A Comparative Analysis of Public, Semi-Public and Recently Privatised Research Centres, Summary Final Report

PREST

A Comparative Analysis of Public, Semi-Public and Recently Privatised Research Centres

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Final Project Report

Part 1: Summary Report

Prepared by PREST on behalf of the project consortium

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THE UNIVERSITY of MANCHESTER

The Evolution of Public Sector Laboratories in Europe

1. Introduction

Voluminous literatures address the evolution of universities and changing practices and structures in industrial research and development. Much less attention has been devoted to understanding the third group of major players in knowledge production, that of public sector laboratories. A particular gap has been in population-based studies aiming to look at the overall landscape constituted by such organisations. In this paper we present an overview of the results of a first attempt to put understanding of the evolution and role of public sector laboratories in Europe on a better-informed basis. This is at a time when these organisations have been subject to some fundamental changes as many governments have reappraised their relationships with this sector.

We begin with a recognition that research centres are a key part of systems of innovation. In recent years there have been some pioneering attempts to understand their operation and contribution to both knowledge accumulation and economic competitiveness. In their broad ranging study of the role of R&D laboratories in the US system, Bozeman and Crow emphasise the need for better understanding of this sector, warning that major redesign of the federal laboratory system without strategic information about the national innovation system and the R&D laboratory community is "a significant threat to the well-being of the U.S. technical enterprise" (p.228)[1]. It has been argued that research centres and laboratories are to science what firms are to the economy: the units of production [2]. An earlier project on public sector research in Europe emphasised the variety present but nonetheless identified a trend of growing flexibility in public financing, research structures and in the employment terms of researchers[3]. Their convergence in mission with university and corporate laboratories has also been noted [4]

Laboratories outside the Higher Education sector usually have a mission beyond the performance of basic research. While some such institutions were founded early in the 20th Century or even before, there was a massive expansion of public sector research establishments in the second half of that century. Missions such as the development of civil nuclear power were added to the existing portfolio of support for government policy in sectors such as agriculture, construction, health and defence, and in support for industry through provision of technological support or infrastructure such as measurement standards. As Figure 1 indicates, governments in the EU spend a larger amount (19,104.58MPPS in 1999) than either the US or Japan, though Japan is the only region to show an increasing trend as its laboratories have benefited from science policy initiatives. The spend for the EU-15 has been remarkably stable in real terms over the whole period.

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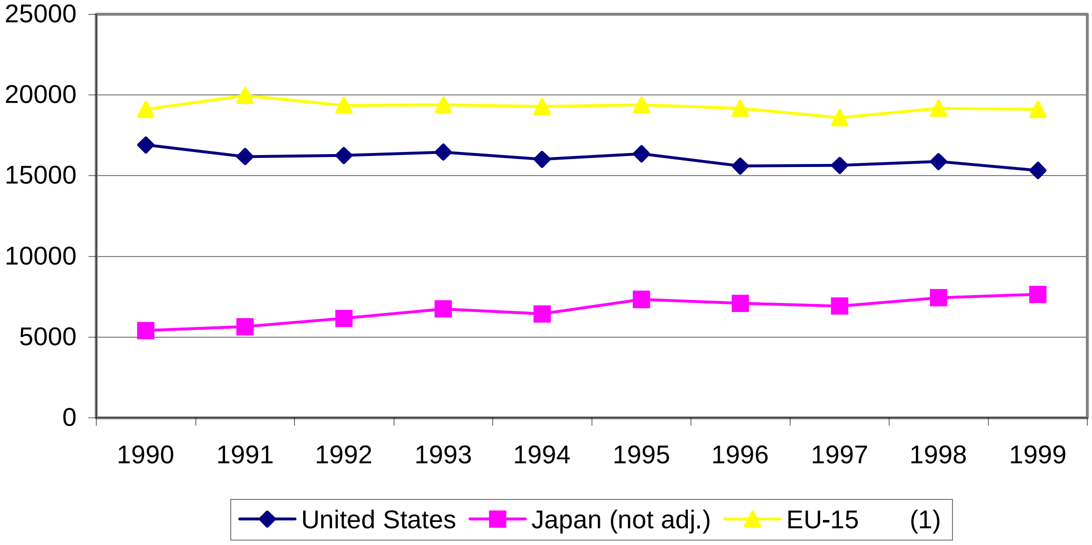
[1] Bozeman B and Crow M, Limited by Design – R&D Laboratories in the US National Innovation System, Columbia University Press, 1998

[2] Larédo P, Mustar P, Callon M, Birac AM and Fourest, 1992, Defining the Strategic Profile of Research Labs: the Research Compass Card Method, in Van Raan AFJ etal (eds) Science and Technology in a Policy Context (Leiden: DSWO Press)

[3] Potì, B and Reale Emanuela, 2000, Convregence and Differentiation in Institutional Change among European Public Research Systems: the Decreasing Role of Public Research Institutes, *Science and Public Policy* Vol 27, No 6, pp421-432

[4] Georghiou L, 1998, Science Technology and Innovation Policy for the 21st Century, *Science and Public Policy* Vol 25, No 2, pp135-139

Figure 1 Government Intramural Expenditure on R&D - GOVERD (mio pps at 1995 prices)



Source: Eurostat data

More recently, in the past twenty years or so the environment for research centres has changed, as has their position within that environment. In many European countries (and elsewhere in the developed world), different notions of what constitutes the role for public good research, new government research priorities and pressure on public funding have had a major impact in re-shaping the system. While trends such as an increased requirement to generate commercial income and more generally to emulate business practices have been common to all, a wide variety of outcomes has emerged in Europe. The most radical changes have come where institutions have left the public sector altogether as a result of privatisation. Changes in ownership or governance have not necessarily signified a withdrawal of government from the mission in question. Privatisation has usually been accompanied by continuation of government sponsorship on a contractual basis.

A recent volume[5] identified a series of challenges facing the sector:

- A changing relationship with other actors in the innovation system, including a convergence in function with universities;
- Renewal of infrastructure and human resources, including both the challenge of renewing equipment and how to construct valid research careers;
- The challenges of commercialisation of research, including a trade-off between provision of knowledge to existing firms and starting new commercial ventures;
- Development of adequate systems to measure and evaluate the processes and effects of research; and

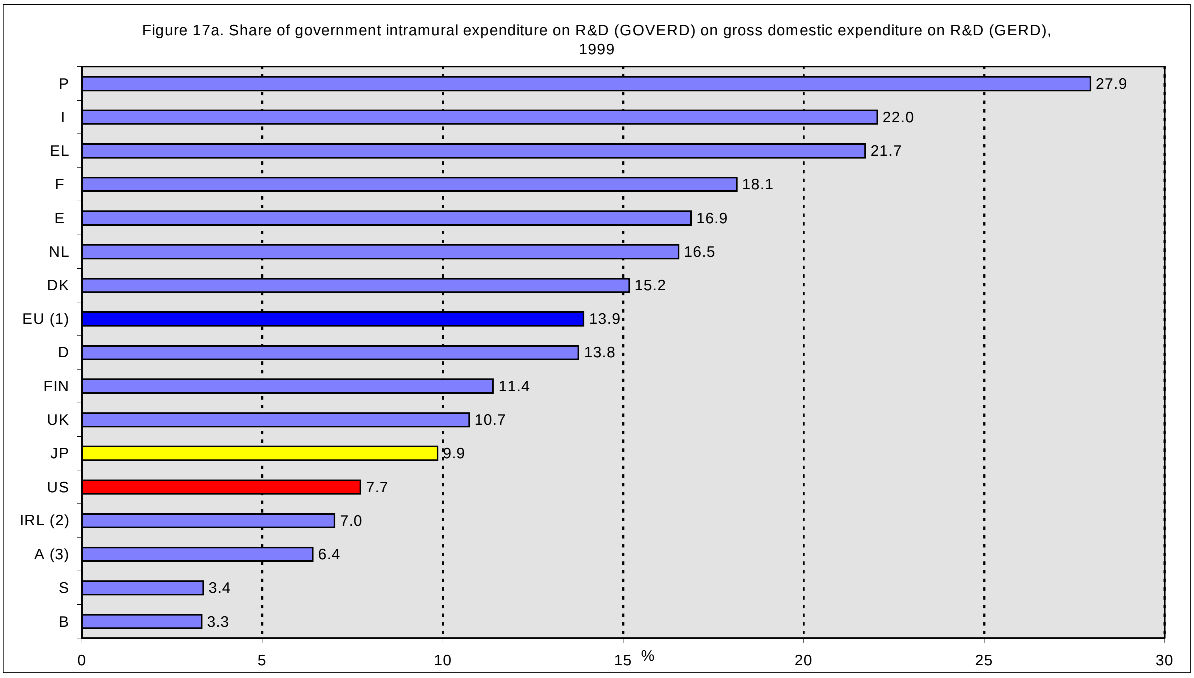
[5] Cox D, Gummett P and Barker K, Government Laboratories – Transition and Transformation, Amsterdam: IOS Press, 2001

- Testing the limits of the market model for organising research in what may still be regarded as a social experiment.

