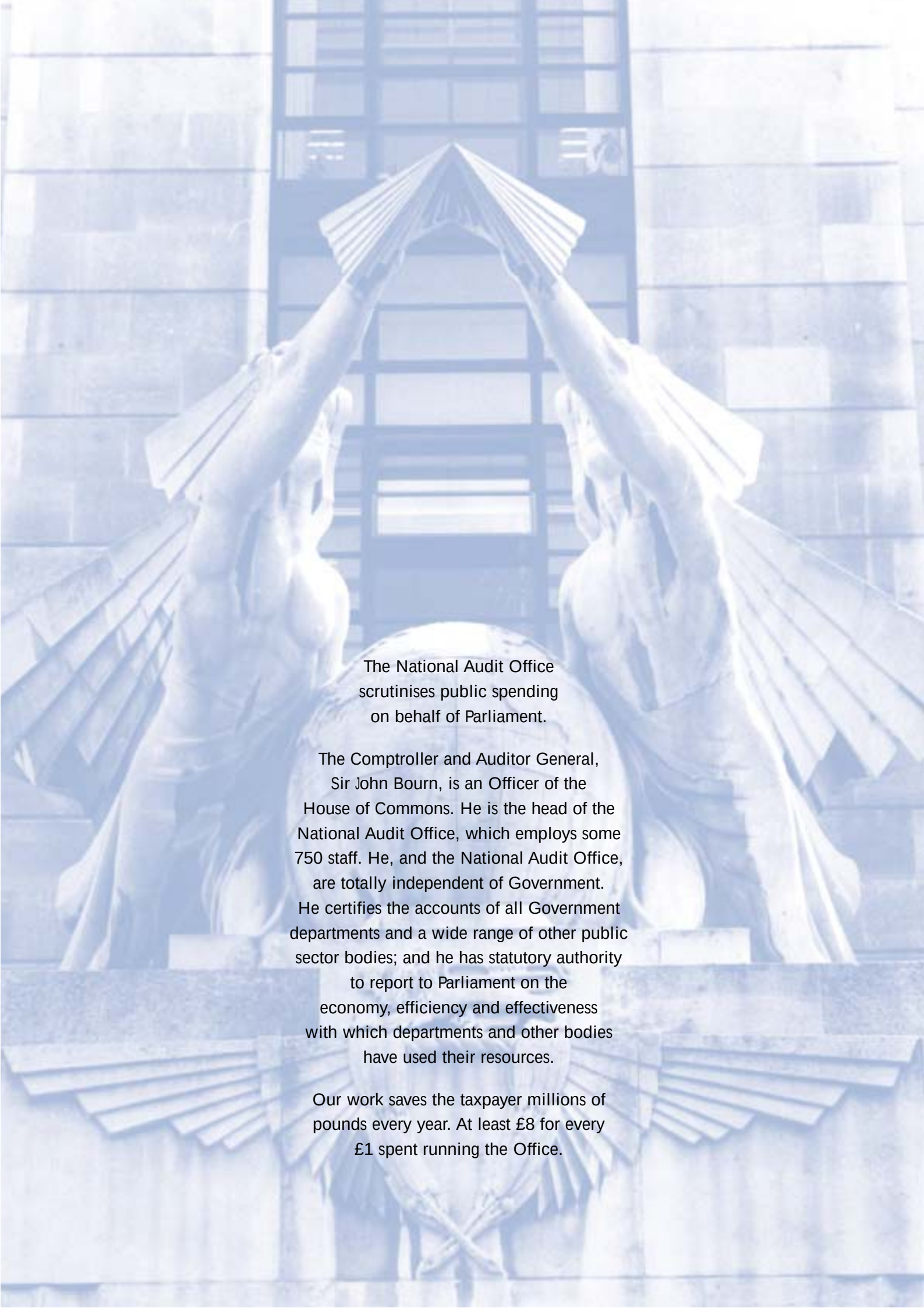
NATIONAL AUDIT OFFICE

An international review on Governments' research procurement strategies

A paper in support of Getting the evidence: Using research in policy making

REPORT BY THE COMPTROLLER AND AUDITOR GENERAL
HC 586-II Session 2002-2003: 16 April 2003



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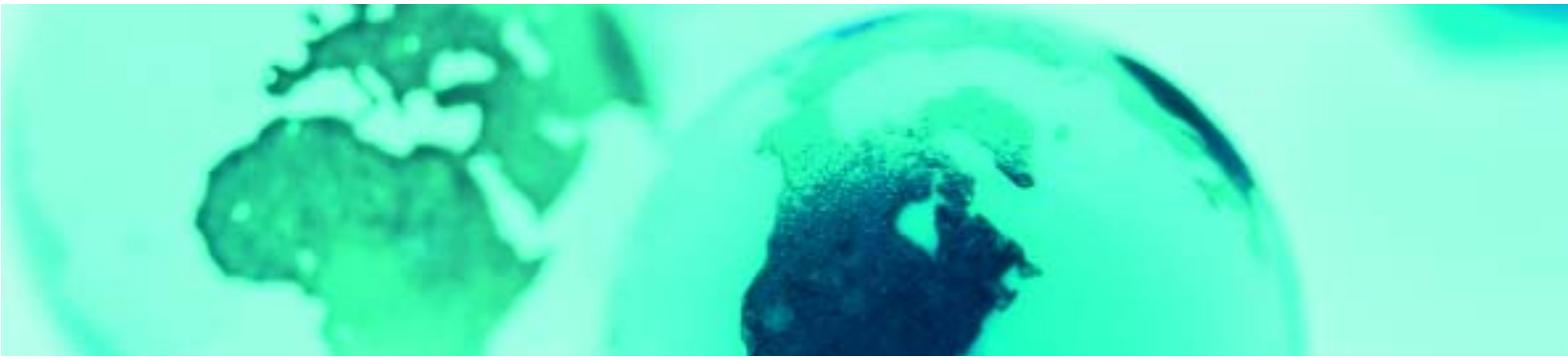

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John Bourn
Comptroller and Auditor General

National Audit Office
10 April 2003

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Preface

This report presents the results of an international review of how the governments of five countries in North America and Europe procure and manage research to improve service delivery and policy development. It complements the National Audit Office report "Getting the evidence: Using research in policy making". The main objectives of this paper, are twofold. First, it aims to describe how research and development is commissioned, managed and used in a number of different countries. Second, it provides a basis for examining the research and development activities of the UK within an international context and for learning how innovative elements from other countries may be incorporated into or modified to suit the UK research and development model.

The executive summary of this report outlines the key findings from the international review. In summary these are:

- There is no uniform approach to determine research priorities and to set research strategies. However, there seems to be increased awareness and activity to make these strategies and priorities a more integral part of policymaking.
- There is growing emphasis on evaluating the policy outcomes of research and development expenditure.
- There is widespread acknowledgement that some research and development expenditure is high risk and will bring no short-term return, but that it is essential for long-term development.
- There are some innovative examples of how research users are incorporated into the research process, with the aim of increasing research utilisation.

The Executive Summary also reviews the significant similarities and differences in research and development practices among the selected countries and between the countries and the UK. First, investment in research and development is summarised, then priority setting and coordinating processes are compared, followed by selecting and commissioning practices and, finally, evaluation and research transfer are examined. The remainder of the report presents detailed information about the context of research and development activities in the five selected countries and describes the different and innovative approaches to research selection, procurement, implementation, management, evaluation and transfer in each.

executive summary

1 This report presents the results of an international review of how the governments of five countries in North America and Europe procure and manage research to improve service delivery and policy development. It complements the National Audit Office report, "Getting the evidence: Using research in policy making", which provides an assessment of the research activities of UK government departments and examines how research is used to improve service delivery and inform policy making in this country.

2 The main objectives of this paper are twofold. First, it aims to describe how research and development is commissioned, managed and used in a number of different countries. Second, it provides a basis for examining the research and development activities of the UK within an international context and for learning if and how innovative elements from other countries may be incorporated into or modified to suit the UK research and development model. Unlike "Getting the evidence: Using research in policy making", the international review covers science based activities as well as research commissioned by Government departments for policy making. This is because these two elements of publicly funded research are not always as easily distinguishable as they are in the UK.

3 Countries were selected according to several criteria. First, only countries with sizeable investments in research and development (at least exceeding 1.75% of GDP) were considered. Second, in order to examine the effects of institutional context on research and development activities and outcomes, countries were selected with a range of government structures. Finally, in order to present comparisons relevant to the UK context, selected countries did not differ fundamentally from the UK on any of the previous criteria.

4 Application of the selection criteria led to a comparative examination of the following five countries: Canada, Finland, Germany, the Netherlands and the United States (US). Information gathering mainly comprised desk research supplemented by additional, targeted interviews. The organisation and analysis of the information was based on a conceptual framework and issues that emerged during the course of the overall study.

5 The executive summary first presents the main findings from the international review. It then briefly reviews the significant similarities and differences in research and development practices among the selected countries and between the countries and the UK. First, research and development investment level is summarised, then priority setting and coordinating processes are compared, followed by selecting and commissioning practices and, finally, evaluation approaches and research transfer are examined. More details on the practices of each individual country are provided according to the same structure in the subsequent chapters.

Main findings

6 The main findings from the international review are as follows:

- Government departments in the selected countries struggle with the complexity of how best to determine research priorities and set appropriate research strategies. New organisations and structures emerge to cope with these complexities, some moving towards centralisation and concentration, some towards decentralisation. Either way, these changes aim to stimulate new ways for departments to think about research and development and policymaking, to prioritise research decisions and to set research strategies.
- The need for more and improved information systems to provide comprehensive overviews of diverse research and development commissioning practices and options is apparent in the selected countries. Ideally, such information systems could serve several important objectives by maintaining and sharing information for analysis, thus improving coordination activities and increasing transparency.
- Evaluation of the quality of the research process is well established. However, there is a strong and developing emphasis on evaluation to encompass research relevance and value for money, as the link between research results and policy formulation increasingly becomes the focus of attention. As yet, obvious models or practices that support the link are not readily available. Similar findings emerged from the UK-based study of research and development transfer into practice.
- As in the UK, government departments and research organisations in the selected countries strive to provide value for money in terms of research output. However, there is widespread understanding of the need for "blue-sky" research that brings no, or little, short-term return on research investments, but is essential for long-term development. Balancing these often competing demands proves difficult.
- In Canada, the "Linkage and Exchange" model provides an interesting example of research implementation in the health services policy arena. It proposes that involving eventual end users at all stages of the research process will result in an increased impact of research on policymaking.

International expenditure on research and development

7 While there is a considerable range in levels of investment in research and development among the selected countries and the UK, two distinct groups can be distinguished. Group one, Finland, the US and Germany, all spend close to or more than 2.5% of Gross Domestic Product (GDP) on research and development, and thus invest more than the Organisation for Economic Cooperation and Development (OECD) average of 2.24%. Group two, the Netherlands, UK and Canada invest less than the OECD average, ranging from between 1.84% (Canada) to 2.02% (the Netherlands). The gross expenditures on research and development (GERD) are shown in **Figure 1**. GERD is the standard expenditure measure which covers all research and development carried out on national territory.

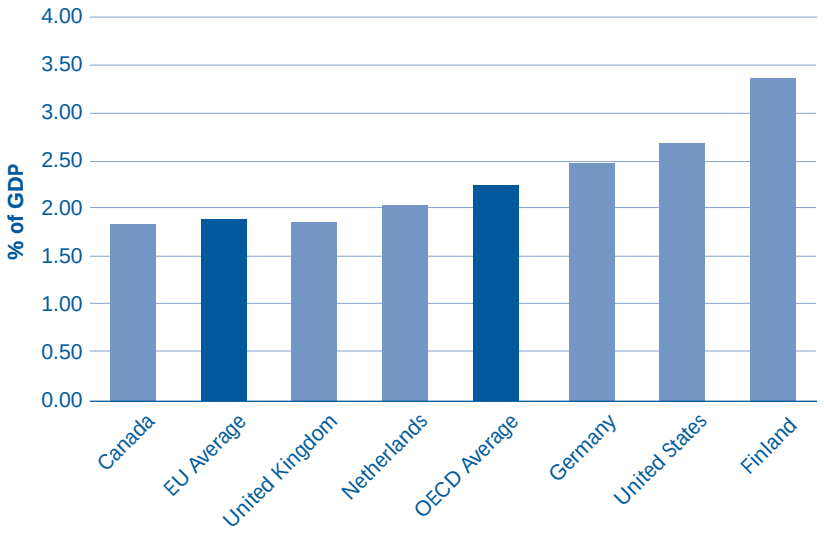
8 **Figure 2** shows the amount of government budget appropriations for research and development (GBAORD), as a percentage of GDP. GBAORD presents information about research and development financed by government based on budget data and is more up-to-date than actual expenditures. Defence spending in the UK and US accounts for more than 50% of total GBAORD. However, when considering civil government spending on research and development (civil GBAORD), it becomes clear that the UK and the US are the lowest investors in civil research and development, dropping even below the civil research and development average expenditure for OECD member countries. In contrast, the importance of civilian research and development spending to the Netherlands, which spends relatively little on defence, becomes clearer and the leading position of Finland, with its marginal defence spending, is even more accentuated.

Similarities and differences in practice among selected countries

9 **On priority setting and coordinating processes**. Two main issues relating to priority setting and research coordination emerged from the review of government departments and research bodies in the selected countries: first, how best to translate policy needs into research priorities, and second, how to coordinate research priorities across, and, to a lesser extent, within ministries.

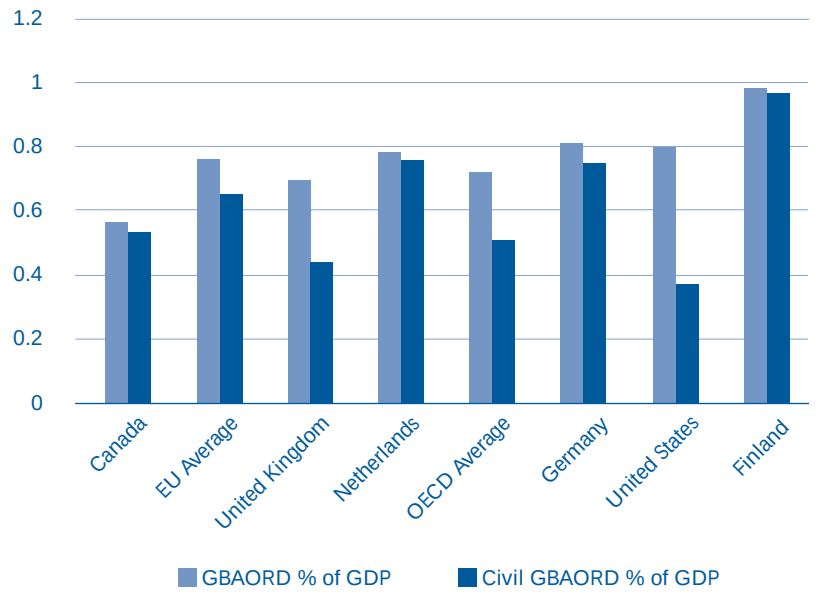
10 Aiming to address the first issue, a number of different practices can be distinguished across the countries selected. The most important differences relate to the level of concentration or centralisation at which priority setting takes place. In Canada and the US, the decisions are made within a highly decentralised environment predominantly via external boards that advise the respective departments and agencies. In Canada, the process is formalised through Science Advisory Boards (SABs). In the US, each agency tends to rely on its own iterative, and often complex, decision making process despite the fact that goals, priorities and budget allocation are all part of the research and development budgeting system.

1 **Gross Domestic Expenditure on R&D (GERD) as % of GDP, 2000**



Source: Main Science and Technology Indicators, OECD, Paris, 2002

2 **Difference between total GBAORD and GBAORD on civil R&D, 2000**



Source: Main Science and Technology Indicators, OECD, Paris, 2002

11 In Germany and the Netherlands, traditional science policy advisory boards provide high level expertise and input to the government as a whole. Their role is strictly advisory. The Netherlands also has a wide net of sector councils to support specific policy areas. In principle, the sector councils are not advisory bodies, but are intended to inform policymaking processes, often through foresight studies. Finally, in Finland the ultimate authority for determining basic science policy and the allocation of government research grants resides with Parliament and the Cabinet of Ministers (CoM). The CoM relies heavily on the scientific expertise provided by the Science and Technology Policy Council (STPC) headed by the Prime Minister. The STPC takes a prominent role in determining research strategies for the Finnish government.

12 With respect to the issue of coordinating research priorities across, and to a lesser extent within, ministries, this takes place mainly at the policy level rather than through external advisory boards. Individual ministries or policy implementation agencies are usually responsible for coordination efforts. Finland is the exception, as the STPC has a visible role in the coordination of innovation policy activities at a national level in addition to its priority setting powers.

