically. One initiative that has influenced this has been the classification system that the Carnegie Institute developed in order to enable universities to understand their various roles in the higher education system and to serve them more effectively. This classification system ranks universities on a scale from 'Research Tier 1' through 'Research Tier 3' to 'Doctoral Tier 1' and so on. The drive to attain Research Tier 1 status has served to increase the number of universities that are involved in research. Some institutes couch their strategic goals in terms of aiming to attain Research Tier 1 status in a certain period of time.

Another initiative that has increased research participation is EPSCoR (Experimental Programme to Stimulate Competitive Research), a federally funded programme that provides

sheltered competitive funds to assist the development of research capabilities among universities in less advantaged states and fosters their participation in research.

The response to changing research opportunities and requirements appears to have led to a corresponding expansion in the curriculum, and this has served to selectively introduce new fields for study and widen the research agenda. However, there has been an historical reluctance on behalf of Congress to support the so-called 'soft sciences'. While Federal funds for social science research have recently been increasing, funds for research in the arts and humanities, while more secure, are reviewed on an annual basis.

Appendix

University research policy in different national contexts

Introduction to appendix

This Appendix contains detailed reports on university research policy and funding in five countries: France, Germany, Japan, the UK and the US. Each national report identifies the main government agencies responsible for allocating funds for university research and analyses emerging patterns in the organisation and management of research. Especial attention is paid to national funding arrangements, including the differentiation between agencies responsible for allocating core funding (for infrastructure and tenure faculty research time) and those that allocate funds for research projects, either in the form of grants or human resources. The national reports include data on expenditure on university research by main field and trends on relative expenditure priorities for university research by main field, to the extent that such information is available from national statistical agencies or other bodies. Caution must be used in attempting to compare data between countries because of strong differences between countries in their institutional arrangements for funding university research and in the basis upon which such data are collected.

The reports also review recent reforms to funding allocation mechanisms and research evaluation procedures, as well as presenting current trends and recent initiatives in relation to five significant issues:

1. Support for world class research.
2. The encouragement of applicable research.
3. Recognition of research networks.
4. Career development and training.
5. Widening research (both the number of universities involved and the research areas covered).

The national reports conclude by summarising the main features of each national system of university research funding. The UK report is somewhat different from the other reports because it reflects the policy-relevant opinions of the experts interviewed and does not attempt to anticipate the results of the other studies in the HEFCE fundamental review.

1 France

There are approximately 160 higher education establishments in France. Research is mainly carried out in the universities (approximately 80) and the Grandes Écoles.¹⁴ In 1995, total Government expenditure on R&D was FF89 billion; 71 per cent of this was spent in public organisations (including universities). The public research budget for higher education establishments in 1997 amounted to FF7,609 million.

1.1 The structure of university research funding in France

Most finance for university research in France is directed through the Ministry of National Education, Research and Technology (MNERT) (Table 1, Figure 1, and Figure 1.2¹⁵). In 1997, it contributed FF3.9 billion to higher education research in the form of core funds for the universities. Core funds provide:

- salaries for full-time technicians and support staff,
- grants for PhD students,
- support for infrastructure, such as equipment and buildings, and
- resources that the university can allocate to meet its strategy (e.g. the development of new research teams).

Additional, but less visible, support for research is provided in the faculty salary component of MNERT's general budget for universities. All professors and lecturers are expected to devote half their time to research activities, and thus 50 per cent of professors' and lecturers' salaries could be considered as support for university research.¹⁶ These funds are not earmarked, but leave the university professors free to choose their own field of research.

Several Grandes Écoles are under the responsibility of other ministries¹⁷ and included in their budgets. Funding for these Grandes Écoles accounts for a large proportion of the funds flowing to higher education research from government departments other than MNERT. Additional resources for university research are provided by the regions, Europe and industrial contracts.

France does not fund research projects through the activities of research councils, as in most other countries. Since the end of the 17th century, the French research system has followed a 'Colbertist model', characterised by the development of a range of scientific and technical institutions within state owned laboratories alongside the university system (Papon, 1998). This structure has enabled the system to conduct academic knowledge production in parallel with mission-oriented research. Figure 1.1 shows public expenditure (in terms of volume and proportion) on research in particular scientific fields.

¹⁴ The Conference of Grandes Écoles comprises 28 engineering schools, 27 management schools and 14 specialised schools.

¹⁵ See section 15.

¹⁶ An estimate of the global investment in faculty salaries for research is not available.

¹⁷ E.g. The École des Mines and École des Télécommunications are under the Ministry of Industry (within the Ministry of Economic Affairs and Finance), and the École des Ponts is under the Ministry of Equipment, Housing and Transport.

Table 1: Summary of University Research Funding in France 1997

Source	Characteristics	Amount and/or trend
Total public funding	From MNERT, via CNRS & INSERM researchers, other Ministries, regional government	FF7609 million (1997)
MNERT	Core funds for certified university research units based on 4-year contracts to meet specified objectives General university budgets (50% lecturers' salaries) 1997: University research manpower 1995: 14,269 doctoral scholarships	FF3900 million. New element of direction attached to funds Amount not available 41,000 (37% growth since 1984) 10.7% inc. over 1993
Other Ministries	Grandes Écoles - carried out very little research 25 years ago. In 1995 employed 5,622 research staff	Growth in research personnel
CNRS & INSERM	Most research units of these 'organismes publics de recherche' are located in universities. CNRS and INSERM fund researchers to work in certified units and their personnel are shared with the university 1997: 11,390 CNRS researchers at universities, 2,110 INSERM researchers at universities	13% inc. over 1984 35% inc. over 1984
Regions	Funds for facilities or research programmes and projects of regional interest (to meet agreed objectives) mark a shift away from funds allocated on a per capita basis	New element of direction attached to funds

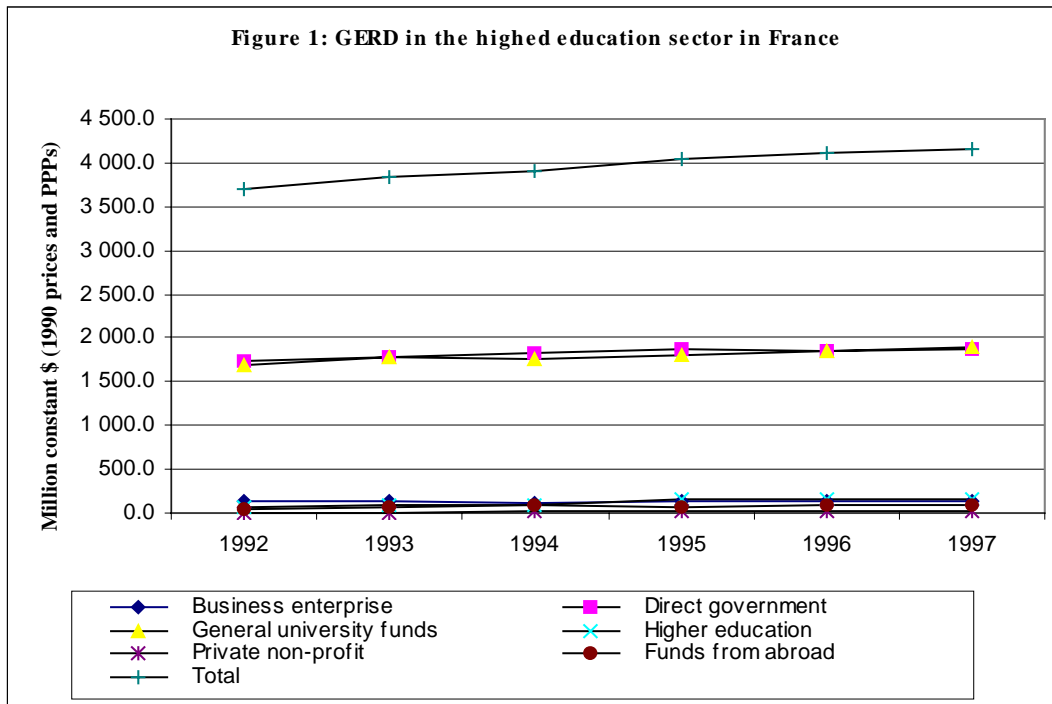
Basic academic research is primarily supported by the Centre Nationale de la Recherche Scientifique (CNRS). In addition, a group of twenty or more mission-oriented research organisations,¹⁸ which have indirect links with university research,¹⁹ support public policies for national development. Despite this variety, the activities of two research organisations are particularly significant to the universities:

- the Centre National de Recherche Scientifique (CNRS), under the responsibility of MNERT, and
- the Institut National de la Santé et de la Recherche Médicale (INSERM), under the joint responsibility of MNERT and the Ministry of Health.

¹⁸ These include the Commissariat à l'Énergie Atomique (CEA) for nuclear energy, the Centre National d'Études Spatiales (CNES) for space and the Institut National pour la Santé et la Recherche Médicale (INSERM) for medical research.

¹⁹ The mission oriented agencies do not monopolise scientific research in their own particular domain, and such research may also be supported by other public agencies (Papon, 1998). For instance, about 33 per cent of marine research is supported by the CNRS.

These agencies recruit researchers as civil servants to work in their network of over a thousand research units and laboratories, many of which are located in universities or in university hospitals.²⁰ CNRS certifies these units and evaluates them every four years, and their personnel are shared between the university and CNRS. In effect, the funds allocated by CNRS and INSERM to support these units and their staff contribute indirectly to the financing of university research. Figure 1.2 shows the organisations involved in funding the French university research system. The most significant organisations to university research financing in this figure are MNERT and CNRS, who are estimated to provide 80 per cent of all funds for university research.²¹

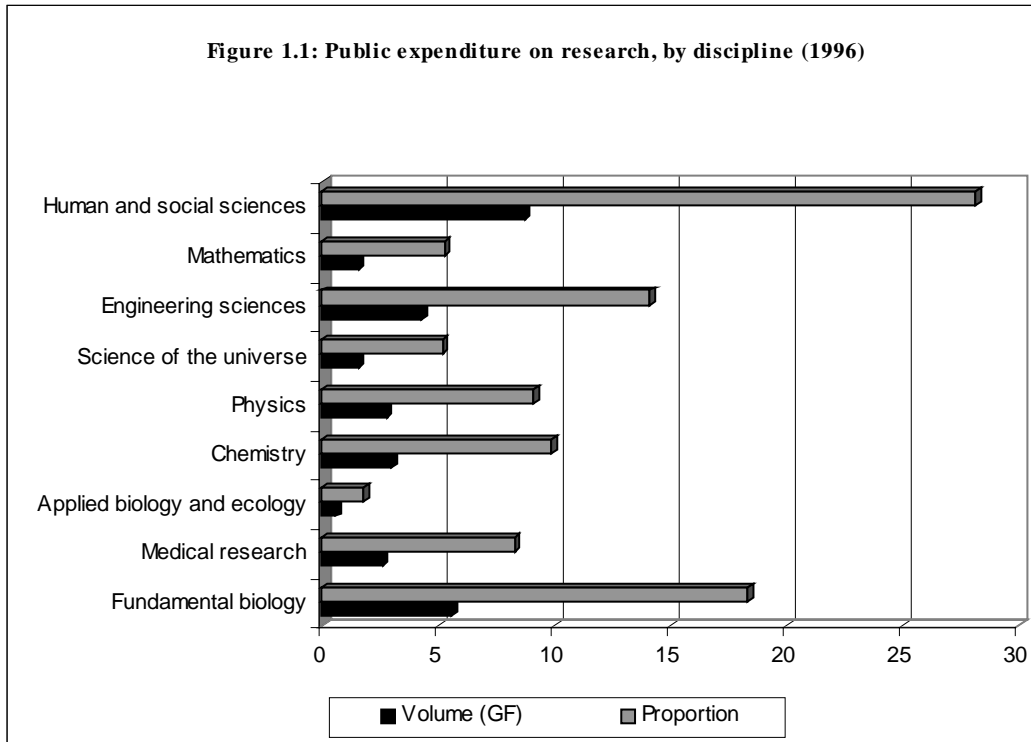


Source: OECD, 2000.

Since 1995, the MNERT has allocated funds to each university on the basis of a 4 year agreement between both parties (contrats d'Établissement) to meet stipulated research and education objectives. CNRS is involved in the part of these agreements relating to its research units, and regional authorities may also be involved. The contracts unify previously autonomous procedures for research and education and take account of the circumstances of each university, the region in which it is located and the wishes of the parties involved. The negotiation and resource allocation process gives room for universities to develop their own coherent research strategies as well as contributing to aligning university objectives with those of the national research policy. The terms of subsequent contracts will be based on the achievements of the preceding contract, which is evaluated by the Comité National d'Évaluation before renewal.

²⁰ It is estimated that 75% of CNRS researchers and 80% of INSERM researchers work in joint units in universities. In 1997 1090 of CNRS 1307 research units were 'mixed' or 'associated' units (Larédo and de Laat, 1998). These were mainly in universities but also in Grandes Écoles.

²¹ Interview with Maurice Gross, CNRS.



Source: OST, 2000.

The regions also contribute funds to university research. The majority of these funds are allocated on the basis of a joint planning process between the government and the region in what is called the ‘contrat de plan État Region’. These pluri-annual contracts cover new buildings, new equipment and programmes or projects of regional interest, and are increasingly connected with the contrats d’Établissement.

1.2 Reforming university research in France

National policy making for R&D has traditionally been the responsibility of the central ministry in charge of science and technology. Recently, this ministry has also taken responsibility for education – formerly, it was merged with industry (Papon, 1998).

The previous allocation of research funds to universities on a *per capita* basis has recently been altered. As mentioned above, university research funding is now the subject of a four-year contract²² drawn up between each university, MNERT and CNRS. Future allocation decisions will now be based increasingly on evaluations of how far CNRS units have achieved the objectives set by the preceding contract (Larédo, 1999).

Evaluation is the responsibility of the Comité Nationale d’Évaluation (CNE) that was set up in 1984 and, like the Comité Nationale d’Évaluation de la Recherche (CNER), granted independent status in 1989. The CNE evaluates all universities and other education institutions under the MNERT. There

²² See DRES (undated).

is no specially designed evaluation mechanism for university research (Geuna et al., 1999b). Rather assessment is carried out on the basis of ‘*a dynamic analysis of the efforts engaged in by universities in response to rapidly growing demand while improving the quality of teaching and research*’ (CNE, 1993). Typically, evaluation involves expert peer review of an information package and set of indicators that have been especially prepared by the university prior to evaluation (Geuna et al., 1999b). In practice, there are three possibilities for certifying university research units and allocating core funding to them. It can be achieved through MNERT, through CNRS and INSERM or through the universities' own non-earmarked funds.

During the period 1984 to 1997 there was a dramatic change in the balance between numbers of university researchers and CNRS and INSERM researchers, in favour of the former. The number of university researchers²³ grew by 37 per cent to reach over 41,000, while a much slower growth for CNRS (13 per cent) and INSERM (35 per cent) researchers gave them 11,390 and 2,110 researchers respectively by the end of the period. Even allowing for the fact that university staff may spend less than 50 per cent of their time on research, this is a much greater rate of growth than the 20 per cent increase in personnel experienced by CNRS and INSERM units. The Grandes Écoles have also experienced a rise in research capability. They carried out very little research 25 years ago. By 1995, they employed 5,622 research staff, of which 3,595 were researchers.

Four main trends characterise the French university research system:

- migration from being solely education institutes into teaching and research organisations,
- growing links between teaching and research,
- blurring of institutional boundaries between university staff and CNRS and INSERM personnel, making it difficult to identify who belongs to which institution, and
- increasing linkages between industry and university research.²⁴

Until relatively recently, there was a clear division between the CNRS, which was fundamentally responsible for the production of academic knowledge, and the other mission-oriented research agencies, which were responsible for developing policy-relevant scientific and technological activities. In effect, the activities of CNRS researchers were guided mainly by scientific criteria with little or no intervention from the government ministries, and those of the other agencies were dictated primarily by economic and political goals, although they could also be involved in funding academic science.

In the last two decades, this system has been radically transformed, partly because the linear model of innovation, that implies a strict division between science and technology, was no longer considered tenable. In 1982, a new law for science and technology, the *loi d'orientation et de programmation de la recherche et du développement de la France*, was passed, which enabled new administrative arrangements. As a result, agencies like the CNRS and INSERM were given new tasks spanning graduate training, technology transfer and diffusion. They were able to create ‘sister companies’ in order to take part in industry-related research ventures. A new legal entity, *Groupement d'intérêt public* (Grouping for public interest), was established to facilitate project-based collaboration between industry and government researchers.

²³ Based on full-time equivalents.

²⁴ CNRS' links with industry have also increased, with a ten-fold increase in the number of industrial contracts between 1980 and 1994.

Decision making about research strategies for the research institutes now follows a two-stage process. At the laboratory level there is considerable freedom. Scientists and research directors can configure their own research programmes. At the global level, however, decisions about how to build the research infrastructure, priority setting for science and so on, are taken at high levels inside particular agencies. Often, strategic decisions and funding allocations are based on bargaining and negotiations between, for instance, CNRS management and ministerial representatives. In contrast, management of the other mission-oriented research institutes is almost solely through agreement with government and agency representatives. The activities of the research units under the CNRS and other mission oriented research institutions are evaluated by peer review under the authority of the Comité Nationale d'Évaluation de la Recherche (CNER) that was established in 1989 as an independent agency reporting annually to the President (Geuna et al., 1999b).

1.3 Significant issues and current initiatives

1.3.1 Support for world class research

The main objective for CNRS units is to add to knowledge. In recent years there has been a demand that research should also be relevant. CNRS does not consider these demands to be in conflict since it believes that the best researchers are driven not only by the need to do good research, but also to ensure that the results are applied. World class research is linked to the 'mixed'²⁵ CNRS/university research units, where both university and CNRS staff have job security based on being civil servants; CNRS staff are able to do research full-time but may undertake teaching if they so wish. University staff are able to undertake research together with their CNRS colleagues and the interactions between CNRS and university staff are thought to be very beneficial to research.

These mixed units exist in many universities, but cover one or only a few disciplines in most. The funding of these mixed units is mainly responsible for encouraging world class research. The long-term core funding from CNRS and the universities represents only 40 per cent of their income. The remaining 60 per cent comes from the EC, national programmes, industry, the regions and Foundations. The fact that funds are provided by numerous sources gives the units stability. The attractiveness of these units to the other funders is fostered by the 'stamp of approval' provided by CNRS 'labeling', the evaluation on which the accreditation is based and the core funds provided to these units.

The CNRS system makes research careers extremely desirable and it is possible to attract the best people even though salaries are relatively low, because researchers are offered good working conditions, high status and a good quality environment. They do not have to seek funds to carry out research, nor do they have to respond to government priorities. CNRS staff are selected at a very young age (applicants must be thirty years of age or younger) and the process is highly competitive. Once recruited CNRS, researchers can choose the laboratories where they wish to work and are free to select the research they wish to do. CNRS also provides resources for their researchers to work abroad for some years. There is dynamism in the system in that CNRS researchers who wish to develop totally new research areas are able to submit proposals (together with university colleagues) for new CNRS units to be established. In addition, all units are assessed every four years and this conditions the core funding received from CNRS. There are two forms of evaluation for CNRS units: the first is based on a detailed report prepared by the team members of each unit. The report is

²⁵ Comments about CNRS also apply to INSERM.

reviewed by peers who consider both the quality and quantity of research outputs from the research team as a whole and from each team member. This is complemented by the report of an evaluation committee that visits each unit at least every four years. The purpose of this evaluation is to develop a deeper understanding of what happens inside the research team and the contribution made by each member. Evaluation reports identify both strong and weak points in each unit and recommend changes, if necessary. All evaluation reports go to the Comité National of CNRS, which takes decisions on whether CNRS units should continue.

Joint CNRS units have a limited life of ten years. If they wish to continue to receive CNRS accreditation they have to re-apply to CNRS, which indicates that research units need to have the capability to evolve their strategy/research mission or they will be discontinued. When CNRS units are discontinued the researchers involved move to other CNRS units of their own choosing.

CNRS and INRA²⁶ are currently experimenting with new forms of collective evaluation in about one-third of their units. There is an audit of capabilities, investments, personnel, the outcomes of research, and also future plans. These new evaluations may transform the relationship between these public research organisations and the units. 'It is becoming a contractual world, not based on projects but on the research collective; it's more of a shareholder/producer relationship than Rothschild's customer-contractor one.'

Some non-CNRS research groups in universities are rewarded by MNERT. They are evaluated as 'good labs' by MNERT, accredited as 'laboratoire recommande' and given some extra resources. Evaluation is qualitative and mostly based on peer review. MNERT now wishes to use quantitative criteria, but this will take time as they currently lack the culture for this. The present Minister is a scientist who recognises that some scientific areas now require big, expensive equipment and there are basic questions about whether specific universities have the competence to manage the equipment. That is why they now wish to use quantitative measures to assess universities' research capabilities.

The core funds provided to universities by MNERT only provide 25-50% of the amount required to do research. The remainder comes from competitive proposals at the national and international level, or from industry. Thus university teachers/researchers perform a lot of short-term contracts, which do not really help promote world-class research. MNERT has therefore recently introduced a new programme for young, newly recruited scientists. About 100-200 of these, identified as being extremely promising and having original research ideas at the interface of more than one discipline, are allowed to spend all their time on research for 3 years. There is some prioritisation in the way these young scientists are selected, with a lower number being awarded in mathematics and a higher number in the biological sciences. The intention is to kick-start the careers of the most promising new recruits. Those who achieve their research aims should subsequently have no problem in gaining promotion or securing funds from competitive sources.

The long-term job stability provided by the university system allows researchers to undertake completely original research which is out of the mainstream. However, the salaries offered by the university system are uncompetitive and do not allow it to retain the best researchers. Although employment security is thought to enhance the capability to do world class research, there is little mobility between universities, or between CNRS and the universities. Policies that try to promote such mobility have been introduced recently by MNERT.

²⁶ Institut National de la Recherche Agronomique.

1.3.2 Encouraging applicable research

As noted in the previous section, the ‘mixed’ university/CNRS units are very successful in attracting funds from industry which indicates increasing recognition that there is no separation between basic research and applied research, rather they overlap. The teachers/researchers in universities who do not belong to CNRS ‘mixed’ units benefit from resources provided by the regions for research directed towards local economic needs. These resources allow them to undertake research relevant to local SMEs, firms in traditional sectors and other economic activities (e.g. tourism); it may also be funded by local firms. MNERT also has a new fund for collaborations between SMEs and teacher-researchers to undertake applied research, especially in the area of new technologies.

Various charities²⁷ raise large amounts of money for research from the public. They allocate funds to current high profile areas of applied research, but do not fund the underlying basic research. There is no co-ordination between these charities and the major funders of university research, and their allocation of resources is not subject to the same careful scrutiny as that applied by CNRS and MNERT. There is a danger that the longer term objectives of CNRS units may be distorted when they receive funds from charities for short-term, applied aspects of research.