In the light of these challenges and given the scale and variety of the sector, this forms a prime area in which comparative analysis and benchmarking could make a useful contribution. Adding both to the interest in doing this and its difficulty is the wide range of structures existing in Europe.

To set a context to the empirical study we first may consider the overall picture of the government sector as set out in the Third European Report on Science and Technology

Figure 2 Share of the government sector (GOVERD) on gross domestic expenditure on R&D (GERD), 1999



Source DG-Research Third European Report on S&T Indicators, 2002
Data OECD, with DG Research provisional estimates.
Notes (1) EU: L is not included in the EU average.
(2) IRL: 1997 instead of 1999.
(3) A: 1998 instead of 1999.

It may be seen from Figure 2 that there is a wide national variation in proportion of GERD spent in the government sector. Belgium, Sweden, Ireland and Austria spend low proportions of GERD and are the only Member States below the levels of the USA and Japan. At the other end of the scale Italy, Greece and Portugal spend over 20%. Low expenditure is normally associated with a prominent role for higher education R&D (Sweden and also the UK) and an absence of defence R&D (Belgium and Ireland). High expenditure levels in this sector are found in systems which are less developed scientifically and remain in an era when state institutions were the principal players (Portugal and Greece) and in those where national organisations of laboratories are dominant research players, and are engaged in basic as well as applied research (France, Italy and Spain).

Table 1 Government intramural expenditure on R&D – change in the share of GERD (%) 1990-1999

	1990	1995	1999	%CHANGE 1990-99
EL	41.2	25.5	21.3	-19.9
IRL	14.8	8.5	5.2	-9.6
FIN	18.8	16.6	11.4	-7.4
F	24.2	21	17.9	-6.3
E	21.3	18.6	16.9	-4.4
BE	6.1	3.4	2.7	-3.4
US	10.5	9.6	7.2	-3.3
DK	18.3	17	15.6	-2.7
UK	13.1	14.4	10.7	-2.4
EU-15	16.4	16.3	14.2	-2.2
S	4	3.7	3.4	-0.6
NL	17.1	18.1	17	-0.1
I	20.9	21.1	21.2	0.3
A	10	9.8	11	1
D	12.9	15.4	14.0	1.1
JP	8	10.4	9.1	1.1
P	25.4	27	28.1	2.7

Source: EUROSTAT data

The share of government research institutions in the public sector's R&D expenditure has changed dramatically in some countries in the past decade (1990-1999), despite the relatively small decline in share for the EU as a whole (Table 1). In relative terms, the greatest change has come in Greece, where a 20% fall reflects the diffusion of EU-funding to other performing sectors. In absolute terms the greatest change is in France, driven both by a reduction in defence spending and by growth in the university sector.

Table 2 Sources of Finance for Government Intramural R&D (GOVERD) Million constant $ (1995 prices and PPPs) and %

	1989		1993		1997		1998	
Business enterprise	889.1	4.0%	1135.4	4.9%	1325.9	6.0%	1456.2	6.7%
Direct government	18720.1	84.2%	19213.9	82.7%	17784	80.4%	17078.1	79.1%
Abroad	391.3	1.8%	625.6	2.7%	790.5	3.6%	782.1	3.6%
Higher education	12.6	0.1%	16.1	0.1%	23.9	0.1%	28.4	0.1%
PNP	235.1	1.1%	246.5	1.1%	198.3	0.9%	241.1	1.1%
	22237.2	100%	23230.5	100%	22120	100%	21583.9	100%

Source: EUROLABS from OECD Basic Science and Technology Statistics (Unadjusted)

Table 2 indicates the sources of finance for intramural government R&D in EU Member States. This shows that government remains the dominant source of funds but is in relative decline. The two main areas of growth are in income from business enterprise, which has risen from 4% of the total to 6.7%, and in income from abroad which has doubled its share from 1.8% to 3.6%. The latter is made up of various sources including EU funds and transnational funds from business.

Table 3 Government Financing by Business Enterprise Million constant $ (1995 prices and PPPs)

	1989	1993	1997	1998
Austria	0.9	4.3	..	..
Belgium	1.5	15.4	16.2	..
Denmark	9.6	11.4	8.1	..
Finland	35.7	33.5	55.5	60.5
France	233.8	275.6	387.5	484.6
Germany	51.6	203.3	117.9	128.2
Greece	2.1	2.4	3	..
Ireland	5.8	13.4	12.5	12.6
Italy	65	36.1	99.5	66.1
Netherlands	148.7	150.1	217	231.8
Portugal	..	..	9.2	..
Spain	26.5	41.9	46.9	57.5
Sweden	13.1	7.7	6.8	..
UK	294.8	340.3	345.8	414.9
TOTAL	889.1	1135.4	1325.9	1456.2

Source: EUROLABS from OECD Basic Science and Technology Statistics (Unadjusted)

Table 3 breaks down the contribution by business enterprise by Member State. It may be seen that the largest magnitude increase was in France, followed by the UK and the Netherlands. Sweden and Denmark registered a decrease over the period for which data were available, though small in magnitude. These figures can be taken as an indicator of the degree of commercialisation of activity.

2. Methodology

The remaining part of this report is based upon the findings from the EUROLABS Project, an empirical investigation of the situation of research centres in the European Uniion. A full account of the EUROLABS project methodology is given in the methodological report accompanying this volume. The box below provides a summary of the approach and its limitations which should be borne in mind when interpreting the data.

EUROLABS Project Methodology

The **main objectives** of the project were:

- To compile a database describing the main features of major public or semi-public research centres;
- To study major public or semi-public research centres in the EU (49 case-studies were completed) by analysing their specific features – status, organisation, research potential, performance and resources, in the context of reforms in the public sector; and
- To develop a methodology for the classification of the centres.

The **database** was designed to capture information available from documentary sources (which is subsequently validated). Key items covered include contact information, ownership, financial income, relationship with other organisations, location and structure, functions, sectors addressed, scientific and technological capability and personnel data. Currently 769 centres are included in the database.

Data collection comprised three stages. The first stage made use of existing data sources. Published sources of data were gathered directly from the research centres. Secondly an Internet based 'pre-survey' was used to confirm and collect further information on the identified research centres. In the final stage the data was printed and mailed to the research centre for validation. A response rate of 66% was obtained. Data were entered in an Access database and analysed in SPSS.

It was decided to **include** only national and not international or pan-European research centres such as the EMBL. Also **excluded** from the study are university dependent research centres, that is, centres that are, effectively, integrated with the university research systems of the member states. A major example of this type is the French CNRS, excluded because of its high level of integration with university teams. Social Science research centres have been included in the database. Another decision affecting the analysis concerned the treatment of the large laboratory associations in Germany. The trade-off was between treating them as single entities, which they are in a legal sense or entering each laboratory separately to capture the variety of activity they cover. The compromise adopted was to enter the ten largest individual institutes as well as the parent organisation but to avoid double counting in the analysis. However, it should be borne in mind that multiples in other countries, such as CSIC in Spain or CNR in Italy, have a single entry.

A particular challenge was the rapidly growing **non-profit foundation** sector. Some of these bodies rely on commercial income but we took the decision to include them where government was the major customer or the driving force behind their creation and existence. Nonetheless, this sector deserves further dedicated study, which should extend also to foundations providing research funding for others.