13 **On selecting, commissioning and monitoring research**. Selecting the best research to inform policymaking is the major focus of research procurement and monitoring activities among the countries reviewed. The link between policymakers' needs and research decisions is also strong in the UK (see "Getting the evidence: Using research in policy making" for detailed discussion of this point). Research providers all understand the importance of external advice as a basis for objective, unbiased research and realise that procurement approaches ought to be determined by the strategic aims specific to each organisation. Examples of approaches to optimise the link between research and policymaking that show the importance accorded to such efforts include: the establishment of independent, intermediary organisations to manage the selection and implementation of research based on expertise and dedicated capacity; the formation of research programmes to bring together research providers and create networks or centres of excellence; and the distribution of guidelines and/or handbooks to operationalise procurement principles.

14 In Canada, a number of advisory reports highlighted the enormous range of approaches used to access and formulate the need for science to inform decision making. The review found that in the majority of cases, the preferred way of seeking advice was through in-house analyses and working groups rather than by seeking independent reviews. A report by the Council of Science and Technology Advisors (CSTA) resulted in the Canadian government publishing a "Framework for Science and Technology Advice: Principles and guidelines for the effective use of Science and Technology advice in government decision making"[1] to make preferred practice guidelines specific.

15 The US General Accounting Office (GAO) Report "Federal Research: Peer Review at Federal Science Agencies Vary" (March 1999) looked at how federal agencies conducted peer reviews of research products and concluded there was no uniform federal peer review policy. There is general agreement that peer review practices should not be dictated uniformly for every agency or for all types of federally funded research. Rather, the practices should be tailored to agency missions and type of research.

1 This report drew heavily on OST guidance in the UK.

16 In Finland, cluster, technology and research programmes are increasingly used as strategic mechanisms for funding research and pursuing science policy objectives. They are multidisciplinary, usually exist for a fixed period and ideally involve consortia that combine several research projects. Programmes have proved to be an effective form for selecting and involving various research-related organisations and stimulating cooperation and networking opportunities between private companies and the research sector.

17 The acquisition, planning, implementation, administration and evaluation of individual projects in Germany are not the responsibility of ministries, but rather of appointed research management organisations (Projektträger) outside of government. Often these organisations are research institutes themselves. Their project management responsibilities are of both a scientific/technical and administrative nature. The need for intermediary organisations is a result of the growth of sponsoring activities by the federal ministries beyond their capacity to manage. The agencies are typically sponsored by federal money. The Projektträger often also functions as an international point of contact.

18 In the Netherlands, intermediary organisations, such as Senter and Novem, coordinate and commission the research activities of several ministries. For programmes that have been set up by various ministries and that are of significant size, some independent or temporary programme offices have been established that are responsible for implementing strategies and commissioning research.

19 **On evaluation and research transfer**: The international review uncovered a large range of long existing research evaluation practices. Evaluations increasingly take place throughout the research base leading to structural changes within the national research systems and the resulting research bodies. Evaluations are also conducted throughout the various stages of the research projects. The practice of ex-ante evaluation to examine the connection between proposed research and government policy needs is also increasing, as is the monitoring of ongoing research and re-evaluating its links to ongoing or upcoming policy.

20 Examples of well developed evaluation practices are found in Finland and Germany. For a long time, evaluation has played a steady role in the formulation of policy in Finland. The effectiveness of government action is assessed at different levels. External and international teams evaluate all major organisations and the major policy players regularly have their programmes evaluated externally.

21 Evaluations in Germany have lead to many improvements in the research system. First of all, funding for under-performing institutes was completely stopped. Second, a concentration of certain research institutes took place to eliminate the fragmentation of the research base. Finally, evaluations have encouraged international cooperation in Germany.

22 Generally speaking, evaluation tools and approaches have become more diverse and sophisticated. Where peer review used to be the default process, standardised performance measures and impact analyses are now preferred and have become more common. In Canada, the research and development Impact Network and the Programme of Energy Research and Development (PERD) have implemented results-based performance measurement. They are two examples of federal science-based department and agency efforts to use impact analysis to assess the outcomes and results of federal research and development and to ensure relevance and value for money.

23 The increased importance of evaluation has led to the need for more reliable, comprehensive and timely data sets about government funded research and development and improved information systems to support policymaking are being developed. The Netherlands Observatory of Science and Technology (NOWT) collects and analyses data about the Dutch research system in a broad sense. RaDiUS, which stands for "Research and Development in the United States", is the first information system that systematically connects highly aggregated budget data on federal research and development with the disaggregated information on individual research and development tasks and awards to provide a complete picture of all federal research and development activities in the US.

24 With the establishment of the 1993 Government Performance and Results Act (GPRA) in the US, federal agencies, including those that fund research, were formally required to set strategic goals and to use performance measures for management and budgeting. The objective of the GPRA is to encourage greater efficiency, effectiveness and accountability in federal programmes and spending. A report by the US Committee on Science, Engineering and Public Policy (COSEPUP) considered the most effective ways to assess the results of research, in light of the GPRA. COSEPUP drew a number of conclusions, including:

- Both basic research and applied research programmes can be meaningfully evaluated on a regular basis;
- Agencies must evaluate research programmes by using measurements that match the character of the research;
- The most effective means of evaluating federally funded research programmes is expert review. Expert review - which includes peer review (judging the quality), relevance review (judging whether an agency's research activities are relevant to its mission), and benchmarking (judging the relative standing in an international perspective) - should be used to assess both basic research and applied research programmes; and
- The development of effective methods for evaluating and reporting performance requires the participation of the scientific and engineering community.

25 In addition to the increasing emphasis on research evaluation in the international arena, more and more attention is being focused on how to promote its transfer into policy. In Canada, the "Linkage and Exchange" model provides an interesting example of research implementation in the health services policy arena. It proposes that specific issues and bottlenecks arise in communication between researchers and policymakers that often prevent effective transfer of research findings into policy decisions. It proposes that involving eventual end users at all stages of the research process will result in an increased impact of research on policymaking.

26 In parallel, several efforts of the CSTA have focused on establishing principles and guidelines to incorporate science advice in government decision making. These principles and guidelines address how science advice should be sought and applied to enhance the ability of government decision makers to make informed decisions.

Part 1 Introduction

1.1 This report presents the results of an international review of how the governments of five countries in North America and Europe procure and manage research to improve service delivery and policy development. It complements the NAO report, "Getting the evidence: Using research in policy making", which provides a value for money assessment of the research activities of UK government departments and examines how research is used to improve service delivery and inform policy making in this country.

1.2 The main objectives of this paper are twofold. First, it aims to describe how R&D is commissioned, managed and used in a number of different countries. Second, it provides a basis for examining the R&D activities of the UK within an international context and for learning if and how innovative elements from other countries may be incorporated into or modified to suit the UK R&D model.

1.3 Countries were selected according to several criteria. First, only countries with sizeable investments in R&D (at least exceeding 1.75% of GDP) were considered. Second, in order to examine the effects of institutional context on R&D activities and outcomes, countries were selected with a range of government structures. Finally, in order to present comparisons relevant to the UK context, selected countries did not differ fundamentally from the UK on any of the previous criteria.

1.4 Application of the selection criteria led to a comparative examination of the following five countries: Canada, Finland, Germany, the Netherlands and the United States (US). Information gathering mainly comprised desk research supplemented by additional, targeted interviews. The organisation and analysis of the information was based on a conceptual framework and issues that emerged during the course of the overall study.

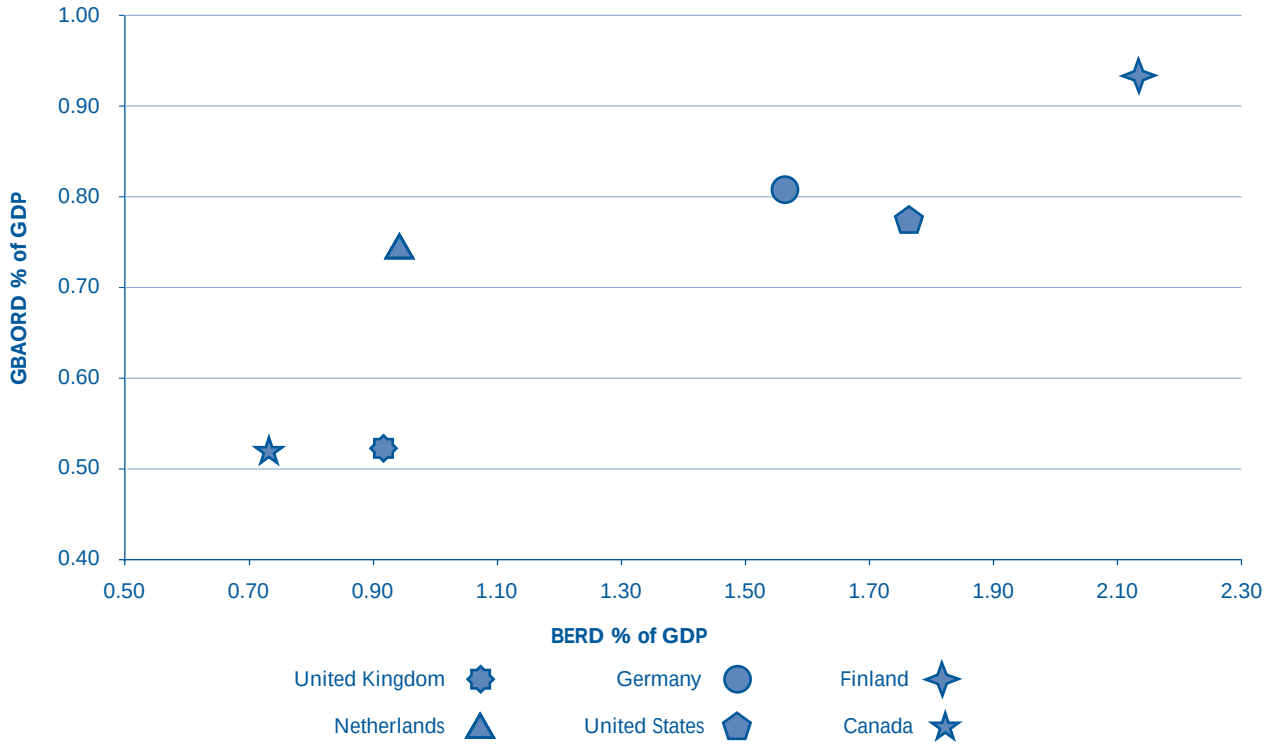
1.5 The next part of this chapter provides an overview of the R&D activities in each of the selected countries and the relative importance of the R&D sector across these countries. The overview is based on a selection of most commonly used R&D indicators which are relevant not only to government departments commissioning research, but also to R&D stakeholders within a specific country. Although governments account for only a fraction of total R&D spending, these indicators suggest the relative value that these countries place on research and development. More detailed information of spending within the various government departments is provided in the country chapters, where available.

Current investment in research and development

1.6 The gross expenditures on research and development (GERD) as a percentage of Gross Domestic Product (GDP) in 2000 for each of the five countries, is presented in Figure 1 (Executive Summary)[2]. There is a considerable range in R&D investment in the countries investigated. However, a clear distinction emerges between two groups. Finland, the US and Germany all spend close to or more than 2.5% of GDP on R&D and are above the Organisation for Economic Co-operation and Development (OECD) average. Finland is one of the world's highest investors in R&D, spending almost 3.4% of its GDP on research. Of the OECD countries, only Sweden at 3.8% of GDP spends more. The other group includes the Netherlands, the UK and Canada, all of whose R&D expenditures fall towards the lower end of the range for western OECD countries.

2 *Only exception is the Netherlands for which the numbers are from 1999.*

3 Levels of GBAORD and BERD as % of GDP, 2000



Source: Main Science and Technology Indicators, OECD, Paris, 2002

1.7 **Figure 3** provides an overview of the relative importance of industry and government contributions to total GERD. Private expenditures are expressed in Business Expenditures on R&D (BERD, presented on the x-axis) and public expenditures as Government Budget Appropriations for R&D (GBAORD on the y-axis)[3]. In all of the selected countries, BERD expenditures exceed GBAORD. In Germany, the US and Finland, GERD is at least twice as much as GBAORD. Observed differences between the countries reflect the structural mix of industries and their reliance on R&D. However, Finland's statistics demonstrate that when a government places priority on the development of R&D intensive industries, it can have a large impact. Within the six countries, the range in GBAORD is much narrower than the range in BERD, although GBAORD in the UK and Canada is noticeably less than in the other four countries.

1.8 As illustrated in Figure 2 (Executive Summary), both the UK and the US spend high levels of GBAORD on defence-related R&D. Defence spending in these countries accounts for more than 50% of total GBAORD. When the proportion of defence spending as a total of government spending on R&D is considered, a different picture emerges as to the importance that governments place on research. After subtracting defence spending from GBAORD, it becomes clear that the UK and the US are the lowest investors in civil R&D, dropping below the civil R&D average expenditure for OECD member countries. In contrast, the importance of civilian R&D spending to the Netherlands, which spends relatively little on defence, becomes clearer and the leading position of Finland, with its marginal defence spending, is even more accentuated.

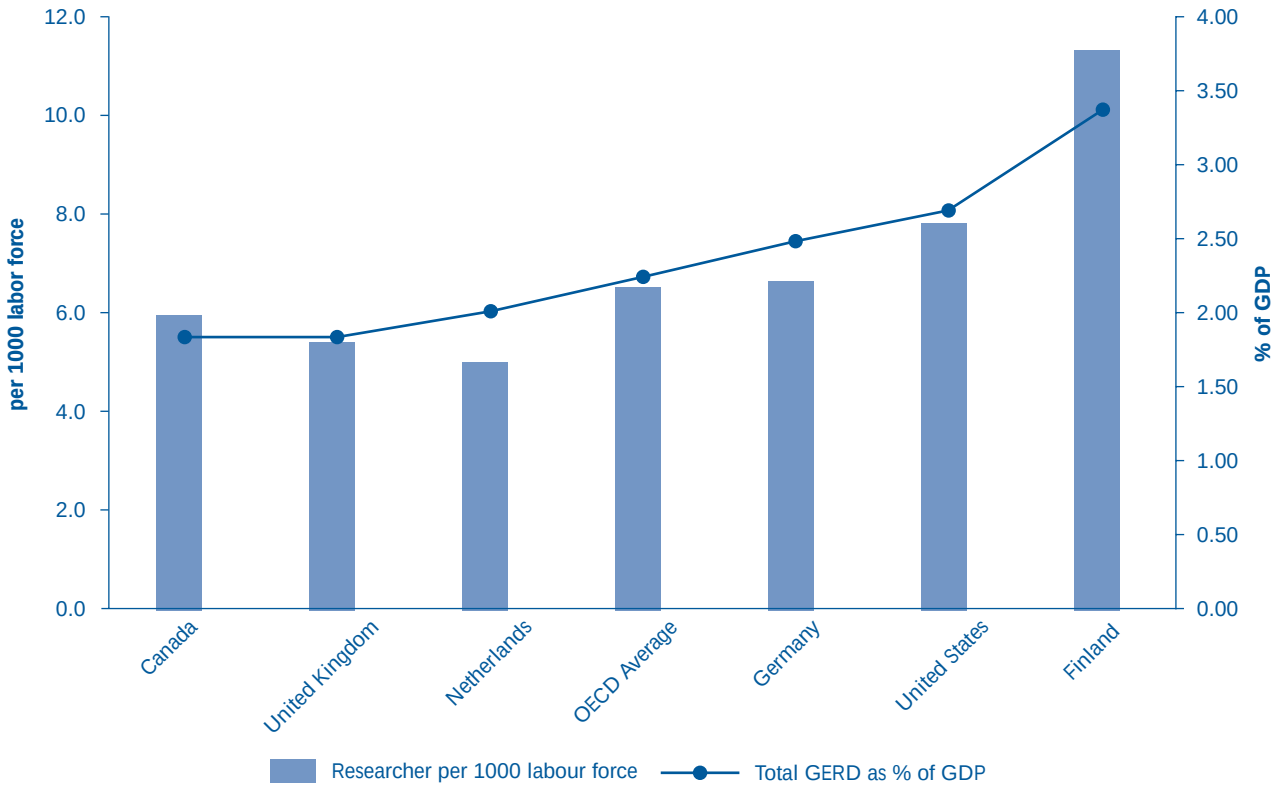
1.9 The level of R&D investment reflects the proportion of the labour force employed in the R&D sector **(Figure 4)**. Canada and Finland employ relatively more researchers than the Netherlands and Germany. In recognition of this situation, the Netherlands has emphasised efforts to attract, develop and stimulate highly talented researchers.