Interactions between teaching, research and other activities

There is lively debate in France on whether some universities should concentrate only on teaching for the first 2 years of the university training. Researchers and professors are strongly opposed to this. They argue that you need to expose students to uncertainty and help them learn how to work in that environment and to cope with novel problems. They stress that the issue for universities is pedagogy and how to shape people and build competencies, and is not about providing knowledge which may become obsolete in 5-10 years. It is considered that the general interaction between teaching and research is too weak in France. There will be an increasing need for teaching also to take place within the professional milieu where such knowledge will be applied because knowledge and practice are evolving so rapidly in certain fields.

Interaction between teaching and research works very well in CNRS laboratories, which are mostly located in universities, even those not officially recognised as ‘mixed’ laboratories. At postgraduate level, it is considered necessary to be in contact with research. Wide differences exist between universities, and those without a CNRS unit or a good track record in research cannot really train PhDs. Therefore most PhD programmes are located in universities with a CNRS unit. The Programme Doctorale is a new initiative that strengthens studies in the last year of study before the PhD. The Programme involves collaboration across a university's PhD programmes so as to provide more structured training. There is currently a big debate in France about whether doctoral training requires significant exposure or deepening of study into related fields? Some multidisciplinary fields may need their PhDs to study under two heads. For instance, scientists may need exposure to management and industry, or other aspects of life so as to encourage them to take up careers outside the university. Academics are not interested in this widening of exposure. They argue that their role is to train people in research and preparing theses, and additional requirements will increase the length of time required for doctoral training.

1.3.3 Recognising research networks

On average, each region in France has 3-5 universities. There is a strong move by the regions to ensure that their universities cover all disciplinary fields. Regional policy actors are growing very powerful in research and innovation because they concentrate on building links with local economic

²⁷ Généthon and various Patients Associations

development. They set clear priorities linked to the economic background of the region, and invest in organising 'poles' and networks around these priorities and fostering co-operation, mainly in research. Technical resource centres are used to foster research collaboration and to bring local researchers together to meet regional objectives. Collaboration is now becoming essential for building the critical mass needed at the EC level, with calls for proposals by the EC now demanding a variety of competencies that can only be achieved through collaboration. The majority of French collaboration occurs either at the regional or the international level.

MNERT's new genome programme, which involves a network of genome centres, is being funded to develop platform technologies. The centres will be based in six areas (Paris, Lille, Strasbourg, Montpellier-Toulouse, Grenoble and Marseille). Each centre will develop a specific platform technology (i.e. sequencing a specific genome) and employ around 100 researchers working on large-scale projects. The teams will develop knowledge either about the relationship between the genome and pathology or the genome and function. Each centre has a bio-incubator and all are linked by IT so as to be able to share knowledge. There is also an intention that the knowledge and equipment in each centre should be shared with other universities in the region. The initiative is a top-down response to the demands of this important research area that requires expensive equipment and large-scale research.

1.3.4 Career development and research training

CNRS has many strict requirements and one is that it shares its vision of science, expectations for strategy, career management and information on PhDs with its researchers. This requirement is crucial but not well implemented. The Comité Nationale of CNRS has a rigorous evaluation system for recruiting its researchers, but there is no ongoing evaluation of researchers that might be used as a basis for developing and shaping human resources. Moreover, the issue that CNRS fails to address is how to cope with its researchers (civil servants with tenure) who fail to meet their promise. CNRS selects the cream of new, young researchers, but not all can rise to become heads of research units. There is a need for better management to gain the best research results, get commitment from the researchers and ensure that what researchers do is best suited to their capabilities. In an ageing population it is a battle to attract and retain good young researchers. Organisations that do not offer good career paths to meet peoples' expectations will be unable to find adequate manpower.

When new CNRS research units are created the Director is immediately sent on a training course about developing strategy and fostering team leaders able to manage research teams. Directors need this training because they have to manage a multiplicity of funding sources (the three that provide core funds - MNERT, CNRS and the region as well as four or five other funders). This requires specialised manpower, and administrative staff that means that the unit has to attain a critical mass. University research groups have no method for building up these capabilities.

The system also has various problems. (1) The university teachers/researchers within these units get tenure at a very young age, have low mobility and less time to do research than their CNRS colleagues, although promotion is based solely on research performance. For CNRS staff there is inadequate human resource development. Evaluation committees (see section 1.3.1) may identify the need for specific individuals to receive training, and CNRS provides many short courses. However, there is no way to compel CNRS staff to attend relevant courses. (2) Universities currently lack the capability to develop a research strategy. It is hoped that the negotiations entered into for four-yearly contracts, subsequent evaluations of performance and re-negotiation may help to develop such capabilities.

1.3.5 Widening research

There is still a strong research hierarchy between universities (a few do most of the research). Some universities still have virtually no research component, even at the level of individual faculty. The teaching load is about the same everywhere, but in some Paris universities over-staffing of faculty is allowed so that they are in fact research universities. However, three changes during the past ten years have widened the number of institutions involved in research and the hierarchy of research capabilities may continue to evolve in coming years. This will not cover all disciplines. Some universities may specialise depending on the strategies of regional actors and of researchers connected with CNRS units.

- Grandes Écoles are now a major element in the research landscape. Their research activities have been promoted by EU programmes that have focused on the engineering sciences, the field emphasised by the Grandes Écoles.
- The numbers of universities have increased. All employ teachers/researchers and all are involved in research. MNERT has created 3,000-3,500 new tenured positions for teachers/researchers each year in the universities. At first this did not keep pace with the increase in student numbers, leaving faculty little time for research. Student numbers have now stabilised, so that the need for teachers/researchers to dedicate all their time to teaching is diminishing. Some academic research groups have acquired funds additional to their core funds for doing research for a variety of economic actors. Emerging research capabilities are evident in the others because CNRS wanted to decentralise its 'mixed' units and has been active in supporting research capabilities in the less privileged universities.
- Research activities in the less privileged universities have also been stimulated by teachers/researchers who train manpower to suit regional economic activities and carry out research to meet the needs of SMEs and traditional economic activities. Researchers work in small teams that are recognised at the regional or local level. It is in this half of the system where the most heterodox people, those who create new research areas, are to be found. Many try, but only a few succeed, those that do form the basis for the new 'mixed' laboratories funded by CNRS or INSERM. For instance staff at a hospital in Nantes were pioneers in gene therapy, before it was considered a theoretical possibility. Now a 'mixed' INSERM unit exists there.

Prioritisation between fields

France is only now beginning to introduce measures to prioritise specific fields. The four-year contracts between CNRS, the universities and MNERT set out expectations for scientific priorities. Decisions about recruitment of new university and CNRS staff are guided by priorities in specific fields. Many of the regions also shape the priorities of local universities by emphasising the need to support local economic development. Evaluations by CNRS and MNERT and the terms of negotiations are also intended to achieve some sort of vision, but MNERT was criticised in interviews with policy analysts for trying to concentrate power at the national level, but having poor operational capability. It was accused of misconceiving its role and becoming inundated with research management questions at the detailed level. For instance, it wants to identify the competencies of individual university laboratories, to control CNRS committees and to take decisions on the allocation of soft money. Meanwhile it lacks any capability to develop strategy or construct a vision for the future, and relies on scientific committees to develop strategy and Foresight. The notion of priorities has to do with capabilities in the system and a substantial project at the laboratory level. However, most research units are fairly free to do what they want. MNERT has recently identified genomics, information technology and informatics as priority areas to support. It is also

giving priority to programmes that bridge biological sciences and the human and social sciences. The genome programme, mentioned in section 1.3.3 above, is one example of these programmes.

CNRS selection of units *de facto* prioritises certain areas, but CNRS also has an annual budget of FF100M to allocate to emerging areas of research. Specific individuals are responsible for keeping abreast of the research frontier in their areas, and the significance of new fields is discussed at weekly meetings of the Directorate of CNRS (the Director General plus nine other Directors). Discussions lead to decisions about the fields to be funded, the amount of money to be allocated to each and the number of groups to be supported in each field. When priorities are identified for support, CNRS circulates calls for expressions of interest by CNRS units. Decisions about which units will be funded are based on submissions by units, which are evaluated to check that units have the appropriate capabilities, and human resources including someone capable to lead the group. These decisions may also affect the new recruits hired each year, with those with specific capabilities being favoured.

MNERT is trying to play a growing role in co-ordinating research policies among the ministries and agencies concerned. It has organised a number of disciplinary committees where all the agencies involved in specific areas of research meet regularly to discuss the development of human resources and facilities, and to develop a national plan for achieving what is required. Agreement is apparently reached about the research topics and amount of resources for which each agency is responsible. Policy analysts perceive that the capability to implement any decisions is hampered by the status of CNRS and university researchers as civil servants, the lack of control over individual research decisions and a static budget. Nor is there the capability to affect the research activities of teachers/researchers in universities or CNRS units, who have a lot of autonomy. This autonomy allows French researchers to enter new fields very quickly because they do not need any extra funding to go into a new field. The French thus entered fields like bio-informatics²⁸ and gene therapy at a very early stage. However, the French system is not good at fostering the second phase of emergence because its institutional design is inefficient and lacks any proper mechanisms to identify second stage opportunities and do something about them.

Policy analysts interviewed emphasised the need for MNERT to change the way that it manages research in terms of building capability to develop strategy, delegating management to the universities, and making decisions based on some sort of Foresight exercise.

1.4 Main features of the French system of university research

The French system of financing university research is characterised by the recruitment and lifetime employment given to French teachers/researchers in the universities and researchers in 'mixed' CNRS units at a very young age. In addition these personnel are given extraordinary autonomy to pursue research of their own choosing, and security of employment. These policies are beneficial in helping creative and highly motivated researchers to undertake world-class research, and may also lead to such research being applied. The limited lifetime of CNRS units and potential to propose the setting up of units to focus on new themes constantly renews the research base. However, these same policies may be very costly in terms of funds allocated to university teachers/researchers who do not carry out research, or to CNRS researchers who fail to live up to their early promise. The system allows maximum flexibility to researchers and leaves very little capability for top-down initiatives or

²⁸ France developed many bio-informatics researchers for whom there were no jobs in France. Many are now working in the US.

priority setting by government, and it is these issues that are currently the focus of government policy.

1.5 French experts interviewed

Rémy Barré, Directeur, l'Observatoire des sciences et des technologies (OST), Paris.

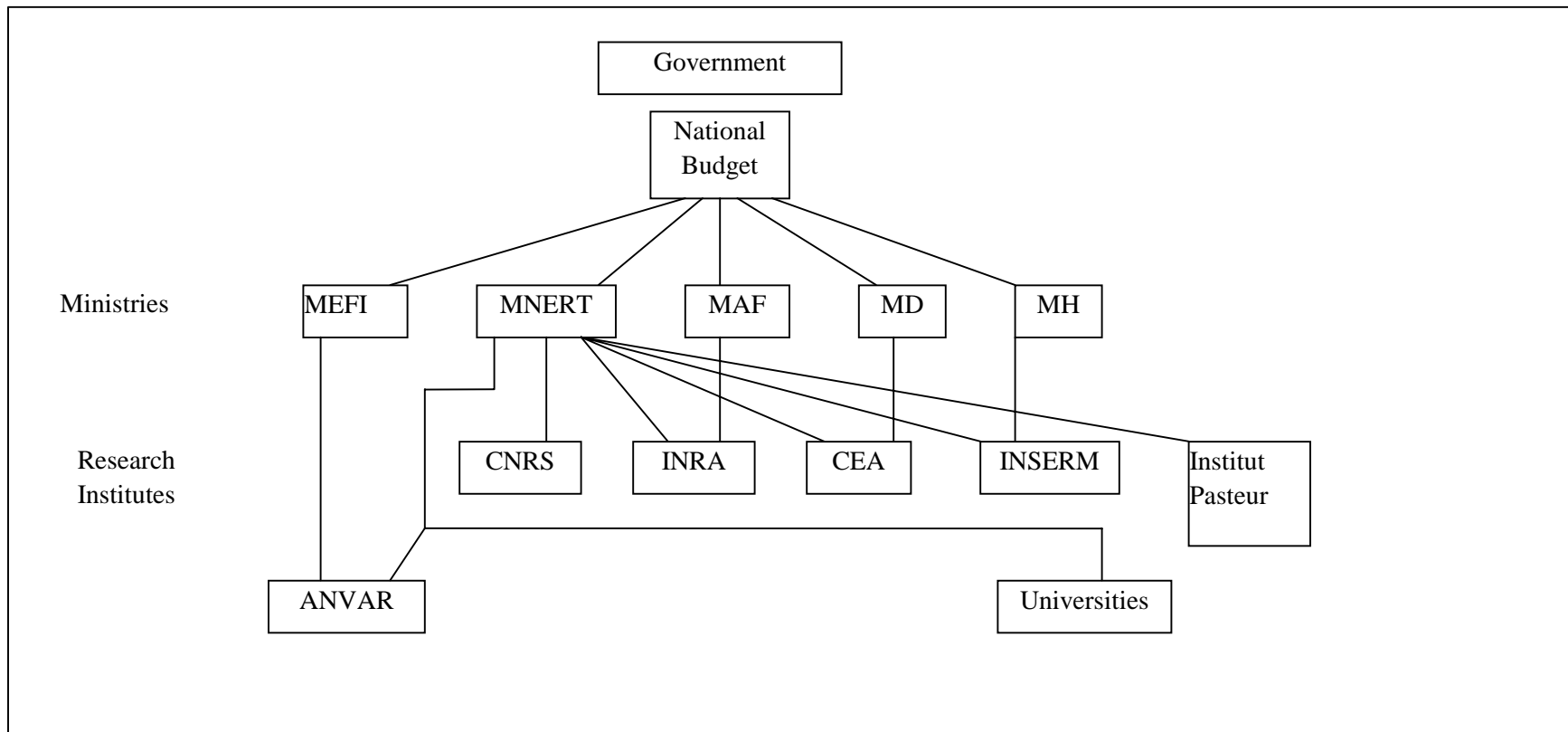
Maurice Gross, Directeur, Direction des Relations avec l'Enseignement Supérieur, CNRS, Paris.

Professor Jacques Haiech, MNERT, Paris and University of Strasbourg.

Philippe Larédo, Centre de sociologie de l'innovation, École Nationale Supérieure des Mines de Paris.

Françoise Paillous, Adjoint au directeur, Relations with Higher Education, CNRS, Paris.

Figure 1.2: Main institutions in the French R&D system



MEFI	Ministry of Economic Affairs, Finance and Industry
MNERT	Ministry for National Education, Universities and Research
MAF	Ministry for Agriculture
MD	Ministry of Defence and of Energy
MH	Ministry of Health

CNRS	National Centre of Scientific Research
INRA	National Institute for Agronomic Research
CEA	Atomic Energy Commission
INSERM	National Institute for Health and Medical Research
ANVAR	National Agency for Innovation and Application of Research

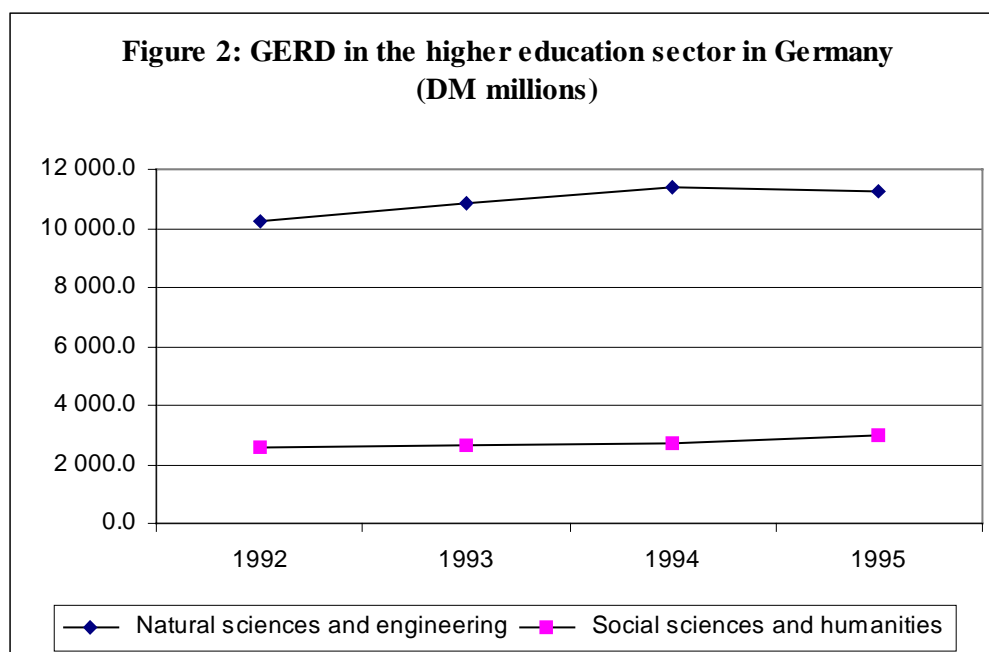
Source: European Commission DGXII, 1999.

2 Germany

In 1997 gross domestic expenditure on research and development (R&D) in the higher education sector was an estimated DM14, 700 million, 17.8 per cent of gross domestic product (BMBF, 1998). By 1998, this had risen to over DM15,000 million (OECD, 2000). Government spending on science, that had experienced an increase in 1991 to cope with re-unification, was frozen in the period 1992-95. The result was a 6 per cent reduction in spending in real terms. The new German government that came to power in 1998 announced a plan to double the science budget over the next four years. There was an increase of 20 per cent in the budget for 1999 and specific areas, including university research projects, university construction and student support, have been targeted for special attention (Balazs, 1999).

Under a dual-support system, in 1996²⁹ the universities also received about DM3.3 billion in 'Drittmittel', or 'third-party' funds, typically in the form of research grants and contracts. Of this, 34 per cent came from the Deutsche Forschungsgemeinschaft (DFG), 25 per cent from the Bundesministerium für Bildung und Forschung (BMBF) in the Federal Government, 26 per cent from industry and 5 per cent from charities.³⁰

There are few available data to identify the trends in university research funding over time. This is mainly due to the close relationship between research and education and the inseparability of accounting systems (BMBF, 1998). Where data are available, they demonstrate the significance

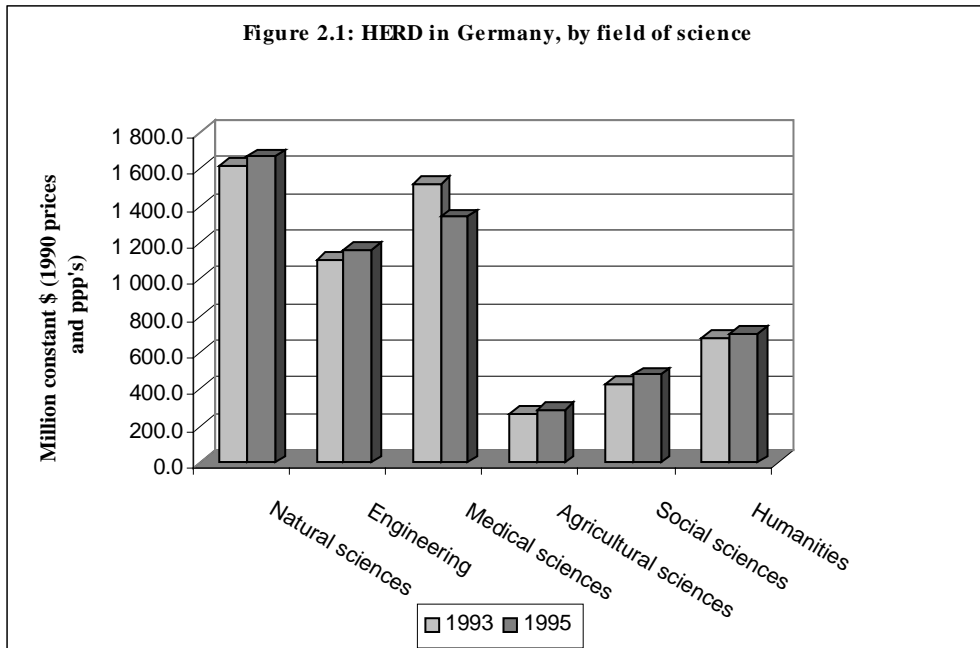


Source: OECD, 2000.

(For 1992 data, there was a break in the series with the previous year for which data were available.)

²⁹ *Pers. comm.*, Dr. Enno Aufderheide, Wissenschaftsrat (Science Council), March, 2000.

³⁰ Comparison with data for 1990 that show the proportions of various forms of research grants and contract income as DFG (37%), Federal government (29%), the Länder (4%), industry (15%), Foundations (10%) and international sources (1%) (Winnes, 1998), indicates the increasingly prominent role of industrial funding for university research.



Source: OECD, 2000.

of expenditure in the natural sciences and engineering (Figure 2). Further separation into sub-fields (Figure 2.1) demonstrates the rise in funding across all fields (with the exception of medical science) between 1993 and 1995.

2.1 The structure of university research funding in Germany

Two sectors of the German higher education system are involved in research: the ‘scientific universities’ (wissenschaftliche Hochschulen) and the ‘universities of applied science’ (Fachhochschulen). Public funds for university research can be divided into three categories (Table 2, Figure 2.2³¹).

1. Institutional or core funding for teaching and research covering staff and operating costs. This amounted to 59 per cent of university expenditure in 1994. These funds are provided by the Länder in which universities are located. The funding for teaching and research is not separately identified, and the global budget is allocated according to criteria such as number of students, scientific personnel and past spending patterns. However, for some decades teaching commitments for tenured professorial staff have been set at 8 hours per week in the ‘scientific’ universities and 18 hours per week in the Fachhochschulen. The remainder of staff time is unspecified, and relatively unmonitored – it is assumed to be dedicated to research. In recent years the Länder have provided additional resources, allocated on a competitive or performance-related basis, for temporary staff.
2. Finance for university construction and large-scale equipment, is jointly and equally provided by the Länder and the Federal Government. In 1994 this amounted to 16 per cent of university expenditure. Planning proposals for construction are put forward, either annually or semi-annually, by the universities to the individual Länder governments which, in turn, propose them to the Federal

³¹ See page 29.

Government. The Wissenschaftsrat (Science Council), an independent body providing advice to the government on higher education and research policy – particularly in relation to structural development, allocates priorities to these proposals and advises the government on funding. A similar process operates throughout the year for assessing requests for funding large-scale equipment, although recently these proposals have been passed to the DFG for peer review. The DFG makes recommendations to the Science Council and the Science Council then publishes a list of instruments that are authorised for acquisition.