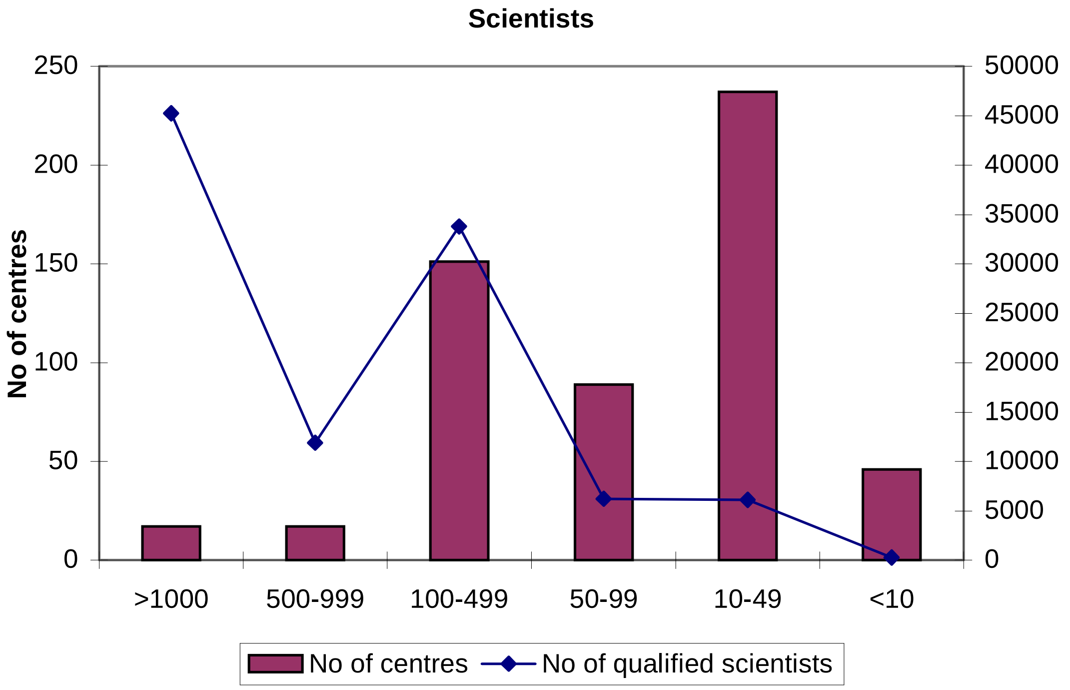
The **principal limitation** of the project methodology is that it relies on a degree of interpretation by the teams responsible for national collection of data, particularly in respect of criteria for inclusion and exclusion against the background of very different national legal and cultural settings for research, and also affecting issues such as ownership and governance arrangements. It was also problematic establishing comparability in financial data. Not all laboratories reported detailed income and expenditure data and even where they did so the reporting period was not always clear, creating problems for setting inflation and currency exchange corrections. Several lessons were noted for future improvements in the database structure. The principal advantage of the methodology is that by maximising the use of publicly available material and confining the survey element to the validation and completion of data, a response rate much higher than that which is typical for mailed surveys was obtained. Data entry by our team also reduced the range of interpretations of the questions.

The **case study** phase of the project involved both a deeper exploration of the information captured in the database and an examination of the historical path and present circumstances of the institutions. While not a representative sample, the 49 case-studies were clustered around organisations with particular missions or functions, for example metrology, former nuclear power research organisations or cancer research. Some were selected because they represented organisational innovation, especially on the interface with the non-governmental sector.

3. Size Distribution of Centres

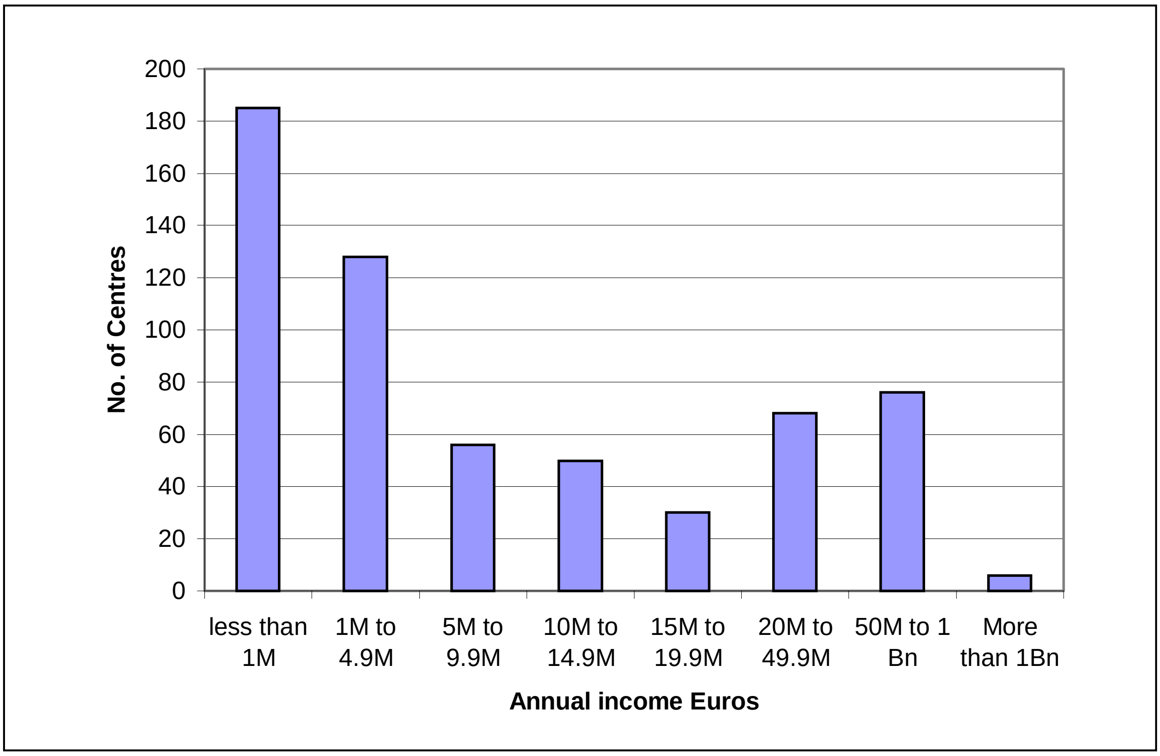
The centres in the database are employing over 100,000 qualified scientists in the 557 cases where the total is available. Figure 3 shows the distribution of these scientists by size of lab in terms of scientists employed and the totals in each band. It may be observed that while the greatest number of centres (237) employ between 10 and 49 scientists comprising 6% of the total, the greatest number of scientists work either in large organisations (45,241 in 18 organisations comprising 43% of the total) or in centres with 100 to 499 scientists (33,785 in 151 centres). The largest number of scientists in specific organisations are in the Commissariat à l'Energie Atomique and the Institut National de la Recherche Agronomique in France and in the Wissenschaftsgemeinschaft Gottfried Wilhelm Leibniz e.V. and the Fraunhofer Gesellschaft zur Forderung der angewandten Forschung e.V. in Germany.

Figure 3 Number of Centres and Number of Qualified Scientists by Number of Qualified Scientists



The distribution by annual income is shown in Figure 4. The aggregate annual budget of the organisations in the database where known (599 cases) was 25.648 Billion Euros in 1999. The size distribution by budget is shown below. While small independent centres predominate numerically, the largest budgets normally belong to national organisations responsible for several laboratories.

Figure 4 Distribution of Centres by Annual Income



4. Foundation of Research Centres

Figure 5 Number of Research Centres Created by Decade

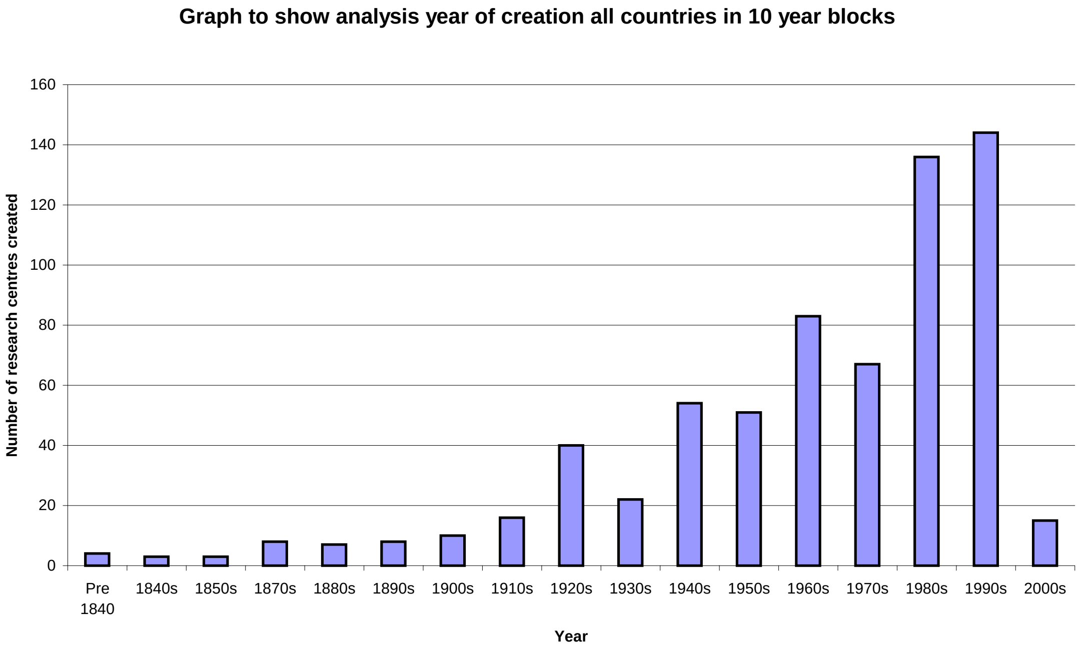


Figure 5 shows the year of foundation of the Research Centres in the EUROLABS database. Several points may be emphasised. One is the extremely long history of a small number of institutions. The oldest laboratory in the database is the Royal Botanic Garden Edinburgh founded in 1670. Other centres originating pre-20th Century are usually observatories, geological surveys and meteorological labs, with health and agriculture becoming more common towards the end of the century. In the 20th Century creation of research centres has proceeded in waves. In each case these covered a wide range of sectors and functions but some patterns may be discerned. An upsurge of activity in the 1920s consisted mainly of health, industry and agri-industry oriented labs. This was followed by another peak in the post WWII period when laboratories were founded as a part of national reconstruction. In the 1950s several national nuclear laboratories were founded. More recent times have seen the emergence of institutes dedicated to IT and biotechnology. The fact that almost half of the centres in the database have been founded in the past two decades reflects both the dynamics of science and technology and the rate of reform and renewal. A substantial proportion of these “new” labs are built with the resources of predecessor organisations.