Developments in R&D investments over time

1.10 In this section, longitudinal statistical data on GERD, BERD and GBAORD indicate the direction of development in particular areas in the six countries through the 1980s and 1990s. The most noticeable development as shown in **Figure 5** is the enormous increase in R&D investment made by Finland. In 1981, Finland was one of the OECD's lowest spenders on R&D. By 2000, it was one of the highest. This turnaround can be attributed to measures that

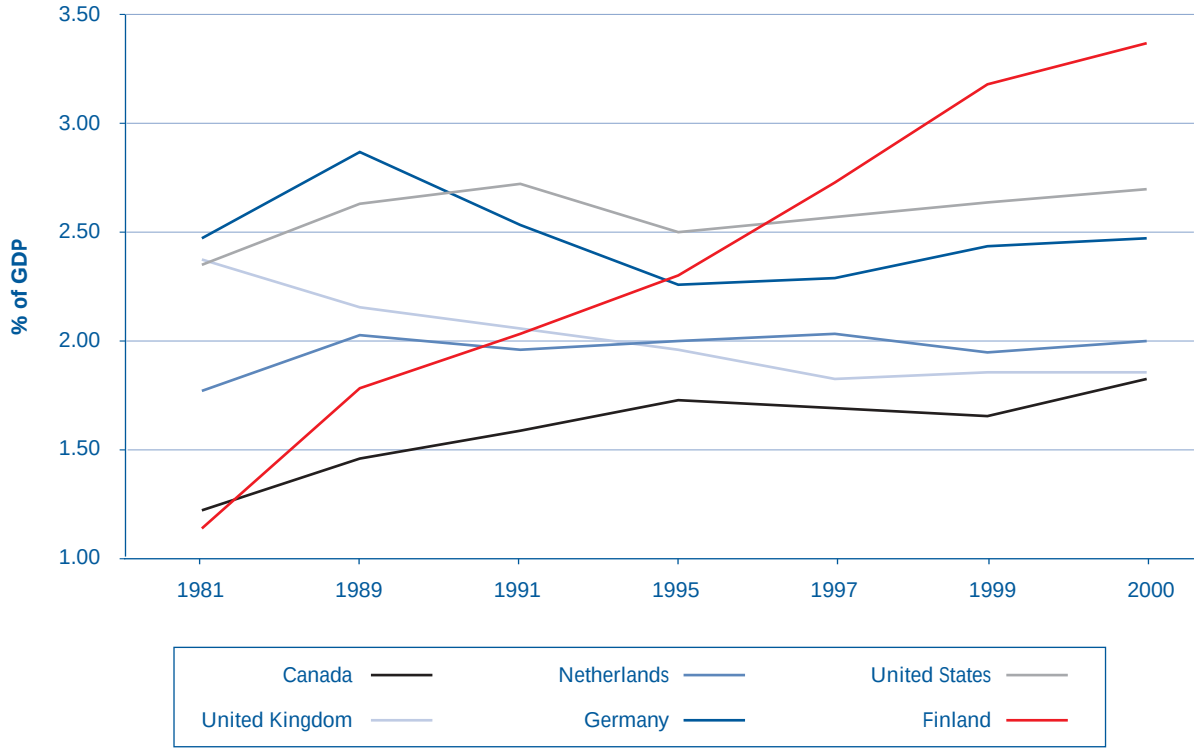
3 *For further explanations of the above terms, see the standard OECD methodology for the collection of R&D statistics entitled The Measurement of Scientific and Technological Activities: Proposed Standard Practice for Surveys of Research and Experimental Development -- Frascati Manual 2002.*

4 Research labour force compared to GERD, 2000



Source: Main Science and Technology Indicators, OECD, Paris, 2002

5 Gross Domestic Expenditure on R & D (GERD), 1981-2000



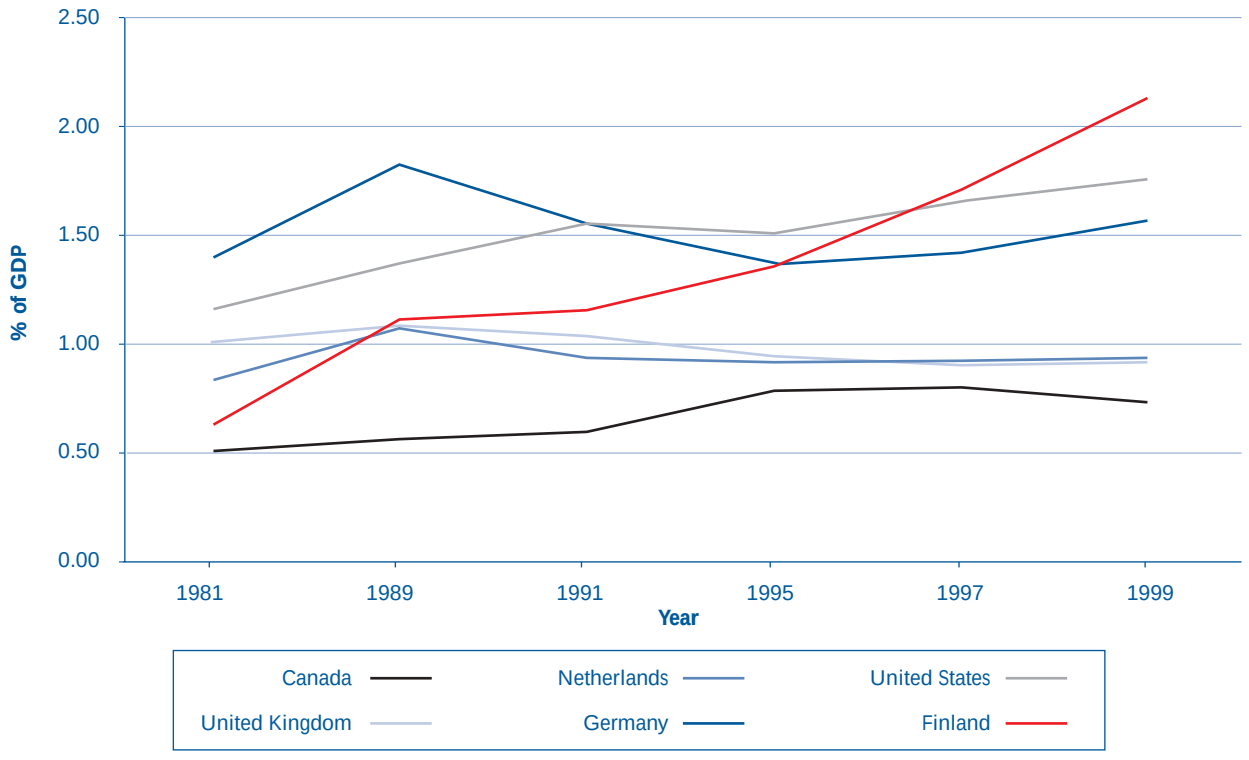
successive Finnish governments have implemented to develop Finland's R&D sector. During the 1990s, gross expenditure on R&D in most countries remained flat. Germany and the US have seen increases in R&D levels since 1995 after years of considerable reductions. R&D spending in the UK has fallen since 1981, dropping below the EU average for the first time in 2000.

1.11 **Figures 6** and **7** show that Finland's growth in R&D spending is primarily a result of an increase in business rather than government investment, as indicated by GBAORD. The increase in industry spending accounts for more than 75% of the total increase in R&D investment. Increases in business-supported R&D exhibit a similar but more modest effect on spending in the US and Germany since 1995. Business spending on R&D in the Netherlands and the UK has remained stable and even decreased slightly in Canada over the last several years. Government expenditure on R&D has decreased over the past two decades in all the selected countries. The most marked decline is in the UK, where government spending on R&D in 1999 was less than 50% of its 1981 level, although following recent Spending Review settlements there has been a recovery with the UK government spending, in 2000/01, 0.7% of GDP on science, engineering and technology. The US government has fallen from being the largest spender on R&D in the mid 1990s, to being the third largest now.

1.12 The remainder of the report presents detailed information about the institutional context of R&D activities in the five selected countries and describes the different and innovative approaches to research selection, procurement, implementation, management, evaluation and transfer. Each chapter follows the same structure, namely:

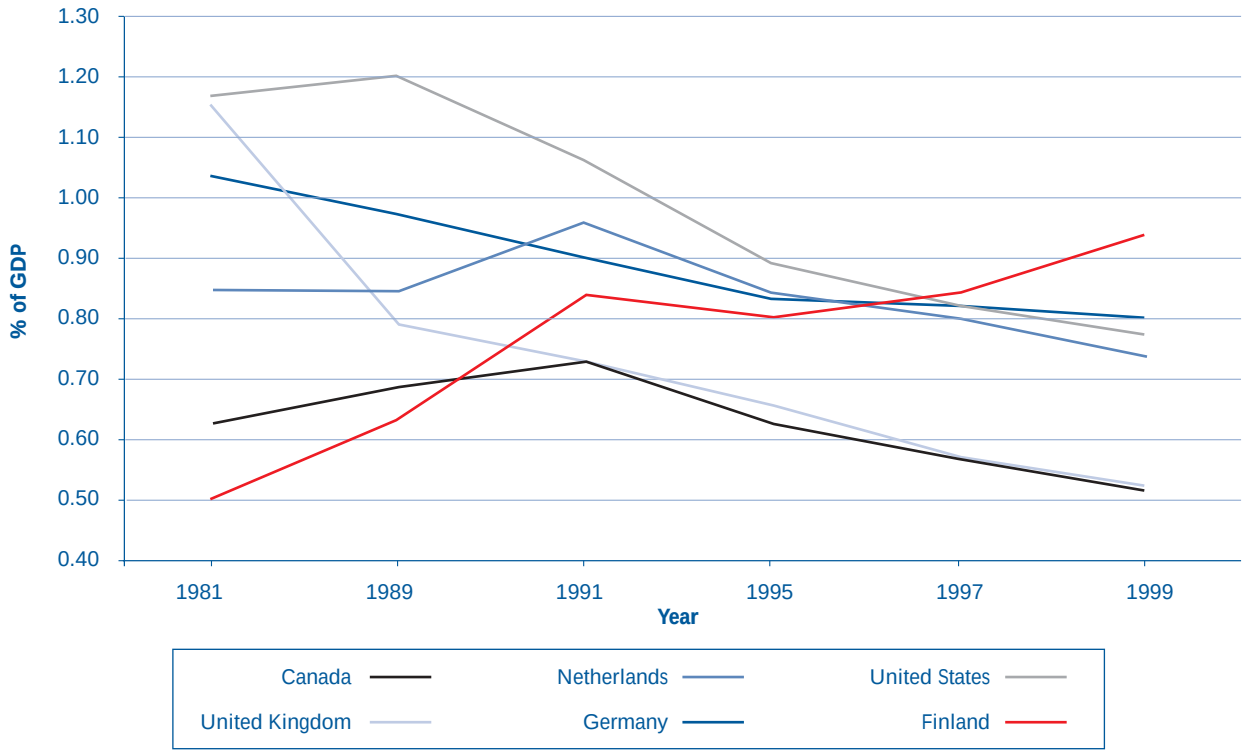
- The institutional context with respect to R&D is presented. The key players and their interrelationships are shown.
- The processes involving research strategising, priority determination and coordination are described.
- The selection and commissioning of research is explained.
- Research outcome measurement and transfer is described, particularly focusing on how research quality is evaluated.

6 Business R&D expenditures, 1981-1999



Source: Main Science and Technology Indicators, OECD, Paris, 2002

7 Government budget appropriations on R&D, 1981-1999



Source: Main Science and Technology Indicators, OECD, Paris, 2002

Part 2

Canada

Institutional context

2.1 Developed in 1996, the document "Science and Technology for the New Century: A Federal Strategy" sets out the vision and organisation of science and technology research in Canada. Resulting from this initiative, new government structures have been put in place and more explicit and structured approaches to determining research strategies and research funding have been developed. **Figure 8** shows the current institutional context of science and technology research in Canada.

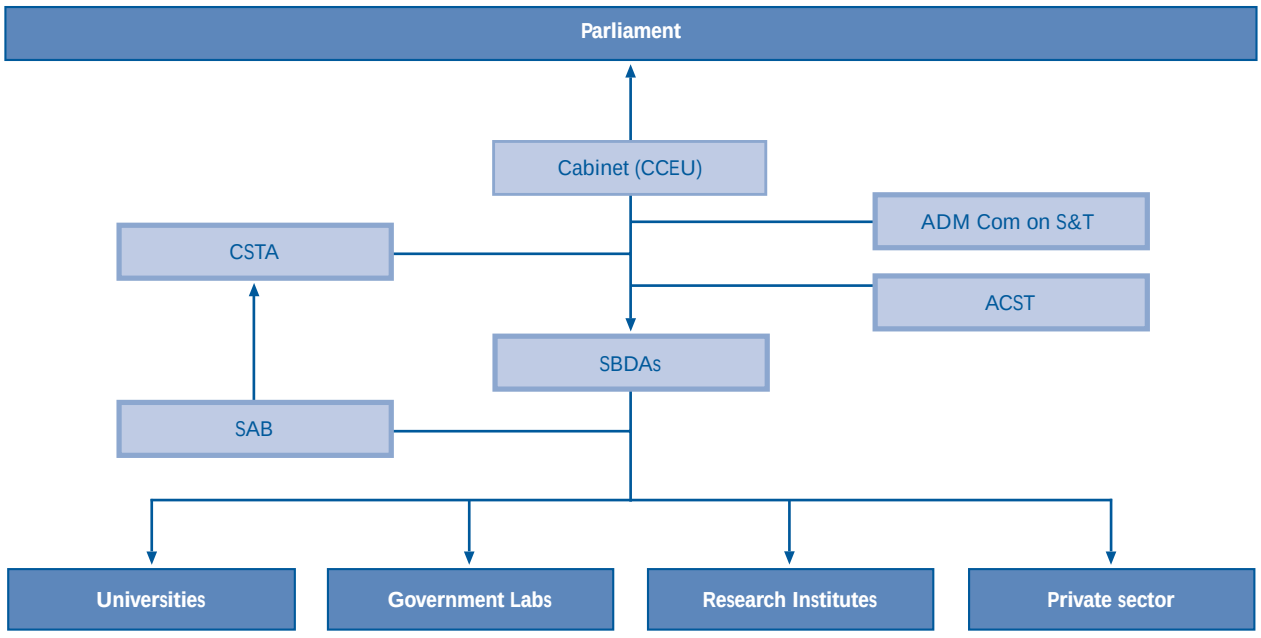
Policy/funding level

2.2 At the highest level, reporting to a Secretary of State, the Cabinet Committee on the Economic Union (CCEU) annually reviews the government's progress and priorities in science and technology (S&T). Below that, the Assistant Deputy Ministers (ADM) Committee on Science and Technology works to coordinate government-wide approaches to managing S&T and to ensure that departmental initiatives and priorities are shared across the federal science and technology community.

2.3 A number of roles can be distinguished among the science-based departments and agencies (SBDAs) at the federal level:

- A number of organisations, e.g., the Canada Foundation for Innovation (CFI) and the granting councils, allocate federal funds to support academic research.
- Industry research is funded mainly by Industry Canada and the National Research Council (NRC).
- Specific topic-related departments, e.g., Health and Environment, mostly fund research conducted by their own institutes.

8 Organisation of research responsibilities in Canada



2.4 The new federal strategy stresses ministerial accountability for science and technology across SBDAs. It also established Industry Canada as the leading government department to coordinate S&T related issues. The Canada Foundation for Innovation was formed in 1997 and has become the single largest funder at the federal level, consolidating the budgets of various other SBDAs and spearheading increased attention on innovation overall. It mainly awards funds to universities, research hospitals and private non-profit organisations to support their research infrastructure. The funding budget of three granting councils was also increased and together they have become the largest source of R&D funding in Canada at the federal level. The established budgets and associated programmes have had a significant impact on academic research in Canada, but much less influence on intramural governmental research.[4]

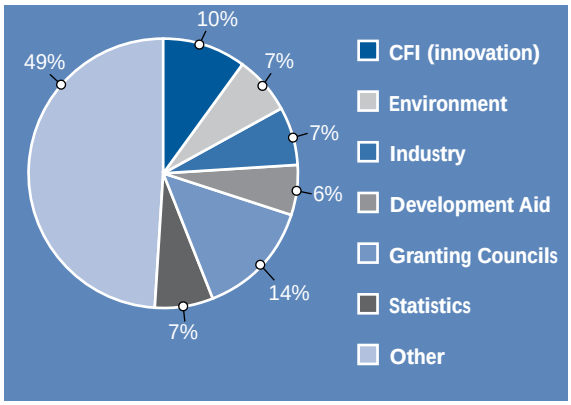
2.5 Despite the increasing concentration of funds for academic research, the overall R&D budget remains fairly stable and fragmented across a large number of departments and agencies. However, in 2001-2002, the federal government planned to spend $4.6 billion on R&D, a 10% increase over 2000-2001, reflecting Canada's resolve to move from fifteenth to fifth place among the most competitive and innovative nations.

2.6 Since the publication of the federal Science and Technology (S&T) strategy, all federal SBDAs have taken steps to increase the effectiveness of federally sponsored research. These steps include establishing new planning and reporting mechanisms and instituting expert reviews, client surveys, impact studies, partnership building and benchmarking exercises. As an example, Health Canada recently appointed a Chief Scientist from academia. One of his primary responsibilities is to ensure governmental research is subjected to the same degree of peer scrutiny and evaluation as academic research.

