AD-A095 275 OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) F/G 5/1
RESEARCH POLICY IN THE FEDERAL REPUBLIC OF GERMANY.(U)
DEC 80 W J CONDELL
UNCLASSIFIED ONRL-R-7-80 NL

1 OF 1
AD
A095275

END
DATE
FILMED
3-81
DTIC

AD A095275

ONR LONDON REPORT

R-7-80

LEVEL II

(12)

OFFICE OF NAVAL RESEARCH

BRANCH
OFFICE
LONDON
ENGLAND

RESEARCH POLICY IN THE FEDERAL REPUBLIC OF GERMANY

W. J. CONDELL

16 DECEMBER 1980

UNITED STATES OF AMERICA

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER R-7-80	2. GOVT ACCESSION NO. AD-A095
3. RECIPIENT'S CATALOG NUMBER	375
4. TITLE (and Subtitle) RESEARCH POLICY IN THE FEDERAL REPUBLIC OF GERMANY	5. TYPE OF REPORT & PERIOD COVERED Technical Report
	6. PERFORMING ORG. REPORT NUMBER R-7-80
7. AUTHOR(s) DR. WILLIAM J. CONDELL, JR.	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE 16 December 1980
	13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

APPROVED FOR PUBLIC RELEASE/DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

research policy
Federal Republic of Germany
research funding

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The research policy of the Federal Republic of Germany as described in Bundesbericht Forschung VI, 1979 is abstracted and compared with trends in the OECD nations as described by the OECD Committee for Scientific and Technological Policy, 1978. Funding estimates for R&D sectors are given. Lists are given of the Big Science establishments, the Max-Planck institutes, and the Fraunhofer institutes.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE
S/N 0102-LF-014-6601

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

RESEARCH POLICY IN THE FEDERAL REPUBLIC OF GERMANY

Preface

Problems facing each of the free world industrial nations today appear in the main quite common. In the short term, they result in part from the energy crisis and its attendant economic impact, as well as increased world-wide competition for markets in a time of economic stress. In the longer term, nations which were primarily agrarian 60 to 70 years ago have now joined the high-technology producers and look to their future economic well-being as dependent on ever increasing high-technology applications, consumption, and export.

(It seems hard to believe that about 100 years ago Great Britain was producing one-third of the whole world's manufactured goods and about two-thirds of the world's coal and ferro-based materials and that today Great Britain, while still enjoying its historic position as a money center, is struggling to keep pace with the more recent entrants, say, France, Germany, Italy, and Japan among the world's major manufacturing nations.)

The overt involvement of government with support of industry, a much more pervasive phenomenon in Europe than experienced in the United States, has been leading over the past few decades to ever increasing public scrutiny and debate. Questions are being asked of the governments concerning not only short-term but long-term consequences of policy many of which are unanswerable with today's methodologies and socio-economic models. The Jeffersonian requirement of common, demonstrable benefit from governmental action taken in the context of the early 1800's pales by comparison to its application today.

The national science and technology policies and the derived programs are believed to determine considerably the health of a country's high technology industries. These programs, standing as they do today in competition with other worthwhile, less arcane programs to benefit the common wealth, must withstand the political process to survive. Unsubstantiable completely by a Utopian (or should it be called Orwellian?) cause-and-effect modeling, these programs fortunately have only to survive a political process, not a scientific one. All of the free-world industrial nations are facing this problem of specification and political justification.

The problem of justification is determining to a degree the nature of the policies and programs the governments are proposing, and the historical, cultural, and political experiences, as they differ among nations, are producing expected variants as to how a particular nation addresses what are considered to be goals shared by all industrial nations.

This report is based on an abridged version of the sixth report of the Ministry for Research and Development of the Federal Republic of Germany (Bundesbericht Forschung VI 1979) which essentially describes the German approach to the support of research and development needed for high technology. To place Germany's approach in some sort of context, a comparison is made, when possible, with an overview of the 24 OECD (Office of Economic Cooperation and Development) nations developed in "Science and Technology Policy Outlook" (OECD, Committee for Scientific and Technological Policy, 1978) as related in *Science & Government Report International Almanac 1978-1979* (D. S. Greenberg, Ed.). The OECD overview is given in italics at appropriate places in the text.