Within these figures there is substantial national variation. Hence, while 18% of the research centres were created before 1940, for Italy the proportion is 44%, for the UK 34% and for the Netherlands 33%. On the other hand Germany renewed its institutions to such an extent that only 5% pre-date 1940. Only 4% of Greek centres and 6% of Spanish were founded earlier. In fact for Greece (16%), Spain (21%) and Portugal (26%) substantial growth came in the 1980s.

5. Ownership, Governance and Reform of Research Centres

Table 4 Ownership of Research Centres

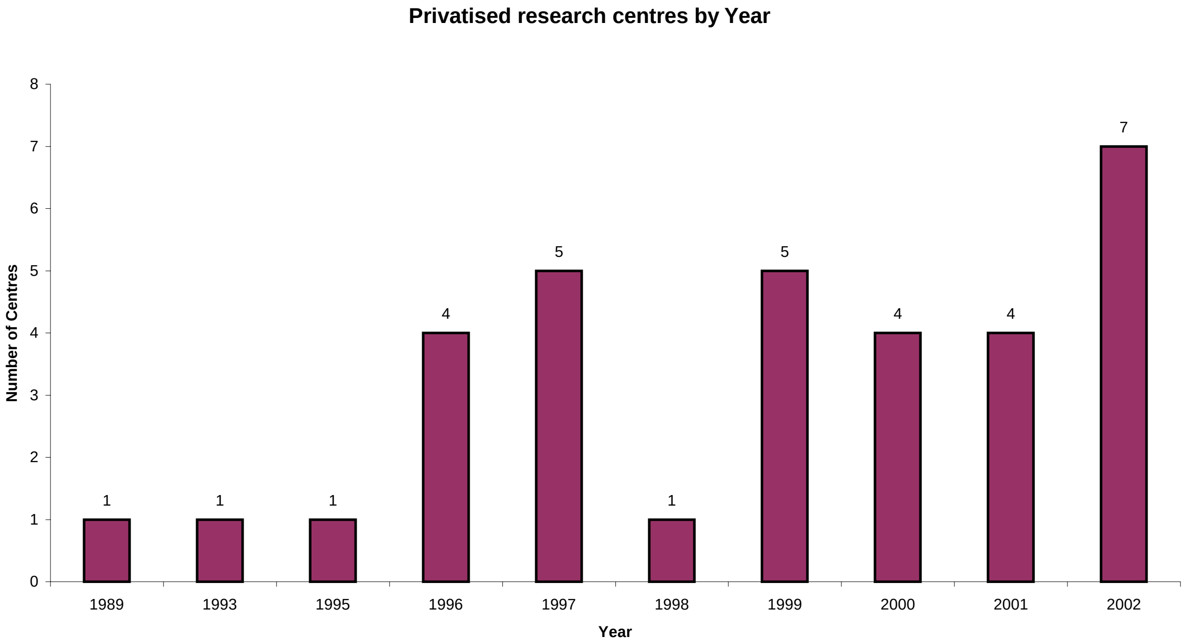
	Central Government	Not for profit foundation	Private sector	Regional or local government	University	Other
A	14	9	4	2	0	2
B	10	15	0	6	0	0
DK	32	15	1	1	0	0
D	7	59	1	3	0	6
FIN	30	2	3	0	0	1
F	34	71	0	0	0	0
EL	52	0	0	0	0	0
IRL	5	1	0	0	0	0
I	63	4	0	0	0	0
L	2	1	0	0	0	1
NL	10	22	15	0	0	1
P	12	33	0	0	1	0
ES	19	60	3	8	0	0
S	9	14	23	0	0	0
UK	41	15	6	11	5	5
Total	340	321	56	31	6	16

Table 4 indicates the distribution of ownership of laboratories in each Member State. Overall it may be seen that the two dominant categories are ownership by central government and not-for-profit foundations. Smaller numbers of labs have passed from government into the private sector or are owned by regional government or universities. Across Member States there is a wide variety of ownership profiles. In Germany, Spain, Sweden, the Netherlands and Portugal, ownership by central government is relatively infrequent (9-25% of entries). At the other extreme, this is the only model in Greece, while Italy, Ireland and Finland all have more than 80% in this category. Not-for-profit foundations are the dominant model in Germany, Portugal and France. Regional ownership is only significant in Belgium, the UK (mainly Scotland), and Spain.

Eight countries have some private sector presence but only five (Austria, Netherlands. Italy, Sweden and UK) report the change of status described as privatisation, covering 30 laboratories in all. Figure 6 shows the year of privatisation. The mid-to-late 1990s includes British national laboratories and Austrian and Swedish industrial research institutes. The late 1990s are mainly agricultural research centres in the Netherlands while post 2000 is accounted for by laboratories in Italy, where the Stazione Sperimentale formerly under the control of the Ministry of Industry were transformed into publicly owned for-profit entities where core funding comes from the market. Privatisation also continues in the UK with the much delayed and debated privatisation of the Defence Evaluation and Research Agency (DERA), the UK’s and possibly Europe’s single biggest laboratory. Work on matters of high sensitivity has been retained in a new government lab, while the rest of the organisation has been re-branded as Qinetiq. An initial plan to float this as a company was abandoned when unfavourable market conditions intervened. The present plan is a direct sale to private owners.

Ownership by a university is a comparatively rare category, as the database excluded universities as such unless they were a vehicle for a public laboratory with a separate mission. However there may be a growing trend of convergence with the academic sector. The UK provides a case, the Southampton Oceanography Centre which is the UK's national oceanography laboratory, which has moved from being a Research Council Institute to that of a joint venture between the University of Southampton and a public sector research organisation, the Natural Environment Research Council. The motivation was to seek scientific synergy by combining the lab with the largest academic department in the field. Dual administrative systems and employment arrangements persist though it is envisaged that eventually all staff will work for the university. The dual status has opened a wider range of opportunities for funding and commercialisation. A more general concern for research centres is the recruitment of highly qualified newly trained researchers. Linkages with universities provide a secured source and hence many laboratories sponsor or provide training and facilities for doctoral researchers. Some 14,500 are recorded in the database.

Figure 6 Year of Privatisation



In the UK, while the number is low, many of the largest national labs have been privatised in the past decade. Change has been driven by the political conviction that application of the principles of new public management should extend beyond the customer-contractor principle to question whether the ministry should own the contractor. However, no single process or outcome exists[6]. A wide variety of science and technology organisations were subject to a succession of reviews and many of these, particularly those where the principal mission was basic research, have remained in the public sector. Privatisation has been on a spectrum encompassing one example of a GoCo model (Government-owned, Company-operated), several cases of Companies limited by Guarantee (private organisations but with certain constraints on behaviour to safeguard the public interest) through to full privatisation or sale of the laboratory to an existing private company. Table 5 indicates the principal models, their characteristics and an example of each.