Table 2: Summary of university research funding in Germany 1995³²

Source	Characteristics	Amount and/or trend
Total public funding	From the Federal Government and the 16 Länder governments. Public expenditure stagnated in real terms from 1994. Plans for science budget to double over 4 years from 1999.	DM billion 1992 13,164 1993 13,837 1994 14,439 1995 14,430 1996 14,967 1997 15,015 1998 15,310 - planned increase from 1999
Federal Government	All Federal funds for higher education sector (including university hospitals)	DM2.3 billion
Länder	Core funding for university professors to cover staff, infrastructure and time to carry out research, calculated according to constant 'R&D co-efficient'. Competitive or performance-based funds for temporary staff. Contributions to DFG and joint funding of construction/equipment. Total Länder research budget DM14.6 billion, of which universities receive 72%.	
Federal Government and Länder	Joint funding for construction/equipment. Federal Government contributed 50% of the costs of jointly agreed projects above a certain level. Funds for DFG (of which roughly 90% are channelled into the HE sector). Funds to the BMBF (1997 = DM 760 million) and other Federal ministries for research projects ('Drittmittel')	(Complicated methods for computing R&D funds for HE sector do not allow breakdown between funding sources for these components.)
German Research Foundation (DFG)	Funded by BMBF (60%) and Länder (40%). Programme and project grants on basis of peer-reviewed proposals. 92% allocated to universities including funds for Doctoral scholarships	1998=DM2.1 billion

³² Data in this table are drawn from BMBF (1996), BMBF (1998) and OECD (2000). Note that data on DFG and joint funding are part of the total research expenditure by the Federal government and the Länder.

3. Separately budgeted research in the form of grants and contracts (31 per cent of research expenditure in 1994). This third source of funds is increasing in terms of its importance to university research. The majority, just under 40 per cent,³³ of these funds is provided by the Deutsche Forschungsgemeinschaft (DFG), the central autonomous research funding organisation in the sciences and the humanities that is jointly supported by the Federal and Länder governments. While the DFG participates in government exercises to set priorities, it pursues its own research policies to promote basic and applied 'science in all its branches' (BMBF, 1999) and does not implement programmes defined by the government.

Although directed programme and project funding has increased, the bulk of the DFG's resources are non-earmarked global budgets. Currently the DFG uses its funds mainly to support university research ideas that are generated either by individuals or groups of scientists in the universities and the Fachhochschulen. This is likely to change. Recent evaluation by the European Commission has recommended that the DFG undertake more responsibility for the strategic direction of university research.

Other important sources of separately budgeted research funding include the BMBF and other Federal Government Ministries (Ministry of Economic Affairs, Ministry of Health, Ministry of the Environment and so on), the Länder, the private sector and private funds. The private sector is largely divided into Foundations. The largest of these is the Volkswagen Foundation which has an annual funding budget of around DM150-200 million. Private funds come from enterprises or from specified and unspecified donations.

Two sectors of the German higher education system are involved in research. First, the 'scientific universities' (wissenschaftliche Hochschulen), about 80 of them, which are based on Humboldtian ideas of 'learning through science' and a 'unity of research and teaching'. They undertake fundamental research and train young scientists. Since the development of science and research training is an integral part of the university mission, the funds from the Länder provide professors with resources for staff, related infrastructure and time to carry out research. In the allocation of core funds to universities the share for research is determined by the use of a constant 'R&D coefficient', based on past surveys of the working time spent on research and teaching by a sample of scientific staff. The R&D coefficient varies between about 29 per cent for medicine and 42 per cent for the engineering sciences.³⁴

The second sector is the 146³⁵ 'universities of applied science' (Fachhochschulen) that are mainly responsible for education, and concentrate on short-term and practical study courses to provide scientific knowledge and methods necessary for non-scientific professional careers for example in the engineering sciences, business and management studies or social work. They are, however, undertaking an increasing amount of applied R&D. Unlike the universities, their funding from the Federal Government and the Länder does not include core funding for research. Research projects are largely funded by grants from local industry or special public funding programmes.

Research in non-university institutions that are jointly funded by the Federal Government and the Länder supplements the research that is carried out in the universities. These institutions include the

³³ *Pers. comm.*, Dr. Christophe Schneider, DFG, March 2000. This has grown from around 36 per cent in 1996.

³⁴ In reality the percentage of time dedicated to research has been eroded as the result of an explosion of student numbers since 1975, without a matching growth of scientific staff (Winnes, 1998).

³⁵ This number excludes the Fachhochschulen operated by the Federal government and the Länder for training high-level administrators.

Max Planck Society (MPG), the Fraunhofer Society (FhG), the Helmholtz Centres (HGF), and some of the Blue List institutions (BLE). This chapter focuses on the university sector.

2.2 Reforming university research in Germany

The 1980s saw public spending on non-university research increase faster than on university research. A slow growth in core funds and rapid growth in student numbers, from about 900,000 to 1.8 million between 1977 and 1997 (OECD, 1998), have impaired the environment for teaching and negatively impacted on research in the universities.³⁶ Non-university institutes often provided a better research infrastructure and more favourable research conditions than the universities.

Since the late 1980s, several initiatives have been introduced to remedy this situation. A jointly funded Federal and Länder programme was set up to improve the infrastructure of universities and the conditions for personnel, including schemes to promote young scientists. The Framework Act of Higher Education, adopted by the German Bundestag in February 1998, promises further change. The Federal Government has pledged allegiance to five priorities for education and research in the future (BMBF, 1999):

- Equal opportunity.
- Creativity through greater responsibility.
- Research for citizens.
- Global sustainable growth.
- Accelerating structural change.

Together with the Länder, the Government (BMBF, 1999) plans to support a reorientation of the German research system and continued high quality of research through:

- Creating growing roles for competition and autonomy in the research system.
- Expanding the Fachhochschulen (universities of applied sciences).
- Providing a substantial increase in the DFG budget for research project funding.
- Giving additional funds to build R&D capabilities in the higher education institutions in the new Länder.
- Increasing funding for the construction and modernisation of buildings and equipment in the higher education sector – particularly in the new Länder.
- Updating personnel structures and employment law in the higher education sector.
- Eliminating barriers between public research and private enterprise and support the creation of new forms of public-private partnership, for example through providing support for the development of ‘competence networks’ to promote innovation and technology transfer in key areas.

³⁶ The teaching requirement for professors has not changed for about 30 years. Therefore it could be argued that research has not suffered from the rise in student numbers. However, core funding is allocated to teaching and research and has reduced in real terms, student numbers have increased and as a result there is less core funding available for research.

2.3 Significant issues and current initiatives

2.3.1 Support for world class research

In Germany, all universities and professorial staff within them are involved in both research and teaching (there is less scope for research among the Fachhochschulen because of their higher teaching load). The identification and pursuit of world-class research has traditionally been the result of generative ('bottom-up') processes, driven by the identification of high quality research ideas that are submitted for funding by individuals and groups within the research system. For example, the DFG (the main funding body for separately budgeted university research) commits about 40 per cent of its funds to an individual grants programme. This programme is open to applications from researchers in any field who have completed a PhD. It provides funding for up to three years to individuals for projects of their choosing and covers all costs that are immediately associated with the project (graduate students or postdoctoral fellows as research assistants, technical staff, apparatus, consumables, travel costs for national or international co-operation, and so on).

This emphasis, which has emerged partly because of the influence of Federalism and partly as a consequence of the basic philosophy of the independence of teaching and research from state intervention, applies to all forms of research and is at the heart of the DFG. This has contributed towards, and been fostered by, a lack of management and business leadership within the universities.

'In the long term there has been an overall tendency by very small steps to increase the possibilities of central university administration, to have a policy and to implement parts of that policy. But they've been very small steps and universities are still very very decentralised systems with a very high degree of autonomy for the individual professor, the individual group of professors or department. It's quite rare to see a university that has a policy where you can say that the university is more than the sum of its parts.'

There is also the risk that critical research areas either will not be addressed at all (perhaps because they are at the intersection between previously unrelated disciplines) or will be weak in globally competitive terms. The lack of strategic direction for research funding is under considerable pressure for change. Increasingly, competitive research programmes in target areas are being used to direct funding towards identified priority areas. For instance, the DFG has recently published a competitive call for tenders in the field of bio-informatics in order to address structural weaknesses in the research system in that area.

Most strategically oriented research is funded by the BMBF and, to a lesser extent, by other government ministries. BMBF funds are typically available to the universities as well as institutions outside the university research system. The BMBF makes no real distinction between efforts to stimulate applied versus basic research. In practice, whether these are funded will depend on the research field and the maturity of the underlying discipline(s). Its main aims are to support the best research and to distribute the available funds as widely as possible in priority areas. However, on occasion, proposals might be funded in certain universities or regions on the basis of equity over excellence as the result of political decision making.

It is very difficult within the established German university research system to establish new and interdisciplinary research areas. Departmental structures are often quite rigid and interaction and the exchange of information and knowledge between them are limited. New interdisciplinary

departments can be formed, of course, but these require either additional money or a shift in resources away from established departments and towards new departments. This, in turn, would require the movement of staff away from the established department. This is difficult to accomplish quickly in an employment system that is based on tenure.³⁷

‘Investments in higher education have been structurally under-funded, I think, for over ten years now. A queuing mechanism had to be installed and there are still far more projects in what the Science Council calls ‘Category 1’ which are, as it were, authorised for immediate funding ... so it’s difficult to ... [determine] what is actually funded. There is not one philosophy but rather a multiplicity of philosophies, because you have 16 Länder and they’re competing with each other for ... procuring university infrastructure.’

In addition, because the university system is premised on a belief of unity between research and teaching, the development of a new research area and the creation of a professorial post in that area is accompanied by the introduction of a new undergraduate course and teaching responsibilities. This reduces the sole focus on research that some argue is necessary when establishing new areas.

2.3.2 Encouraging applicable research

Traditionally, the universities were required to conduct research across all fields of scientific study, depending on the interests of the researchers. A shortage of funding requires that decisions be made about the allocation of funding between research areas and institutions. Such decisions are very difficult to implement in Germany. There is an implicit assumption that all universities and faculties are equal. At present, the vast proportion of funds is allocated to the universities without any competition or selectivity.

Despite the identification in the late 1990s by the Federal Ministry of Research and Technology and the Federal Ministry of Education and Science of a pressing need for evaluation, research assessment is not carried out in Germany. There are two main reasons for this. The first is that most universities are funded at the regional level. The second is a perceived reluctance on behalf of some, but notably not all (Brookman, 1997; Freemantle, 1997), universities to introduce competition and comparison between universities in order to encourage research because these measures are seen as counter-productive (Geuna et al. 1999b).

The Framework Act of Higher Education aims to counter these views. In order to secure the competitiveness of German higher education institutions, it provides infrastructural support for reform including the stimulation of competition through a mix of measures including incentive schemes, performance orientation and deregulation (BMBF, 1998).

The introduction of competition between departments and universities for the allocation of core funds, promoted by the government in the belief that,

‘Germany must have an efficient, competition oriented science system if it is to maintain its position in today’s global competition’ (Viehoff, 2000).

is therefore recent and highly controversial, requiring the differentiation between universities on the basis of merit and negotiating power. It requires change to established university structures and

³⁷ Under the tenure system, if professorial staff have been employed in an institution for more than 15 years and that institution is re-configured or closed down and their services are no longer required, then the Länder is responsible for finding them alternative employment. Those who have been employed for less than 15 years have their tenure terminated and are given some financial compensation.

practices and the development of capabilities for the creation and implementation of strategic policies at the departmental and senior administrative levels within the system. The DFG considers that the universities would prefer more freedom from the performance-oriented distribution of funds (in teaching and research) and from state regulation and public micro-management. The universities are not convinced that government initiatives are directed towards strengthening research but are instead oriented towards cost reduction.

The Wissenschaftsrat has been examining the potential to introduce some form of quantitative research assessment in order to assist its evaluation of institutions. However, at present research assessment is based on peer review and visits to selected institutions. Through the implementation of these methods, the Wissenschaftsrat is attempting to establish an overall view of research quality (not a well understood or standardised concept in the context of the German research system) and the strengths and weaknesses of each institute's research profile.

In addition, there is concern that allocation decisions made on the basis of research excellence might not appropriately reward the activities of the Fachhochschulen. These institutes have traditionally relied on third-party money but have recently been attempting to develop profiles and status akin to the scientific universities through research. This is partly because university staff have higher salaries (professorial staff in the Fachhochschulen tend not to have achieved habilitation) and a lower teaching load.

Teaching and students

Professorial staff in the universities are required to teach for 8 hours per week,³⁸ those in the universities of applied sciences have an 18-hour per week teaching commitment. Aside from this, they are free to decide how to use their time. It is expected that professors will have some additional contact time with students aside from teaching but this is not required. Some professors live considerable distances from their universities and only come to work for one or two days to fulfil their teaching obligations. Universities in some Länder are introducing 'time of presence' requirements to increase the availability of professorial staff to students. Postdoctoral staff also teach. Their teaching load is typically reduced (to about 4 hours per week), as is the scope of their teaching responsibilities.

Staff numbers have not grown in pace with student numbers. Teaching time is fixed but class sizes have increased considerably.³⁹ The reputation of teachers comes mainly from research and publication. As a result, there has been no real incentive within the German system to achieve excellence in teaching. In general it is now considered more important to improve teaching than research performance. One initial step towards the identification of and reward for teaching quality is the development and implementation of teaching assessment methods within the universities. However, the concept of teaching quality is largely undeveloped in Germany.

It is very difficult for the government to intervene in this process. While it is fundamental to the overall system that professors conduct both research and teaching, the Federal Government is only able to support research and is not allowed to provide assistance for teaching. However, the Federal Government can support research into teaching, for example through the development of pilot

³⁸ Professors allocate this time according to where they see their priorities within their discipline.

³⁹ While there is a complex method for calculating the maximum capacity for certain courses, there is concern that these calculations are inaccurate and overestimate capacity load.

projects in teaching assessment. At present, there are a few regional agencies that are experimenting with teaching evaluation at the departmental and single course level.

In effect then, while it would be an overstatement to say that there is no assessment mechanism to assist in the allocation of core funds, there are a multiplicity of assessment mechanisms under development. None of these aims to address departments or universities as a whole or to tie consequences for core funding to their outcomes. Instead they monitor the research performance within departments.

At present then, and in general, neither ability in teaching nor in research carries any consequences in terms of the allocation of core funds. However, as the exception that proves the rule, selectivity has recently been introduced in the allocation of core funds to medical schools. Here, two thirds of funds are provided on the basis of student numbers and the remainder is allocated according to success in attracting third-party money and publication performance.

Prioritisation for research

While there have been attempts to develop centralised systems for research prioritisation in Germany, for instance in 1994, a pilot study using foresight and Delphi techniques was conducted in three areas of materials research, these have generated resistance. In Germany, priorities for research are seldom centrally planned. The initiative to open new research areas generally resides with the university researchers (and sometimes the Länder).

Nevertheless, in June 1999 the BMBF launched FUTUR, a new internet-resident, policy-oriented national forum for scientists and industrialists to debate and share visions of the future of education and research that could be supported through funding, for instance for integrated innovation and new application-oriented programmes of education and research (Viehoff, 2000).

Moreover, in selected key areas attempts to implement priority research programmes to stimulate research are escalating. Both the DFG and the BMBF support priority programmes of research in selected fields where researchers are free to define their research project within a given scope. These programmes are operated through competitive calls for proposals and these are then subjected to open panel review. One example is the BMBF's BioRegio competition launched in 1995 for the targeted development of biotechnology applications. To date, the programme has allocated DM150 million to support biotechnology projects in three winning regions.

Co-ordination of research policies

There are two main central co-ordinating bodies for research policy and funding in the German research system: the Wissenschaftsrat (Science Council) and the Bund-Länder Commission for Educational Planning and Research Promotion (BLK).

The Wissenschaftsrat is an independent advisory body between the Federation and the Länder. It employs 32 scientists, 6 representatives of the Federal Government and 16 representatives of the Länder Governments. Its role is to draw up recommendations regarding the development of future higher education, research and science policy. It is responsible in particular for consideration of the quantitative, financial and implementation-related implications of research and infrastructure proposals and directly assists in allocation decisions. As part of that role, it regularly conducts evaluations of funded research institutes and has been deeply involved in the restructuring of the higher education system in the new Länder.

The Wissenschaftsrat supports, and is facilitated by, communication and agreement of common strategy between the various Länder – especially concerning the ‘big research questions’. It is particularly concerned with strengthening competition between universities, assisting co-operation and facilitating mobility between different Länder (e.g. by supporting the seamless exchange of personnel and practices through creating a common understanding of infrastructure and research practice in the different regions).

The BLK is the highest consultation and decision making body in the German research system. It includes representatives from both the Federal and the Länder Governments. Their roles are to collaborate in order to plan for education, to promote institutes and support scientific research projects of national importance. Decision-making is supported by two committees, on ‘Educational Planning’ and ‘Research Promotion’; in addition, working groups, working panels and *ad hoc* groups are set up to contribute towards the preparation of draft decisions.

Co-ordination between the 16 Länder Governments is the responsibility of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder (Kultusministerkonferenz, or KMK).

2.3.3 Recognising research networks

Increasingly third-party money requires research collaboration for funding. For example, the DFG provides funds for undertaking intermediate scale scientific research projects on a co-operative or inter-disciplinary basis.

The DFG also funds 280 collaborative research centres that are distributed across 8 universities. These centres are collaborative across departments within particular universities, they aim to be collaborative between the university and its neighbouring institutions but they are rarely collaborative between universities (the programme is locally focused). There is a strong inequality in this distribution. Some universities have as many as 12 collaborative research centres and many have none.

A parallel programme that was initiated in the 1980s, also funded by the DFG, is collaborative across the nation and aims to strengthen particular research areas. Projects may, for example, involve between 15 and 45 teams of researchers collaborating for about 6 years.

Graduate research schools have grown up⁴⁰ over the last 10 years to provide support for groups of academics that collaborate to implement joint graduate studies courses. These schools, many of them inter-disciplinary, recruit national and international graduate students to their PhD programmes. One of the positive effects has been to reduce the net time between diploma and PhD by more than a year (over 20 per cent).

The lack of any clear distinction between applied and basic research is now generally accepted in Germany. The linkage between the two has generated the potential for universities to attract industrial income. Universities often therefore compete with the Fachhochschulen for applied research contracts from industry. In general, the Fachhochschulen tend to be smaller than the universities and the universities tend to attract the more costly and larger scale applied research projects. The projects undertaken by the Fachhochschulen are more often directly linked to local industry. The universities and Fachhochschulen do co-operate in areas of industrially relevant

⁴⁰ There are currently about 300 graduate research schools in Germany. Again they are heavily concentrated in particular universities.

research – especially in areas where they have complementary skills. Sometimes, however, co-operation is stimulated by cost. For example the cost of equipment testing might be lower in the Fachhochschulen than elsewhere.

From the perspective of the BMBF, one of the main problems of university-industry collaboration is the lack of genuine exchange between the parties, involving the movement of key staff across institutional boundaries. Overcoming the institutional distance between the various actors in the research system (the universities, the DFG, MPG and FhG) is therefore a priority. One of the reasons for this is that the system of professional rewards (pensions and so on) is not transferable between sectors and disadvantages those university researchers who want to take leave in order to collaborate in industrially relevant research. Steps are underway to overhaul the university salary system.

The BMBF provides substantial funds for collaborative, industrially relevant, pre-competitive research in order, among other things, to pool resources for research and stimulate technology transfer between science and industry (OECD, 1998). The BMBF's 'research co-operation' programme, which aims to strengthen innovative capability among small and medium sized enterprises, supports the generation of sub-contracting relationships, contract R&D work and temporary personnel exchange between business and higher education institutions.

2.3.4 Career development and research training

Student training is typically discipline based. The BMBF takes the view that the German research system is best strengthened by first providing researchers with a strong foundation in core disciplinary studies and then, at the research level, by providing support for inter-disciplinary research through the introduction of special programmes. As a result, the pattern of research output from the universities is considered to be very different from the structure of the universities themselves.

Young scientists in Germany take a considerable amount of time to reach professional independence compared to their counterparts in other countries.⁴¹ The typical tenure track career path leading to a professorial appointment requires students to complete 13 years of schooling, 4/5 years as an undergraduate to reach diploma or MA level, a doctorate and then a postdoctoral period of 'habilitation' which represents a further 5 years. In an effort to curtail this pattern, the requirement for habilitation may now be substituted by outstanding research or publication (implementation of this is at the discretion of the Länder). To date this has failed to change the overriding culture of research and 98 per cent of professors still take the traditional path.

This makes university research unattractive as a career. It also negatively impacts on female participation. The proportion of women in research is low – about 4 per cent at professorial level and, depending on discipline, 10-15 per cent at postdoctoral level. It is particularly low in areas like civil engineering and computer sciences where there are now structural weaknesses in the German research system.

Students tend to complete their PhDs in the same institute where they completed their diploma. There is a certain amount of mobility, including international mobility, at the end of the PhD phase. The DFG is attempting to stimulate this by privileging those graduate schools that have exchanges

⁴¹ The system is particularly poor at identifying and coping with students who are not performing well. As a result, there is often a considerable difference between the official and actual times taken to complete undergraduate degrees.

with university institutions in other countries, currently mostly in Holland and France but increasingly in the US.

Within its individual grants programme, the DFG awards more than 1,000 fellowships per year to outstanding young scientists and scholars. For example, the Gerhard Hess Programme rewards the excellent scientific achievements of junior scientists (under 33 years of age) with a five-year grant of up to DM200,000 per year to establish an independent research team.

Many grant holders go abroad to participate in international research teams. Another programme is being developed that will stimulate 100 young scientists per year, who are under 30, to spend a post-doctoral period abroad and, upon their return, fund the establishment of a junior research group within a university. These students would be expected to qualify for a senior (professorial) academic post within 5 years (by which time they would still be substantially under 40 years old).

‘Two questions haven’t been answered. One is, what’s going to happen to these people when they’re 45 or when they’re even 50 or 55? ... The other one is how are they going to be established and grow professional roots in an environment which still has the same structures as traditional university structures?’

University salaries in general are considered to be uncompetitive. Most professorial staff are awarded the same salaries. Tenured professors are given a salary increment if they are selected for and accept a tenured professorial position in another university (of course, their home university can match or increase this salary to entice them to stay). This initiative, intended to reward excellence and stimulate mobility in the system, has been open to some abuse as some professors have joined forces and exchanged jobs with those in other universities in order to spiral their earnings. A new system of performance related pay is under development to link professorial salaries to performance in teaching and research.

Universities compete to attract and retain good research staff, often on the basis of investments in the scientific infrastructure. Universities of applied sciences (the Fachhochschulen) find it difficult to attract and retain staff, especially in new study programmes that are commercially relevant, for example multimedia. This is because there are so few with the academic qualifications for teaching in those areas and those with qualifications can attract much higher salaries in private enterprise.

2.3.5 Widening research

With the exception of the new Länder, there has been considerable stability in the number of universities in the research system over the past 25 years. There has been expansion, for example through recruitment and the creation of new departments, leading to more research actors within the same institutional frame. Prior to unification, the universities in Eastern Germany performed very little research. Research was mainly located in the Academies of Sciences. After unification there has been a drive to introduce and build capabilities for basic and applied research in the former East German universities. For example, the BMBF’s InnoRegio funding programme (launched in April 1999) is dedicated to the development of innovative capabilities among the new Länder. It provides support for the creation of new forms of co-operation between education, research, economy and administration in order to foster the development of marketable products and services. Over 400 applications for support were submitted and of these, 25 winners will be nominated for a grant of DM300,000 to develop their initial ideas (Viehoff, 2000).

2.4 Main features of the German system of university research

Key strengths of the German system of support for university research are the variety of ways that research can be funded by combining core funding with project funding from a range of different sources.