The abstracts given of Bundesbericht Forschung VI (BbF VI) are based on a rather literal translation of the German, although some license has been taken to improve readability. BbF VI contains extensive statistical and descriptive material not practical to abstract here but of essential importance for conclusions concerning German R&D policy and support.

Appendices have been included to describe some key organizations and funding profiles. A very good source for information on organizations and institutions in the FRG is *Science in the Federal Republic of Germany—Organization and Promotion*, R. Geimer and H. Geimer, Fourth Revised Edition 1978, Deutsche Akademischer Austauschdienst, Bonn. An older but worthwhile reference is *Guide to World Science, Vol. 3, Germany*, T. I. Williams Ed., 1974, Francis Hodgson, Guernsey, British Isles.

Abstracts from Cover Letter to "Bundesbericht Forschung VI" by Minister Volker Hauff

NEW FOCUS FOR R&D

The cover letter of the sixth report of the Ministry for Research and Development of the Federal Republic of Germany (FRG) (Bundesbericht Forschung VI, 1979) was written by the Minister, Volker Hauff. (The fifth report was issued in 1975.) He pointed out that economic problems, more critical social needs, and increased demands on R&D to solve immediate problems, such as energy, set in the context of growing public criticism of new technologies and their effects have led to new focuses and formulations of the FRG research policy.

(All italicized sections represent an overview of all OECD nations and do not necessarily apply to the FRG.)

...world-wide economic disruptions, particularly the oil crisis, have pointed to the need for strengthening the competitiveness of each national economy, i.e. for stimulating and broadening the science- and technology-intensive sectors.

At the same time, the demand for greater social relevance of the fruits of economic growth has steadily made itself felt, often resulting in an appreciably larger share of public R&D expenditure in sectors which may be said to come under the heading of "quality of life": health, protection of the environment, town and country planning, social development and welfare services.

Minister Hauff cites particularly conservation of resources, preservation of natural requirements of life, implications of technological development, and balancing of opportunities against risks as new considerations in the focus and formulation of research policy. Previous goals which he stated were still applicable are:

- extending and deepening the level of scientific knowledge

- maintaining and increasing the efficiency and competitiveness of the economy

- improving living and working conditions.

Hauff points out that the carrying out of the research policy requires public support not only at the Federal level but also at the Länder government level. (The role of the Länder governments, roughly like our state governments, will become clearer later in this report.)

Abstracts from Bundesbericht Forschung VI

Aims and Measures of Research and Technology Policy

BASIC GUIDELINES

The basic guidelines for research and technology policy as given in this report are:

- extending and deepening the level of scientific knowledge
- maintaining and increasing the efficiency and competitiveness of the economy
- conserving resources and preserving the natural requirements of life
- improving working conditions and the well-being of society
- recognizing the implications and correlations of technological developments, discussing and balancing their opportunities against risks, and substantiating decisions on the utilization of technologies.

Foreign policy requirements provide yet another guideline.

1978-9 R&D BUDGETS (SEE ALSO APPENDIX V)

The 1978 and 1979 budgets, viewed in the light of these guidelines or aims, are shown in Table I.

The FRG system of research has a deliberately diffuse organization. Government-sponsored research determines only in a limited way the content of research activities. Being diffuse, the FRG system often may require the cooperation of various political entities in the development and application of particular technologies to meet public needs. Basic research, though, is determined in subject and methods primarily by the performing scientific institutions.

BASIC RESEARCH PLANNING

The report points out that the search for knowledge must develop freely if it is to retain its cultural significance and its importance to scientific application. The search for knowledge and its contributions will not lend themselves to detailed planning.

Thus, a political issue which arises in global terms and sometimes with force, is that of the effectiveness of R&D, concerning all components of the R&D system. Special attention is paid to fundamental research, which so far has remained largely impervious to any attempted systematic comparison of input of funds with output of results.