Table 5 Privatisation models in the United Kingdom

Organisational model	**Government-owned, company operated**	**Company limited by guarantee**	**Fully private company**
Example	National Physical Laboratory	Building Research Establishment	AEA Technology
Characteristics	Government owns the site and buildings. A private contractor provides the "service" of running the establishment and delivering the research and technical support. The staff are employed by the private contractor.	Private organisation with certain constraints on behaviour in order to safeguard the public interest. Typically has involvement of stakeholders (eg construction industry, government)	Publicly quoted company which made subsequent acquisitions and divestments

Ownership may also be mixed or "semi-public". The emergence of this model may be seen in the case of industrial research institutes in Sweden. Originally established as R&D resources for specific industry sectors, but now organised around technological competences, they receive around one third of their income from government and obtain the rest from contracts for applied research and knowledge transfer. These had previously operated as independent foundations but are now being reorganised to become limited liability companies. A minority shareholding will be taken by a governmental holding company, IRECO (Institute for Research and Competence Holding) while the majority shareholding will belong to an association of member companies. The Members Associations are intended create closer links between the institutes and industry and also to provide a platform for cooperation and joint action between the firms. The Austrian Research Centres Siebersdorf (ARCS) has a similar ownership structure in which central government holds 51% of the shares, while a consortium of the country's leading industrial and commercial organisations retains a

[6] Gummett P, Cox D, Boden R and Barker K (2000), The changing central government of science and technology, in Rhodes RAW (ed), Transforming British Government Vol.2: Changing Roles and Relationships (Houndsmills: MacMillan)

49% interest. The aim of this structure is again to promote linkage with and input from industry.

In Spain a similar position has resulted almost from a reverse sequence whereby independent non-profit industrial research associations, with origins in the cooperative movement, have drawn closer to national or regional government. At a basic level this trend has been driven by a desire of the associations to gain a status which provides access to national funding for technological development, or to regional funds for development. In one example, INESCOP (Technological Institute for Footwear and its Related Industries) evolved to become a collective resource with a certain degree of independence from its member firms and empowered itself through adopting an intermediary role between the sector and government. At a regional level, a second example is IKERLAN, a private cooperative which has evolved strong links with the Regional Government of the Basque Country. The effect of the introduction of public financing (around 50% of the budget) was to raise the technological level, and critically, to open its services beyond the cooperative membership group. However, the regional government participates in the governing council only as a guest, without voting rights.

Table 6 Governance of Research Centres

	Accountable to foundation or regulator	Accountable to shareholders	Branch of Government	Independent public organisation/agency
Austria	8	8	11	3
Belgium	18		3	10
Denmark	13		30	5
Finland	4	1	20	11
France	73	1	2	29
Germany	46	2	8	14
Greece	22	9		21
Ireland	1		2	3
Italy	2	1	3	58
Luxembourg				3
Portugal	1	32	7	6
Spain	58	7	8	17
Sweden	17	20	10	1
The Netherlands	12		2	33
UK	14	5	24	39
Total	**289**	**86**	**130**	**253**

In Table 6, the overall distributions of forms of governance is shown. It may be seen that most research centres today operate at arms length from government. Countries with the largest number of institutes under direct government control are Denmark, with its Government Research Institutes (GRIs), Finland, and the UK, where this category was the most common until 1979 but has since declined. Laboratories which have not been privatised typically have transformed to agency status, with structures more similar to the private sector, including the ability to trade in the market and to employ staff on terms which do not necessarily follow civil service practices. Agency relations with government are typically of a contractual nature.

The category of being accountable to a foundation or regulator is particularly emphasised in France, Germany and Spain. For France, this category is mainly composed of technical centres serving particular industrial sectors, traditionally funded by levy, though this mechanism will cease in 1993 owing to European regulations. However, though numerous, such centres are usually small and hence have much less weight in the system than the "grand organisms" which dominate the public sector in France. The latter are themselves subdivided into different categories according to the legal framework deriving from the 1982 Research Act (LOP) which brought about a financial division between institutions and their parent ministries but which brought many researchers into the civil service. Table 7 shows the types of status and the largest examples in each category.

Table 7 Status of French Public Research Institutions[7]

Status	**Function**	**Examples in research**
EPA – Établissement Public Administratif	General status for state-owned agencies or institutions	AFSSA – Animal & food safety INRP – Pedagogical research
EPST – Établissement Public à caratère Scientifique et Technologique	Specific status created by 1982 law for research agencies or institutions	INRA – Agricultural research INSERM – Health and medical research
EPIC – Établissement Public à caratère Industriel et Commercial	Specific status for state-owned organisations which engage in economic activities (staff not civil servants)	CEA – Research in nuclear energy ONERA – Aerospace research CIRAD – Agricultural research for development IFREMER – Ocean, marine & fisheries research

The process of change and reform is an ongoing one. At present the greatest activity is in the Italian system where the financial law for 2002 provides for the possibility of public agencies being transformed either into foundations or commercial companies. The future structure of major national bodies such as CNR and ENEA is in the process of reform but the likely final outcome is unclear.

6. Orientation of Research Centres

To explore where research centres fit in the innovation system we can examine their orientation in terms of the types of activity they undertake, their scientific and technological capabilities and the sectors which they address. The following analyses

[7] Based on Larédo P and Mustar P, French research and innovation policy; Two decades of transformation, in Larédo P and Mustar P (eds), *Research and Innovation Policies in the New Global Economy*, Cheltenham: Edward Elgar, 2001

are from the EUROLABS database. Since many labs have multiple orientations, the data show the overall situation.

Figure 7 Function of Research Centres

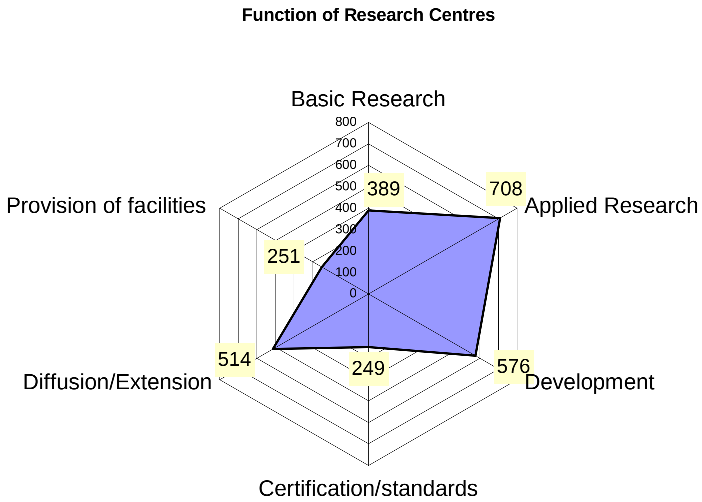
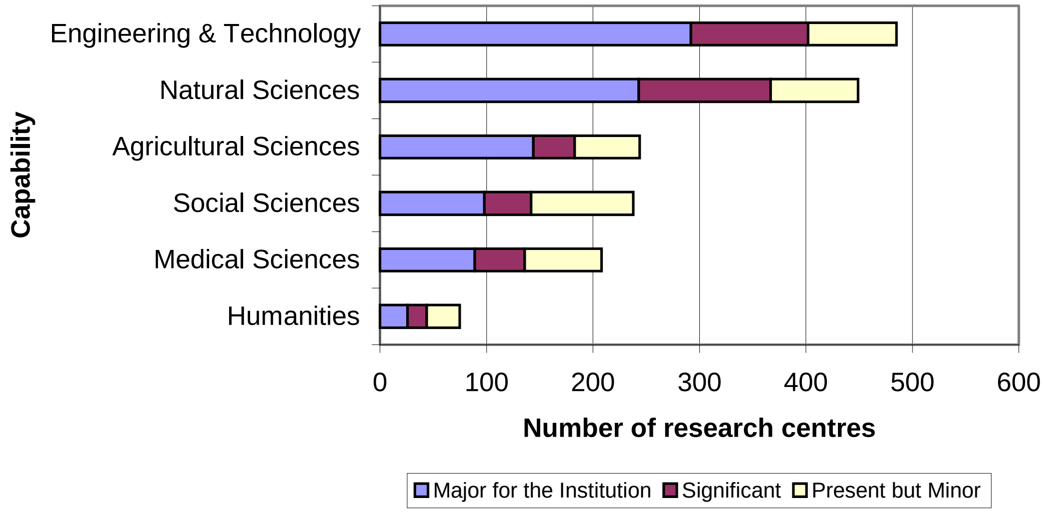


Figure 7 indicates that the most frequent orientation of this sector is applied research, which is carried out by almost all of the laboratories in the database, reflecting the mission-orientation of the majority. Basic research, by contrast is only carried out by around half of the labs. These fall into two main categories: those for whom basic research is the central mission including national organisations such as the Max Planck Gesellschaft in Germany and the Consejo Superior de Investigaciones Científicas (Higher Council for Scientific Research) in Spain; and the second group being mission-oriented institutions which nonetheless perform some basic research in order to maintain their scientific capability. This is particularly the case for laboratories working in health and life sciences. Centres are also engaged heavily in the application of their capabilities: both development and diffusion/extension activities are a part of the activity of about 70% of the database. A variety of mechanisms are cited for diffusion. Most common are the provision of training and education for users, and presentation of outputs and other technical information through information services, publications, reports, seminars and conferences. The other main mechanism is through commercial activities including consultancy and technology transfer. Provision of facilities for use by other researchers provides one of the rationales for the existence of research centres. This represents an activity for about 30% of the database.