This is complemented by the substantial capability for research within the system. All professional staff in the universities and the Fachhochschulen are research active and there is also the potential for interaction with a variety of different types of research institutions outside the university system.

The education system, closely linked to research, has a very broad base. One reason for this is that decisions about discipline specialisation are taken late. As a result, regardless of discipline, it is possible to pursue a successful professional career from almost any university in the German research system.

However, the effectiveness of the system is limited by a range of factors including:

- Rigidity of traditional university structures and procedures.
- The absence of competition and selective allocation of funds.
- The late attainment of research independence for career professionals within the system and lack of effectiveness of measures in place to address this.
- The entrenched disciplinary basis of university research.
- Lack of strategic direction and management within departments and universities.

The main challenges that the German system faces, then, are to:

- Raise and sustain a high level of investment in information and knowledge.
- Develop and implement instruments to help prioritise and select between research areas and universities and co-ordinate the activities of the research system at the national level.
- Meet the need for major improvements to the university system infrastructure.
- Create an appropriate professional career structure for university researchers.
- Increase collaboration between the university and non-university sectors, including co-operation in training doctoral students.
- Enable scientists to hold joint appointments in the university and non-university sectors.

2.5 German experts interviewed

Dr. Enno Aufderheide, Wissenschaftsrat, Cologne.

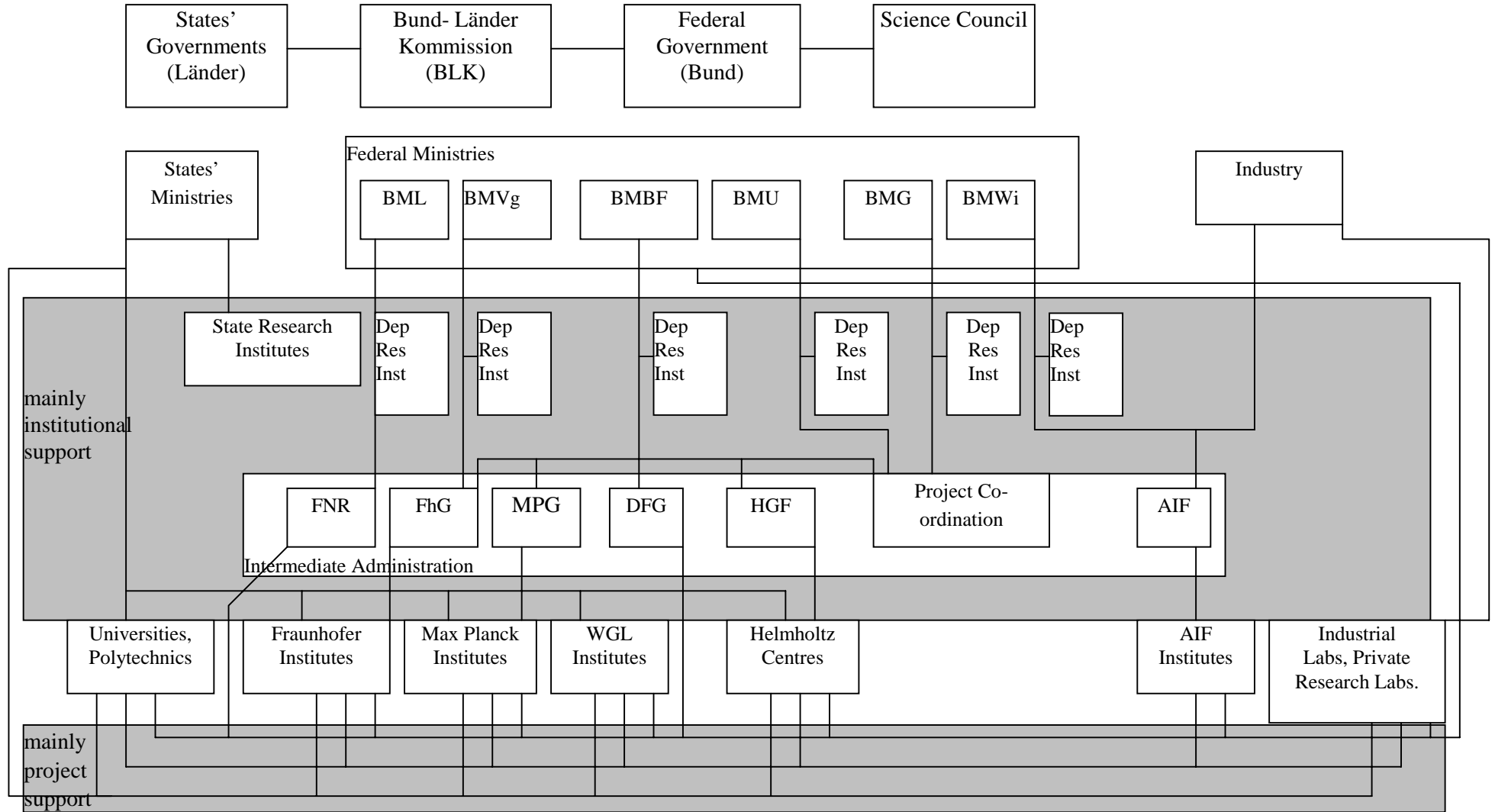
Magnus Milde, BMBF, Federal Ministry of Education and Research, Bonn.

Dr. Christophe Schneider, DFG, Bonn.

Roland Thiefelder, KMK Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland.

Ludger Viehoff, BMBF, Federal Ministry of Education and Research, Bonn.

Figure 2.2: Structure of the German R&D System



Source: Adapted from European Commission, 1999.

3 Japan

Japanese research policy has placed a strong and growing emphasis on the role of the higher education sector, universities and national/public research institutes, in achieving world class status in research. The decade-long trend, according to which academic research accounted for a declining⁴² share of total Japanese R&D performance between 1980-1991, ended in 1992. The 'Reform of University Education' in Japan (OECD, 1998), together with revised Government policies for university research and funding has contributed towards this.

According to a recent report by the National Science Foundation, *'In the 1990s, the government is the dynamic growth sector of R&D in Japan. After a decade of stagnant funding throughout the 1980s, Japanese government support of R&D has increased 5.7 per cent annually in real terms in the 1990s'* (NSF, 1997). Policy reforms, particularly those that have been implemented through the new funding programmes of the 1990s, have aimed to alter the culture of science in Japan and stimulate creative and internationally competitive research. These have:

- increased government spending on scientific and technological research within universities - especially basic strategic research,⁴³ which has been receiving special attention,
- increased the selective allocation of funding, for instance through the competitive grants-in-aid for scientific research programme in universities,
- created Centres of Excellence (COEs) to pursue world class science,
- fostered research co-operation between universities and industry as well as between universities in Japan and those in other countries,
- invested in improvements to the scientific research environment in universities by widening sources of funding and upgrading facilities and equipment,
- introduced new mechanisms for funding young scientists from industry and university on fixed term appointments,
- stimulated researcher mobility, including researcher participation in international research, and
- encouraged flexibility and growth of the university education and research training system.

In 1998, Japan had 587 universities.⁴⁴ These can be divided into three main types: national, private and local public (municipal and prefecture). The 431 private universities educate over three-quarters of all university students, the 98 national universities train about 20 per cent, and the 57 municipal and prefecture universities train the remainder. One 'University in the Air' was established in 1983⁴⁵ in order to provide multi-media based lifelong learning opportunities to people across the nation. In addition, inter-university research institutes, not attached to specific universities, are available for use by all university researchers. These have been established in fields that require large-scale facilities and equipment, or where research demands the participation of large teams of researchers (Sigurdson, 1995, p. 74).

⁴² From 17 per cent to 12 per cent.

⁴³ This term reflects the government's view that it should invest in basic science as a strategic imperative, it does not mean that strategic areas of basic science should be identified for support.

⁴⁴ See <http://www.monbu.go.jp/armashi/1998eng/e4051.htm>

⁴⁵ Student enrolment started in April 1985. Broadcast services were initially limited to the Tokyo area. National coverage began in January 1998 (<http://www.monbu.go.jp/armashi/1998eng/e4051.htm>).

Most research is carried out in national universities; the private and public universities, with some exceptions, have weak science faculties and support very little research. In 1996 universities⁴⁶ employed 243,000 researchers,⁴⁷ 36 per cent of all researchers in Japan.⁴⁸ The main purpose of the universities 'is to conduct in-depth teaching and research in specialised academic disciplines and to provide students with advanced knowledge'.⁴⁹

In Japan, most of the issues that relate to university research are dealt with by the Ministry of Education, Science, Sports and Culture (MESSC) (Table 3, Figure 3). The MESSC is responsible for both:

- the distribution of general university funding to national universities, and
- financing separately budgeted research.

This section, examining research policy and funding in Japan, is therefore constructed primarily on the basis of interviews with, and documents produced by, the MESSC and its implementation arms such as the Japan Society for the Promotion of Science (JSPS). Other ministries and agencies also have some limited influence over government research policy and funding. For example, the Science and Technology Agency⁵⁰ (STA) and the Ministry of International Trade and Industry⁵¹ (MITI) can directly provide funds for university research. Where appropriate, the views of their representatives who have been interviewed in the context of this study are reflected.

3.1 The structure of university research funding in Japan

Japan's national system of university research funding consists of two sub-systems (Table 3, Figure 3.2⁵²). The first is the direct funding for university research that comes from the MESSC and its implementation arms such as Japan Society for the Promotion of Science (JSPS). The second is research funding from other ministries and agencies to which individual researchers and teams of researchers of universities have access.

⁴⁶ 'Universities' includes university departments (including graduate schools), university research institutes, inter-university research institutes, junior colleges and colleges of technology.

⁴⁷ It has been suggested that official statistics on the number of university researchers do not accurately present the relative weight of the universities' role in Japan's science and technology system. The MESSC provides less than 10 per cent of total national expenditure on R&D. Sigurdson (1995, p.68-69) offers two main reasons for this mismatch. The first is that university researchers are poorly equipped and, apart from salaries, given limited research funds. The second is that the number of academics engaged in research has been distorted by including those who are wholly engaged in teaching, and those who are only involved in conducting tests required by the curriculum.

⁴⁸ Based on Figure 2-1, MESSC, 1997, p. 21.

⁴⁹ See <http://www.monbu.go.jp/armashi/1998eng/e4051.htm>

⁵⁰ The STA is mainly responsible for funding a range of national laboratories such as the National Institute of Science and Technology Policy. They also fund 'big science' facilities, competitive grants-in-aid funding programmes and conduct regular and detailed surveys of key research areas.

⁵¹ MITI increasingly supports basic research and the broad exploration of innovative potential. In contribution towards government initiatives for future innovation through basic science, MITI has formed the National Institute for Advanced Interdisciplinary Research (NAIR) and the National Institute of Bioscience and Human Technology.

⁵² See page 48.

An analysis of science and technology expenditure in the overall government budget (Table 3) reveals that research-related expenditure in Japan totalled ¥3,652 billion for the fiscal year (FY) 1998 (April 1998 to March 1999). Of this, the MESSC accounted for ¥1,499.7 billion, or 41.1%, the STA for 23.3%, and the MITI for 18.5%.⁵³ While the MESSC's science and technology budget is principally directed to university research activities, the budgets for the other ministries and agencies are not. The MESSC is the main source of funds for university research in Japan.

Table 3: Summary of university research funding in Japan 1997

Source	Characteristics	Amount and/or trend
MESSC	Provides: Core research funds for national universities Facilities etc. for national universities Inter-university institutes Contribution to private & local universities Competitive research grants Grants to JSPS	¥1289 billion(1997)* 10% annual increase ¥637.4 billion ¥154.8 billion ¥172.6 billion ¥157.9 billion ¥112.2 billion ¥39 billion
Japanese Society for the Promotion of Science (JSPS)	Administers new Research for Future Programme (created 1996) based on priority fields and projects. Funds from seven govt. ministries and agencies, allocated to commissioned research, mainly in universities JSPS Research Fellowships (established 1996) to support 10,000 post-doctoral researchers by 2000. Funded by MESSC, MITI and Ministry of Agriculture, Forestry and Fisheries	¥56.9 billion 77% annual increase 7,926 (doctoral and post doctoral studentships) 30% annual increase
Competitive research grants	75% increase in budget since 1992 with plans for continuing increases Fund includes allocations to selected Priority Programmes	¥112.2 billion (increasing) Priority Programmes to be expanded

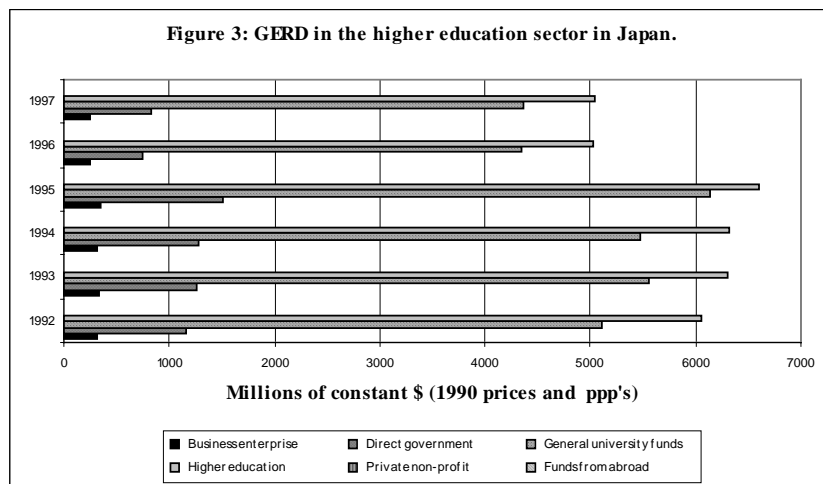
* Total budget includes other unspecified costs

Funds for science and technology are provided through the allocation for science and technology in the general and special accounts of the government budget. In FY 1999, the MESSC general account had an appropriation of ¥5,876.1 billion, including ¥131.4 billion for grants-in-aid for scientific research, ¥25 billion for the Research for the Future (RFTF) programme, ¥1.2 billion for local public universities, and ¥305.1 billion for private universities.

Funding for national universities is provided through the special account for national educational institutions, including national universities and inter-university research institutes, which is separate from the general account. In FY 1999, the special account provided ¥2,726.1 billion for national universities including staff salaries, unit costs per professor, and facility improvement costs. Staff salaries are funded under the *koza*, or chair, system. Each *koza* is responsible for both teaching and

⁵³ MESSC (1998), p. 385.

research; the MESSC funding covers the salaries of a professor and associate professor, two assistants and two technicians; all are employed by the MESSC and have the status of civil servants.



Source: OECD, 2000.⁵⁴

Research funding from the MESSC is allocated by a dual support system, which consists of two parts: basic funds and competitive research funds. Basic funds cover the general research funds and costs of operation, research facilities and equipment that enable researchers to undertake fundamental research activities on a regular basis. A prime example of basic funding in the MESSC budget is the unit cost per professor in national universities. Competitive funds are allocated selectively to researchers or research groups on the basis of appropriate screening and evaluation. Competitive research funds include both grants-in-aid for scientific research and research expenses provided under the Research for the Future (RFTF) Programme. These types of competitive programme funds have priority in Japan and have increased throughout the 1990s. In addition, the MESSC has passed legislation to enable the STA and MITI to directly fund university researchers. Overall, the dual support system is considered to have functioned well so far. However, due to tight budget constraints, and especially since the 1996 financial crisis, it is strongly pressed to promote efficient and effective utilisation of science and technology funds by expanding competitive research funds relative to basic funds. Figure 3 shows (in constant 1990 \$) gross expenditure on R&D in the higher education sector between 1992 and 1997.

3.2 Reforming university research in Japan

Until recently the main function of the universities had been to educate the large numbers of people, particularly engineers, required by industry. In global terms, the Japanese research system was not considered to be competitive - especially in comparison with the United States. In order to become world class, the 1995 Science and Technology Basic Law aimed to achieve a higher standard of science and technology in Japan. Following this, a 1996 Science and Technology Basic Plan was drawn up to foster the development of a more open and flexible research system and to reinforce basic research and development activities, in which universities play an important role. The main elements of this Plan are:

⁵⁴ The data on which this figure is based suffer from a number of problems including adjustment, estimation and over-estimation and breaks in series from the previous year's data.

- a substantial increase in budgets for competitively allocated research grants,⁵⁵
- an expansion of priority funds (for nationally important big science and large-scale projects in fundamental domains relevant to humankind, environment and society), and
- an increase in basic funds for *koza* in national universities.

The MESSC also seeks to improve research facilities and equipment, to establish and upgrade scientific information distribution systems, promote information exchange and research collaboration between sectors, regions and nations, to stimulate researcher mobility and to promote the inclusion, for example, of women into the university research system (Lepkowski, 1997a).

The Plan further recognises that university research is enriched by diverse sources of funding. External funding for national universities increased steadily between 1985 and 1996. For instance, commissioned research income quadrupled in the period, reaching ¥14.1 billion in 1996. New schemes to encourage university-industry collaboration aim to further this trend.

A 1998 Report by the University Council, 'Educational Reform Moving Forward' elaborated the main tenets of the Plan and specified its dual aims of '*diversification and individualisation of higher educational institutions*'. It echoed earlier reports, such as the 1997 White Paper on Science and Technology, in putting the 'establishment of a plural evaluation system' on the agenda as critical to ensuring the global competitiveness of university research and stressed the importance of linking this to resource allocation. The main themes (Lepkowski, 1997a; Lepkowski and Seltzer, 1996) that characterise the prevailing university research system in Japan include:

- Awareness of significance of basic research for innovation.

It is increasingly recognised that, in a growing range of fields where basic research is closely linked to applied and development research - such as bioscience, the outcomes of basic research can lead to immediate practical benefits.

- Recognition of the need for effective collaboration and co-operation between academic and industrial research.

In more and more fields, research is beginning to depend on co-operation among numerous institutes and researchers. This is especially true of so-called 'big science', including accelerator science and research on nuclear fusion, research in human genomics, brain research, cancer and AIDS research, and strategic research, such as environmental science. Such multidisciplinary fields demand joint research spanning a range of disciplinary fields. There is growing awareness that progress in these areas requires the promotion of comprehensive and balanced policies that take interrelationships between natural sciences, the humanities and the social sciences into account.

- Japan was becoming an unpopular place to conduct research.

Traditionally, good research facilities were not located in universities but in industry, in applied ministerial research institutes and in special corporations. However, industry was progressively moving its research and manufacturing activities offshore, a process that the Japanese call 'hollowing

⁵⁵ This increase continues a trend of annual growth rates of 10 per cent or more for budgets for these grants since 1993 (see Figure 2-10, MESSC, 1997 p. 33).

out' (Lepkowski and Seltzer, 1996). Efforts are being made to change the culture, standard and public perception of university research.

- University research lacked a career structure for young researchers and there was insufficient mobility between research jobs.

In order to grow the university research base, policies have been put in place to attract, retain and develop young research professionals and improve their status.

- Women were under-represented in the research system.

Policies recognise, but have been largely ineffective in combating, the weak representation of female researchers in universities.

3.3 Significant issues and current initiatives in Japan

3.3.1 Support for world class research

The MESSC aims to stimulate basic research that requires an organised and international approach, that addresses social needs, or that depends on relatively high levels of expenditure for large-scale facilities and equipment. This promotion of so called 'big science', or large-scale research, for example accelerator science, space science, astronomy and fusion research, involves the intensive channelling of considerable resources including researchers, research funds, research facilities and equipment, within a specified period.

Table 3.1: Budgets for grants-in-aid for scientific research

Fiscal Year	Budget (¥ billion)	Applications ('000s)	Acceptances ('000s)
1989	52.6	61	19
1990	55.8	64	20
1991	58.9	66	21
1992	64.6	70	23
1993	73.6	76	26
1994	82.4	80	29
1995	92.4	87	33
1996	101.8	94	35
1997	112.2	99	37
1998	117.9	103	42
1999 (planned)	131.4	n.a.	n.a.

Source: Adapted from MESSC, 1998, p.386

One prime example of the promotion of basic research is the grants-in-aid for scientific research programme. The MESSC regards this as one of its most important programmes for promoting scientific research and, over the last ten years, has considerably increased its budget (Table 3.1). This trend is set to continue.

The grants-in-aid for scientific research programme aims to stimulate creative and pioneering research in all fields. Grants are awarded to individual researchers or research teams for projects that

involve basic research that is in keeping with current scientific trends. The grants are allocated subject to impartial screening by the Science Council. In practice, the majority are awarded to the national universities (Table 3.2).

Table 3.2: Grants-in-aid for scientific research: awards made (1999)

Type of Institution	Average value of award (¥ million)	Total value awarded (¥ million)
National universities	655.9	64,934.1 (73 %)
Private universities	35.1	12,886.5 (14.5%)
Research laboratories (public and private) and others	57	5,812.5 (6.5%)
Local public universities	74	4,292 (4.8%)
Colleges of technology (public and private)	8.5	500.6 (0.6%)
Colleges (public and private)	2.6	511.2 (0.6%)
Total		88,936.9

Source: Based on information obtained from a member of the Ministry of Education

Other competitive programmes for long-term basic research that, while not considered to be ‘large-scale’, nevertheless require intensive promotion on a significant scale within certain time frames are funded through a range of priority programmes. These include specially promoted research,⁵⁶ research on priority areas, new programme research, Centre of Excellence Formation Programmes (below and section 3.3.3), and the Research for the Future Programme (below). Of these, the Centre of Excellence formation programme and the Research for the Future programme deserve special attention because of their potential impacts.

The Centre of Excellence programme (COE) was created, in 1997, in order to stimulate new advances in scientific research in preparation for the 21st century and, at the same time, upgrade the infrastructure for research in the country (see section 3.3.3). COEs, established at selected research institutions, receive priority resource allocation. Researchers within them are given considerable freedom to decide their strategies for pursuing world class science. Two particular policy instruments have been developed in order to promote the establishment of COEs and strengthen the research infrastructure in Japan.

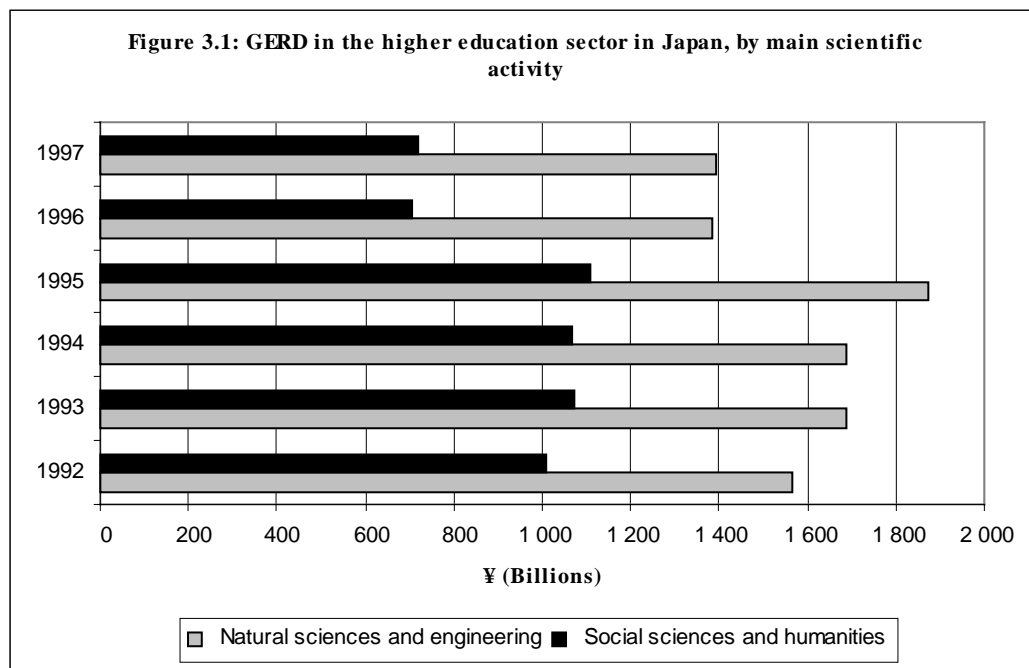
- First, the provision of support for core research institutes that display characteristic features of COEs in certain fields.
- Second, existing research institutes and groups that might contribute towards internationally competitive, state-of-the-art research in the future are given support to assist them in developing into COEs.