Advisory roles

2.7 In "Science and Technology for the New Century: A Federal Strategy", the government made the commitment that "each science-based department and agency will set clear S&T targets and objectives, establish performance measurement indicators based on outputs, develop evaluation frameworks, and maintain mechanisms for external advice and review." Accordingly, most of the science-based departments and agencies have established external advisory bodies. These Science Advisory Bodies (SABs) have replaced the industry-related advisory boards and are consulted on issues related to policy formulation. The SABs bring relevant knowledge and expertise on S&T issues and advise on broader policy issues from an S&T perspective. The roles of the SABs vary, and, while their value is undisputed, there are concerns that their potential contribution to policy making is not being maximised. A government report, "Reinforcing External Advice to Government" (READ), recently examined the roles and contributions of the SABs to ensure their resource potential is being exploited.

9 Distribution of R&D funding among Federal SBDAs



2.8 Established in April 1998, the Council of Science and Technology Advisors (CSTA), provides the Cabinet Committee for the Economic Union (CCEU) with external expert advice on internal federal S&T issues. It comprises primarily representatives from the SABs, who report to ministers or other senior officials of SBDAs. The CSTA draws these advisors into a single body to improve federal S&T management by examining issues common to a number of departments, and by highlighting opportunities for synergy and joint action.

2.9 The Advisory Council on Science and Technology (ACST) provides the Canadian Prime Minister with expert, non-partisan advice on S&T goals and policies and their application to the Canadian economy. This body reviews Canada's performance in S&T, identifies emerging issues and advises on a forward-looking agenda. It comprises leading industrialists and academics with S&T experience and knowledge. Its role and composition are comparable to many advisory councils in other countries.

Research providers

2.10 Compared to other countries, relatively large amounts of the Canadian federal R&D budget of $4.6 billion support intramural research activities. More than 40% of the total budget funds 120 federal research laboratories to conduct research for government departments, particularly agriculture, energy, defence and health and environment. The National Research Council (NRC) is Canada's foremost federal scientific research organisation and is responsible for

4 Examples of these are the Canada Research Chair Programme (annual investment of Can $300 million), Genome Canada (funded with a Can $300 million endowment) and the indirect cost payment programmes for universities.

approximately 20 research institutes. Furthermore, there are several federal science-based departments, such as Natural Resources Canada (NRCa), who also conduct research in their own labs. Universities receive approximately one third of the total federal funds, mainly from the Canada Foundation for Innovation (CFI) and the granting councils. Universities are also funded by provincial governments who receive a largely undirected allocation from the federal government for education research.

Priority setting and coordinating processes

Identifying emerging issues

2.11 Since the introduction of the S&T strategy in 1996, R&D priority setting has taken on new levels of importance within the federal government. Newly established and/or restructured external S&T advisory boards and technical review panels are now consulted by departments and agencies reviewing the relevance of their S&T programmes and activities. SABs help departments meet their science mandate by focusing attention on relevant lines of scientific inquiry. Federal SBDAs help steer internal R&D planning towards emerging areas of high priority. The READ report made clear that no single model of external S&T advice will meet the needs of all government departments. The significance of future planning has been recognised by departments aiming to identify relevant issues for scientific enquiry. At the same time, however, many departments feel that they lack the capacity to conduct planning and horizon scanning activities.

Coordinating S&T activities

2.12 The 1996 federal S&T strategy provides a framework for enhanced cooperation and collaboration among SBDAs, and between federal and non-federal partners on issues of shared concern. Since the release of the strategy, federal departments and agencies have significantly improved how they interact with other players in the Canadian and international research environment. While each SBDA is responsible for setting its own S&T policies and research activities, the need for cooperation across SBDAs remains paramount and should go beyond simple coordination to include collective action. The Auditor General noted this in 1998. Several facilitative mechanisms have since been put in place.

2.13 As mentioned above, the Cabinet Committee on the Economic Union (CCEU) conducts an annual review of the government's progress and priorities in S&T research activities. Beyond that, the ADM Committee on S&T coordinates government-wide approaches to managing S&T and ensures that departmental initiatives and priorities are shared across the federal science and technology community. In addition to the Cabinet's explicit S&T mandate, the Advisory Council on Science and Technology (ACST), with eminent representatives from industry and academia, was created in 1996 to review the nation's performance in S&T, by identifying emerging issues and advising on a forward-looking agenda. While ACST and also CSTA are positioned to coordinate research policies and strategies, as yet, their mandate and level of activity have been too restricted to make a significant impact on the formulation of an integrated policy on research and development.

2.14 The Assistant Deputy Ministers (ADM) Committee on S&T has taken an overall coordinating role of broad, shared interests, e.g., science capacity and technology transfer.[5] The committee adopted the following new mandate:

- to implement appropriate cross-government S&T planning, e.g., the sensible use of federal investments in S&T and the sharing of best practices;
- to develop proposals and advise government on key shared S&T policy issues; and
- to provide a forum for interdepartmental consultation on S&T policy and programme directions, sharing of information, and coordination of efforts and initiatives across the federal S&T community.

2.15 The committee comprises assistant deputy ministers or equivalent-level representatives from departments and agencies with S&T activities and/or interests. With the strategy in place, the ADM Committee has helped develop a stronger sense of community among federal S&T bodies, by encouraging information-exchange and raising the profile of S&T issues within the government. These activities have facilitated increased cooperation and collaboration between departments and agencies. The committee has provided the Canadian Cabinet with a clearer and more comprehensive picture of the federal S&T effort, and is currently working to create new mechanisms for addressing national S&T needs in ways that integrate capabilities across the federal government and throughout the S&T community.

Selecting and commissioning research

2.16 Various CSTA reports have shown that most government agencies base their decisions about the need for various S&T initiatives on in-house advice and working groups rather than by seeking independent reviews. As a result of one of the CSTA reports, the Canadian government developed a "Framework for Science and Technology Advice: Principles and guidelines for the effective use of

5 *Smith and Halliwell (1999).*

Science and Technology advice in government decision making".[6] One of the guidelines stresses that "while advice from external and international sources needs to be sought regularly, it is especially important to seek such advice when:

- the problem raises scientific questions that exceed the expertise of the in-house staff;
- the issue is 'horizontal' or cuts across lines of jurisdiction within or among departments;
- there is significant scientific uncertainty;
- there is a range of scientific opinion;
- there are potentially significant implications for sensitive areas of public policy; and
- where independent scientific analyses can strengthen public confidence."

A subsequent CSTA report "Science and Technology Excellence in the Public Service" (STEPS) reviewed ways to ensure that the best possible advice was indeed sought by focusing on employing external, expert review processes to support project selection.

Measuring outcomes

2.17 The concept of "Linkage and Exchange" developed by the Canadian Health Services Research Foundation is discussed in detail in "Getting the evidence: Using research in policy making". The model proposes that bottlenecks arise in the communication between researchers and policymakers that can prevent the application of research into effective policies. To overcome these barriers, the model suggests involving policymakers in priority setting, programme funding decisions, assessing research applications, conducting research and communicating findings. The Foundation has adopted the model aiming to increase the impact of their research on policymaking. The effects and transferability of the model are yet to be fully tested, however, other organisations active in funding health research, e.g., the Canadian Institutes for Health Research, have stated similar aims and approaches.

2.18 The CSTA have established principles and guidelines for better incorporating scientific research in government decision making. They state:

- The government needs to anticipate, as early as possible, those issues for which science advice will be required, in order to facilitate timely and informed decision making.
- Advice should be drawn from a variety of scientific sources and from experts in relevant disciplines in order to capture the full diversity of scientific schools of thought and opinion.
- The government should employ measures to ensure the quality, integrity and objectivity of the science and science advice it uses, and ensure that science advice is considered in decision making.
- Science in public policy always contains uncertainty that must be assessed, communicated and managed. Government should develop a risk management framework that includes guidance on how and when precautionary approaches should be applied.
- The government is expected to employ decision making processes that are open, as well as transparent, to stakeholders and the public.
- Subsequent review of science-based decisions is required to determine whether recent advances in scientific knowledge have an impact on the science advice used to reach the decision.

The CSTA also recommends appointing Science Advice Champions to guide and encourage the implementation of these principles and guidelines.

2.19 In an effort to ensure increased value for money from S&T initiatives, the federal SBDAs conduct R&D impact analyses to assess the outcomes and results of S&T activities. The R&D Impact Network and the Programme of Energy Research and Development (PERD) have implemented results-based performance measurement, two examples of how government is aiming to ensure relevance and value for money. The R&D Impact Network was established by National Resource Canada (NRCan), the Treasury Board and other research partners to advance R&D impact assessment and provide research organisations with simple, credible and broadly accepted performance measurement tools for results-based management and decision making. The network has refined and adapted tools for measuring the social and economic impacts of R&D, developed strategies to communicate impact information and promoted the exchange of best practices. Many departments and agencies now routinely make use of R&D impact analysis in addition to traditional audit and evaluation practices.

2.20 PERD is a competitive process administered by NRCan that provides funding for non-nuclear federal energy R&D. After reviewing PERD programming in 1999, NRCan negotiated a revised memorandum of understanding with the 12 participating federal departments and agencies, incorporating new accountability provisions and performance measures. Implementation of results-based performance management is leading to closer monitoring of the results of work conducted with PERD funds and to better resource allocation decisions in the future.

6 *This effort and the subsequently published framework drew heavily on guidance by the OST in the UK.*

Part 3

Finland

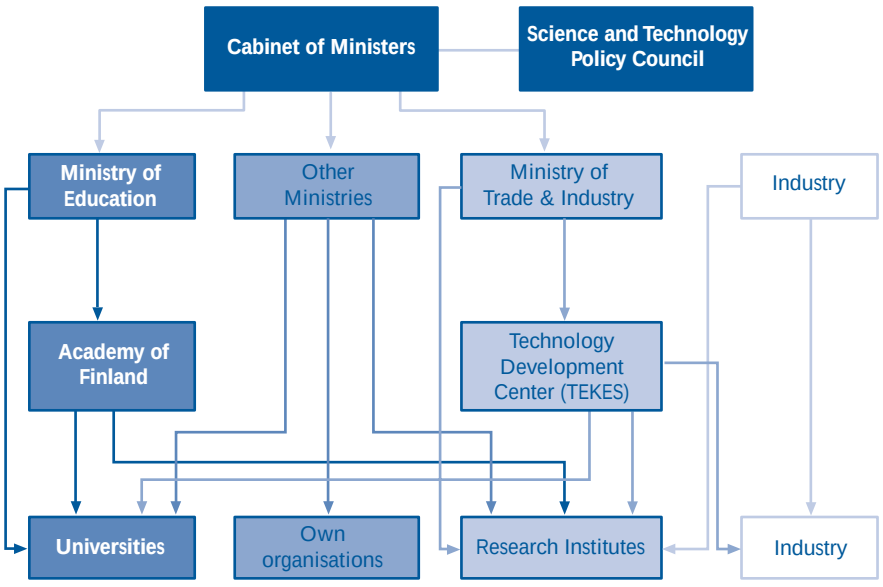
Institutional context

3.1 In Finland, the ultimate authority about science policy and decisions involving granting and allocating government research funds resides with Parliament and the Cabinet of Ministers (CoM). The CoM relies on the scientific expertise provided by the Science and Technology Policy Council (STPC) headed by the Prime Minister. The STPC is responsible for directing and integrating science and technology policy, developing scientific research and education and for organising Finland's participation in the international science and technology community[7]

3.2 **Figure 10** shows the institutional context in which policymakers, research funders and research providers operate in Finland and the relationships among them. At the highest level, the CoM, aided by the STPC, is responsible for developing science policy. The various ministries then translate this policy into specific projects through their various research institutes. The research institutes finance these individual projects. Both public and private bodies carry out research.

3.3 The Ministry of Education is the general science ministry and bears primary responsibility for promoting basic research. The universities and certain research establishments are subordinate to this ministry. The Academy of Finland, whose mandate includes advancing scientific research, developing international research cooperation and serving as an expert body on questions relating to science policy, also reports to the Ministry of Education.

10 Institutional context of science and technology in Finland



7 *Euromecum, Euroresearch: An overview of Research Policy in Europe, 1996.*

3.4 The Ministry of Trade and Industry is responsible for the promotion of technology, as is its reporting body, the National Technology Agency (Tekes). Tekes seeks to promote the well-being and stable development of society by enhancing, either directly or indirectly, industry's capacity for technological innovation through competitive products, production methods and services.

3.5 The Finnish National Fund for Research and Development (SITRA) is an independent public fund that provides venture capital for high technology companies and has its own research programme. Other important public financing sources for start-up companies are the Regional Development Fund (KERA) and Finnish Industrial Fund (Suomen Teollisuussijoitus Oy) which invests mainly in a variety of regional funds.

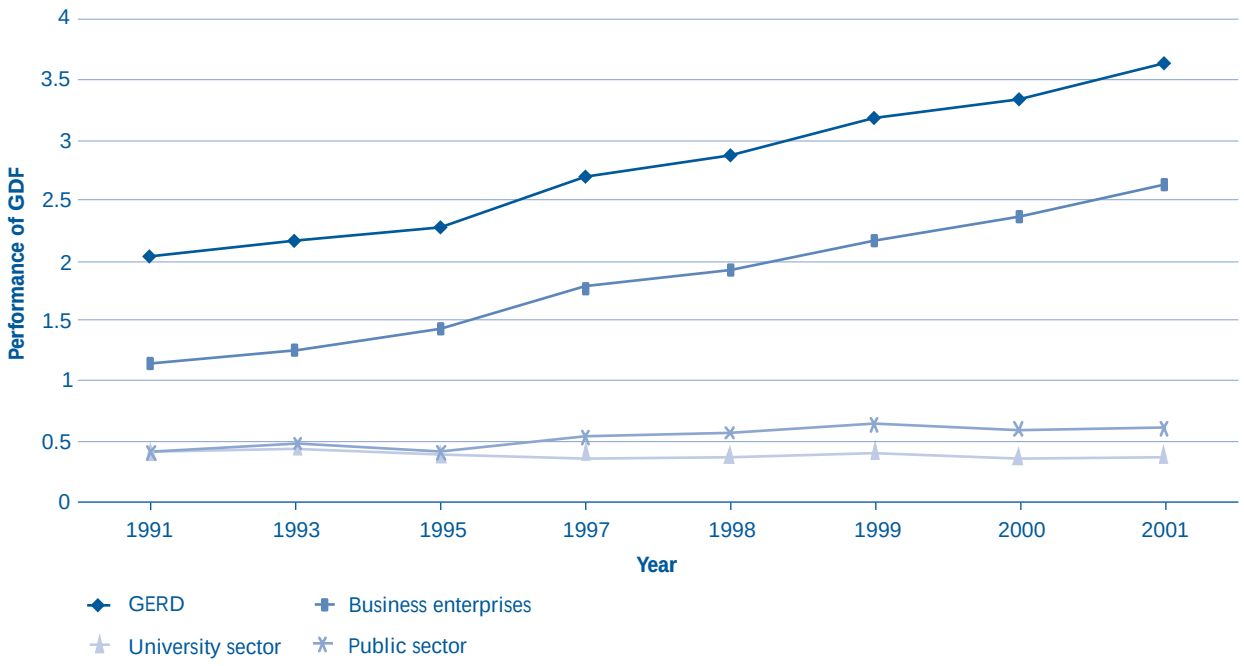
3.6 The Technical Research Centre (VTT) is one of the largest research institutes in Scandinavia. VTT reports directly to the Ministry of Trade and Industry, although most funding is channelled through Tekes. The Centre conducts research for a wide range of clients including other ministries, foreign clients and private industry. A third, more minor, element of the Finnish public research system comprises sectoral ministries such as Health and Agriculture and Forestry with their own research institutes. The most significant of these are the National Research and Development Centre for Welfare and Health (Stakes) and the Finnish Forest Research Institute (Kurki, 1996).

3.7 Despite the dramatic recession that hit Finland during the early 1990's, the Finnish government has invested heavily in R&D during the last decade. R&D spending has grown faster than overall government spending. There is a wide consensus on the overriding importance of R&D policy and the need to view different policies as parts of a whole.

3.8 **Figure 11** shows the development of the gross domestic expenditure on R&D (GERD) from 1991 to 2001. It indicates that growth in GERD is driven mainly by private business, while funding from public and university sectors has remained fairly stable. The government investment in R&D has grown to €1.4 billion in 2002, increased from the previous year by about €50 million. Government research funding amounted to 4.5% of total government expenditure, excluding state debt management cost, and remained at the same level as in 2001.[8]

3.9 The share of total public R&D expenditure (shown in **Figure 12** as both public sector and university funding) of the gross domestic product was 1.05% in 1999, while the EU mean was only 0.7%. As a result of rapid growth in GDP the share of public R&D funding has decreased to 1.0% in 2001.[9] In 2000, the gross domestic expenditure on R&D (GERD) was 3.4% of GDP. Government financed 26% of GERD while 70% was financed by industry.