Figure 8 shows the distribution of capabilities in the database. It may be seen that overall Engineering and technology and Natural sciences are the predominant primary and secondary skills. However, more specialised capabilities in agriculture, medicine and social sciences are also well-represented and even the humanities are covered with 78 centres involved in topics such as languages, culture and aspects relating to societal issues. Co-occurrence of capabilities is also high with the categories "significant" and "present" always being alongside a different major interest.

Figure 8 Capabilities by Main Field



Changing the Knowledge Base – The case of Former Nuclear Laboratories

An example of the drive to acquire capabilities valued by the market can be seen in the case-studies of former national nuclear laboratories. All have pursued diversification strategies. The favoured pathway has been towards environmental sciences and materials, both of which feature strongly in the nuclear technology sphere. For some the impetus to diversify was political. ARCS in Austria and ENEA in Italy both responded to public referenda rejecting nuclear power. Riso National Laboratory in Denmark also experienced a political abandonment of nuclear power in 1985. For ARCS the change came in 1978 and after painful adaptation the new mission was to support Austrian industry. ENEA experienced a similar decision in the mid 1980s and eventually acquired a mission aimed at developing alternative sources of energy and addressing environmental problems. A similar route was followed in the 1980s by CIEMAT in Spain. In the early eighties, when the socialist party arrived to the government, the centre started a process of diversification of its traditional research mission. From concentration in nuclear energy areas, it moved towards a new orientation on general energy and environmental research. Many of the competencies and services that *Junta de Energia Nuclear* (JEN) monopolised over decades were distributed among other newly created organisations and firms: In 1972 the government created ENUSA a firm to work on nuclear fuels; in 1980 the Consejo de Seguridad Nuclear (CSN- Nuclear Safety Board) took all the competencies for security after an Act that was approved by the Parliament, and in 1984 a new firm, ENRESA, was created to manage the Spanish nuclear waste. In the mid eighties it changed the name from *Junta de Energia Nuclear* (JEN) to the present CIEMAT and it was recognised as a "Public Research Centre - PRC" (OPI-Organismo Público de Investigación), and thus it received the legal capacities to act as such entities by the Science Act. However, for ARCS the transition is complete while ENEA remains with over 30% of its activities in nuclear related areas and Riso includes nuclear safety among its seven research departments, the others of which are concerned again with materials and alternative energy but also include optics and sensors and plant production and ecology.

Elsewhere in Europe, Demokritos is a lab which originated as the research branch of the Greek Atomic Energy Commission but since 1988 has been an administratively independent organisation under the Ministry of Development with a diverse portfolio of public good research, including nuclear activities.

Perhaps the most spectacular change has been witnessed in AEA Technology, the privatised Atomic Energy Authority which originally developed the UK's civil nuclear power programme. As noted in Table 3 this is now a public company and has developed an impressive international contract research business. However, growth has been on the basis of a programme of acquisition and diversification followed by a more recent decision to focus on two areas, rail and environment, with the remaining nuclear capabilities sold off. This reflects the difficulties in finding markets for some of the more direct applications of nuclear capability, especially in materials. ARCS also had this experience and faced a second crisis point in the mid-1990s from which recovery was obtained only by changing the knowledge-base and ethos, with IT as applied to testing and simulation becoming the core competence and previous equipment and material based competencies being downgraded.

Certification and Standards as a Mission – Alternative Formats for Metrology

Five case studies of the public sector funded delivery of metrology services and research were undertaken during the course of the project. The research centres studied were the National Metrology Laboratory (NML) in Eire, Bureau National de Metrologie (BNM) in France, NMi Van Swinden Laboratory (NMi) in the Netherlands, the National Physical Laboratory (NPL) in the UK and Istituto Elettrotecnico Nazionale Galileo Ferraris, and (IEN) in Italy.

The mission of the metrology cluster can be summarised as the development, maintenance and measurement of measurement standards. All the metrology research centres in this cluster participate in the process of metrology policy formulation. Not all do the research themselves. NPL has a mission to carry out research into new standards of measurement and their realisation. The mission of BNM is to prepare and implement the national metrology policy – it commissions research but does not carry out the research itself. NMi is the official state metrology standards laboratory, it develops and maintains the primary, national, physical and chemical standards for the Netherlands. NML's mission is to develop, maintain and disseminate national measurement standards in accordance with the International System of Units (SI), so as to contribute to economic growth, scientific innovation and improved quality of life.
Different types of organisations, embodying different legal status and funding mechanisms, deliver metrology research across the five countries studied. The National Physical Laboratory in the UK is a Government Owned Company Operated research centre. The Laboratory is operated under contract to the UK government Department of Trade and Industry (DTI) by NPL Management Limited, a wholly owned subsidiary of Serco Group plc. The BNM is a groupement d'intérêt public (public interest group) whose role is to co-ordinate national metrology policy. BNM does not carry out research itself, it is a small organisation of only a few people and its function is the co-ordination of national metrology research in France. NMi in the Netherlands, a former public sector research establishment (PSRE), privatised in 1989, is now a private company owned by TNO. NML is a division of a larger organisation, Enterprise Ireland, which is a Government agency with responsibility for developing Irish business through a range of financial and other activities. IEN is a non instrumental public body, which means that it is affiliated to the Ministry of Universities and Scientific and Technological Research. It has enjoyed this status since 1992 and has considerably more independence that its previous status as a national research centre.

Each national metrology system also has a different funding model. This is an important point as the constraints on a laboratory for funding sources and expenditure determine the type of R&D carried out and what the research centre will do with the results. In terms of the customer base the main customer of NPL is the DTI and NPL still has a duty to DTI as an owner. However 20 to 30% of customers are now from outside of the DTI but this figure does not exclude other government departments such as DETR. There has been a significant growth in the amount of work being carried out for DETR on topics such as air quality. The main source of income for NPL is UK government. For BNM the main income source is the French government Ministry of Industry c. ∈14m in 2001, with a small complement by the Ministry of Research ∈122k and ∈30k from the EC. In the Netherlands the Dutch government fund 52% of the activity of NMi Van Swinden Laboratory with the market generating 40%. At NML there is a mix of fee income for work undertaken and government subvention. The mix is 55% from fees and 45% from government. The government money is from the vote to Enterprise Ireland. IEN income is ∈14.2m of which ∈11.6m is from public funds. State funding is an important factor for each of the research centres in the metrology cluster. For NPL, BNM, IEN and NMi Van Swinden government is their largest customer.

The size of each of the entities in the cluster measured in terms of personnel and income is significantly different. NPL is the largest with 774 staff and a turnover of was ∈76.8m. BNM has 8 staff and in 99/00 total budgeted income for BNM in 2001 was ∈17m. NMi has 105 staff at Van Swinden and a turnover of ∈15m and NML 23 staff and a budget in 99/00 of ∈11.3m. The low personnel figure for BNM reflects the mission of the organisation; it commissions research to the value for 4.4m FF but does not carry it out; it is a co-ordinating entity for French metrology. NPL is not only the largest of the studied laboratories it is also the oldest. It was established in 1900. The other centres in the cluster were established far more recently BNM 1969, NMi 1989 and NML 1975.

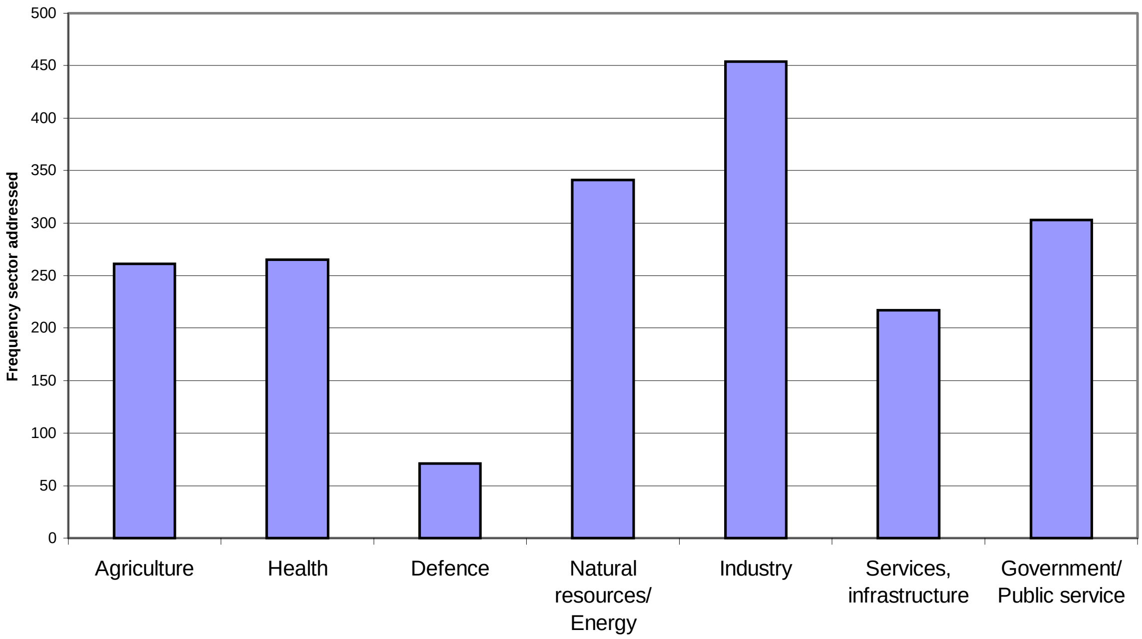
The dominant activity of the cluster is applied research. There is some basic research carried out in the cluster but this is a small percentage of the cluster activity in comparison to applied. Each of the metrology research systems develops and diffuses their research outputs in the form of calibration and standards. All of the research centres participate in European collaboration for the purposes of inter-comparisons. Key capabilities within the sector are the natural sciences, engineering and technology. Specifically these are maths/computer sciences, physical, chemical sciences and electronic engineering.