The ‘Research for Future Programme’, created in 1996 and administered by the Japan Society for the Promotion of Science (JSPS), is designed to stimulate future-oriented research in selected fields through a co-ordinated system of funding that involves seven government ministries and agencies. Research fields are specified by the Research for the Future Programme Committee of the JSPS on

⁵⁶ In FY 1997, research themes funded under the Specially Promoted Research programme focused particularly on the physical and engineering sciences and biology.

the basis of a) recommendations from the Science Council and b) the results of research from the grants-in-aid for scientific research programme and other similar initiatives. Research promotion committees established in priority fields, including the Committee for Research Promotion in Specialised Areas and the University-industry Co-operative Research Committee, help to co-ordinate, plan, propose and advise researchers on research projects.

Projects are typically carried out by way of a research contract between JSPS and the university or research institution where the project members are employed. Research teams are encouraged to adopt an international perspective to their activities. Travel expenses, costs of inviting the participation of foreign researchers, costs of organising international symposia, and salaries of postdoctoral research associates from overseas are covered under the research funding. Research projects funded under this scheme generally last for five years and cost on average ¥100 million (individual projects cost between 50 to 300 million yen per year). In FY 1997, the RFTF programme funded 204 projects in 26 research fields, 11 in the engineering and physical sciences. Gross domestic expenditure on R&D in the higher education sector (Figure 3.1) shows that expenditure on R&D in the natural sciences and engineering has been consistently higher than that in the social sciences and humanities.⁵⁷



Source: OECD, 2000.⁵⁸

Selection and allocation procedures for prioritised programme research

Applications for funding in the grants-in-aid for scientific research programme are screened by the Committee on Grants-in-aid for Scientific Research, part of the Science Council that advises the MESSC. The Committee consists of about 2,000 examiners, leading researchers who are appointed for a single two-year period. Projects are screened, and grants allocated, on the basis of published criteria that include originality, contribution to knowledge, and appropriateness of the research organisation.

⁵⁷ Data are not available to enable the identification of trends in university research funding by main field.

⁵⁸ Some of the data on which this figure is based suffer from overestimation and breaks in series with previous years.

The implementation of the JSPS's Research for the Future (RFTF) programme is somewhat different from the grants-in-aid for scientific research programme. The RFTF Programme Committee identifies specific research fields to be targeted and sets up Research Promotion Committees to further research in each of the fields. Between FY 1996 and 1999, the number of Research Promotion Committees has risen from 17 to 37 (JSPS, 1999b). Other JSPS committees, for example those set up to promote university-industry research co-operation, can also apply for funding under the RFTF Programme.

3.3.2 Encouraging applicable research

Significance and importance of research evaluation

Recent and growing interest in the evaluation of the scientific research conducted in universities and national research institutions has been stimulated by:

- Japan's tight fiscal situation, and the steadily growing budget for scientific research.
- Criticism of the research community as being insulated from competition, making it necessary for researchers to ensure that their activities are transparent so as to gain public understanding and support.

In Japan, the evaluation of scientific research is discussed from a perspective that recognises

- that scientific research is driven by the ideas of researchers and is characterised by variety in objectives, nature, scale, and methods, and
- that the benefits of the results of research may lie many years in the future. As yet, there is no national system to support the collection, collation, analysis, and distribution of information and quantitative data to support research evaluation. The creation of an overall evaluation policy has been identified as critical in the Science and Technology Basic Plan and various approaches are under consideration.

Evaluation, involving peer review of interim and post-completion grant assessments, currently focuses on academic significance, although, depending on field, social and the economic contributions may be taken into account. Evaluation of research institutions mainly takes place via the implementation of self-monitoring and self-evaluation systems for teaching and research. Inter-university and joint-use research institutes attached to national universities are evaluated by boards of trustees that include external experts and researchers, management councils and committees.

Promotion of applicable research in regions

In order to promote research that is applicable to local and regional needs, the government plans to intensify its support for better public awareness of science and technology and construct unique science/technology related facilities designed to deal with issues that are locally specific. The development of policies to stimulate co-ordination, co-operation and exchange among industry, academia, and the government in order to promote effective dissemination and use of research results is also recognised as critical. The government aims to intensify support for:

- R&D and technical assistance by public research institutes that lead to the development of regional industries.
- co-operation among public research institutes.

- exchange of people and information between public research institutes, and national/public universities and national public research institutes.
- improved training systems for researchers at public research institutes.

Co-ordination of university research policy

The Council for Science and Technology (CST), which advises the Prime Minister, is responsible for the overall co-ordination of government policies for science and technology, except those that relate solely to the humanities and social sciences. The CST is chaired by the Prime Minister and composed of relevant ministers, including the Minister of Education, Science, Sports and Culture. The CST is also responsible for overseeing scientific research in universities. Secretariat services are provided jointly by the MESSC and the STA.

The STA also co-ordinates policies for science and technology between relevant administrative organisations. It actively promotes research and development in a variety of different fields through co-operation across the boundaries of different government ministries and agencies. Special Co-ordination Funds for Promoting Science and Technology (SCF) are managed and distributed by the Science and Technology Agency (STA). These aim to:

- Promote advanced and basic/generic research.
- Promote research and development requiring co-operation among several research institutes.
- Strengthen organic ties among industries, the government, and academia.
- Promote international collaborative research projects.
- Respond flexibly to urgent research needs.
- Conduct research evaluation, as well as investigation and analysis of research and development.

While these initiatives do provide an institutional framework that is capable of co-ordinating activities related to government-funded science and technology, this co-ordination has not always been satisfactory. One reason for this is because individual ministries are inclined to retain authority over their own areas and are reluctant to co-operate in joint approaches to research funds allocation. Initiatives are being taken to remedy this situation. First, MITI and the MESSC are jointly trying to establish a 'Matching Fund Scheme' to assist the joint allocation of research funds by of NEDO (New Energy and Industrial Technology Development Organisation) and the JSPS. This new approach aims to break down the hitherto strong division of authority between government ministries. Second, in December 1999, the first report of the Working Group of National Strategy for Industrial Technology (MITI, 1999), a policy group that depends upon collaboration between industry, academia and almost all of the government ministries was published

3.3.3 Recognising the significance of research networks

University-industry collaboration

In Japan, industry is still the preferred location for research and advanced training (Table 3.3). Industry secured this position, particularly during the 1980s, by investing heavily in industrial research facilities and capitalising on their ability to attract and train the best graduates. Recently, however, Japanese industry has been increasing its involvement with Japanese universities by issuing donations and research contracts and through participation in university-based doctoral research programmes (NSF, 1997).

Table 3.3: Annual trends in the number and location of researchers

Year	Total	Universities	Research Institutes	Industry
1975	310,111	134,458	29,049	146,604
1985	447,719	180,606	36,016	231,097
1996	673,421	242,862	46,459	384,100

Source: MESSC, 1998, p22.

The government has increasingly looked to university research for new advances that can lead to commercial success, contribute to industrial restructuring and revitalise local economies. The promotion of co-operation and interaction between industry, academia (national and international) and the government is a pillar of the 1996 Science and Technology Basic Plan.⁵⁹

The MESSC has implemented a variety of measures to promote research co-operation between universities and industry in ways that reflect the different characteristics of national and local, public and private universities. For example, schemes to promote collaboration between industry and the private universities include subsidies for the creation of joint research promotion centres and tax concessions for donations to private universities. Research co-operation between national universities and industry is being actively encouraged through the introduction of various publicly funded arrangements. These include:

- Joint research with the private sector.

This focuses on themes of common interest to researchers in national universities and private enterprises. It is carried out in a wide range of fields, bringing together the research capabilities of the national universities and the technological strength of the private sector. The number of projects funded has increased steadily over the years and is expected to grow even more in the future (Table 3.4).

Table 3.4: Joint research with the private sector

Fiscal Year	No. joint initiatives	No. researchers involved
1989	705	842
1990	869	1,031
1991	1,139	1,288
1992	1,241	1,398
1993	1,392	1,527
1994	1,488	1,602
1995	1,704	1,843
1996	2,001	2,192

Source: MESSC, 1998, p.411.

- Commissioned research.

Private companies, government agencies and institutions sometimes commission basic research to national universities. National university researchers who accept commissions undertake research at

⁵⁹ The Action Plan for Economic Structure Reform, which was adopted by the Cabinet in May 1997, and the Programme for Educational Reform (revised edition), a report submitted to the Prime Minister by the Minister of Education, Science, Sports and Culture in August 1997, also call for increased efforts to promote research based on university-industry co-operation and collaboration.

the expense of the companies or agencies commissioning it and co-operate in those organisations' research and development efforts by providing reports on the results of their work. The number of research commissions accepted has quadrupled (to 3,714) in the decade since FY 1985 in FY 1996 were worth 23.2 billion yen (Table 3.5).

Table 3.5: Commissioned research

Fiscal Year	Number of researches	Amount of commissioned research (¥ billion)
1989	2,025	4.7
1990	2,203	5.2
1991	2,121	5.0
1992	2,189	5.3
1993	2,432	6.9
1994	2,586	6.6
1995	3,027	14.1
1996	3,714	23.3

Source: MESSC, 1998, p.412.

- Commissioned researchers.

This scheme enables engineers and researchers employed in the private sector to receive up-to-date graduate-level guidance on research at national universities and inter-university research institutes. Participating researchers and engineers can use this scheme to improve and update their talents and skills.

- Grants and endowments.

National universities accept donations to encourage scientific research from private firms, individuals, and other sources under the scholarship endowment accounting system. These donations make up the bulk of funding that national universities receive from the private sector. The national universities are able to deploy these funds flexibly, for example, to provide scholarships for students, to finance research or fund international exchange. Donations to national universities are treated as donations to the government, making them eligible for tax benefits.

- Endowed chairs and funded research departments.

Scholarship donations to national universities and inter-university research institutes can be used to establish endowed chairs or funded research departments. Endowed chairs have been created in a range of fields spanning economics, engineering, science, and medicine.

- Establishment of joint research centres.

The MESSC has established joint research centres at 49 national universities in 42 prefectures. These centres interface between industry and academia, stimulating research collaboration with local industry by providing engineering staff in private companies with advanced technical training, technical advice, and other assistance relating to research and development. In addition, national universities are progressively establishing research co-operation departments to link research with the wider community.

Research co-operation between universities and industry through external organisations

A range of measures has been established to promote university-industry collaboration. These include the university-industry co-operation programmes of the JSPS and the activities of research grant foundations. For example, the JSPS has established various expert fora, such as the Advisory Committee to University-Industry Research Committees, the Committee for Research Promotion in Specialised Areas, and the University-Industry Co-operative Research Committees, in order to develop new fields for research collaboration between universities and industry. Many incorporated non-profit organisations have also been established to provide grants for scientific research. As of May 1997, 132 foundations and 32 trust funds were providing support for scientific research.

The MESSC has removed several barriers to university-industry collaboration. Some of these concern university researchers in national universities who previously could not conduct research within the facilities owned by companies with which they collaborated except under exceptional circumstances; suffered financial penalties to their pension if they took leave to participate in joint projects with companies; and were restricted in conducting research for profit-making enterprises outside of normal working hours. Since 1997, when initiatives were introduced to promote researcher exchange between industry and the universities, these restrictive conditions have been changed. Researchers are allowed to conduct research at the facilities of their partner companies, and restrictions have been removed on the number of jobs or number of hours that they can work for industry in their own time. In addition, the law on pensions has been changed to remove the negative consequences for those who spend time in industry. Administrative procedures for accepting commissioned research and scholarship donations have been simplified and speeded up and there is no longer any need for MESSC approval for payments from international agencies and foreign organisations.

Companies were also addressed in the 1997 reforms to encourage research collaboration with the universities. Their rights to patents from the results of research with national universities were extended from seven to ten years from the date of patent application, with provision for further extension. In addition, there were tax reforms to encourage joint research and the joint experiment and research tax system was extended to the end of March 1999 and expanded to cover expenditures for specific joint research projects carried out in-house by private companies.

Intra-university and inter-university collaboration

The formation of Centres of Excellence (COEs) was first identified by the Science Council in 1992 as a means of promoting highly original, pioneering research. The aim is to create centres where top international researchers can come together in a high-quality research environment, exchange scientific information and share original ideas. In 1995, the Science Council produced a set of recommendations for the formation of COEs, defined as *'a pre-eminent research base that promotes highly creative scientific research at the most advanced level in the world'* MESSC, 1996.

Depending on the research field and the nature of research activities, a COE might include a chair and research section, a special course, a major field, a discipline, a research department, a research facility or centre, or a network of related research organisations. These can be broadly divided into the following categories, depending on the nature of the research organisation:

- Relatively large research organisations with clearly defined organisational structures.
- Groups of loosely linked research organisations.

- Groups of researchers working together under a pre-eminent researcher.
- Joint-use groups established primarily to share facilities and equipment.

Japan already has some university and graduate school research organisations and inter-university research institutes that qualify as COEs. In the future, these and other COEs are to be developed aggressively across a range of research fields.

It is intended that the initiative for COE formation should come from research institutes, individual researchers, and research groups themselves. A variety of implementation programmes are being created to further develop and enhance the COE concept.

- Programme to form core research bases.

This programme will focus on research organisations that are established around pre-eminent researchers and carrying out world-class research and that have the potential to evolve into core research bases in specific fields. Such organisations would be fostered as COEs.

- Programme to support the creation of advanced research environments.

This programme aims to contribute to the formation of COEs in specific fields by developing a high-quality research environment capable of attracting a wide range of researchers from Japan and overseas. This will require the prioritised establishment of superior research facilities capable of supporting world-class research.

- Support programme for core research institutions.

This programme will promote the further advancement of field-specific research institutes that already have the distinctive features of COEs. It will also help research institutes that, because of their nature, could be developed into COEs (such as inter-university research institutes, and facilities attached to national universities for the joint use of all university researchers in Japan).

International collaboration

The past few years have brought a notable increase in international scientific exchange in Japanese universities and inter-university research institutes. According to the MESSC, in 1998 the number of Japanese researchers sent overseas to conduct internationally collaborative research increased to 2,814. The number of foreign researchers accepted into Japan in the same fiscal year was 2,881 (JSPS, 1999b). Recognition that international scientific exchange depends primarily on co-operative relationships among researchers has led to Japanese participation in international schemes such as the United Nations Educational, Scientific and Cultural Organisation (UNESCO) research programmes and Organisation for Economic Co-operation and Development (OECD) working groups.

Japan currently has government-level science and technology co-operation agreements with 32 nations. For example, focusing on the United States, the MESSC (through the JSPS) has established a special programme for American researchers under its Postdoctoral Fellowships for Foreign Researchers. This provides funds to enable universities in Japan and the United States to conduct organised research into earthquake disasters. Japan has also increased the number of American researchers involved in Research Experience Fellowships for Young Foreign Researchers from eight to fifty.

One consequence of the growth in international co-operative research has been an increase in international co-authorship in the scientific literature. Between 1988-93, almost 11 per cent of Japan's scientific papers in this range of literature were internationally co-authored compared to 4 per cent in the period 1981-87 (NSF, 1997). Most (43 per cent) collaboration involved scientists in the US and Europe (34 per cent).

3.3.4 Career development and research training

Expansion of graduate education

Graduate education, historically small in scale, has begun to expand in Japan. With this particular aim, in the late 1980s, the MESSC started to create new universities solely for graduate students.⁶⁰ Between 1990 and 1995, annual graduate student enrolment rose by 15 per cent (MESSC, 1995). One policy initiative taken in 1994 has aimed to double the number of graduate students by the year 2000 from 138,000 to 277,000.

In 1997, all of the national universities and about two thirds of private and local public universities (about 70 per cent of all universities) had graduate schools (OECD, 1998) contributing towards research and human resource training in specialist areas. National universities accounted for two thirds of graduate school enrolment and graduate enrolment has been consistently rising for over a decade.

Until recently, the majority of doctorates in natural sciences and engineering were awarded to researchers in industry who had completed many years of corporate research (NSF, 1997). University-based doctoral programmes have been expanding. Doctoral training is now provided by 50% of universities, mainly the national universities (less than half of the private universities offer doctoral training) and, in 1994, there were 39,000 students in doctoral training programmes.

Japan has traditionally provided little financial assistance to graduate students and most students cover their own fees. In 1994, the Japanese Scholarship Foundation provided about 16,000 scholarships for doctoral research, primarily in the form of loans. There are some indications that this is beginning to change. The high priority given to research and the consequent need to cultivate and support researchers in order to strengthen the country's scientific foundations has led to schemes to promote and support the participation of young and particularly women researchers in the university research system.

Young researchers

The MESSC, in collaboration with other government organisations, is promoting a programme to support 10,000 postdoctoral researchers by FY 2000. The aim of this programme, which began in 1996, is to recruit and train outstanding and creative young researchers. In FY 1997 the MESSC, the STA, MITI, and the Ministry of Agriculture, Forestry and Fisheries supported 7,926 postdoctoral researchers, an increase of 1,809 over the previous year. The MESSC funds over 70 per cent of these (5,701 researchers), an increase of 1,145 over the previous year. The programme is being implemented through a range of fellowship schemes (below). Typically, these schemes offer young (under 34 years of age) postdoctoral researchers or doctoral candidates fellowships or research grants

⁶⁰ For example, the Japan Advanced Institute of Science and Technology, East (Ishikawa Prefecture) focuses on training and research in the information and materials sciences and the Advanced Institute of Science and Technology, Nara Prefecture concentrates on information science and bioscience.

for up to three years to follow innovative research, in a research domain and location of their own choice.

- JSPS research fellowships for young scientists

This fellowship scheme was established in 1985 by the JSPS and it has been enhanced over the years. It now forms the core of the Programme to Support 10,000 Postdoctoral researchers. The scheme provides young researchers at the start of their careers with the opportunity to engage in full-time research and with the autonomy to freely select themes and venues for their research. The scheme appoints, for periods of up to three years, outstanding young researchers who are currently enrolled in, or have completed, doctoral programmes and who wish to carry out full-time research in universities or other research institutions. In FY 1999, a total of 3,770 doctoral course students and postdoctoral researchers were supported under these fellowships, a slight increase of 90 over the previous year.

- JSPS research fellowships for young scientists (cancer, new programme, COEs).

This scheme supports young researchers who have completed doctoral courses and are participating in cancer research and research under the New Programme System and the Centre of Excellence (COE) Formation Programme. In FY 1999, a total of 100 researchers received these fellowships, an increase of 10 over the previous year (JSPS, 1999b).

- JSPS postdoctoral fellowships for research abroad.

This programme was created to enable young Japanese researchers to devote themselves to long-term research in overseas universities and research institutes by providing living allowances, research funds, and other forms of assistance. The aim is to foster outstanding researchers whose research reflects an international perspective. In FY 1998, the number of researchers supported under this programme increased by 37 to 175 (JSPS, 1999b).

- JSPS postdoctoral fellowships for foreign researchers.

The purpose of this programme is to contribute to training young researchers who have just obtained their doctorates in other countries by accepting them into Japanese universities. Recruits receive living allowances and other forms of assistance. The programme also contributes to the training of young Japanese researchers by providing opportunities for interaction with researchers from other countries. In FY 1998 support was provided to 1,094 people, a rise of 251 over 1997 (JSPS, 1999b).

- JSPS research associates under the research for the future programme.

The JSPS Research for the Future Programme was launched in FY 1996. Young researchers who have completed doctoral courses can be employed by research institutes to participate in a research project under this programme. In FY 1997 the number of participants is expected to total 640, an increase of 200 over the previous year (MESSC, 1996).

- Part-time researchers:

By employing young postdoctoral researchers to work as part-time researchers, this programme aims to contribute to recruiting, training, and improving the quality of young researchers and to facilitate research projects in national universities and inter-university research institutes. In FY 1997 assistance was provided to 486 people, 160 more than in 1996 (JSPS, 1999b)

Female researchers

Female researchers represent about 10 per cent⁶¹ of the workforce in Japan. The Science Council (1999b) have identified the need for a range of measures to address the relatively weak position of women researchers. These should:

- encourage the greater participation of female researchers in research projects.
- disallow sexual discrimination, especially in recruitment and promotion and in decisions relating to research themes and the allocation of roles and responsibilities for research.
- improve the research infrastructure to support female researchers (for example through the introduction of more flexible working, maternity leave and childcare).

Generally, infrastructural support for female researchers appears less-well developed in Japan than it is in other advanced nations in Europe and America. Yet despite the identification of such issues as priority, little has been done to implement policy measures to support equity on the basis of gender.

Relationship between teaching and research

Teaching and research are generally considered to be two sides of the same coin in Japan. In principle, all university professors are supposed to research and teach. Historically, specialisation in either research or teaching has not been permitted. Recently, this has begun to change and some professors have started to specialise.

3.3.5 Widening research

Against the backdrop of heightened expectations of science and technology, the Science and Technology Basic Law was promulgated and put into effect in November 1995, and the Science and Technology Basic Plan was formulated by the Council for Science and Technology and approved by cabinet decision in July 1996. This plan, which looks ahead over the next decade, formed the basis for the development of policies for science and technology for the five years between FY 1996 and FY 2000. It defines two basic directions for research:

- the vigorous promotion of research and development in response to social and economic needs, and
- the active encouragement of basic research having aims like explaining the origins of matter and the behaviour of the universe or discovering new laws and principles.

In Japan, promoting research and development means encouraging both basic research and research and development in a growing range of key fields and expanding the sources of funding available to researchers and facilitating growth in the numbers of institutional and individual participants in the research effort. Progress in research must harmonise with human lifestyles, society, and nature. In addition, researchers' autonomy must be respected, and the characteristics of research in universities must be taken into consideration.

In addition, and in line with the Science Council recommendations, the MESSC has been making systematic, prioritised efforts to bring Japan's research infrastructure up to international standards and to create a scientific research system that is open to the world.

⁶¹ According to the Statistics Bureau and the Statistics Centre, in 1999 there were only 73,000 female researchers in Japan compared to 659,600 male researchers.