Aims and Priorities of the Federal Government's Research and Technology Policy

Aims of Research and Technology Promotion	Priorities of Research and Technology Promotion	R&D Expenditure of the Federal Government in Million DM in 1978	in 1979
	General research promotion and basic research	1497,7 (790)*	1509,6 (794)*
Extension of scientific knowledge	Educational and vocational training research	163,5 (86)	171,3 (90)
	Information and documentation	80,1 (42)	93,7 (49)
Increase of economic efficiency and competitiveness	Securing of energy and raw materials supplies	1721,5 (906)	2128,5 (1120)
	Information technologies and technical communications	447,1 (235)	459,0 (242)
Conservation of resources and preservation of the natural preconditions for life	Electronics, other key technologies, innovation	490,5 (258)	550,4 (289)
	Space research and space technology	593,0 (312)	644,0 (339)
	Research and development in the service of health	270,2 (142)	282,2 (148)
Improvement of living and working conditions	Research and development in the service of nutrition	233,9 (123)	235,0 (124)
	Humanization of the working environment	100,8 (53)	103,4 (54)
	Environmental engineering	468,5 (247)	483,4 (254)
Improved knowledge on opportunities and risks of technologies	Transport and traffic technologies	561,4 (295)	682,1 (359)
	Maintenance of external security	1707,0 (898)	1728,0 (909)

*The numbers in parentheses are approximate $M based on $1 = 1.90 DM

TABLE I

ECONOMICS & SOCIAL SCIENCES

Applied research in economics and social sciences is promoted in the FRG insofar as it is thought to describe, analyze and explain the connections and interdependencies between technical and economic development, on the one hand, and social and political change on the other.

The most ambitious solution is to integrate R&D activities in overall socio-economic planning. Here, however, increasing difficulties arise owing to the growing inter-dependency between economies and the complex nature of short-term issues. The need for an overview is nonetheless urgent if priorities are to be defined. Hence the problem is to lay down a set of general guidelines and to roughly define matching R&D requirements without adhering to any rigid decisional framework.

DEPENDENCE ON HIGH TECHNOLOGY

An underlying tenet of the FRG policy is that high technological competence and application are essential to the country's well-being. The production of technically sophisticated goods and efficient and low-cost methods of manufacture are thought to be prerequisites for both effective foreign trade and for domestic productivity. The competitive edge in more conventional consumer goods is thought to depend, as well, on high technology.

ENVIRONMENT

The research and technology policy is designed also to increase knowledge of harmful effects on people and their environment while developing more acceptable processes and materials. Air pollution control, sewage treatment, waste disposal, and noise abatement are identified as applications for improved technologies.

WORKING & LIVING CONDITIONS

The research and technology policy is also intended to improve working and living conditions. Not only must new technologies introduced into industry provide relief from problems of dust, heat, noise, and dangerous substances, but they must also provide social and working conditions that will reduce the psychological strain of monotonous labor and the possibility of technological redundancies. In public health, the policy must lead to better health protection, preventive care, and improved health standards while increasing the economic efficiency of the public health service. Town planning and housing construction are also considered proper research areas. Information transfer, combining data processing and improved communications techniques, is thought to provide an opportunity for greater population decentralization and provision of public informational services of importance to regional planning.

RISK ASSESSMENT/ TECHNOLOGY ASSESSMENT

The report makes the point that technology advances, even though having many advantages, still may have harmful effects or associated risks if they are improperly adopted. Consequently, a governmental responsibility for technology assessment is identified. The assessment process requires the full range of scientific evaluation of societal impact.

The above summarizes the general aims and guidelines for the research and technology policy. The report goes on to give the setting from which the policy arises.

Current References and Perspectives of Research and Technology Policy

TECHNOLOGY RELATED TO ECONOMICS

New technology both in its development and commercialization must be viewed as an integral part of the economic structure. Technical progress is essential to the adaptability of the country's economy to international competition as well as to solving the immediate problems which create bottlenecks or shortages such as raw materials and energy. Yet as new technology is the requirement for adaptability, it is also the cause of change in the economic structure. It is a crucial factor for growth in labor productivity and thereby produces uneasiness about job security.