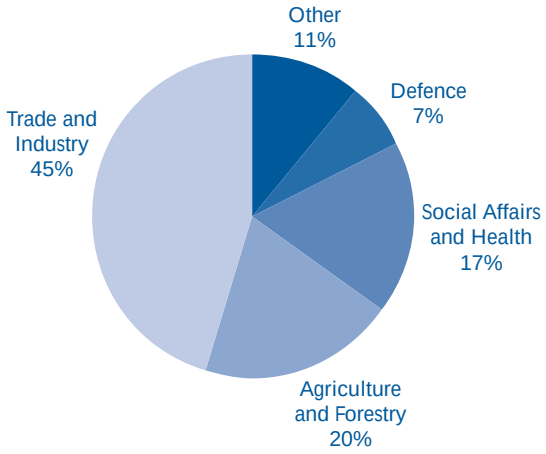
11 Gross domestic expenditures on R&D (GERD)



Source: Satistics Finland

8 *Source: www.research.fi*
9 *Source: www.research.fi*

12 Distribution of R&D funding across main government departments



Source: Statistics Finland, http://www.stat.fi/tk/yr/tttiede_rd11_en.html (updated 07.02.02)

3.10 Figure 12, shows the distribution of research funding across the national funding agencies. Tekes (Ministry of Trade and Industry), the Ministry of Agriculture and Forestry and the Ministry of Social Affairs and Health fund most of the R&D activities. Although the R&D expenditure of the Ministry of Education is quite small, its reporting body, the Academy of Finland, is responsible for developing basic research policy.

Priority setting and coordinating processes

3.11 Coordination and priority setting in Finland is approached in two distinct ways:

- Horizontal coordination through STPC and agency level cooperation aims to avoid duplication of effort.
- Vertical coordination/integration seeks to translate policy needs into research strategies, with Tekes as a key player.

3.12 In Finland, the STPC takes a prominent role in determining research strategies for the entire government. Unlike advisory councils or sub-councils of cabinets at this level, it has real decision making power, as it is headed by the Prime Minister and includes members from both government and key stakeholder organisations. The members must include representatives of the Academy of Finland, Tekes, universities and industry as well as employer and employee organisations.

3.13 The STPC has a visible role coordinating innovation policy activities at a national level. It is a strategy building body, employing a consensus approach to decision making that minimises conflict and duplication across different ministries. While Finland is clearly a small country, it is not just size that facilitates the consultative process. The Finnish policymaking culture of foundation laying via informal discussion promotes consensus building, often obviating the need for more formal procedures. The STPC has the following responsibilities:

- To direct S&T policy and ensure its national compatibility and to prepare relevant plans and proposals for the Council of State.
- To develop scientific research and education, prepare relevant plans and reviews for the Council of State and to review the need for research in various fields.
- To follow up and assess measures taken to develop and apply technology and to prevent or solve eventual problems associated with this.
- To handle important issues relating to Finland's participation in international scientific and technological cooperation.
- To issue statements on the allocation of public science and technology funds to the various ministries, and their allocation to the various fields.
- To handle the most important legislative matters pertaining to the organisation and prerequisites of research and the promotion and implementation of technology.
- To take initiative and make proposals in matters under its competence for the Council of State and its ministries.

3.14 While STPC is the example of horizontal coordination at a policy level, agency level cooperation between Tekes, Academy of Finland, Sitra, Finnvera, TE-centres, Finnvera, Finpro and TESI (Industry Investments Ltd) also exists. Among research providers, the main platform for horizontal coordination is at the programme level. This is especially true of the Tekes technology programmes. Tekes has the main coordination and implementation responsibility for directing public R&D funds to industry. In 1998, Tekes distributed around 90% of the public R&D money directed to industry; 20% was given to companies as loans and the rest as subsidies for product development and research.[10] Tekes operates by:

- coordinating and implementing technology programmes, as well as providing funds for individual R&D projects;

10 *Tekes Annual Report 1998.*

- offering strategic advice and technology expertise to companies, focusing on small to mid-sized enterprises (SMEs) and new technology-based businesses; and
- developing the innovation environment, by encouraging networking, disseminating information and participating in technology policy discussions.

3.15 The Academy of Finland supports research activities in universities. It also has in-house research programmes that provide additional research funds for universities and focus on specific themes. During the 1990s, the Academy of Finland and Tekes increased their level of cooperation.

Selecting and commissioning research

3.16 In Finland, cluster, technology and research programmes are increasingly viewed as strategic means for funding research. Historically, these programmes have played an important role in pursuing scientific policy objectives. They are multidisciplinary, usually exist for a fixed period of time (around three years), and often involve consortia combining several research projects. Such programmes have provided an effective means for selecting and involving various research-related organisations and for stimulating cooperation and networking opportunities among private companies and the research community.

3.17 In Finland, research projects are generally commissioned as a result of companies and/or research institutes responding to a public call for proposals. Proposals are usually evaluated by committees based on a loosely defined set of criteria. Specification of the work required is often left quite open, and proposals and the ensuing projects can therefore vary widely in content. Programmes are under no obligation to spend all of their budget if the quality of proposals is low.

3.18 Technology programmes have been introduced recently to promote development in specific sectors of technology or industry, and to transfer research results to business in an efficient way. Private companies, research institutes and Tekes jointly plan the technology programmes in work-groups and open preparatory seminars. The decision whether or not to launch a particular programme is made by the Tekes board. Each technology programme has a steering group, a co-ordinator and a responsible person at Tekes. Programme duration ranges from three to five years and funding levels range from €6 million up to hundreds of millions of euros. Tekes usually finances about half of the cost of each programme. The remaining funding comes from participating companies. Foreign evaluators assess many of the completed programmes. The main benefits lie in the close cooperation between research institutes and industry, the widespread involvement of small and medium sized companies and the high level of international cooperation.

3.19 The Academy of Finland is the central financing and planning body for basic research. The majority of Academy funding supports basic research conducted in universities. The Academy of Finland uses research programmes to achieve its goals relating to science policy. Various annually launched research programmes are gaining more and more importance. These programmes consist of several connected projects within the same field of research. Programmes focus on topical research problems, important research fields and new fields and disciplines generated by research findings. The aims of the programmes are to raise the standard of research, to promote interdisciplinary, multidisciplinary and international research, to advance researcher careers and researcher networking, to intensify researcher training and to contribute to creative research environments. They are set up for a fixed term, usually three years, and are often co-financed by other partners. In 2001 the Academy supported 23 programmes, of which four were new and six were about to be completed.

3.20 The STPC guidelines also set out funding principles, in particular the targeted allocation of financing and the allocation of funding on the basis of competition. With regard to university training, graduate placement is considered one performance indicator and is used to direct resource allocation. In research, the selection of so-called 'Centres of Excellence' by the Academy has strengthened the competitive element among research groups.[11] The Academy funds the best researchers, research teams and the most promising young researchers. Funding decisions are based on careful scientific assessment of the applications and cover a fixed period of time.

Monitoring and managing Research

3.21 Research programmes and individual projects are usually overseen by steering groups. Generally, during the course of a project the burden of reporting is kept to a minimum. Private contractors are often only required to provide proof that they have conducted the work; other public documentation, such as the research results, is not demanded. Projects conducted by research institutes are generally required to report more formally and produce publicly available results. Project work generally follows the submitted proposal and,

11 Centres of Excellence are selected on the basis of international evaluations for a period of six years. They are subject to interim evaluations after three years. If the evaluation is negative, the unit is given one year in which to correct its shortcomings; if it fails to do so, it loses its Centre of Excellence status.

because Finland is a small country, failure to meet project goals becomes well-known, jeopardising future funding opportunities. Recently, more attention has been paid to project dissemination activities and networking of information providers and users. Programmes usually include seminar activities where the results from different projects are presented at a programme level.

Measuring outcomes

3.22 Evaluation has long played an important role in policy formulation in Finland. National policies, institutions and research programmes have been subjected to extensive evaluation, especially since the early 1990s. The effectiveness of government action is assessed at different levels. All the major bodies (e.g., the various ministries, Tekes, the Academy of Finland and research institutes) have been evaluated by external teams. Experts from abroad are commonly involved in evaluation panels. In this way, new evaluation examples are taken into account and the objectivity of the evaluation is increased. Furthermore, the opportunities for sharing and disseminating knowledge, practice and policies across countries are increased. Evaluations feed into recommendations for future programme, project and instrument development.

3.23 A primary responsibility of researchers at Tekes is to assess the impact of technology on economic development. The findings are used to steer technology funding and the development of the technology programmes. Impact analysis has been integrated into Tekes operations, which are steered according to impact targets. Impact is monitored and evaluated at the project level. Tekes also commissions external evaluations of all national technology programmes.

3.24 Towards the end of the 1980s, all Tekes technology programmes were evaluated. Since that time, experts have evaluated more than 60 programmes. In recent years, evaluations have become more structured and standardised and are the responsibility of a specifically created Impact Analysis Directorate, consisting of an Evaluation Unit and a Quality Unit. As far as possible, external evaluations and international experts are employed. The Impact Analysis Directorate uses external experts to evaluate technology programmes and to compile varied and independent effectiveness data. The evaluations highlight research and development practice and the factors contributing to its success or failure. One evaluation can cover several programmes if they belong to the same field or cluster, if they have similar goals, or have some relevant feature in common. Impact assessments also aim to provide answers to ongoing queries and make it easier for those concerned to respond to changes.

3.25 Tekes technology programmes are always evaluated upon completion and sometimes midway through. The evaluation provides feedback on whether and to what extent the programme aims have been realised and on the relevancy of the programme. It also produces information to support the strategic development of future programme activities and the activities of Tekes in general.

3.26 Evaluation is a primary function of the Academy of Finland. Expert opinions, impact analysis, disciplinary evaluations and research system reviews all serve as evaluation mechanisms. Between 1983 and 2000 the Academy conducted a total of 21 disciplinary evaluations. Reviews of the whole research system were published in 1997 and 2000. A few discipline-based evaluations are carried out annually and greatly influence the future development of the field. At the Ministry of Education, a Higher Education Evaluation Council was set up to assist higher education institutions conduct evaluations.

3.27 Over the past years, the structure of research institutes has been revised after feedback from peer review. VTT was reorganised throughout 1993 and 1994, primarily to become more customer-orientated, improve internal and external interaction and to support functional and economic rationalisation. Direct budget appropriations allocated to state research institutes decreased in real terms between 1992 and 1996 by as much as one-fifth. Research organisations compete for research assignments and financing and also form partnerships. The trend towards sectoral research is eliminating strong demarcation lines between different fields and between and among ministerial research institutes and other research organisations. Research institutes now also compete with university research groups for Tekes and Academy funding. Academic research groups have been especially successful in acquiring external funding from these sources. The government has acknowledged the success of universities in the research provider market and has allowed universities more freedom to define their own research priorities, while simultaneously tightening financial accountability.

Part 4

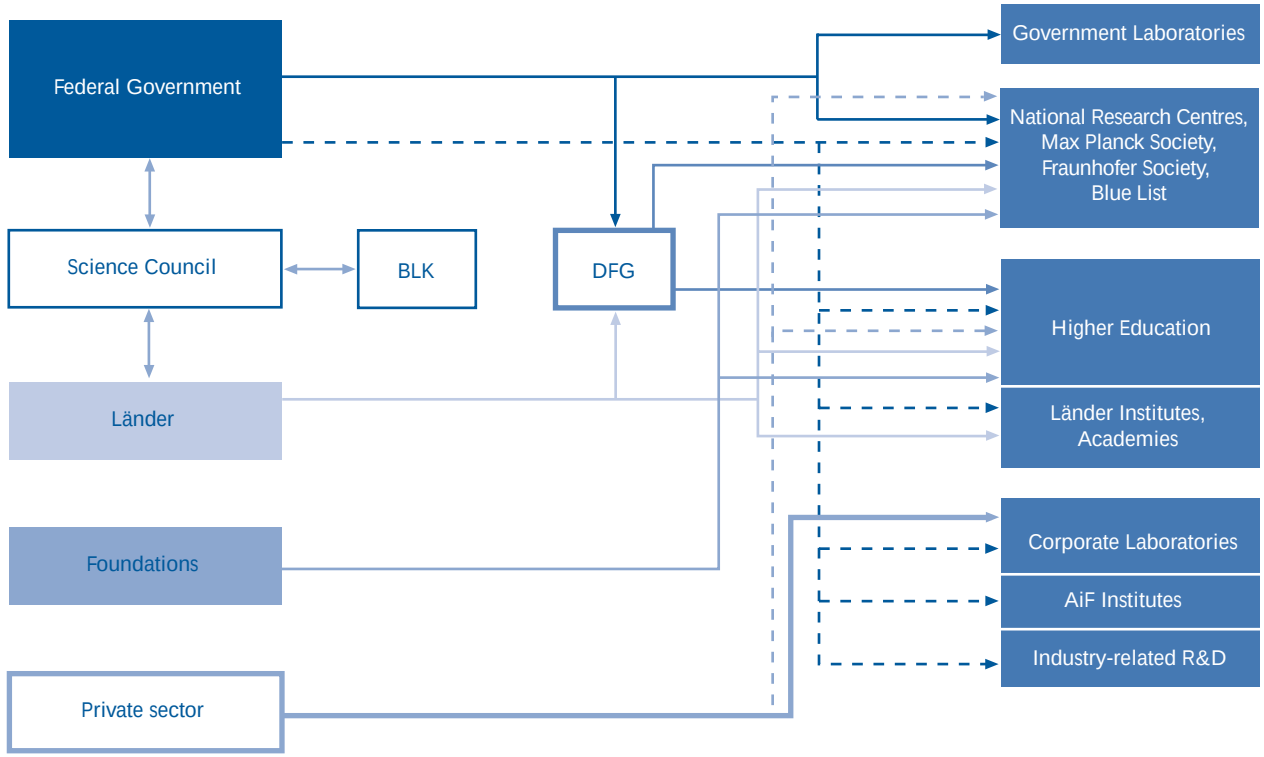
Germany

Institutional context

4.1 In Germany, the context in which science policy is set and research produced is complex, due both to the diverse and fragmented research provider base, and because responsibility for science and technology policy is split between the federal government and the Länder (states). The resulting institutional context reflects the size of the country, the federal structure and significant historical developments. In Germany there is no single, central body determining research and funding policies, in fact there is a fundamental philosophy of separation between the funders and providers of research, reflected by the number of institutions playing an intermediary role. **Figure 13** provides an overview of the flow of institutional and project-oriented R&D funding in Germany, depicted by solid and shaded lines, respectively.

4.2 The responsibility for education, including higher education and academic research, lies solely with the various states (Länder). They provide the basic funding and institutional support for universities as well as a number of independent research institutes. At the state level, there is very little programmatic coordination, let alone control, of research. An indirect influence is exercised by those bodies that provide additional funds (Drittmittel) to supplement the budgets of the various research providers. Where the states have any control at all over setting research strategy, it tends to take the form of medium-term plans developed by the joint Federal/Länder Commission for Education Planning and Research Promotion (BLK), and thematic guidance to universities through the Science Council. The Federal government supports almost all research providers by giving institutional support to

13 System of Research Funding in Germany



Source: Cave et al (1999)

government research establishments and the Deutsche Forschungsgemeinschaft (DFG) and project-oriented support to other providers.

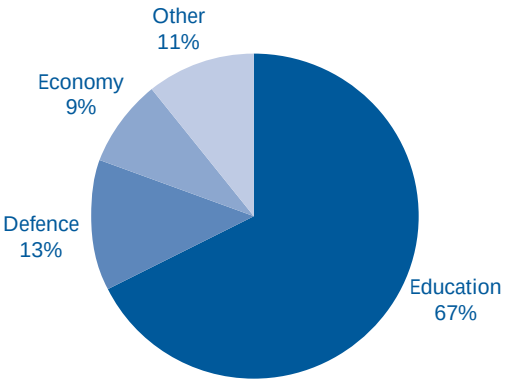
Research funding agencies

4.3 At the federal level, the main research funders are the Federal Ministry of Education and Research (BMBF), the Ministry of Defence, the Ministry of Economy and Technology (BMWi) and the Deutsche Forschungsgemeinschaft (DFG). The DFG is equivalent to Research Councils in the UK and receives money from the BMBF and the various state governments. It supports academic research that is aligned with its own research strategy. As shown in **Figure 14 below,** BMBF is the largest research funder, disbursing more than 60% of the total federal R&D budget.

4.4 The states also provide an important source of funding, primarily offering institutional support to higher education institutes and research institutes. Some states, for instance Bavaria through the Bavarian Research Foundation, have specific agencies to oversee research that supports their mission. State R&D expenditure almost equals that of the federal government and their funding efforts are coordinated to some extent by the German Science Council (Wissenschaftsrat) and the BLK.

4.5 The BMBF focuses on applied research and tends to employ a top-down approach to its allocation of funds, broadly divided between institutional and applied research, the latter being complementary to the DFG. Institutional funding (approximately 60% of BMBF budget) is mostly disbursed under a federal framework agreement. German research institutions such as the Fraunhofer Society (FHG) which mainly conducts application-driven research, or the Helmholtz Association that assembles 16 national laboratories with remits covering a broad range of research fields from particle physics to cancer research, or the Max-Planck-Gesellschaft (MPG), are the typical recipients of this funding. Such research institutes receive approximately 90% of their funds from the federal government and only 10% from the states.