Future **strategy** of the centres in the cluster include NML's reorientation from low level calibration work to move into high level calibration and standards maintenance and development. This will orientate NML towards a more appropriate model of a national metrology centre. When formulating strategy NPL in the UK have to consider the priorities of the laboratory owner the Department of Trade and Industry. The owner is the largest spending customer, consequently priority setting is negotiated with the DTI. For BNM in France their most important strategic objective is to solve the problem of BNM's status. The public interest group status is temporary; it has been renewed once and the BNM state that it will not be renewed again.

The adoption of a particular organisational form and legal entity for the delivery of metrology research in a particular country is dependent upon the prevailing political climate of that country. As this brief comparison indicates each of the countries selected has chosen to deliver metrology research via a different type of entity. However there is a trend towards the privatisation of the publicly funded metrology research centres reflecting their role in providing a service to industry.

A key point stressed by all the participating research centres is that metrology is an infrastructure as well as a technology. Metrology addresses all industry sectors in the OECD typology and is important for industry in Europe. It is an area where European cooperation has been a positive factor but where considerable scope remains for progress towards a single infrastructure. However, the variety of current formats and traditions makes this a formidable task.

Figure 9 Sectors addressed by Centres



In Figure 9 the sectors addressed by the centres are shown. The only area to be the focus for more than half of the entries in the database is that of support for industry. The next categories are natural resources and energy, and support for government or other public services. Specialised concerns follow, with health and agriculture the focus of around one third of the centres. One third of the centres address only one sector, the most common being industry (88) and agriculture (44). One quarter address two sectors, with the most frequent combination being industry with natural resources and energy (33 cases). Nineteen labs address every sector except defence and 14 address all sectors, these being the large umbrella organisations with multiple research centres.

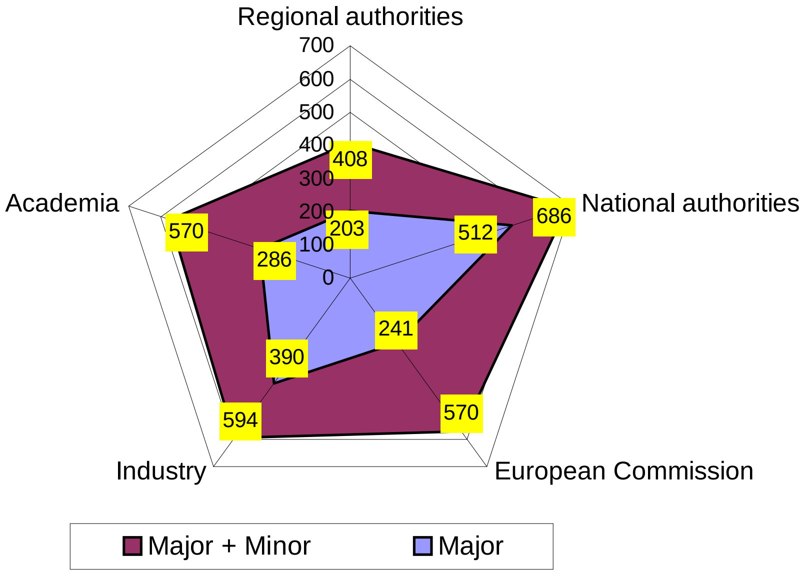
Table 8 National Distributions of Sectors Addressed by Research Centres

	A	B	DK	FIN	F	DE	EL	NL	IRL	I	L	P	ES	S	UK
Agriculture	15%	13%	10%	9%	19%	8%	13%	12%	21%	23%	8%	12%	9%	7%	19%
Health	14%	14%	12%	6%	15%	19%	16%	16%	17%	21%	17%	9%	8%	8%	17%
Defence	1%	4%	3%	2%	6%	3%	2%	5%	4%	1%	0%	5%	4%	4%	5%
Natural Resources/ Energy	19%	20%	14%	16%	19%	21%	14%	18%	17%	15%	17%	22%	17%	13%	20%
Services, infrastructure	14%	11%	10%	11%	4%	16%	21%	12%	8%	8%	25%	11%	11%	12%	13%
Industry	18%	19%	20%	22%	24%	23%	27%	24%	8%	24%	17%	26%	39%	33%	10%
Government/ Public service	19%	17%	32%	34%	13%	9%	6%	13%	25%	7%	17%	15%	12%	21%	15%
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Table 8 shows national differences in the spread of sectors addressed. It should be noted that this does not reflect relative expenditure on the sectors. It may be seen that

Ireland, Italy and the UK have substantial numbers of centres addressing agriculture, with the range going from 23% in Italy to 7% in Sweden. Spain (39%) and Sweden (33%) have higher than average percentages addressing industry, by contrast with the UK (10%) and Ireland (8%) where there are few of this type. Government and public service is most strongly emphasised in Finland (34%) and Denmark (32%), while health features most frequently in Germany, the UK, Ireland Greece and France.

Figure 10 Linkages of Research Centres



To complete the examination of the orientation of the research centres, their linkages with other actors in the innovation system are shown in Figure 10. It may be seen that both for major linkage and overall, national authorities are the most important contact for the centres (92% of centres where linkages are known are in this category). This is not surprising since most of them exist principally to serve the needs of national policy. Industry provides the second most important direction for major linkage (57%) and overall (84%). Similar proportions have major linkages with academia and the European Commission (43% and 37% respectively) and again the great majority have some form of major or minor linkage. Regional authorities are less evident but one third of centres still register them as a major link.

7. Conclusions and Policy Implications

7.1 Overview

The methodology adopted in building the prototype database has presented a number of problems, but also points to some alternative solutions for future iterations of such studies (see accompanying report on methodology). Nonetheless, it has provided a basis for the examination of a previously neglected set of issues. The research centres of the European Union present examples both of variety and of similarity. Some of the key points emerging are:

- A higher proportion of research spend takes place in the government sector in Europe than in the USA or Japan. In broad terms GOVERD has been fairly stable, falling from 16.4% of GERD to 14.2% for the EU15 from 1990 to 1999.

- The overall stability disguises wide national variation both in the reliance placed on research centres within the research system and in the trends in that reliance as measured by share of GERD, ranging from a fall of 19.9% to an increase of 2.2%.

- The 769 centres in the database account for over 25 billion EURO per annum (599 cases) in their budgets and employ over 100,000 scientists (557 cases). The greatest number of centres (237) employ between 10 and 49 scientists comprising 6% of the total number of scientists. The greatest number of scientists work either in large organisations (45,241 in 18 organisations comprising 43% of the total) or in centres with 100 to 499 scientists (33,785 in 151 centres).

- The oldest centres date from the 19th Century or before, with a series of waves of creation taking place in the 20th Century. Almost half of the centres have been founded or radically restructured in the past twenty years.

- The dominant ownership categories are central government, with 340 cases and not-for-profit foundations with 321 cases. However, in five member states under a quarter of centres are owned by central government. Privatisation is reported in five countries but accounts for only 33 cases in all. However, the process continues in some countries.

- The most frequent orientation of the sector is applied research, carried out by almost all labs in the database (705) while basic research is carried out by just over half (388). Development, diffusion, provision of facilities and certification and standards are further roles undertaken.

- Capabilities are concentrated in engineering and technology, followed by natural sciences, but more specialised capabilities are also evident in agricultural sciences, social sciences, medicine and humanities.

- Sectors addressed by centres are quite diverse, with support for industry being the only one to be a focus for more than half of the entries. Health and

Agriculture each are the focus for about one third of the centres. One third of centres address only one sector while 14 national organisations address all sectors.