3.4 Main features of the Japanese system of university research

To summarise then, the Japanese system of funding for university research has been striving, through implementation of a range of measures, to change the research culture in Japan in order to make it more globally competitive. Central to this change have been:

- a focus on basic strategic research,
- the creation of a more flexible and open research system,
- the expansion of competition as a means of stimulating research excellence,
- consideration of instruments to reward excellence, and
- the development of multiple systems of interconnectedness.

3.5 Japanese experts interviewed

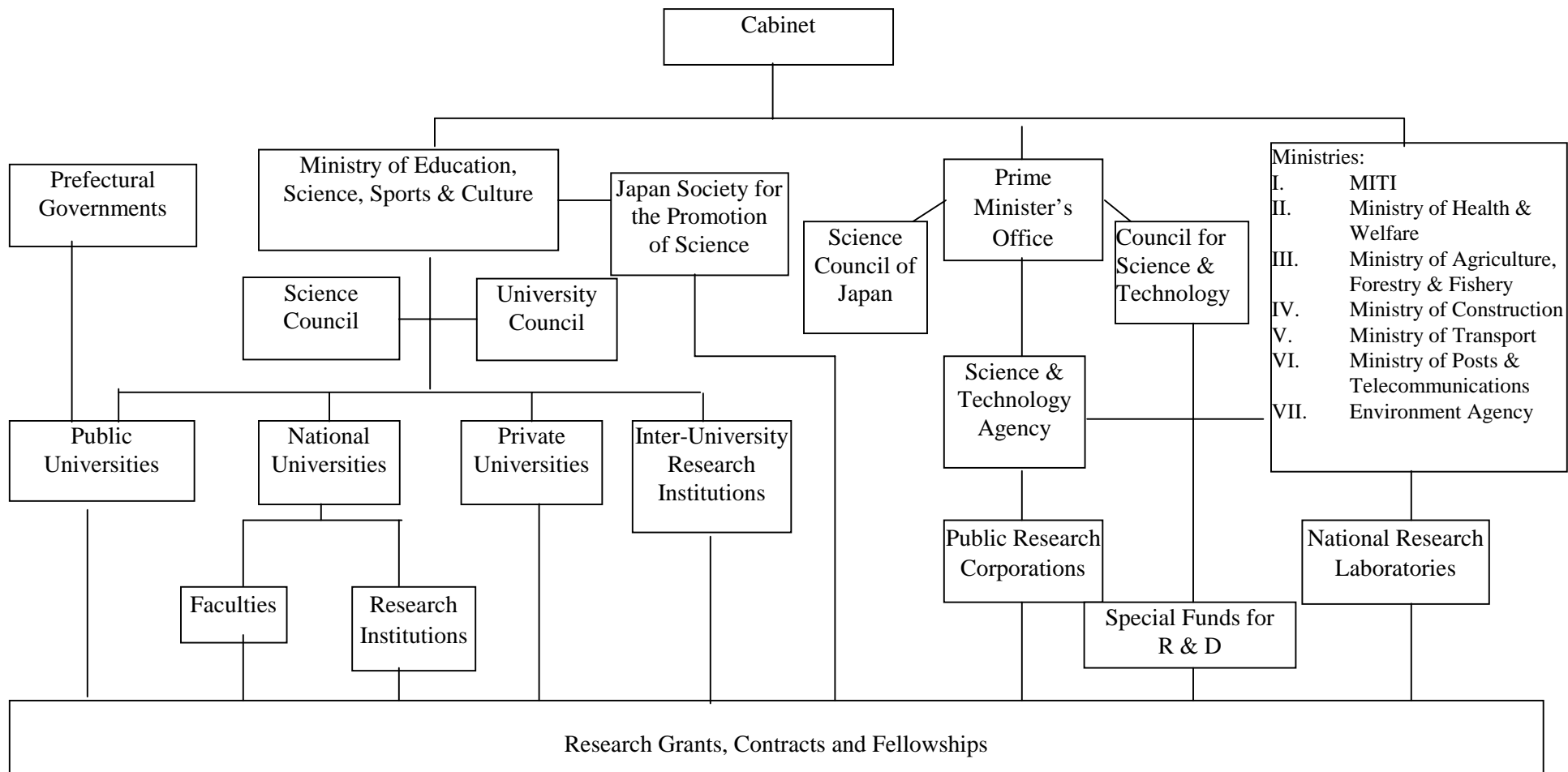
Mr. Aoi, Co-ordination Division, Science and Technology Policy Bureau, Science and Technology Agency (STA).

Mr. J. Kitami, Director, Industrial Policy Bureau, Office for Promotion of Academia-Industry Co-operation, Ministry of International Trade and Industry (MITI).

Mr. Nagata, Science and International Affairs Bureau, Ministry of Education, Science, Sports and Culture (MESSC).

Mr. N. Shimizu, Administration Department, General Affairs Division, Japan Society for the Promotion of Science (JSPS).

Figure 3.2: The structure of government support for academic and related research in Japan



Source: Constructed from various reports (e.g. Science and Technology Agency, *The 1999 Science & Technology White Paper*)

4 *United Kingdom*⁶²

Higher education was responsible for approximately 23 per cent of government expenditure on R&D in 1996. In 1996/97 expenditure on research totalled £2,837.5 million. The government contributed 71 per cent of these funds (through core funds, research grants and contracts). The remainder was supplied by charitable foundations (13 per cent), industry (6 per cent) and the EU Commission (6 per cent) (Department of Trade and Industry, Office of Science and Technology, 1998).

4.1 The structure of university research funding in the UK

The higher education sector, until 1992, was divided into two main parts: universities and polytechnics. University funds covered the resource and personnel costs for carrying out undergraduate and postgraduate teaching and costs associated with the basic research infrastructure required for research. University lecturers wishing to engage in research had to seek funds from funding organisations - the Research Councils, charitable foundations or the EC. Polytechnics, funded by local government, were mainly involved in undergraduate and postgraduate education and only carried out research on a very small scale. Polytechnics were not explicitly funded to maintain a general research infrastructure. In 1992 the division between universities and polytechnics was abolished, the polytechnics were given the right to the title of university and funding arrangements for the two sectors were unified. There are now 115 higher education institutes with the title of university (this number includes constituent parts of the Universities of London and of Wales).

Under the British dual support system, funds for teaching and the core infrastructure for carrying out research are provided through Funding Councils (Table 4, Figure 4).⁶³ Their allocations of funds for research are based on a periodic Research Assessment Exercise (RAE)⁶⁴ that measures the quality of research output for numerous subject areas⁶⁵ in terms of publications, numbers of research students and studentships and amounts and sources of external research income (Geuna, et al, 1999). Only those departments that have achieved national excellence in a majority of sub-areas in their subject area are allocated funds. The highest performing departments, those achieving international excellence in a majority of sub-areas, receive a greater proportion than do those with lower performance. Departments that have failed to achieve significant research outputs receive no funds. The 1992 RAE included a special development fund for which former polytechnics could bid. The intention was to foster research potential in institutions that previously had not received even a minimal level of research funding.

Funds for research projects, programmes or centres in universities are provided by six Research Councils and the Arts and Humanities Research Board (AHRB) on the basis of competitive, peer-reviewed grant proposals. The Research Councils traditionally awarded grants to 'blue-sky' research but a growing proportion of their budgets is now devoted to funding projects that are consistent with the research priorities identified by the government's Foresight exercise or to programmes of research

⁶² While this report shares a similar structure to the other country reports, rather than attempting to second-guess the results of the in-depth studies undertaken by other contractors for the HEFCE, its content reflects the policy-relevant views of the experts interviewed.

⁶³ These funds are distributed on a regional basis by the Higher Education Funding Council for England, Scottish Higher Education Funding Council, Higher Education Funding Council for Wales and the Department of Education Northern Ireland.

⁶⁴ Usually every four years.

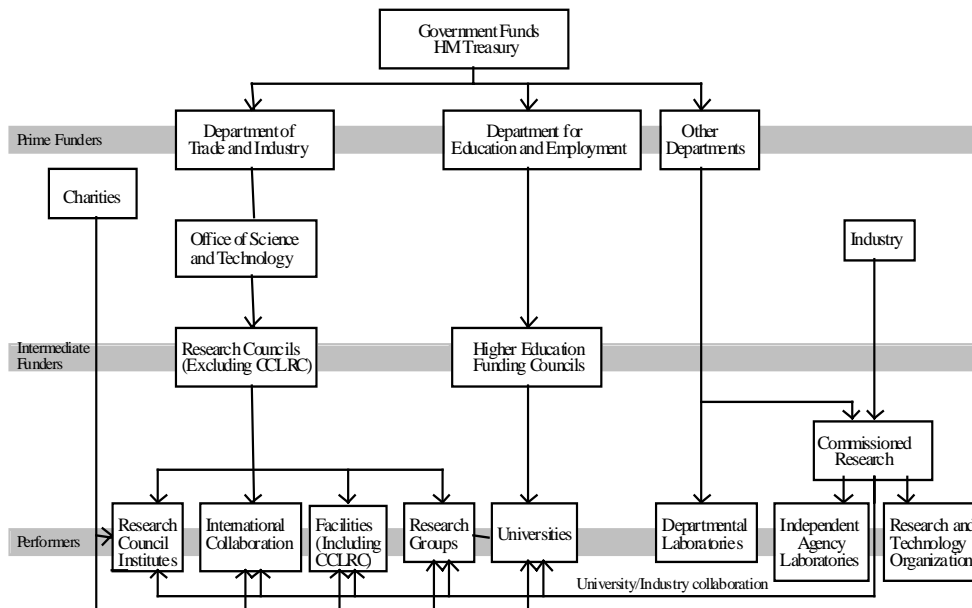
⁶⁵ In the 1996 RAE there were 69 subject areas.

jointly funded by industry. Over time, Research Council funding has increased in terms of its significance as a source of support for research.

Table 4: Summary of university research funding in UK 1996/97⁶⁶

Source	Characteristics	Amount and/or trend
Total government funding	Provided by Higher Education Funding Councils, Research Councils and Government Departments	£2,017 million (rising trend since 1986-87)
Higher Education Funding Councils	Support for research infrastructure distributed to university departments on the basis of research performance	£1,027.5 million
Research Councils	Grants allocated on the basis of peer review with growing proportion for research in priority areas and collaborative research with industry Doctoral studentships	£525 million (Proportion for priority areas increasing) £168M 3701 studentships (fluctuating trend)
Government Departments	Contract research and grants	£296.7M

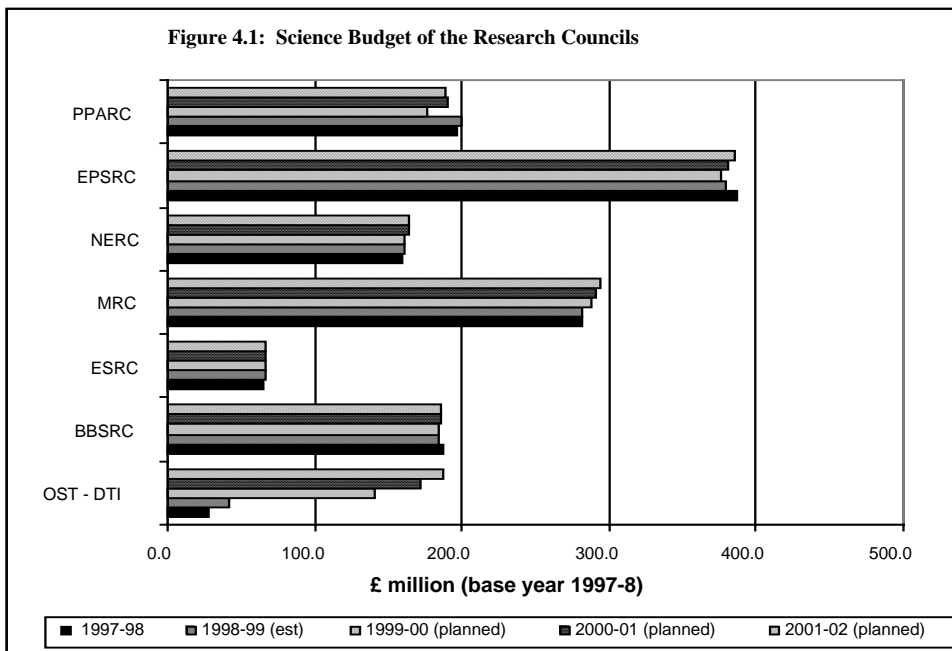
Figure 4: Simplified organogram of research funding in the UK



Source: Based on P. Cunningham and S. Hinder (1998), p.8.

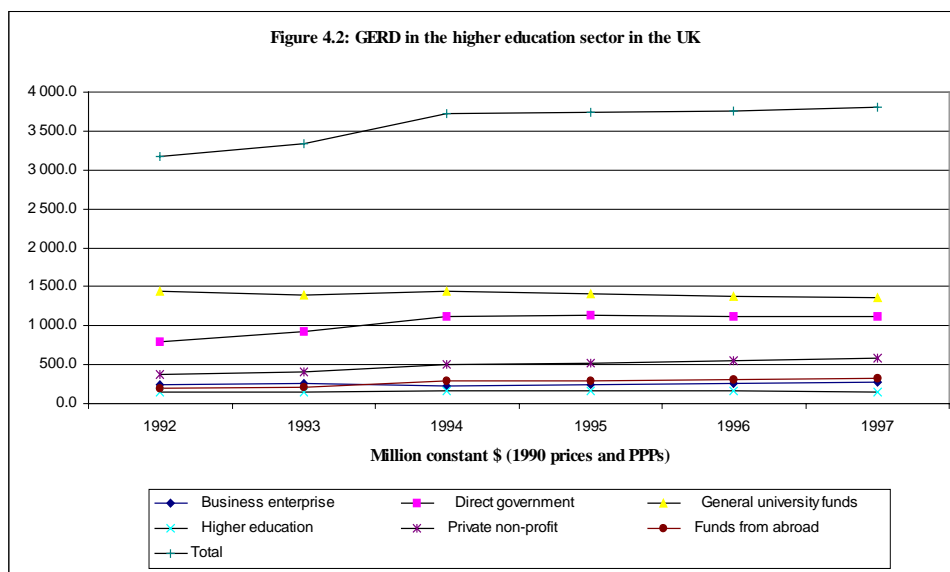
Figure 4.1 shows the budget allocations for science to the main Research Councils, the DTI and the OST and how these are intended to change in the near future.

⁶⁶ These data exclude the Research Councils spend on central facilities that HEIs can access.



Source: OST, 1999.

Figure 4.2 shows the relative proportion of gross domestic expenditure on R&D in the higher education sector that is funded by various sources in millions of constant US\$. This demonstrates the relative decline, over time of general university funds for R&D.



Source: OECD, 2000.

Absence of published data prevents the identification of funds for university research by subject area and over time.

4.2 Reforming university research in the UK

As the result of wider British policy during the 1990s, there has been a shift in the balance of research being carried out in different types of public sector research institution. There has been an increase in research at universities and a corresponding decrease at Research Council institutes and government research establishments. Within the university sector, research has become concentrated more in established universities, especially in large departments that achieve high scores in the RAE.

The main historical strengths of the UK research system are in the biosciences, some of the physical sciences and, to a lesser extent, in some areas of engineering. The keys to these strengths are the competitiveness of the system⁶⁷ and its strong reliance on the peer review system (by the Research Councils) and research assessment exercise (by the funding councils). However, in considering reform of the university research system, most respondents expressed the need for government to:

'... separate issues of current performance which are heavily relied on, particularly by government ... to justify the present system and its outcomes ... from issues about capacity building and new challenges.'

This requires that a balance be struck between both the present system and the system that will be required to support world-class research and researchers in the future. Respondents also provided a strong and consistent view that the UK scientific enterprise is not in crisis, at least, that it is no more in crisis than any of its major competitors. Nevertheless, all identified that it does have some major systematic weaknesses that may negatively impact on attempts to address future challenges. The following section examines some of these weaknesses and approaches towards their amelioration.

4.3 Significant issues and current initiatives

4.3.1 Support for world class research

In order to continue to support a university system that is capable of producing world class research, two main (and inseparable) challenges need to be addressed. The first is conducting sufficient (*the quantum of*) basic research to stay internationally competitiveness. There is a perception that there are insufficient funds to support adequate basic research because of the decline in the public funds being invested in the research infrastructure. The second is how the amount of public money provided for university research should be allocated, strategically, according to the intended outcomes of investment.

Linked to this is the need for the HEFCE to provide universities with a very clear guidance on the objectives that their funding for research is intended to achieve, as well as developing assessment criteria based on these objectives. In addition, it is necessary for the Research Councils to articulate their relationship to achievement of HEFCE's objectives and identify the role of project-based funding in meeting such objectives.

There is no doubt that the Funding Council has insufficient funds to support the broad development of capabilities for world-class research.

'The main weakness of the system is that it is almost certainly under funded, we compare very badly with our main competitor nations. Measures like percentage of GDP are rather crude, because they don't reflect differences in the balance of industries, but nonetheless, a back of envelope calculation suggests that we should continue the level of increase of the last comprehensive spending review for ten years to reach an international standard, which itself is a moving target.'

⁶⁷ In many areas, this has been nurtured through strong linkages and active working with modern industry.

The funding system relies mainly on one standardised method, the research assessment exercise (RAE), to selectively distribute those funds to the best performers of research in the sector in order to get a good return on the limited resources that are available for investment. The RAE is effectively an assessment of research quality that is also informed by peer review. Within a defined period, each university research department provides the RAE process with:

- summary details of all staff, research students and studentships,
- details of research active staff including their publications and other public support (each member of research active staff may submit up to four items),
- information on the amount of research income received from external sources, and
- a statement of future research plans.

These data and information are assessed by a panel of judges and their assessment leads to the identification and attribution of a quality rating point (from 5* to 1) to research performance within that department.

'The RAE has become, as Sir. Robert May called it, the only game in town. It has become the only quality indicator that's felt by all of the stakeholders to be reasonably secure. And the difficulty is it then becomes a proxy in all of these other fields for which it was not designed.'

This rating point is then used in a formula to calculate the allocation of research funding and this contributes to determining the amount of block grant that will be received by the entire university.

The RAE represents a source of strength as well as weakness in the university research system. Its main strength is that it provides a retrospective view of university research performance that has financial implications for the universities involved.

'It seems to me good to have a system that has both prospective and retrospective elements. Fundamentally, the Research Councils reward people who describe well and convincingly what they intend to do and the research assessment exercise rewards those who have achieved excellence. ... to have both parts together is really very good, it is sensible.'

Excellence in research performance is rewarded by allocation of more core funds and consequently greater freedom to direct research.

'... the funding that comes to the universities via the research assessment exercise, gives them a welcome degree of freedom to pursue research topics that are, to some extent, unfashionable with government and the Research Councils but which are nevertheless important.'

However, from the perspective of a new university attempting to achieve excellence in basic research in selected areas without compromising historical patterns of performance in teaching or near market and applied research, there is concern that the RAE does not adequately reward excellence in other areas. In addition, and more generally across all universities, the RAE can give rise to a system that becomes fixed, in tried and tested research portfolios.

'Just to have a cut off saying that we're only going to fund 4's and 5's means that we would never invest in those areas where better research is required [such as nursing and

primary care] to improve them and international competitiveness might involve improving them.'

Initiatives of the Research Councils, charities and other bodies can, to a limited extent and in selected fields, compensate for lack of dynamism in the system. For example The Wellcome Trust's 'Showcase' programme funds innovative and creative ideas in the biomedical sciences through a system that '*goes against all the rules of how you should support research*'.

Partly because of concerns over research dynamism, it is felt that there is need to develop mechanisms to enable core funds to be provided for new patterns of research enquiry involving, for example, inter-disciplinary and inter-agency research. This would enable the generation of new skills, subjects and research areas that are appropriate to the changing knowledge requirements of the wider economy. In addition,

'... if you do start dealing with value for money and if you do start really gearing the money towards distributing it to those who've done more with less, the people right at the top, they start hitting an artificial ceiling. Value for money ... finally converges on the maximum ... that you can get.'

The introduction of the '5*' rating may be seen as one attempt to overcome this barrier. At the other end of the performance spectrum, those institutions that receive low ratings of '2' or even '3b' in the RAE should, perhaps, be provided with incentives to strategically build capabilities in other areas rather than to take part in the next assessment exercise. Many of these are new universities, with traditional excellence in areas other than basic research. At present, there are too few honourable alternative routes through which such institutions can attract funding.

'I think that we have ended up with a system which is undesirable as far as the new universities are concerned. Really, you're looking at a system in which the T funds are determined formulaically. Given that the total numbers are controlled, the R funds are really the only free funds that the new universities can earn. And therefore they all felt obliged to succeed in achieving R funds when probably this was not in all of their best interests.'

Several reports during the 1990s noted that there was a shortfall between the costs of research and the combined public funding for research that was available through the dual support system. One consequence of this was an inadequate infrastructure for carrying out research that was manifested in the poor condition of much university research equipment. In addition, the growth in non-public funds for university research, for example from charities and industry, has contributed towards a shift in the balance between project and infrastructure funding in favour of the former and this has further aggravated concern about the level of investment in facilities and equipment.

'... the sophistication factor continues – the cost of staying at the leading edge of equipment is growing at a faster rate than any cost reductions due to technical change. In equipment intensive fields, that has clear implications for selectivity and concentration. But there's no reason why those arguments should apply to other fields ...'

In 1996 the Joint Research Equipment Initiative (JREI), an initiative that was conceived and is largely funded by the HEFCE, was launched by the government's Office of Science and Technology (OST). The JREI is administered by the Research Councils and provides funds on a competitive basis for scientific and engineering research equipment. Bids up to £150,000 require that additional funds be provided from external sources, such as industry or charity. Bids over £150,000 do not require such

support. In the period 1996-1998 the JREI made awards totalling £205 million, with a contribution of £110 million from external sponsorship.

In addition, in 1998 a combined government-trust fund, the Joint Infrastructure Fund (JIF), was set up by the Wellcome Trust and the DTI for large-scale infrastructure including equipment, buildings and refurbishment. The fund was initially worth £600 million (the DTI and the Wellcome Trust contributed equal amounts). Recently it has been increased to £750 million through an additional £150 million from the HEFCE. Universities are invited to bid in response to a series of five calls for proposals being issued between December 1998 and March 2001. After two rounds of proposals, approximately £470 million of this fund has already been allocated.⁶⁸

JIF funds are seen positively by those who have benefited. Others with different needs, for example traditional universities facing severe restoration costs, view JIF differently:

'JIF's a nonsense as far as our needs are concerned. It's not to do with infrastructure ... if you talk to the Research Councils about JIF, they are not interested in infrastructure or in things like heating systems, ducting, drains. They say 'we're interested in quality, research quality' that's their business.'

Since 1993, research priorities in areas of science, engineering and technology have mainly been identified through the UK Foresight Programme. This programme is steered by a Foresight Steering Group and is based on the recommendations of panels drawn from business, academe, the voluntary sector, government departments, research councils and other public bodies. A range of techniques are used to develop visions of the future through the identification of key issues and trends that are driving research (Georghiou, 2000).