14 Distribution of research and development funding over Federal ministries



Source: BMBF BERICHT Faktenbericht Forschung (2002)

4.6 The various departmental research institutes are those most closely linked to the federal government. Their research relates directly to the mission of a particular ministry and informs ministerial policy making. BMBF funds specific projects at some government research institutes, for instance at the Robert-Koch institute. Within the framework of its government research programmes, BMBF primarily funds applied research projects that adhere to particular key themes, such as laser research or nanotechnology. Project selection results from a strategically driven top-down steer, which sometimes has a detrimental effect on the funding of new projects. Quality control is carried out through international reviews.

4.7 Research funding by DFG is governed by a bottom-up approach, with "Normalverfahren", or normal procedures, at its core. In the various DFG programmes, both individuals and their institutions can compete for funding which is awarded on the basis of scientific excellence. This approach aims to encourage innovative thinking at an individual level. However innovative proposals can still be difficult to support as the funding decision relies on a high degree of consensus at a supra-regional level.

Advisory Councils

4.8 The BLK provides a permanent forum for discussing questions concerning education and research of common interest to the federal and state governments and submits recommendations to policy makers at both levels. The Science Council (Wissenschaftsrat) is Germany's independent science policy advisory body. Its members include representatives of the federal and state governments and eminent scientists. Its remit covers higher education and research policy issues, including the evaluation of research organisations and individual institutes, proposals for university infrastructure investment and the structure of the research system.

Research Providers

4.9 The research provider base has traditionally been divided among:

- Independent academic centres at over 100 universities and similar institutions with 140,000 full-time research staff.
- Government research[12] at federal and state research institutes (Bundes- and Ländesforschungsanstalten) that conduct research directly related to the sponsors' missions (Ressort-Forschung).
- Other research institutes, for instance the MPG, the FHG, the 16 national laboratories Großforschungseinrichtungen (GFEs) now assembled under the umbrella of the Helmholtz society, the institutes of the Leibnitz-Gemeinschaft and others. Together these institutes employ about 70,000 full-time research staff.
- Product-oriented industrial research laboratories, for instance the Confederation of Industrial Research Associations (AiF) which conducts research on applied topics particularly for small to mid-sized companies (SMEs) and is funded by a mix of public and private sources.

Priority setting and coordinating processes

4.10 Despite the complexity of Germany's decentralised research system, there are distinct functional roles that federal and state institutions have assumed to provide coherence and coordination of overall research strategy, research structure and programme focus of civil research. Towards these aims, two organisations have been assigned specific advisory responsibilities: the Science Council and the BLK. In addition, the federal government and state ministries have devolved funding responsibilities to organisations with specific research commissioning functions. The central independent organisation for funding and coordinating academic research is the DFG. It supports the entire spectrum of research from the physical sciences to the humanities. Research priorities at government level are to some extent determined by the BLK, which is responsible for coordinating federal and state research and education policies, and developing medium- and long-term research programmes. Its three main areas of responsibility are:

- to coordinate the federal and state governments' research policy planning and develop their medium-term plan;
- to prioritise and make recommendations concerning the mutual exchange of information between the federal and state governments in matters of research promotion; and
- to propose to the heads of the federal and state governments annual grants for research institutions, research funding organisations and jointly financed research projects.

4.11 The recommendations of the Science Council are not binding. They advise on issues broadly relating to science and evaluate the structure and institutions of the German research system. The Science Council is currently examining the potential role for a National Academy of Science and is reviewing the existing system of scientific advice to government.

4.12 The DFG is the principal intermediary organisation that coordinates activities between research funders and providers. Its corporate membership includes representatives from universities, research institutes and academies and it performs both intermediary and research provider roles. Project funding decisions, particularly those affecting universities, are taken by bodies comprising more scientists than government representatives. To promote innovation and as the main source of support for basic research, DFG stresses the importance of adopting a bottom-up approach to proposal generation. Approximately 40% of DFG funds are disbursed to investigator-initiated peer reviewed proposals, judged on the scientific quality of each project rather than on considerations such as their potential social or economic impact. DFG does not attempt to steer research in particular areas.

4.13 In summary, government-level research is coordinated at 3 levels:

- at the ministerial level within research institutions, where strategic themes are discussed and the DFG president is present.
- within the Science Council which provides broad scientific advice and evaluates the structure and institutions of the German research system. The council represents both state and federal government but its advice is not binding.
- among the advisory bodies and peer review committees of the BMBF at a programme level. Rounds of experts review and evaluate research proposals and ensure that research objectives are achieved. The DFG would be included in this evaluation process, but its primary objective is basic research whereas BMBF has a programme-specific focus. Currently, approximately 20 such programmes have been defined.

12 *Typically guided by considerations of security, standardisation and other public concerns.*

Selecting and commissioning research

4.14 The degree of autonomy granted to research institutions to determine their own research priorities and strategies is unique to Germany. In theory, research content is entirely independent of state influence. However, there is a long-standing, mutually advantageous relationship of cooperation between the government and research institutions.

4.15 Specific research projects are selected and commissioned according to a framework of programmes defined on the basis of either particular themes or disciplinary fields. However, all steps in the research process (e.g., purchase, execution, administration, evaluation) are the responsibility of appointed research management organisations (Projektträger) outside the government. Often these organisations are research institutes themselves, such as the German Air and Space Institute, the project management organisation Julich, (housed within the Julich Research Centre), or Fraunhofer project management. As authorised funding agencies for the government, their responsibilities combine both scientific-technical and administrative roles. They also organise project seminars and workshops and assist with results dissemination on behalf of their contractors.

4.16 Intermediary management agencies became established when the increase in research sponsored by federal ministries became too great to manage in-house. The agencies are funded typically by federal money and provide a higher level of relevant R&D support than the ministry itself. They also function as an international point of contact for other research or government organisations in their respective areas of expertise.

4.17 Research support for BMBF and BMWi activities has been accompanied by various quality assurance measures, relating to both institutional and programme/project funding. An assessment of the potential results takes place even before a project is funded, and monitoring continues throughout the lifecycle of the project. Developing and checking the performance plan has become mandatory, enabling government departments to monitor how research funding is being used.

4.18 DFG supplies grants to academics on the basis of review and competition. Most reviewers are selected by the programme directors and managers in the DFG office, but a core of some 600 are elected each year. Project selection and review are maintained as separate activities. However, this independence has recently come under threat as increasing workloads have made reviewers reluctant to serve on committees. Furthermore, as demand for proposals increasingly outstrips supply, criteria other than scientific merit are beginning to play a part in funding decisions. In response to falling approval rates, the DFG has developed adaptive mechanisms, such as a three-year grant to supplement existing 1 and 2-year grants to reduce the overall volume of applications.

4.19 In contrast, priority programmes in specific areas make use of invited calls for proposal. Funding for research units, clinical research and centres of excellence are comparable to the UK programme of centre funding. Funds are available for a limited 6 to 12-year period, compared to 10 years in the UK. These funds are allocated competitively, against individual grant applications. On average, between 3 and 10 individual grants are awarded, spread over a 6-year period.

4.20 The Helmholtz Association, one of Germany's four non-university research organisations, is in the process of major structural reform following a recent review by the Science Council. Helmholtz has an annual budget of over €2 billion and employs more than 25,000 staff. In future, its research activities will be carried out in-house and funded on the basis of strategic research programmes rather than as a part of institutional funding. The reform efforts aim to increase competition, promote collaboration between individual centres and thus improve the exploitation of synergies. Developing priority programmes will continue to be an ongoing process, taking into account the federal government's research priorities as well as input from the science community and industry.

4.21 When the programme-based funding strategy is in place, about 80% of all government funding will be allocated on a competitive basis under specific programmes. Approximately 90% of the funds will come from the federal government and 10% from the states. About 20% of the public sector funding will remain unallocated to be used on a flexible basis to strengthen core competencies of individual centres and to develop new research priorities. During the transition period, about one-third of the Helmholtz Association's institutional funding will be allocated on a competitive basis.

Measuring outcomes

4.22 Germany has a rich tradition of evaluation of its research institutions and activities. Evaluation takes place at the system and institutional level, as well as at the programme and project level. It also occurs during several stages of the research process, mostly in the form of internal or external peer reviews by academics and industrialists.

4.23 As discussed previously, the Science Council has the primary responsibility for evaluating research organisations and institutes and the structure of the research system itself. An evaluation of the entire structure has taken place during the past decade. As a result of German reunification, the Science Council first reviewed all major research institutes in the former East Germany. Subsequently, the responsible federal ministries and the BLK decided to review the remaining non-university research institutions across all of Germany. The 'Blue List'[13] and Helmholtz organisations were evaluated by the Science Council and various international evaluation committees reviewed DFG, Fraunhofer and the Max Planck Society.

4.24 The evaluations have resulted in a number of changes to the research system. First, funding for six institutes on the Blue List was completely halted. Second, within Fraunhofer, a number of research institutes were consolidated to reduce fragmentation of the research base. Finally, the internationalisation of research in Germany has been strongly encouraged.

4.25 In addition to imposed external evaluations, self-evaluation has long been an integral part of scientific life in German research institutes, albeit to differing degrees. Internal reviews are usually conducted by the scientific advisory boards of the research centres and are generally highly significant to the self-assurance and perspective of the individual institutes. Over that last few years all non-university, government-funded research institutes are expected to show evidence of regular, systematic evaluation. Furthermore, they have been compelled to undergo external evaluations, some of which had grave repercussions for their future. Evaluations also take place at the programme and project level, mostly initiated within the individual research organisations. There is no common framework for evaluation at these levels, nor is there agreement on the impact evaluations ought to have on future operations and research work.

4.26 Research project evaluation takes place at various stages of the project life-cycle. Ex-ante evaluations are often conducted by means of workshops aimed at assessing the appropriateness of certain research priorities and programmes. Since 2000, all programmes of the BMWi, the main sponsor of research, use programme monitoring systems to assess how the objectives of the research programmes are translated into action and the effects of the preliminary results.

13 *The 'Blue List' are research organisations founded in 1999, and focus on long-term, interdisciplinary research that is independent of university research, but supports both Laender and federal research objectives.*

Part 5 The Netherlands

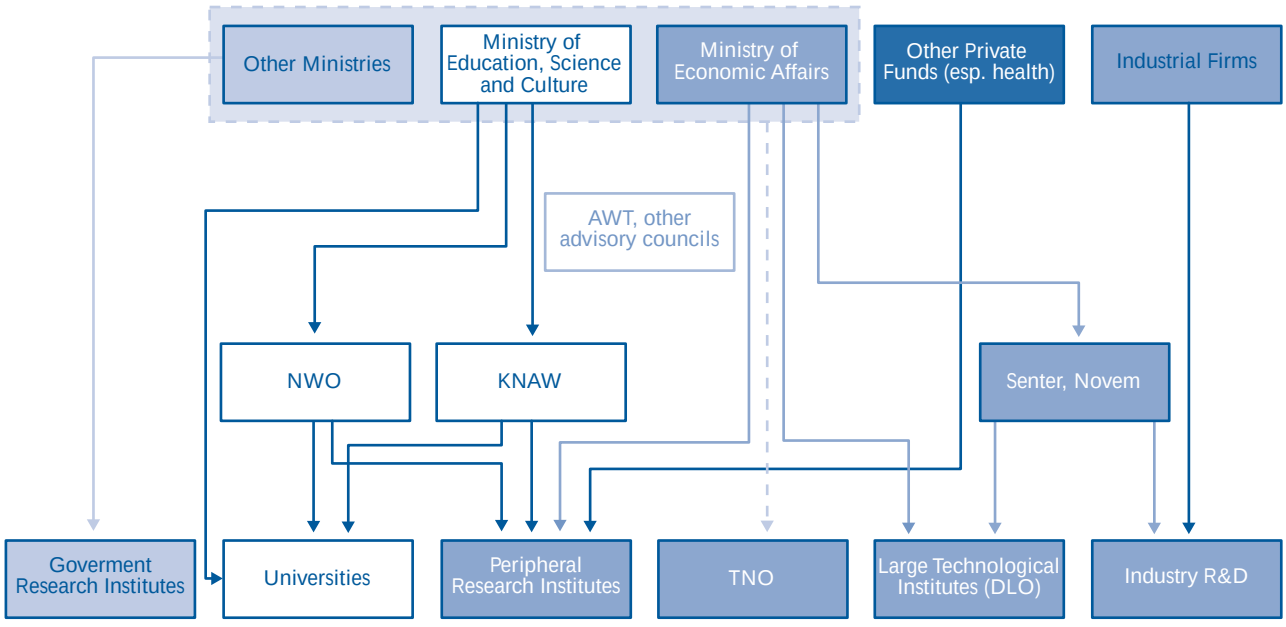
Institutional context

5.1 The system of government funding of research and development in the Netherlands, and the organisations that play a role within it, have not changed significantly over the past decade. However, recent changes have been implemented to simplify regulatory environment. As shown in **Figure 15**, at the funding and/or policy level, two organisations play a dominant role, the Ministry of Education, Culture, and Science (OCenW) and the Ministry of Economic Affairs (EZ). The former focuses primarily on education and research while the latter is concerned with technology development and innovative aspects of research. Together, these two ministries provide approximately 80% of all research funding at the national level in the Netherlands.

5.2 At the intermediate level, the Netherlands Organisation for Scientific Research (NWO) finances university research through various initiatives, including project financing[14], research programmes and individual support. Other intermediary organisations, e.g., Novem and Senter, implement policy, apply research subsidies or provide information services.

5.3 Government research institutes are financed by their respective ministries. The Ministry of Agriculture and Fisheries (LNV) is in a special position because it finances research in its own governmental research institute (DLO), as well as in the Agricultural University in Wageningen. The Ministry of Economic Affairs (EZ) supports the research institutes, including the Large Technological Institutes (DLO), that conduct research which is of particular significance to the Dutch economy.

15 System of research funders and providers in the Netherlands



Source: Frinking et al

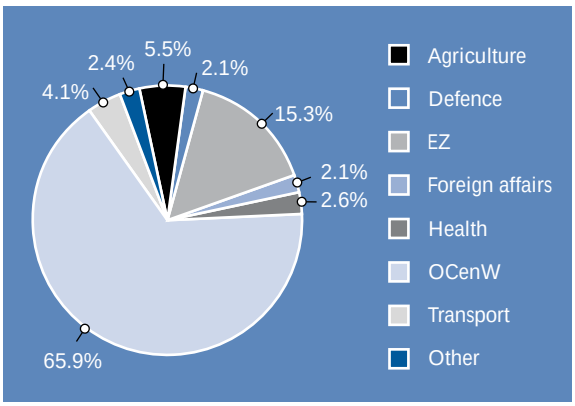
14 In the case of the NWO, Foundation of Technical Sciences (STW) funding also requires the participation of firms with a potential interest in the results.

Funding/policy level

5.4 The Ministry of OCenW provides the major overall source of R&D financing in the Netherlands, funding nearly 66% of government expenditure on R&D in 2002. Almost 70% of these funds is allocated to universities as so-called 'first flow funding' for research. The Ministry also indirectly supports university research by its contribution to the research council budget. Universities receive direct ministry funding through two routes; partly via a block grant allocation based on student numbers, and partly as conditional financing explicitly directed to support research based on five-year plans. Recently this latter route has changed. Conditional financing now occurs through research schools within the university which must have gained the approval of a Royal Academy of Sciences (KNAW) committee. The Netherlands Organisation for Scientific Research (NWO) finances university research, and both NWO and KNAW fund research in institutes peripheral to the universities. The Ministry's policy role regarding R&D is to promote an environment that encourages optimal use of resources to support the transfer of high standard research into policies to improve the welfare of society.

5.5 The Ministry of EZ is responsible for more than 15% of the national research expenditure. Its R&D related mission is to stimulate new fields of scientific and technological research deemed significant to the Dutch economy. The Ministry promotes technological innovation by introducing tax incentives and encouraging research cooperation among companies and between companies and educational and research institutes.

16 Distribution of spending across main national ministries



Source: Science Budget 2002, Ministry of OCenW

5.6 As **Figure 16** shows, with the exclusion of OCenW and EZ, the other ministries together fund less than 20% of R&D at a national level, with the ministries of agriculture and transport being the largest contributors among them. Agriculture allocates two-thirds of its funds to its own agricultural research institutes while Transport funds a wide variety of research activities, only 25% of which directly through government related research institutes.

Advisory Councils

5.7 Advisory councils support the government and the research system as a whole. The Advisory Council for Science and Technology Policy (AWT) provides general science and technology policy support. Sector councils, with the Sector Councils Consultative Committee (COS) as their consultation platform, support policymaking in a number of social science areas. In principle, the sector councils are not advisory bodies, but are intended to inform the policymaking processes.

5.8 The Netherlands Scientific Council for Government Policy (WRR) was established originally on a provisional basis in 1972. It was granted formal legal status under the Act of Establishment of 30 June 1976. The Council focuses especially on developments that affect society in the longer term. Policy decisions taken in areas like health-care, transport, communication and education can determine the shape of society for decades. The Council seeks to explore new problems, analyse existing problems from a coordinated standpoint, outline new perspectives and offer possible directions for government policy. By addressing the uncertainties inherent in particular policy areas and the potential consequences of various options, decision making quality ultimately can be improved.