- In terms of linkages, national authorities are the most important contact for the centres (92% of centres where linkages are known are in this category). Industry provides the second most important direction for major linkage (57%) and overall (84%). Similar proportions have major linkages with academia and the European Commission (43% and 37% respectively) and again the great majority have some form of major or minor linkage. Regional authorities are less evident but one third of centres still register them as a major link.

7.2 Rationale for Continued Existence in the European Research Area

Despite the evidence of growing cross-border linkages, both in scientific collaboration and in contract business, the majority of research centres addressed in this study are essentially nationally-orientated institutions. As remarked above, this reflects the status of many, and the origins of others, as institutions created to meet the research needs of central government. What implication does this have for their role in the European Research Area?

At a basic level the laboratories represent a scientific resource able to contribute to the objectives of ERA. Participation in the Framework Programme has been strong in the past and is likely to continue. It is probable that the institutions focussed on applied research will find for themselves a natural role within Integrated Projects. For the smaller group that has a main focus on basic research, the Networks of Excellence provide a target. Nonetheless, some potential problems exist. Government ownership could potentially constrain the degree of structural integration that could be achieved if it restricts the ability of centre management to commit resources to that integration. A rationale for collaboration exists in terms of enhancing their critical mass to achieve their mission but some legislative adjustments maybe needed.

Commercialisation has also created a possible obstacle to participation for applied research laboratories. As they are increasingly obliged to cover their costs from contract sources, the shared-cost funding model of European programmes is proving an obstacle for some and certainly constrains the level of participation. Others use the Framework Programme (and similar national initiatives) to support their own strategic research programmes so as to develop competences which they can market in their contract research portfolio.

Looking more strategically at the European landscape, it seems clear that there is scope for rationalisation in the provision of many of the services offered by the research centres. The overhead costs of maintaining expertise and facilities in particular areas could be borne much more easily across the European market as a whole. This is especially the case for those areas where the call on expertise is intermittent but important, for example in dealing with crises in health and safety matters. Growing harmonisation of public services and legislation also provides a positive impetus for integration. The answer does not necessarily lie in the creation of monolithic centres; the requirement for local presence and delivery remains important in many cases, especially where the clients are small businesses. A more promising solution would be an agreed division of labour across networked organisations, preferably one which also maintained scientific and commercial competition by normally having more than one network competing for a given activity. The practicality of achieving this degree of integration remains questionable in the short term. A series of barriers would have to be overcome:

- Continued specificities in local markets for scientific advice caused by variation in legislation, standards etc.;
- Continued specificities in local markets for industrial services;
- Variety in legal and ownership structures to perform the same mission;
- Variety in scientific and technological structures providing a setting for a particular competence;
- Variety in level of scientific achievement and facilities;
- Lack of management capability in operating a multi-national service;
- Variable rates of subsidy or core funding between countries.

The emergence of research services as a major business area has further implications for European Union policy. The ambitious target of achieving an R&D spend of 3% of GDP by 2010 can only be met if there is a substantial increase in the research spending of business enterprises. There are two important ways in which research centres can contribute to achievement of this goal:

- There is substantial evidence to show that outsourcing of R&D by firms has trebled in recent years to account for around 15% of spending. A significant share of this outsourcing goes to industry-oriented research centres. While much of this comes from existing large R&D spenders seeking to reduce costs or to access external capabilities, there is also a unique role for research centres. This lies in the provision of R&D and technical services to traditional firms, many of which are SMEs, and which have little or no R&D capability of their own. The industrial structure of Europe is such that progress towards the target necessitates revitalisation of these sectors through improved innovative activity. Research centres provide a natural route to reach this part of industry. They have a particular comparative advantage in areas of innovation which are structured by regulatory change. Hence, policies to enhance their capability to support innovation should be on the agenda. The already acquired commercial skills of some centres also suggests a potential role for them as intermediaries able to improve the linkages between university research and industry.

- The second modality of contribution comes from the role of research centres as a source of new technology-based firms. Here, the greater contribution is likely to come from those centres which are performing more basic and strategic research as, crucially, they and not their clients will own the intellectual property in these circumstances. Some organisations have already achieved success in this respect but for many a challenge remains in creating the right culture and incubation facilities, instituting appropriate intellectual property management and incentive schemes and in gaining access to the necessary capital to take forward ideas.

The drive to commercialisation should not obscure the fact that for many centres the prime goal remains the public interest, including R&D for public goods and the provision of scientific advice to government. The effects of public sector reforms are complex to assess here[8]. On the one hand the creation of arms-length relations with government departments avoids the problems which emerge when those departments have dual responsibility for promotion and regulation of a sector (for example food safety). Placing the supply of scientific advice into a contestable market allows for plurality and potentially transparency. On the other hand, the argument can also be made that sourcing advice from an organisation which depends upon contracts from both the government department and potentially the industry being regulated may place limitations on the ability of the supplier to give unpalatable advice to its customers. Perhaps the key issue in a market model for the provision of advice to government is the necessity for the presence of an intelligent customer in government, willing and able to take responsibility for the maintenance of capability in the longer term that can be called upon when necessary.

Undoubtedly, laboratories are having to compete to a greater extent for activities which were previously their own preserve against universities seeking external income and the private sector seeking new business. On the other hand research centres increasingly have become more active in providing services which were previously undertaken by the private contract research sector, to the extent that the borderline between the two is becoming obscured. The relationship with universities is more complex as many labs have sought to redress their problems of recruitment and replenishing ageing staff profiles by creating links with universities and encouraging postgraduate study on their premises. Location on university sites of distributed centres is another factor reducing the difference, while on the other side the emergence of graduate schools and interdisciplinary institutes makes universities look more like research centres.

What in this context of convergence, competition and cooperation could be said to be the distinguishing characteristics of research centres? In part they can continue to be defined by what they are not – not teaching institutions and not bodies carrying out R&D to support broader corporate objectives. Several roles remain.

- For those laboratories performing basic research, the institute model can provide a critical mass in a single location suited to a strong and undistracted focus on an ambitious scientific goal. The emphasis then is on the mechanisms by which such an institute is first selected, then evaluated and ultimately terminated or redirected. National research bodies are normally the sum of such parts with an institutional framework attached.
- Provision of technical facilities for others to use could be managed by a university but there are strong arguments for a specialised base where facility management is the main mission and where there is a focus on good management and maximising the added value the facilities can provide across the community of researchers they address.
- In applied research, the rationale is maintenance of expertise and facilities in some cases to serve the needs of a single customer (for example a defence

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[8] Georghiou L and Metcalfe JS, Convergence and Division of Labour in Policy for Science, NPRNet Conference, University of Sussex, 2002

ministry needing advice on procurement), and in other cases providing services which are important in socio-economic terms but which are difficult to capture in the price mechanism (for example metrology research). In neither case could a responsible government expect the market to provide adequate service without a corresponding commitment from its side, especially in providing a commitment to continue its custom for a period long enough to encourage development of research and research careers. The need for ownership by government is harder to argue but may be necessary to prevent a crowding of potential suppliers around areas of short-term high returns at the expense of neglecting long-term needs.

- A key difference between mission-oriented and academic science is the extent to which scientific excellence is a goal in itself. While most research centres take pride in maintaining their professional standing through publications and conferences, this is not their primary purpose. There are functions, such as taking long-term measurements which are important science but mundane in research terms. It is doubtful whether these would prosper in the long-term in a university environment, particularly in the fluctuating funding climate of competitive grant-based research funding.
- The remaining specialised role for centres lies in their potential to act as an instrument of diffusion of technology. This is increasingly a goal for universities, but not their primary purpose. The large number of centres identified with an orientation to industry and especially to SMEs shows that both policy (manifested by specific government funding) and the market (manifested by industrial contracts) have identified a need. Older models such as research associations funded by levy are being superseded by new forms of non-profit body. In this respect research centres are becoming embedded as an instrument of innovation policy. However, in these circumstances the pressure is to be an agent for the transfer of existing technology and consulting services. A key policy and strategy issue will be how to ensure that the intellectual capital being expended can be renewed.

7.3 Concluding remarks

Inevitably in a first investigation of this kind more issues are opened than resolved. Each of the different types of research centre we have studied deserves further study. The combination of a database and case-studies has provided a balance of quantitative and qualitative information. However, they each provide a static picture, or at least a picture frozen at a point in time. There is a high premium on maintaining and developing these instruments to gain an understanding of the dynamics of public, semi-public and recently privatised research centres in Europe through the accumulation of longitudinal data. This is especially the case at a time when the European research system is striving to meet a challenge to improve its scale and performance to keep up with leading competitors.