4.3.2 Encouraging applicable research

The general economic pressures on universities have increasingly required them to seek funds from a range of available sources, including industry and charities. The need to attract and benefit from non-public funds such as those provided by industry places the universities under considerable pressure to show the relevance and appropriateness of their research profile to commerce. This is intensified by an historical gap in funding for technology transfer activities (i.e. to bridge between research and commercial demonstration and development).

'If you look at our present range of innovation policies, somewhere the right thing is always being done. The main problem with them is that they are at least an order of magnitude too small in scale. We spend a pitiful amount on innovation policy. Probably less than 10 per cent of similar sized nations.'

In addition, more efforts are required to support technology transfer between university researchers and the users of their research. This is 'not just about ... turning research into patents and companies' but should involve genuine collaboration and integration between the activities of participants in researcher and user communities. It touches on the increasing need for interconnectedness in the system in order to achieve enhanced economic benefits from investment in research.

'I think we probably make more effort than any other country, at least in policy terms to try to stimulate knowledge transfer. Nonetheless, we are still behind the USA in terms of

⁶⁸ For further details see <http://www.wellcome.ac.uk>

actually achieving it. Their success is not particularly policy driven, its much more to do with a successful entrepreneurial culture.'

A key part of the HEFCE's mission is to foster research that is responsive to industrial and other user needs. To this end, in FY1999, the HEFCE provided £20 million to support, through the Generic Research (GR) Initiative, longer-term research that is developed in collaboration with its user communities. In addition, the Higher Education Reach Out to Business and the Community Fund, created jointly with the DfEE and DTI, provides between £10 and 20 million each year to institutions that make a commitment to building capability to respond to business needs. Other avenues of support for inter-institutional research collaboration includes the HEFCE's £17 million CollR initiative.

Linkages between teaching and research

Teaching and research are appreciated as complementary activities and, in most cases, academics undertaking research are considered to have an enhanced ability to teach students (and vice versa). However, according to interview respondents, three sets of pressures militate against researchers considering teaching as a primary activity.

- Financial incentives favour research, as a result there is a tendency to 'buy out' from teaching.
- Linked to the above, and also due to the 'massification' of teaching, an increasing amount of teaching is being done by research students and others.⁶⁹
- Within universities, teaching specialists are rarely accorded the same status as researchers.

Policy co-ordination for research funding

The UK research system has been characterised as '*over-regulated and under-planned*'.

'We are ... extremely strong on accountability and on competitively based investment, on audit, on assessment, on instant evaluation rather than medium to long-term impact evaluation. We aren't terribly good at taking a long view and actually saying if we would like the system, as opposed to all our autonomous institutions and other agencies within it, to get from here to there [and] what are the kinds of changes that would be necessary ...'

This means that it is difficult to achieve the co-ordination, with the collective involvement of the government and the other funding institutions, that is required for international competitiveness. In practice, sometimes initiatives from different ministries compete and therefore fail to capitalise adequately on university research.

4.3.3 Recognising research networks

There have been some spectacular successes in providing support for collaborative and networked research, for example:

⁶⁹ This should not be taken to imply that every student, at all times, should be taught by a research active member of staff.

'... the whole JANET system. That the UK system had in effect virtually top sliced itself to build broad band communications capacity that joins up libraries, joins up research groups, that enables us to share data and conduct research in real time with people looking at the same phenomena in other labs in different countries.'

While this initiative was partly driven by government, the real initiative came from the Joint Information Services Committee, a committee that is dominated by the institutions themselves.

The Research Councils and the DTI in particular place a premium on collaborative research and do a lot to encourage and support it. LINK, the main mechanism for supporting university-industry research collaboration, supports long-term enabling or generic research. The Teaching Company Scheme (jointly funded by the Research Councils, the DTI and corporate investment) enables young graduates to conduct research and development in a directly applied or commercial area. It sets up partnerships between academic institutions and companies to provide industry based training, supervised jointly by academic and industrial staff, for young graduates intending to pursue careers in industry. Some Research Councils favour research proposals containing an expression of interest and/or involvement by the user community and the Medical Research Council has replaced standard project funding with collaborative grants.

The HEFCE is also concerned to promote collaborative research both directly and indirectly. Direct measures include the provision of support for generic research (GR)⁷⁰ that is developed in collaboration with its user communities, funds for inter-institutional research collaboration (for example the £17 million CollR initiative) and other special initiative programmes. Indirectly, the HEFCE encourages collaboration where it is appropriate for world class research by providing funds for quality-related (QR) research.⁷¹ EU funds are the main instrument for encouraging international collaboration in research.

4.3.4 Career development and research training

Career development and research training have led to the considerable success of the university research system. The UK system has consistently provided very highly trained people, particularly through the PhD studentship system, to support leading-edge research. Since 1998, additional funds have been provided to the Research Councils to sustain student numbers and increase the student stipend (that had remained unchanged since 1966). Other schemes are in place in selected areas to attract the very brightest and the best post-doctoral students to enter careers in university research (e.g. the Royal Society's University Research Fellowship scheme).

However, there are doubts that they are being used efficiently and effectively and concern that our traditional patterns of employing and managing people have been put under strain by the demands of professional research practice in the university sector. With growth in the number of part-time and short-term contracts, many researchers are finding it difficult to build secure professional research careers. As a result, some take teaching positions in universities that have more permanent contracts associated with them, others leave the sector.

'There's an impending crisis in several fields. The base salary level, particularly in the South East, simply isn't enough to retain staff in subjects such as computer science. We have an ageing profile of academic staff. We have a very large proportion of staff now, almost half, on short-term contracts and therefore at any time at risk of being lost to the system. So, by and large it would be hard to think of a system that could be worse in terms of career development.'

⁷⁰ In 1998-99, GR funds amounted to £20 million.

⁷¹ In 1998-99, the HEFCE provided £804 million in QR funds across 69 subject areas.

There are mixed feelings about the abilities of the sector to attract and retain the brightest and the best researchers. While some consider that the current system works well and that researchers who are unable to attract longer-term research funding should be encouraged to seek other employment, others are more critical.

The Wellcome Trust, which funds a considerable proportion of doctoral research in the UK, has conducted a review of their PhD studentships and found that about two thirds are not sure whether they will stay in academic research because of the lack of career opportunities in the sector. The Wellcome Trust has also tracked about 150 people who have been through their applied studentship programme and found that, by about the second postdoctoral position, about half have left academic research. Most have gone to industry. While some of this might be evidence of desirable throughput from research to industry, it might negatively impact on the research infrastructure, especially if the trend continues.⁷²

There are no mechanisms in the UK that specifically direct funding towards women, ethnic minorities or people with disabilities.

'... most universities and heads of department are happy with the statements that have been made concerning particularly treatment of women with regard to maternity leave or career breaks. But, nonetheless, most of them have then said they have some scepticism about whether the statements will be adhered to when the panels come to do their job.'

4.3.5 Widening research

Participation of the new universities in the RAE and their entitlement to government funds for basic research has, according to some, widened the number of institutes that are performing research in the UK. However, caution needs to be exercised in interpreting such data.

'... you've only got to go back to before the '92 RAE to see one part of the sector almost receiving as an entitlement about a 40 per cent funding premium on the assumption that it did research. And the first RAE really came in as a sort of retrospective accountability exercise ... probably a lot of what was going on there was informal subsidy of teaching by research [in the traditional universities]. ... What people often forget is that on the other side of the house there was equally illegal cross subsidy in the polytechnic sector who were not funded in terms of block grant for research from teaching to research. A lot of research groups who grew up in polytechnics certainly had contracts, certainly could, to a certain extent, feed into Research Council grants. ... There was never a clear separation between teaching funding and research funding. There was pollution of one by the other in both parts of the sector.'

Hence, the suggestion that the new universities have taken money belonging to the traditional universities away from them does not adequately describe the situation. Subsequently, however, competition for government money has indeed intensified. Competition, when considered:

'... not so much in terms of the distribution of grades, but in terms of the funding decisions that result from those grades, the curve is so steep that we still have the situation where the vast majority of funds go to a small set of institutions. What has increased of course is the transaction costs of people lower down the curve who are spending an enormous amount of effort chasing funds which ... wasted effort.'

⁷² Pers. comm., Dr. Clare Matterson, Wellcome Trust.

Of course, some consider that the creation of the new universities made the RAE an inevitability, given that there were no new research funds in the system, the number of universities more than doubled and many did not have a history of research that could be used to grant awards.

It is considered that the net effect of efforts to set priorities for research, like the UK Foresight Programme, has been to widen the fields of research addressed by universities.

‘ ... although Foresight was an exercise in prioritisation, it has mostly resulted in the identification of new opportunities and so in a sense accelerated the process of diversification in what [the universities] cover - as most new things are interdisciplinary.’

There is very little evidence that priority setting has produced any negative priorities or that the Research Councils have removed support from particular areas.

4.4 Main features of the system of university research funding in the UK

Funding for university research in the UK is managed according to a dual support system that separates core funds from project-related research funding. The system has worked well to date and continues to operate effectively, although strains on efficiency are evident in certain areas. The overriding problem is a shortage of funds to adequately support the high potential for world-class research in the system. As a result, while policy initiatives for research may be appropriate to their goals, they are often of an order of magnitude too small to be truly effective. Linked to this is the need to attain the best value from available funding.

The main concerns are that the system should be adequately structured to achieve a set of well understood and appropriate strategic goals and at the same time be flexible enough to be responsive to change; that appropriate resources and structures can be established that will continue to attract and nurture the brightest and the best young researchers and that a range of reward systems can be developed to recognise excellence in areas other than disciplinary-based research.

4.5 UK experts interviewed

Professor Luke Georghiou, PREST, University of Manchester.

Dr. Clare Matterson, Head of Research Policy, The Wellcome Trust.

Lord Ron Oxburgh, Vice Chancellor, Imperial College, London.

Sir David Watson, Vice Chancellor, University of Brighton.

5 United States

The higher education sector in the United States has over 3,600 universities and colleges. Research is concentrated in only a few hundred of these, typically those that offer graduate degree courses, and particularly those that award doctoral degrees.⁷³ These institutions are mainly universities, many of which include law or medical schools, as well as institutes of technology or polytechnic institutes. The latter tend to focus on science and engineering and usually lack professional schools in medicine or law.

In 1998, US universities and colleges (excluding federally funded research schools) were expected to spend an estimated US\$25.7 billion on research and account for 11.6 per cent of the national R&D performance effort (NSF, 1999b). In 1995, 94 per cent of government expenditure on research went to only 200 institutions. The research-performing higher education institutions in the US are highly diverse⁷⁴ - some are public and others are private. Public universities are usually controlled and funded by the state or local government; private universities, independently endowed and controlled, are chartered by the state in which they are located.

5.1 The structure of university research funding in the US

The Federal Government provides the majority of funds for academic R&D (Table 5, Figure 5⁷⁵) and in 1997 they spent an estimated US\$14.2 billion, or about 60 per cent of the total. Federal support has been declining fairly steadily since 1970, when its share amounted to 71 per cent.⁷⁶ During the 1990s, however, academia was the only R&D performing sector not to suffer a cutback in Federal support, in contrast to industry and Federal intra-mural facilities. The other sectors that support academic R&D, and their amount and share of funding in 1997 were:

- academic institutions' own funds US\$4.4 billion (19 per cent),⁷⁷
- state and local government US\$1.8 billion (7.5 per cent),
- non-profit organisations US\$1.8 billion (7.5 per cent), and
- industry US\$1.7 billion (7 per cent).

A proportion of academic institutions' own funds derive from Federal or state and local government sources. These are classified as institutional funds because they are not restricted to research, and the universities decide how to use them. Industrial and institutional support for research have been growing over the past two decades. These have gone some way to compensate for the decline in Federal funds. Public and private universities differ in the proportion of funds that they receive from the various funding sources. In 1995 public universities received 54 per cent of their research funding from Federal government, 23 per cent from institutional funds and 10 per cent from state and

⁷³ In 1992, 364 institutions provided doctoral programmes (Geuna, et al, 1999)

⁷⁴ For purposes of simplicity, all these institutions will be referred to as 'universities' in the remainder of this section.

⁷⁵ See page 74.

⁷⁶ National Science Board (1998), pp. 5-8 and 5-9.

⁷⁷ The sources of institutional funds are general purpose appropriations from state or local governments; general purpose grants from industry, foundations and other external sources, together with endowment income, tuition and fees and gifts. Income from patents or licences are another potential source of institutional funds.

local funds. In comparison private universities received 73 per cent from Federal funds, 9 per cent from institutional sources and 2 per cent from state and local funds. Both public and private universities, however, receive approximately 7 per cent of their R&D funds from industry.

Three Federal agencies accounted for over 82 per cent of all Federal funding of academic R&D in 1997. These are the National Institute of Health, which provided 57 per cent, the National Science Foundation (15 per cent) and the Department of Defense (10 per cent). Small amounts of money were also provided by the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Department of Health and Human Services (HHS), and the Department of Agriculture (USDA).

Table 5: Summary of university research funding in US 1997

Source	Characteristics	Amount and/or trend
Total public funding	Provided by Federal government, state and local government	US\$16.1 billion
Federal government	Three main agencies are NIH (57%), NSF (15%) and Department of Defense (10%). NSF funds basic research. Other Federal agencies manage programmes to meet their missions. Funds allocated to individuals, projects and centres	US\$14.2 billion (60% of university support, declining from 68% in 1980)
State and local governments	The amount is for funds directed to R&D activities, and is an under-estimate because it does not include general purpose funds which may support research, or Construction/repair of R&D facilities	US\$1.8 billion
Doctoral research	Funded through self-support, institutional funds, research grants from Federal agencies and state and local governments	475,200 scientists and engineers in the labour force with doctoral degrees from US universities. Of these, 217,500 are employed in academia.

The National Science Foundation is responsible for funding basic research and science education and it mainly supports individual investigators in universities. The other agencies initiate and manage programmes to meet their specific missions and fund research in their own laboratories as well as in external organisations, including universities. Federal research funds for universities are allocated on the basis of proposals that request support for an individual, a specific project or a centre. Decisions on which proposals should be funded are based on a process of review, which may range from 'peer review', i.e. soliciting advice from external experts in the field, to 'manager discretion', relying on the judgement of an agency research officer. The generation and management of financial resources for teaching⁷⁸ is the responsibility of individual universities⁷⁹; there is no block grant system.

⁷⁸ These may originate from a range of sources including tuition fees, endowments, Federal research grants and the state.

⁷⁹ Over 20 years ago the NSF and the NIH both had programmes that awarded funds on a formula basis that selectively rewarded those institutions that were the most successful in attracting competitive research funds up to some stipulated cap. These 'supplemental' awards, at their peak worth about US\$100,000 per year, could be used at the universities' discretion.

5.2 Reforming university research in the US

In the mid- to late 1980s, significant funds were allocated to the construction of new academic R&D facilities. Much of this construction replaces obsolete or inadequate facilities. Funds for construction of new facilities, as well as for the repair and renovation of existing academic R&D facilities, comes mainly from state and local governments together with institutional⁸⁰ sources. Funds for instrumentation are generally received as part of research grants, or as separate instrumentation grants from specific Federal agencies.

Other tensions between the universities and the Federal government, for example concerning the implementation of management⁸¹ and accountability procedures following the Government Performance and Results Act (GPRA), 1993, in the context of declining R&D budgets and perceived loss of national direction in research, have led many to believe that the two no longer share common goals (Lepkowski, 1997b). As a result, the National Science and Technology Council set up an interagency task force in 1997 to identify areas where, for example:

- increasing stress and diminishing trust were undermining the government-university relationship,
- the policies and processes underlying government support for research could be made more explicit,
- there were imbalances between the funding of established and new researchers,
- the rate of success in attracting funding for new proposals had changed,
- the adequacy of the size of awards might be questioned, and
- incentives for interdisciplinary research could be developed and implemented.

This task force has recommended that (NSTC, 1999):

- a statement of principles of the Government-university partnership, clarifying the roles, responsibilities and expectations of the two parties, should be developed and adopted,
- steps should be taken to improve linkages between research and education, and
- a set of actions to help make the partnership more effective should be adopted. These include:
 - measures to ensure the integrity of research,
 - the promotion of a ‘merit review’-based reward system for excellence,
 - the dissemination of explicit statements about the grant administration process including cost sharing policies and practices,
 - measures to streamline the processes responsible for the production of certification and assurances by which universities demonstrate their compliance with particular national policies, and
 - the development of practices to ensure that research is conducted in an environmentally and socially responsible manner.

⁸⁰ Some of these funds may derive from overheads on Federal grants and contracts.

⁸¹ Some would say the ‘micro-management’ of university affairs by the Federal government.

5.3 Significant issues and current initiatives

5.3.1 Encouraging and supporting world class, applicable research

University research in the United States is conducted in a merit-based and competitive environment that ensures a tight relationship between world-class and applicable research. The structure of this section of the country report for the United States therefore departs from the standardised structure of the corresponding sections in the other country reports. Here the two issues, support for world-class research and encouraging applicable research, are examined together.

The entrepreneurial character of the university research system in the United States is one of its core strengths.

‘The merit-based allocation system⁸² ... has fed the entrepreneurial spirit of both individual faculty across the fields of science and engineering as well as the institutions, because they have to compete.’

Table 5.1 lists the main factors that have been cited in the published literature as contributing to research competitiveness among US universities.

Table 5.1: Factors influencing research competitiveness among US universities.

Rank	Factor
1	Facilities, modern instrumentation, staff to operate and maintain equipment and the willingness of administrators to provide resources for investigators.
2	Flexible administrative practices to foster timely responses.
3	A good support staff, including secretaries and contract administrators.
4	An active capital development office.
5	Discretionary resources to fill in the gaps left by funding agencies.
6	High calibre students (to operate equipment and bring faculty up to date on newest techniques)
7	Access to administrators.
8	Support from department heads for junior faculty in getting them exposure and protection of junior faculty from extraneous activities.
9	Creation of an intellectual climate.
10	Support and collaboration with colleagues, including co-operation in the use of facilities.
11	Lighter and/or reduced teaching loads.

Source: Feller, 1996, p52.

Other studies draw attention to the priority that department heads give to research; the hiring of new research faculty; the creation of cross-disciplinary research institutes; and decisions to focus on priority areas, in accounting for institutions that have increased their share of federally funded R&D (Feller, 1996). In addition, strong leadership, the match between expectations and resources and the interdependence and inter-connectedness of the research system are also identified as critical (Teich and Gramp, 1996). A recent international benchmarking exercise has identified key factors

⁸² According to which funds are awarded on the basis of the scientific and technical merit of proposals and through a competitive process that involves rigorous ‘peer’ or ‘merit’ review by staff from the funding agency as well as experts from outside of that agency.

influencing the future position of the US in international research (NAS/NAE/IOM, 2000). These include:

- Intellectual quality of researchers and ability to attract talented researchers.
- Ability to strengthen interdisciplinary research.
- Maintenance of strong, research-based graduate education.
- Maintenance of strong technological infrastructure.
- Co-operation among government, industrial and academic sectors
- Increased competition from Europe and other countries.
- Effect of the shift towards health-maintenance organisations on clinical research.
- Adequate funding and other resources.

Linked to competitiveness is the hallmark diversity of the university research in the US. The different ways that universities implement policies and practices for research make it difficult to consider them as a unified system.

Federally funded university research in the US takes place in a highly and increasingly politicised context and is guided by political, rather than scientific, rationality. This is strength in that there is an assumed linkage between spending and the wishes of the electorate, and a source of weakness in the possibility that it may distort the allocation of funds for research.

The budget requests to Congress from the funding agencies are allocated according to a negotiated process that takes place in one of thirteen allocation sub-committees that are part of the full appropriations process. In each of these sub-committees, different constituencies compete for the total amount that is allocated to that sub-committee. For example, the NSF research budget requests compete with the more immediate concerns of veteran issues and housing which fall under the same allocation sub-committee. The budget allocated for research has never exceeded the NSF budget request. Two reasons for this may be first, that research is inherently longer-term in its objectives and second, that it is more difficult to describe in terms of benefits to the electorate. In contrast, the NIH budget, which competes for allocations with welfare programmes, education and other social programmes that are less politically charged, is almost always allocated more funding than it requests. Each of the thirteen bills needs to be approved by a sub-committee of the appropriations committee, reconciled by the President and voted on by the full appropriations committee before it is settled.

This process has led to concern over the lack of balance in the Federal investment portfolio. For example, a few years ago Congress embraced the need to double national investment in bio-medical research without a corresponding investment in the physical sciences and engineering. As a result, the government's investment portfolio:

'... looks like a diverging set of escalators, where you have the biomedical sciences ... on a rapid rate of ascent and ... the physical sciences and engineering down twenty to thirty per cent according to field over the last five years. If this continues, I'm not sure ... we're going to have a healthier national enterprise because it misses the central point of interconnectedness of science, engineering and the other fields ... [that] ... provide the tools, the instruments, technologies to accomplish ... that.'

The NSF's current request to Congress for a 17 per cent increase in its budget (Table 5.2), the largest single increase ever requested, is one indication that the need for interconnectedness between research fields is being recognised.

Table 5.2: NSF funding by appropriation (US\$ millions)

	FY 2000 Current plan	FY 2001 Request	Percent change
Research and related activities	2,958.46	3,540.68	19.7
Education and human resources	690.87	729.01	5.5
Major research equipment	93.50	138.54	48.2
Salaries and expenses	148.90	157.89	6.0
Office of Inspector General	5.45	6.28	15.2
Total, NSF	3,897.18	4,572.40	17.3

Source: NSF, 2000.

One half of the requested increase is for four cross-cutting, multi-agency, focused initiatives⁸³ (Table 5.3):

- Information technology research (ITR),
- Nanoscale science and engineering,
- Bio-complexity in the environment, and
- 21st century workforce.

Table 5.3: NSF Funding by Initiative (US\$ Millions)

Initiative	FY 2000 (Current Plan)	FY 2001 (Base Reallocation)	FY 2001 (New Funding)	FY 2001 Request	Percent change
Information Technology Research	126.00	20.91	180	326.91	159.5
Nanoscale Science and Engineering	97.3	50.35	69	216.65	22.7
Biocomplexity in the Environment	50.00	20.31	66	136.31	172.6
21 st Century Workforce	73.66	43.39	40	157.05	113.2
Total, Initiatives	346.96	134.96	355	836.92	141.2

Source: NSF, 2000.

The other half of this increase will contribute towards the NSF's on-going core research programmes. These core programmes are fundamental to the achievement of required changes in research. Yet:

'Given the appropriations sub-committees that this agency is with, veterans, housing ... the sub-committee might say 'Well, we could cut this back to ten per cent and still have double digit increase, what's so bad about that?'. ... What will be interesting is what will not get funded that was scheduled for funding within the 17 per cent increase. My guess is what would get short shrift would be core support. Major initiatives, because they are

⁸³ These initiatives cut across the interests of several of the funding agencies, they have been packaged together at a supra-agency level

administration priorities, are going to get funded. ... They will distribute the smaller increase over more communities, more disciplines.'

The increasing propensity of individual researchers to turn to the political arena, to circumvent the merit review process and use measures to ' earmark ' funding have also had a negative impact on the affected mission agencies (like the Department of Energy and the Department of Defense).