Intermediary agencies

5.9 Intermediary organisations and boards implement policies and perform brokerage activities at a middle level between the ministries and the specific research provider institutes. Their role has been strongly developed and emphasised in the Netherlands, originating from the principle of separating policy decision making and policy implementation. Both the Ministry of OCenW and the Ministry of EZ have a number of implementing agencies that manage their research programmes and other policies that aim to stimulate research and innovation.

5.10 NWO and the Royal Academy of Sciences (KNAW) are the two dominant intermediate national institutions that fall within the domain of the Ministry of OCenW. NWO is the central Dutch organisation in the field of basic and strategic scientific research. NWO acts as the national research council of the Netherlands. NWO finances and commissions research throughout the country, usually at universities, on issues relating to innovation, quality, society and international profiling. KNAW is the major advisory council for the Dutch government on scientific matters. Its function is to ensure scientific foresight studies are carried out. It also plays important roles with respect to quality assurance, the maintenance of width and balance in the Dutch science portfolio and by providing scientific advice to the Cabinet. NWO and KNAW also finance their own research institutions, with overall budgets of €120 and €60 million, respectively.

5.11 Other important institutions at this intermediary middle level are the government boards of international and national research institutions, such as TNO or the GTIs (see below), and universities. The main intermediary agencies that report to the Ministry of EZ are Senter and Novem. Both agencies are responsible for large subsidy schemes relating to research and technology development in the fields of energy, environment and technological innovation.

Research providers

5.12 In the Netherlands, scientific research is conducted at the level of the research institutions, the majority within the university system. Other important research institutions are:

- the Netherlands Organisation for Applied Scientific Research (TNO), a for-profit research contractor. TNO forms a bridge between basic research and practical application.
- the five 'Large Technological Institutes' (GTIs). A more competitive programme of government funding is being established for the GTIs, whereby a certain fraction of government funding has to be matched by industry, to ensure that the institutes' research takes a direction that will be of interest to companies.
- the research bodies of some of the ministries. The ministries for health, transport, environment and justice all maintain in-house research facilities.

5.13 Universities receive research funding from various sources. A distinction is made between the so-called first, second and third money streams flowing into the universities.

- The first money stream largely follows historically established mechanisms. It takes the form of a lump sum budget calculated on the basis of number of students and research criteria. The calculated research component in the lump sum budget is about €1.4 billion annually and is divided among 14 universities. In 1999, the total of the first money stream including the education component amounted to €2.2 billion. First money stream budget allocations are not dependent on evidence of scientific research quality[15] although the Ministry intends to change this situation.
- The second money stream, amounting to about €250 million, is allocated by the National Science Foundation (NWO) on the basis of quality, through which it aims to reward excellent research. It also publishes priority research themes that provide guidance to research organisations who submit winning proposals. NWO has an €25 million annual capital budget to cover the purchase of technologically advanced equipment. The demand for these monies outstrips the availability by 2 to 5 times. KNAW's budget is about one-fifth the size of NWO's, and is largely used by its own research institutions. It has no specific capital expenditure budget for outfitting research.
- The third money stream, totalling about €300 million, finances contract research. Independent medical foundations fund more than half of the third money stream. Only about 20% of contract research is paid for by private industry.

15 *Of course, universities and institutes have their own independent internal and external quality assurance procedures.*

5.14 The organisations that play a significant role in the Dutch R&D system are fairly constant. However, changes within them and the context resulting from different science and technology policies of successive Dutch governments have resulted in overall changes to the system. Among the most significant changes are the following:

- The Ministry of OcenW's direct funding of university research changing from block grants based on student numbers to explicit research financing, first within the 'conditional financing' scheme and, more recently, with the establishment of research schools.
- NWO evolving from an organisation dedicated mainly to basic research to an organisation with activities in all research fields. The organisation also changed its project-oriented research funding focus to more programme- and individual-oriented schemes. Moreover, the organisation now also attracts funds from other ministries, including the Ministry of OcenW.
- TNO evolving from an organisation predominantly financed via public administration block grants to one financed by programme contracts with ministries and private enterprises.

Priority setting and coordinating processes

5.15 Foresight helps play an important role in the process of setting research strategies and priorities in the Netherlands. Foresight exercises are specifically designed, interactive processes. As described above, the Netherlands has a dense intermediary level of institutions, councils and independent bodies which contribute to agenda setting, mediate the link between resource allocation and research production and oversee parts of the research processes. Each of these organisations conduct foresight activities, however, in most cases from a distinct perspective, e.g.:

- The Advisory Council for Science and Technology Policy (AWT) looks broadly at the strategic direction of science and policymaking.
- The Royal Academy of Sciences (KNAW) examines developments that affect the various scientific disciplines.
- The Sector Councils initiate foresight studies that explore the social, economic and environmental challenges to specific policy domains.

5.16 These information-gathering exercises ensure that all relevant stakeholders, such as academics and industrialists, as well as interest groups and research users are all included in the process and decisions that affect them.

5.17 The AWT and the sector councils assess the demand for specific research. It is the AWT's task to advise the Government and the Parliament on the science and technology policy to be pursued nationally and internationally, and on information policy in the science and technology fields. It is also the Council's task, at the request of the Minister of OCenW, to carry out foresight studies in the field of science and technology or else to commission them. The core of its advisory function is focused on the knowledge and innovation process and its development. The recommendations made by the Council may also relate to matters that affect, or are the result of, research and science practice and technology development. The Council comprises representatives from academia, industry and government who are elected on personal merit and do not represent any vested interest.

5.18 The most significant structural example of horizontal coordination is the Consultative Committee of Sector Councils (COS). It is the platform for cooperation among sector councils and their members. The functions of the COS are as follows:[16]

- to consult on issues of common interest, exchanging ideas and discussing research themes and information;
- to promote a coordinated approach by addressing multidisciplinary issues, organising projects and joint studies by COS members, funded by the COS Co-ordination Fund;
- to organise studies, workshops and conferences on method development;
- to coordinate joint input during administrative consultations (e.g., between ministries, NWO, the Associations of universities in the Netherlands);
- to reflect joint interests; and
- to conduct PR at a system level.

5.19 Currently, there are four sector councils (The Innovation Network Rural Areas and Agricultural Systems, The Netherlands Development Assistance Research Council, The Council on Health Research, The Council for Research on Spatial Planning, Nature and Environment) with another four councils are being added (Public Administration, Justice and Security, Education, Traffic, Transport and Infrastructure, Employment, Health and Social Security).

5.20 The councils do not endorse a particular policy approach. Their priorities are determined on the basis of societal support, interest and/or scientific need; in other words, they are primarily 'curiosity driven'. However, since this approach tends to provide the primary research focus it can be considered consultative, involving many potential research providers.

5.21 In a sector council, researchers, members of society, (including trade and industry), and government representatives (as advisory members) together explore medium- and long-term scientific and social trends and present an independent view of the priorities for strategic medium- and long-term research in their sector. On the basis of these explorations or foresight activities, sector councils also look at trends in science and technology and their consequences for society. Sector councils are independent. They are not responsible for policy setting, nor do they allocate funds or manage research. They derive their authority from the weight of their evidence.

5.22 The integrated explorations and analyses of the sector councils can identify knowledge gaps and lead to basic and strategic research programmes, which in turn may lead to the establishment of a research programme by, for example, NWO. NWO's strategic plan would be based partly on the input of the sector councils and also on the mandate of the ministry involved. Sector councils may also make proposals to the ministers concerned about the coordination of research, development and knowledge infrastructure. Furthermore, although they are not advisory bodies, the sector councils may, through their explorations, contribute to policymaking in general. The ministries involved may take the results from sector councils' efforts into account when making policy decisions or when formulating requests for advice to advisory bodies.

5.23 The Dutch Cabinet published five foresight reports in September 2001 covering main issues and policy options for five different ministries, including the ministries of OCenW and EZ. In the wake of these reports, policy options for a more quality-based allocation of government funds to universities are being considered.

Selecting and commissioning research

5.24 In the Netherlands, organisations such as Senter and Novem coordinate and commission some of the research activities relevant to the ministries of EZ, Transport and Environment. Various other independent or temporary programme offices are responsible for implementing research strategies and commissioning research for programmes significant to the other ministries, e.g., the Economy, Ecology, Technology (EET) programme, and Flyland.

5.25 Flyland is a programme of research examining the feasibility and implications of an airport in the North Sea. It is a Dutch cabinet level initiative, with funding of €22.7 million, shared among the ministries of Transport, Public Works and Water Management; Economic Affairs and Housing, Spatial Planning and the Environment and by the air transport sector. Parliament has granted the Flyland programme office independent agency status. It started operations in spring 2001.

16 *Source: www.minocw.nl/cos*

5.26 The Minister of Transport, Public Works and Water Management holds primary political responsibility for the research programme. The Minister acts on behalf of all involved as the principal of the programme office and reports to Parliament. The programme office commissions specific studies. It is Flyland's aim that, upon completion of the programme in 2006, there will be agreement that the relevant questions have been investigated in the appropriate manner. Heavy emphasis is placed, therefore, on quality assurance and the public 'anchoring' of the research programme by acting on results from authoritative experts. The Minister receives advice from one of the sector councils at the programme level and from the programme office at the topic level.

5.27 The aim of the Dutch Economy, Ecology, Technology (EET) programme is to stimulate and support long-term projects aimed at technological breakthroughs that will generate substantial ecological and economic profit. During the past five years, private companies and research institutes have collaborated on 150 EET projects with ambitious goals in the field of sustainability. EET is a joint programme of three Dutch Ministries: the Ministry of Economic Affairs, the Ministry of OCenW, and the Ministry of Housing, Spatial Planning and the Environment. The practical execution of the programme is the responsibility of the EET programme office, a partnership between Novem and Senter. Within EET, projects are awarded by an external advisory committee on the basis of quality and expected contribution to the policy aims of the programme.

Measuring outcomes

Communication of results

5.28 The Netherlands Observatory of Science and Technology (NOWT) plays a significant role in the communication of information to policy makers. NOWT is a formal cooperation between the Centre for Science and Technology Studies linked to the University of Leiden and the Maastricht Economic Research Institute on Innovation and Technology of Maastricht University. It is funded by the Ministry of OCenW.

5.29 NOWT's mission is to collect and analyse data about the Dutch research system in a broad sense, including its interface with public information services relating to science, higher education and technological innovation. NOWT is monitored by a committee comprising representatives from all large public organisations involved in the preparation or realisation of national research policy.

Evaluation

5.30 Resulting from pressure by the General Audit Office of the Netherlands, the Dutch government introduced a new concept relating to the presentation of the government's budget. Rather than presenting traditional itemisation of expenditure, the budget must now show a more transparent relationship among policy, effect and funding. The government bill "From Policy Budget to Policy Accountability" formalised this concept. The presentation of the 2002 budget was based on this new approach and subsequent funding reports will require a similar approach.

5.31 The ministry of EZ has recently established a separate evaluation unit, which will be responsible for monitoring the effectiveness of its policies, including the investments to research. The unit has developed evaluation guidelines and conducted a review of evaluation techniques. These guidelines emphasise the need for improved data collection, ex-ante evaluations and the use of econometric methods in evaluation.

5.32 Evaluation of scientific research is conducted systematically in the Netherlands. Academic research units are required to conduct internal evaluations of their objectives and programmes every three years, supplemented by external evaluations every six years. In 2000, the association of universities, NWO and KNAW presented a report on the quality assurance systems in the Netherlands. It outlined a new approach to conducting quality evaluations. Research units now provide frequent information to supervising bodies on input and output indicators (e.g., personnel, budget, publications), conduct internal evaluations approximately twice every six years and undergo external, ex-post evaluations every six years based on peer review. This approach replaces the more frequent practice of continuous external evaluation which places considerable stress on the research organisations.

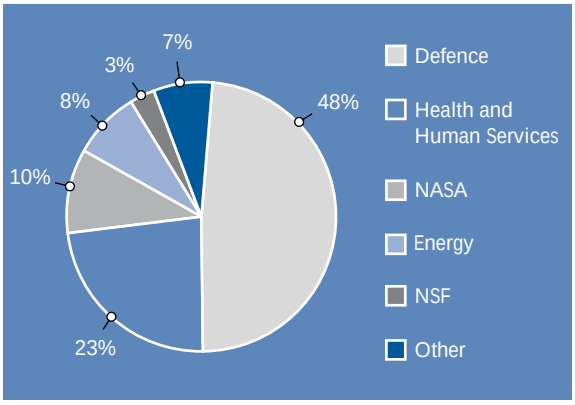
Part 6

United States

Institutional context

6.1 The US federal government supports R&D in pursuit of diverse national goals and objectives. Federal spending for R&D is heavily focused on defence, health, space and energy, as indicated in **Figure 17**.

17 Distribution of R&D funds among the agencies, FY 2002



Source: AAAS Report XXVI: Research and Development FY2002, Intersociety Working Group, 2000.

6.2 Federally supported R&D is performed in a number of diverse institutions, including government laboratories, industry, academic institutions and independent R&D organisations. Thousands of institutions in the US conduct R&D, funded by government, industry, state and local governments, private foundations, funds from colleges and universities and other sources. Industrial research is carried out by thousands of firms, large and small, although some 100 large firms account for more than 50% of all industrial R&D spending. The largest providers of industrial R&D are the aircraft, communications equipment, chemical and computer and office equipment industries. Nearly every academic institution conducts some research. However, about 100 universities account for more than 80% of all academic R&D spending. It is estimated that there are more than 700 federal laboratories including federally funded research and development centres (FFRDCs). However, a much smaller number of these are of substantial size, with a few dozen conducting most of the R&D done in such facilities.

Priority setting processes and coordinating processes

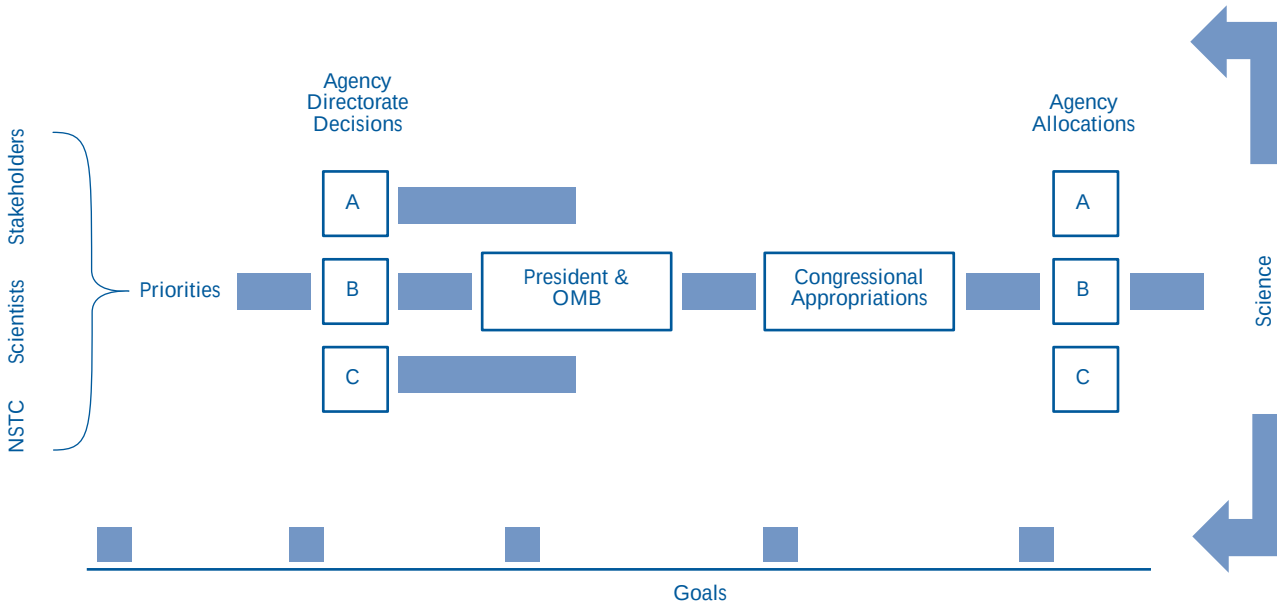
6.3 The US federal research funding process has traditionally been highly decentralised. During the last decade, various reports have been published emphasising that the lack of coherence in this funding process results in the suboptimal transfer of research results to support national interests. One of the conclusions of a National Academy of Sciences (NAS) report (NAS, 1999) stated that "mechanisms for coordinating research programmes in multiple agencies whose field or subject matters overlap are insufficient."

6.4 Goals, priorities and budget allocation are all a part of the R&D budgeting system, yet there is no formally defined process within the federal government to set goals and priorities or make allocation decisions for science. The process is iterative and complex. Many players with different interests interact to influence the outcomes. As the NAS has noted, as these players interact, the interests of science come up against other national goals and priorities, and funding for specific areas of science compete with one another for allocation of funds (NAS, 1995, p. 4). The outcome is roughly balanced across many areas of science and targets a number of specific goals and priorities.

6.5 The Executive Branch has initiated various debates and initiatives to support coordination of research across agencies.[17] However, it has not yet generated a widely accepted process for the federal government.