'Over the last fifteen years, [there has been] ... a constant ... growing intrusion of the political judgement on the system as members of Congress direct, by law, funding for university research facilities construction as well as the conduct of research through particular programmes, projects, faculties or institutions. This is, not in kind but in quantity, new... Over time ... agencies begin to lose control over where their programmes are going and they spend an awful lot of time managing projects in institutions which really don't have the core of expertise to use the funds successfully.'

Priorities for university research are influenced by a multi-layered and highly interactive system⁸⁴ that operates top-down (directed by the Federal funding agencies) and bottom-up (driven by the ideas of researchers themselves) simultaneously. Each Federal research funding agency follows its own research mission and has its own methods for setting priorities and allocating funds but there is no single mechanism to review priorities across government. For example, within each of the Federal funding agencies there are a variety of mechanisms that feed into and inform an evolving programme of research and policy development such as the advisory bodies to the heads of agencies, advisory councils to individual programmes, external review panels and so on. In specific areas, such as high-performance computing or materials science, formal cross-agency co-ordination may be provided by sub-committees of the Federal Co-ordinating Council on Science, Engineering and Technology.

Above the funding agencies sit the President's Council of Advisors on Science and Technology (PCAST), the Office of Science and Technology Policy (OSTP) and the National Center for Science and Technology (NCST) where emerging priorities and opportunities are addressed in interaction with senior officials from the funding agencies. Some high priority issues are allocated the status of 'Presidential Initiative' and backed by the blessing of the President and the prestige and power of his office. In this politically charged environment:

'... the opposition at Congress sometimes needs to know only that something is identified with this President or that Vice-President and no more to know they're opposed to it.'

The amounts that the Federal funding agencies are able to spend on university research do not, therefore, depend on any central 'grand plan' but rather on the amount that the various agencies are given by due process, and this is facilitated by the way that the appropriations process is set up (see above). In effect:

'... priorities on different areas of research become a function of the priorities of the missions of the agencies that fund those different areas of research.'

The absence of central control has advantages in that it supports variety in the system. Its main disadvantage is that change is very slow. In the FY 1996, data on university expenditure on R&D by field in terms of percentage shows that life sciences (including agricultural sciences, biological sciences and medical sciences) accounted for 55.2 per cent, engineering for 16 per cent and physical sciences for 9.8 per cent (NSF, 1999b). These proportions had changed little in a decade. Data for

⁸⁴ Internally as well as having links to the political side of the administration in the White House.

FY 1989 showed that life sciences then accounted for 53.8 per cent, engineering for 16 per cent and the physical sciences for 11 per cent.

Individual research proposals that are submitted to the funding agencies are selected on the basis of peer or merit review. However, examination of the implementation of peer review has given rise to concern about whether reviewers are applying the criteria that have been laid down for funding.

'There are four merit review criteria ... Two of the four criteria were found to be largely ignored by reviewers and program officers. The two had to do with social relevance and building the human and physical infrastructure. The reason that they were being ignored ... was that reviewers didn't know how to evaluate them. And the other two were the quality and soundness of the ideas, the intellectual content and then the adequacy of the researcher and his or her facilities, laboratory institution and all that, the traditional kinds of things. The [NSB] ... decided that they would convert the four criteria to two big criteria, one having to do with technical merit and the other having to do with everything else really. They subsumed under each of the criteria, a set of questions, totalling 10 in all I think, ... inviting reviewers to respond to as many questions as they possibly could. The agency has now launched an analysis of this. The preliminary finding that has been leaked ... is that reviewers are ignoring one of the two criteria instead of two of the four criteria.'

Industry has played an increasingly important role in providing funds for university research. Between 1980 and 1998, industrial funding for academic R&D increased at a rate of 8.1 per cent per year (Press and Washburn, 2000) and by 1998, preliminary calculations show that it had reached about US\$1.8 billion (NSF, 1999b), almost eight times greater than it had been twenty years previously.

However, there is growing anxiety over the extent of industrial sponsorship for research and its influence over the missions and goals of universities and the normative behaviour of scientists.

'Corporations not only sponsor a growing amount of research – they frequently dictate the terms under which it is conducted. Professors often own stock in companies that fund their work. And universities exhibit a markedly more commercial bent' (Press and Washburn, 2000, p.40.)

These include threats to the pursuit of disinterested-enquiry,⁸⁵ the inability of scientists to disclose the results of their research for agreed periods due to commercial interest and the potential for commercial intervention in the interpretation of research results.

Commercial investment, coupled with diminishing public support, may also skew the field-mix of academically related R&D, for instance,

'While humanities professors in some schools are battling to save their departments from being eliminated, others are discovering, much to their surprise, that university administrators have taken a sudden interest in their course material because of its potential for being marketed on-line.' (Press and Washburn, 2000, p.52.)

⁸⁵ The US\$25 million agreement in November 1998, between Berkeley and Novartis (a Swiss pharmaceutical giant and producer of genetically engineered crops), whereby Novartis funded a substantial proportion of basic research in the department of Plant and Microbial Biology in return for five seats on the department's research committee and the right to negotiate licences on about one third of the departments findings, caused uproar (Press and Washburn, 2000).

Implementation of the shift of rationale for research from the defence-oriented policies during the cold-war period to post-cold war, innovation-oriented policies has also given rise to concern that it might inhibit the attainment of current political goals. For example, the Department of Defense has traditionally accounted for over 40 per cent of all Federal investment in fields that are intrinsically linked to emerging new defence capabilities (materials science, computer science, electrical engineering, mechanical engineering and so on) but that also feed into broader technological innovation in the country. Its readiness to sacrifice its science budget in order to pursue a shorter-term research agenda may weaken the country's future level of technological achievement and economic competitiveness.

Such changes challenge the political debates that surround analyses of university research and are predominantly conducted in terms of R&D. An interpretation of universities' function i.e. as performers of R⁸⁶ and not D,⁸⁷ suggests that these debates and analyses need to be reconsidered.

5.3.2 Recognising research networks

A great deal of university research in the US is conducted in academic departments by individual faculty members working alone and by others working with groups of graduate students. However, few individuals are able to gain resources to establish large-scale research units. A significant and growing amount of research is also conducted in Research Centres that may be established by one of the main Federal funding agencies, by individual states, with assistance from industry or with contributions from universities own funds. These Centres, which may vary in scale from 'a single individual, to segments of a department, entire departments, individuals from several departments, and from various universities and companies' (Etzkowitz and Kemelgor, 1998), are often organisationally distinct from departments. Many Research Centres are staffed by members of faculty and graduate students, but others rely on non-faculty research staff. There are various reasons for establishing these centres, including the need to bring together researchers from a range of different disciplines, to focus attention on a specific subject area, to share resources and expensive equipment or to respond to the demands of a sponsor.

Inter-university collaboration

The creation of inter-university collaborations, such as university consortia,⁸⁸ to conduct inter-disciplinary research can lead to problems for the evaluation of that research and the researchers involved in it:

'... there is a conflict between the desire of research funders and scientific leaders to talk about the need to do interdisciplinary research and the way that universities are structured to give rewards. When you are evaluated for tenure, you get more credit for things that you can do by yourself, that can be identified as your products, rather than you as a member of a team. ... There are just a lot of ways in which the reward system does not adequately provide for inter-disciplinary research.'

There are also concerns that the provision of funding for targeted inter-disciplinary research might lure young career professionals to undertake research in such areas, where they may not be

⁸⁶ The academic sector is the largest performer of basic research in the US (NSF, 1998a).

⁸⁷ Two-thirds of academic R&D expenditure is still characterised as basic research and the remainder is applied and development research (NSB, 1998).

⁸⁸ Consortia are the most recent forms of university collaboration, they may be physically resident, for instance in Research Centres or virtual collaborations supported by telematics.

adequately rewarded, and divert their attention away from more rewarding, conventional, research pursuits.

University-industry collaboration

Industrial collaboration has been central to the appropriateness of research in the university system and funding programmes that have targeted research collaboration with industry have been highly successful. These were boosted in 1980 by the Bayh-Dole Act, which enables universities to patent the results of federally funded research, and has helped with the transfer of the results of scientific research into the marketplace.

More recently there are signs that university-industry collaborations are becoming more strategic, involving the establishment of bilateral relationships to address specific industrial needs and target societal problems. Universities increasingly need to evolve mechanisms that create and capitalise on patents and licences and protect against the infringement of intellectual property rights over research undertaken in the universities.

5.3.3 Career development and research training

A key strength of the university research system in the US results from the decision to '*couple research, the responsibility for the conduct of basic research, and education*', and the commitment to create education out of research thereby making research central to the education of future generations of scientists and engineers. Many students get their doctorates by working as research assistants on project grants from the funding agencies.

Universities are organised into disciplinary departments, in which university faculty carries out teaching and research.

'Faculty might even be described as living in terror if they lost their graduate students ... because they depend on the continuous revitalisation provided by those students for their own intellectual vitality and growth.'

Nevertheless, some faculty members do specialise in research and use their research income to buy themselves out from their teaching commitments. Teaching load and staff/student ratios vary considerably between institutions, departments and research fields. Teaching loads are typically lighter in the more elite and prestigious institutions because faculty is expected to conduct more research, but this is not determined by any formal policy. Teaching loads may also be lighter during the earlier stages of faculty members' careers when they would be expected to establish themselves as professional researchers and attract funding into the department. In reaction to the overriding priority that has historically been given to research, for example as a result of the Carnegie Institute's classification system (see below), there has been a growing emphasis on teaching quality within universities. Teaching assessment, where it is used, varies across universities and between departments within universities. Sometimes it will impact on the faculty member's career progression, sometimes not.

Stephan (1997) notes that research in the US focuses extensively on individuals as opposed to groups. She explains this by the structure of academic appointments. New faculty members are given fixed period initial contracts (for 6 or 7 years). Tenure, or permanent appointments, is granted to those who demonstrate academic achievement by making a significant contribution to the discipline during this period. These achievements are generally measured by publications in peer-reviewed journals

and recognition from other scientists in the discipline. Stephan (1997) suggests that a significant component of the tenure decision is also based on an individual's ability to obtain research funds.⁸⁹

The education and human resources part of the NSF budget for science and engineering that provides financial resources and training support services to promote the early career development of scientists and engineers, is undergoing considerable change. Although the proposed increase of that directorate is only 5.5 per cent (Table 5.2) in the current NSF budget request to Congress (NSF, 2000):

'The argument that was made was that more and more education and human resource development is going on throughout the research directorate, so that the percentage increase is misleading.'

This has put pressure on the Government which, despite various attempts (for example by the OSTP), still *'...does not have a human resource development policy for science and technology'*, to develop such a policy. This is even more urgent because,

'There is a 21st Century Workforce initiative that's part of the 21st century research plan of the administration. The workforce initiative is focused a lot on the science and engineering workforce, of course, and it has a lot to do with technical workers, people who come out of the community colleges. It has to do with the instructional workforce, in other words, teachers, it has a literacy or public understanding component, and this agency has got a whole regiment of programmes devoted to all those things. The question is, how are they going to be able to harness those programmes into something coherent, number one. And number two, how are they going to be able to tie the human resources objectives, particularly supporting diversity and increasing participation by under-represented groups, and at this point under-represented groups include majority citizens, it's not just minorities, it's majority citizens.'

The encouragement of research participation by women, ethnic minorities and people with disabilities is highly sensitive. The NSF is the only Federal agency that has a congressional mandate to increase the representation of women, minorities and persons with disabilities as part of the 1980 re-authorisation of the agency. The NSF did have various affirmative action programmes but, since the Adarand⁹⁰ case in 1995, has been prevented from implementing them.

'For women ... it's a little different. [The NSF] have women's programmes, but I think that there are stigmas attached to women's programmes. ... The kind of money that you get from a Federal agency that is most valued or most respected by departments is money that comes out of research directorates, not money that has some set-aside kind of label attached to it, kind of tainted money. Even though those programmes are supposed to ease you in, to seed and effort ... what you usually get when anything has an equity program is somehow you're compromising excellence in order to serve equity, even though they're all awarded on a competitive basis.'

While the participation of women and minorities in science and engineering has risen, their levels of involvement are still not equal to their representation in the US population of 18-30 year olds (NSF, 1999a).

⁸⁹ Start-up capital is often provided by the institution, but research funds are required for supplies and equipment, and for hiring the graduates, post-doctoral students and technicians required for the project.

⁹⁰ The NSF was sued for discrimination against non-minorities in their graduate minority programme. The settlement was an agreement to cease running the programme and a payment to the plaintiff.

In order to assist young researchers in their efforts to attract funding, several of the funding agencies including the NSF, NIH and DOD, have provided additional funding streams that are targeted to new faculty members. One such programme, 'Young Investigative Awards' that was later converted into 'Presidential Awards' provides between three and five years' funding, on a competitive basis, to help young faculty establish their careers. Despite these efforts,

'In 1997, for the first time in almost 20 years, total doctoral awards in science and engineering (S&E) did not increase. After reaching an all-time high in 1996 (27,230), the number of S&E doctoral awards in 1997 was slightly lower (26,847). Although a 1-year decrease is not sufficient evidence for determining if this is a new trend, some broad S&E fields⁹¹ have been experiencing declines in doctorate awards for the past several years.'
(NSF, 1999c)

Those who are not awarded tenure in one university⁹² may go to another institution and do very well there. Others (the 'un-faculty' or 'perpetual postdocs') may take non-tenure track jobs, fixed term research appointments in academic institutions that depend solely on outside funding and typically involve no teaching. This type of appointment has been increasing recently, partly because it provides scope for flexibility in the system. However, in career terms, successive non-tenure positions over time may negatively impact on the ability of a researcher to attract a tenured faculty appointment.⁹³

The ability to attract and retain key staff is a constant feature of inter-institutional competition. As there are no fixed salary scales for university faculty members,

'If an institution sets its sights on being in the top ten in a particular field ... they can make it very difficult for other institutions ... to retain their star in that field.'

As a result, there is considerable mobility amongst faculty members in particular fields and universities.

5.3.4 Widening research

The range of universities that are involved in research has increased dramatically and this has been stimulated by the competitive desire to seek prestige and finance through research. According to one respondent, who is supported by National Science Foundation (1998) data:

'If you were to take a look ... over the last thirty years at the fraction of total Federal research support accounted for by the top ten, the top twenty or the top thirty research intensive universities you would find a steadily declining fraction of the total ... because more and more institutions are pursuing a research mission and ... competing for the funding.'

⁹¹ For example, agriculture (down 10 per cent between 1994 and 1997), physics (dropped by 11 per cent, 1994-7), chemistry (6 per cent decline between 1994-7), mathematics (7 per cent decline between 1995-7) and computer sciences (11 per cent decline, 1995-7) (NSF, 1999c).

⁹² Universities differ in their propensity to award tenure. For example, Harvard has the reputation of 'using the system of professors like Kleenex'.

⁹³ This often happens to 'trailing spouses' who are married to tenured academics and move with them when they are appointed to new positions.

One initiative that has influenced this has been the classification system that the Carnegie Institute has developed in order to enable universities to understand their various roles in the higher education system and to serve them more effectively. This classification system ranks universities on a scale from 'Research Tier 1' through 'Research Tier 3' to 'Doctoral Tier 1' and so on. In 1960, the Carnegie Commission formally recognised 52 institutions as Research Tier 1 universities. In 1996 there were 88 such universities.

'... the number of universities seriously incorporating research into their mission has consistently grown ... Enhancing research competitiveness has thus been a concern of American universities for a long time.' (Geiger, 1996, p113).

The drive to attain Research Tier 1 status has served to increase the number of universities that are involved in research. In addition, the creation of what many perceive as a hierarchy of university functions (and interpret as a progressive ladder towards excellence) may have contributed towards undermining the significance of teaching. Some institutes couch their strategic goals in terms of aiming to attain Research Tier 1 status in a certain period of time.

In addition, the EPSCoR (Experimental Program to Stimulate Competitive Research), a federally funded programme that was originally launched in 1978 by the NSF, provides sheltered competitive funds to assist the development of research capabilities among universities in less advantaged states and fosters their participation in research. Investments from 1978-1996 are recorded at US\$182.2 million in grants and co-operative agreements (NSF 1999d). This represents one attempt to balance excellence and equity in the university research system in recognition that the constant pursuit of 'more bang for your buck' on behalf of funding agencies would inevitably result in permanent disadvantage for some regions (and this would be politically unacceptable).

Among leading universities in the US, there has been a continuous and rapid expansion of the curriculum in response to changing opportunities and requirements. This has served to selectively introduce new fields for study and widen the research agenda. Some MIT courses, developed with considerable industrial support, have cut across several disciplines, involved a substantial proportion of faculty members within those various disciplines and required the creation, revision and modification of course content. When funding the creation of new and inter-disciplinary research domains, the challenge to such universities has been to mobilise resources quickly and economically despite pressures for stasis within the university tenure system. This has depended on strong leadership.

'It is always more difficult to talk of abolishing something ... fields have growth cycles, a hot field today might be ice-cold a decade from now.'

There has been an historical reluctance on behalf of Congress to support the so-called 'soft sciences' (the social and economic sciences), the arts and humanities. There are indications that the position of Congress with regard to the soft sciences is changing, and social science research is increasing in terms of its perceived national importance, e.g. the NSF has a US\$10 million proposal to assess the social implications of new and potentially 'transformative' technologies. The arts and humanities, however:

'... are a separate issue entirely, and each of those is separate from the other. The Republican Congress that came in 1995 ... came in committed to abolishing both of those endowments ... They were successful in sharply cutting the budgets of both ... Today ... both of them are secure for the future ... the more secure is the foundation for the

humanities, always the more vulnerable is the foundation for the arts, because art projects tend to be visible and controversial ...'

5.4 Main features of the system of university research in the US

The US system for university research is a highly plural and multi-layered system that relies on strong and frequent top-down, bottom-up and horizontal interaction and flexibility to retain the excellence and appropriateness of the research base. The system is strongly competitive and self-aware. It is closely linked to relevant user community groups (especially industry) that may be involved in directing the teaching as well as the research agendas. Research exists in a political context and evolves through negotiations that are often driven by political, rather than scientific, rationality.

The main concerns that are driving change in the US research system relate to the balance between funding for research in different fields. One reason for this has been the overriding emphasis on research in the bio-sciences without corresponding investment in complementary research in other areas that would be required for investments in the bio-sciences to have full economic impact. Another is the extent to which the short-term needs of industry are driving research, directing the research agenda and distorting the results of research.

Additional anxiety is being caused by the increasing use of short-term contract researchers, especially in science and engineering subject areas. Moreover, there is concern that the lack of secure career options in these areas may be reducing the attractiveness of embarking on doctoral research in those areas.

5.5 US experts interviewed

J.S. Bond, Program Director, Science and Engineering Indicators, National Science Foundation, Arlington, Virginia.

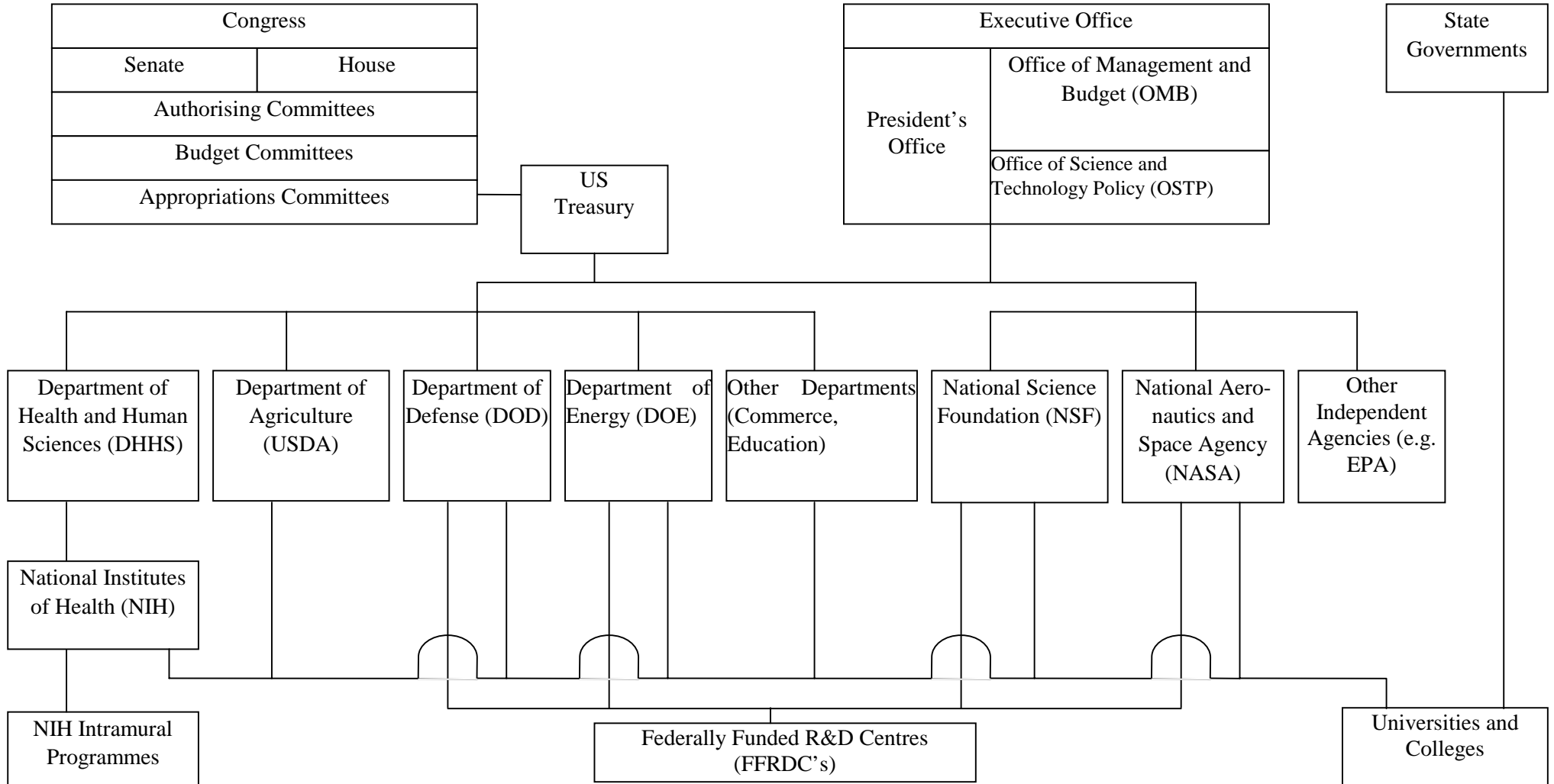
Dr. D. Chubin, Senior Policy Officer, National Science Board, National Science Foundation, Arlington, Virginia.

Dr. J. Crowley, MIT, Washington Office, Washington DC..

Dr. J.M. Johnson, Senior Analyst, Science and Engineering Indicators, National Science Foundation, Arlington, Virginia.

A.H. Teich, Director, Science and Policy Program, American Association for the Advancement of Science, Washington DC.

Figure 5: Structure of government support for academic and related research in the United States



Source: Irvine, J. et al. (1990).

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