17 *National Academy of Sciences (1995); National Science Board (1997)I National Science Board (2001).*

18 Goal setting and allocation process in the US federal goverment



Source: Popper (2001)

6.6 The Office of Science and Technology Policy (OSTP), under the direction of the Science Advisor to the President, provides a resource for scientific and technical information within the government. It also plays a role coordinating R&D activities throughout the agencies and ensuring comprehensiveness in the budget for science activities. Its main responsibility is the continuing development and implementation of a national strategy to determine and achieve the appropriate scope, direction and extent of scientific and technological efforts. The science advisor and his staff serve as advisors to the President and so act to implement the President's policy. (OTA, 1991, p. 74) With each new administration, the goals and priorities for science and technology funding change. The OSTP helps to coordinate federal science activities to help meet the President's goals.

6.7 Within the domain of OSTP's responsibilities are two advisory councils, the National Science and Technology Council (NSTC) and the President's Council of Advisors on Science and Technology (PCAST).[18]

6.8 NSTC was established to integrate the President's S&T policy agenda across the federal government and ensure that S&T is considered alongside the development and implementation of federal policies and programs. It is a policy and budgetary coordination body through which all-executive departments and agencies coordinate S&T activities that require significant levels of interagency coordination. It operates with assistance from the OSTP which helps to set the NSTC agenda by suggesting topics around which the NSTC forms committees. These committees then review government spending in specific areas of research and recommend to OSTP where priority or allocation shifts might be needed. The members of PCAST are drawn from industry, education and research institutions. PCAST was established to solicit advice from the private sector and the academic community on technology, scientific research priorities and mathematics and science education.

6.9 The OSTP uses the information from both councils to advise executive agencies where shifts in funding priorities might be considered. OSTP also solicits input from the larger scientific community about where priorities and resource allocation should focus. This does not translate directly into budgetary action, however. The Science Advisor and his staff at OSTP are advisors to the President, and therefore do not have direct line responsibilities for budget allocation. The OSTP director and staff act primarily to coordinate activities and persuade other players of the importance of science.

6.10 The Office of Management and Budget (OMB) compiles the President's Budget seeking, within budget constraints, to support the President's policies, programmes and commitments. The formal process starts each summer in the Executive Branch when the

18 In Figure 18, OSTP, PCAST, and NSTC all fall under the direct responsibility of the White House, i.e., the US President.

agencies begin preparing their budgets for the fiscal year beginning in October of the following year. OMB reviews and coordinates the budget, resolves any disagreements and submits the budget to Congress in late January or early February. There is no one R&D budget as such: there are many R&D budgets embedded in the budgets of 21 federal departments and agencies that conduct or support R&D. The R&D requests are handled in the budget process as parts of the agency's total budget. OMB seeks to implement the President's policy and so does not set specific priorities for science. The OMB also has a responsibility to examine agency proposals for redundancy and opportunities for coordination.

6.11 OSTP and OMB issue a budget memorandum to all research agencies each year on research and development priorities. Guidance is sent to agencies listing presidential priorities, including trade-offs and reallocations across agencies that reflect these priorities, as well as crises, opportunities or evaluations. The priorities for R&D are based on a set of goals named by the Administration.

6.12 Agencies differ in setting priorities for science, based on whether they have a scientific or mission orientation. Most agencies now use some combination of an outreach or advisory approach to priority setting by gathering views from various stakeholders, combined with a strategic planning approach, setting strategic goals and seeking to implement them.

6.13 Three main models for priority setting can be distinguished at the agency level:

- Agency Outreach Model, where input from leading scientists and technologists from government, industry and academia is sought. Research themes are defined and then prioritised.
- Advisory Model, where an agency asks an independent organisation (often the NAS) to provide input and recommend priorities.
- Science Advisory Board Model, where agencies are advised by committees that are established to perform that specific task.

6.14 The budget that the US president submits to the US Congress might benefit from coordination efforts. However, as there is no single R&D budget presented to Congress, several committees consider various budget appropriations to R&D. There is no congressional coordinating authority for R&D to overview and coordinate changes made to the budget. The House Committee on Science, which has oversight authority over all federal non-defence R&D, comes closest. However, it does not have legislative authority over the budgets of various departments, including the two biggest funding agencies The Department of Defence (DoD) and The National Institutes of Health (NIH).

Selecting and commissioning research

6.15 US federal government research is conducted in a number of different organisational settings. Each places different contractual obligations and levels of freedom upon the research providers. The four most commonly used approaches are:

- Government-owned, government-operated laboratory, or GOGO-a laboratory owned, operated and funded by the federal government and staffed by federal employees. Examples include National Institute of Standards and Technology (NIST) laboratories, NIH intramural laboratories, the National Institute of Occupational Safety and Health and the U.S.D.A. Peoria Regional Laboratory.
- Government-owned, contractor-operated laboratory, or GOCO - a laboratory owned and funded by the federal government and operated and staffed by a private contractor. The contractor may be a profit-making firm, a non-profit organisation or one or more academic institutions. Examples include all of the Department of the Energy (DOE) national laboratories mentioned below.
- National Laboratories - e.g., a large, multipurpose laboratory of the Department of Energy, including the major weapons laboratories - Los Alamos, Sandia, and Livermore - as well as Argonne, Brookhaven, Oak Ridge, Lawrence Berkeley, and others. (National Laboratories are one type of FFRDC).
- Federally funded research and development centres, or FFRDC - a particular form of long-term government contract with a non-governmental organisation to staff and operate a laboratory or other research centre that is funded in whole or in substantial part by the federal government. Some FFRDCs are agreements to operate GOCOs, while others are contracts that support contractor-owned and contractor-staffed organisations (NAS, 1995, p.60).

6.16 Within the individual programmes of agencies and directorates, research funds are allocated on the basis of peer review, an agency's board review, managers' discretion and combinations thereof. Grants are often provided on the basis of peer review while contracts are often established on the basis of a board review or by research managers. Through annual budget guidance to federal agencies, the OSTP and the OMB encourage funding of research projects that are peer reviewed over those that are not reviewed.

6.17 The US General Accounting Office (GAO) Report "Federal Research: Peer Review at Federal Science Agencies Vary" (March 1999) looked at how federal agencies conducted peer reviews of research products to chart the various expert review procedures. It concluded that there was no uniform federal policy for conducting peer reviews. Each of the 12 agencies examined by the GAO conducted their peer reviews according to a variety of policies, orders or other internal guidance. There is general agreement that peer review practices should not be dictated uniformly for every agency or for all types of federally funded research. Rather, the practices should be tailored to agency missions and research type.

6.18 The US Environmental Protection Agency (EPA) has made the most intensive effort to expand the application of peer review to the use of science in its own decision making. In the mid 90s, US EPA issued a formal peer review policy that outlined the need for peer review of all scientific and technical products. In the late 90s, to aid the implementation of the peer review policy, the EPA developed a Peer Review Handbook to ensure that proper peer review procedures are followed for major work products. EPA strives to ensure that the scientific and technical underpinnings of its decisions meet two important criteria: they should be based upon the best current knowledge from science, engineering and other domains of technical expertise; and they should be judged credible by those who deal with the Agency. For those work products that are intended to support important decisions or that have special importance in their own right, external peer review is the procedure of choice. Peer review is not restricted to the penultimate version of work products; in fact, EPA has found that peer review at the planning stage can often be extremely beneficial.

Measuring outcomes

Tracking research investments, activities and outcomes

6.19 Decision makers both inside and outside the US federal government have lacked a tool for understanding where and how much the federal government is spending on each area of science and technology. RaDiUS, which stands for "Research and Development in the United States", is the first information system that systematically connects the highly aggregated budget data on federal R&D with the disaggregated information on individual R&D tasks and awards to provide a complete picture of all federal R&D activities. RaDiUS collects data on federal R&D activities from information already gathered by the federal government, even if they have not traditionally been viewed as relevant to the tracking of federal R&D activities. For example, RaDiUS includes information from the Federal Assistance Awards Data System (FAADS) and the Federal Procurement Data System (FPDS), neither of which has ever before been used to track R&D. The data have then been brought together and augmented with information from agency-specific R&D databases and information gathering using common data fields and codes to form a comprehensive picture of federal R&D. RaDiUS has been used by numerous federal agencies and contractors to support R&D planning and coordination efforts, leverage R&D investments and transfer technology. RaDiUS allows users to see the total R&D investment in specific areas of science and technology across all federal agencies or examine the details of research investments within a specific agency. It thus offers the potential for monitoring redundancies in federally supported research and development.

Utility of research outcome

6.20 With the establishment of the 1993 Government Performance and Results Act (GPRA), federal agencies, including those that fund research, were formally required to set strategic goals and to use performance measures for management and budgeting. The objective of the GPRA is to encourage greater efficiency, effectiveness and accountability in federal programmes and spending. The GPRA has been an important driver for increased pressure on research funding agencies to demonstrate effects and results of their research and development investments[19].

19 At the same time, some scholars (e.g., C. Hill, P. Shapira) argue that accountability systems have already been in place for a long time to ensure that mission oriented R&D programmes accomplish their objectives and that fundamental research programmes are well managed and directed.

6.21 The US GAO published a report on measuring R&D performance. While it had, in the first instance, focused on two specific technology programs, the report drew some general conclusions with respect to measuring the impacts of federal research programs: "there is no single indicator or evaluation method that adequately captures the results of R&D. However, indicators do provide helpful information for making decisions about R&D." Establishing relevant quantitative and qualitative output indicators are seen as supporting policy decisions but have clear limitations in their performance demonstration. The report stresses that "output measures are highly specific to the management and mission of each federal agency and that no single indicator exists to measure the results of research" (GAO, 1997, p. 6-7).

6.22 Because of concerns that implementing the act would be particularly difficult for research activities, the Committee on Science, Engineering and Public Policy (COSEPUP) of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine considered the most effective ways to assess the results of research. The results of this study are described in two reports: Evaluating federal research programs: Research and the GPRA and Implementing the Government Performance and Results Act for research. COSEPUP made a number of conclusions, including:

- Both basic and applied research programmes can be evaluated meaningfully on a regular basis. For the applied research programmes of the mission agencies, specific practical outcomes can be documented and progress toward their achievement can be measured annually. Basic research yields annual results that can be evaluated meaningfully, but these evaluations might not give sufficient information about the ultimate practical outcomes.
- Agencies must evaluate research programmes by using measurements that match the character of the research. Differences in the character of the research will lead to differences in the appropriate timescale for measurement, in what is measurable and what is not, and in the expertise needed by those who contribute to the measurement process. Evaluating basic research requires substantial scientific or engineering knowledge; measures of the practical outcomes of basic research usually must be retrospective.
- The most effective means of evaluating federally funded research programmes is expert review. Expert review, including peer review (judging the quality), relevance review (judging whether an agency's research activities are relevant to its mission), and benchmarking (judging the relative standing in an international perspective), should be used to assess both basic research and applied research programmes.
- The development of effective methods for evaluating and reporting performance requires the participation of the scientific and engineering community.

References

BMBF BERICHT Faktenbericht Forschung (2002). Bundesministerium für Bildung und Forschung (BMBF), January 2002

Cave J, Frinking E, Malone K, van Rossum W, te Velde R (1999). Modalities of R&D Funding: A Comparison of EU Member States. Leiden, RE-99.018.1.

Cook-Deegan RM (1995). Previous Analysis of the U.S. R&D Allocation Process, working paper, Washington, D.C.: National Academy of Sciences.

Council of Science and Technology Advisors (Canada) (1999). Science Advice for Government Effectiveness (SAGE) A Report of the Council of Science and Technology Advisors. Ottawa, CSTA.

Council of Science and Technology Advisors (Canada) (2001). Science and Technology Excellence in the Public Service (STEPS): A Framework for excellence in Federally Performed Science and Technology, Ottawa, CSTA.

Council of Science and Technology Advisors (Canada) (2001). Reinforcing external advice to Departments (READ) a report of the Council of Science and Technology Advisors (CSTA), Ottawa, CSTA.

Cunningham, P (2001). European Study Report: Germany, in: Measuring and Ensuring Excellence in Government Science and Technology: International Practices (Report prepared for the S&T Strategy Directorate, Industry Canada; In support of the work of the Council of Science and Technology Advisers).

Environmental Protection Agency (EPA) (1997). Peer Review and Peer Involvement at the U.S. Environmental Protection Agency. Washington, DC: EPA Available at http://www.epa.gov/ordntrnt/ord/spc/perevmem.htm.

Environmental Protection Agency (EPA) (1998). Science Policy Council Peer Review Handbook. Office of Science Policy. EPA 100-B-98-00. Washington, DC: EPA.

Frinking E, Hjelt M et.al (2002). Benchmarking Innovation Systems: Government Funding for R&D, Tekes Technology Review 122/2002, Helsinki, 2002

Frinking E, Kahan JP (2000). Stimulating Industrial Innovation for Sustainability: Country Reports, Leiden, RE-2000.16, November 2000.

General Accounting Office (1997). Measuring Performance: Challenges in Evaluating Research and Development GAO/T-RCED-97-130.

General Accounting Office (1999). Federal Research: Peer Review Practices at Federal Science Agencies Vary, GAO/RCED-99-99.

Government of Canada (1996). Science and Technology for the New Century, a Federal Strategy. 1996. Government of Canada, Minister of Supply and Services Canada.

Hannele, K (1996). The Finnish Research System in the 1990s, in: EUROMECUM: An Overview of Research Policy in Europe, Raabe, Stuttgart, 1996.

Hickling Arthurs Low (1999). The Roles of the Federal Government in Performing Science and Technology: An International Perspective (Report Prepared for Canadian Council of Science and Technology Advisors Secretariat Industry Canada)

Hill, CT (1995). On the Allocation of Federal R&D Funds, working paper, Fairfax, Va.: The Institute of Public Policy, George Mason University.

Industry Canada (2000). Framework for Science and Technology Advice: Principles and Guidelines for the Effective Use of Science and Technology Advice in Government Decision Making. 2000. Ottawa.

Industry Canada (2000). Forging ahead: a report on federal science and technology: 1999. 2000. Ottawa.

Industry Canada (2001). Investing in Excellence, 1996-2001: A Report on Federal Science and Technology - 2001 Ottawa.

Kai H, Karjalainen S & Parkkari T (2000). The State and Quality of Scientific Research in Finland: A Review of Scientific Research and Its Environment in the late 1990s. Helsinki: Academy of Finland.

Lomas J (2000). Jonathan, Using 'Linkage And Exchange' To Move Research Into Policy At A Canadian Foundation. Health Affairs, **19 (3)**, p.236-240.

Ministry of Education (2001). Research in Finland, Helsinki: Ministry of Education.

Ministry of Education, Culture and Science (1999). Nothing ventured, nothing gained, Science Budget 2000. Zoetermeer: Ministry of Education, Culture, and Science.

Ministry of Education, Culture, and Science, Progress Report Science Policy (2002). Zoetermeer: Ministry of Education, Culture and Science.

National Academy of Sciences (1999). Evaluating Federal Research Programs: Research on the Government Performance and Results Act. Committee on Science, Engineering, and Public Policy.

National Academy of Sciences, Committee on Criteria for Federal Support of Research and Development. (1995). Allocating Federal Funds for Science and Technology, Washington, D.C.: National Academy Press.

National Science Board (1997). Government Funding of Scientific Research, working paper, Washington, D.C.: U.S. Government Printing Office, NSB-97-186.

National Science Board (2001). Federal Research Resources: A Process For Setting Priorities Washington, D.C.: U.S. Government Printing Office, NSB-01-156.

Popper SW, Wagner CS, Fossum DL, Stiles WS (2000). Setting Priorities and Coordinating Federal R&D Across Fields of Science: A Literature Review (DRU-2286-NSF). Washington DC: RAND Science and Technology Policy Institute.

Prihti A et.al (2000). Assessment of the additional appropriation for research, Sitra Reports Series 2. Helsinki: Sitra

Science & Technology Policy Council (1993). Towards an Innovative Society: A Development Strategy for Finland, Helsinki.

Shapira P. and Kuhlmann S (2001). Proceedings from the 2000 U.S. - European Workshop on Learning from Science and Technology Policy Evaluation, Bad Herrenalb, Germany: School of Public Policy, Georgia Institute of Technology, Atlanta, U.S.A and the Fraunhofer Institute for Systems and Innovations Research, Karlsruhe, Germany

Smith W and Halliwell J (1999). Principles and practices for using scientific advice in government decision making :international best practices : report to the S&T Strategy Directorate, Industry Canada in support of the work of the Council of Science and Technology Advisers Ottawa: Industry Canada

Statistics Finland, Science and technology statistics (see http://tilastokeskus.fi/tk/yr/tttiede_en.html)

Svein K (1997). Funding University Research in the Nordic Countries. Science and Public Policy, **24** (4), August 1997 (pp.233-244).

Tekes Annual Review 2001. Helsinki: Tekes National Technology Agency.

Tuomaala, E (2001). Research and technology programme activities in Finland, Helsinki: Tekes Technology Review 106/2002.