ELECTRONICS

Electronics with its ever-increasing range of applications is a prime example of a new technology which permits rationalization and automation. The major fields of application for process innovations with electronics are thought to be:

- supervision and automatic growth of production processes

- automata such as computer-controlled machine tools and industrial robots

- computer-aided design

- replacement of labor-intensive precision mechanical devices and systems resulting in reduction both in manufacturing and maintenance such as in the watch and cash register industries as well as in the transmission of news and information

- automated text processing by means of computerized typewriters with stored texts, etc.

- printing processes in which automated text processing is combined with phototypography.

EMPLOYMENT EFFECTS

In the period 1973 to 1977 there was a drastic decline in employment in certain sectors. Some samples for selected industries are:

Industry	Decrease in employment 1973-1977
Building & Civil Engineering	445,000
Textiles & Clothing	210,000
Agriculture	298,000

Clearly these decreases cannot be attributed solely to the introduction of new technology, but others can:

Printing	30,000
Watches & Precision Mechanics	10,000

The negative impact on employment is projected to be greater in the future.

NO ALTERNATIVE TO NEW TECHNOLOGY

The report sees no alternative to the introduction of new technology because restricting its introduction will cause loss of markets which will present an even greater risk.

On the other hand, the report notes that new technologies will lead to product innovation and expanded markets through price reduction as well as new products. This trend will tend to improve employment. The intent of the research and technology policy is to produce a net positive impact between these two opposing trends.

SOLUTION OF ECONOMIC & SOCIAL PROBLEMS

ENERGY

The report goes on to describe how technological innovations can contribute to the elimination of economic and social problems which hold up growth and progress. Of the problems, the first identified is energy supply and utilization. Increasing prime costs with decreasing fossil fuel resources are anticipated along with concern for ecologically acceptable limits of pollution resulting from fossil fuel use. Future tasks for the energy sector are said to be:

- economic and cost-efficient use of energy by optimizing conversion and distribution along with selective measures for conservation like insulation, interconnected heating systems and waste-heat recovery

- improvement of the use of domestic coal through new technologies

- increase of the use of regenerative energy sources such as solar energy

- development and use of nuclear energy (within certain limitations).

EMPLOYMENT OPPORTUNITIES RELATED TO ENERGY

Estimates of employment opportunities related to the above have been made. Thermal insulation of dwellings in the FRG shows a potential for DM200,000 million ($105 billion) over the next 20 years providing for 200,000 additional jobs. Construction of nuclear plants today provides for about 100,000 jobs. The investment potential for interconnected heating systems and waste heat management is estimated at DM35,000 million ($18.4 billion) over the next 15 years.

RAW MATERIALS

Raw materials, much like fossil fuels, will require improvements in prospecting, mining, and enrichment by, as examples, deep-drilling and bacterial leaching. Recycling will be required for certain materials. Materials research will be required to find substitutes for certain raw materials; ceramics, composites, and synthetics are expected to play key roles.

CLEAN AIR & WATER

Environmental protection, advanced significantly by the Federal Emission Control Act, the Technical Instructions on Maintaining Air Purity and the Waste Water Charges Act, will require new technology particularly for coal use, flue gas decontamination (particularly for desulfurization), sewage treatment, biological pest control, and artificial fertilizers.

Housing and town planning are both areas for the application of new technology. Six million housing units are now in need of modernization. Demand-oriented short-distance traffic systems are needed.

PUBLIC HEALTH

The humanization of the working environment and the promotion of public health are thought to be aided by noise reduction in factories by replacement of conventional forging practice by screw presses, avoidance of dangerous working materials, substitutes for x-rays, and new techniques for diagnoses, therapy, and rehabilitation. Data processing will play an important part in the improvement of health care delivery.

Production engineering using integrated information techniques is identified as a priority item for R&T efforts.

INFORMATION PROCESSING & COMMUNICATIONS

The number of office workers and administrators is rising in all the industrialized countries. This is consistent with the growing significance of information processing and communications. In 1961 only 23% of the FRG work force was engaged in jobs having large informational functions. In 1976 the figure was 33%. It is thought that the FRG's future economic capacity will depend on the effective use of new technology in this sector.

DEVELOPING COUNTRIES

The FRG as a leading industrial nation identifies with problems of the developing countries. While humanitarian motivation for assisting these countries is noteworthy, the report identifies first and foremost the economic and ecological consequences of poverty and over-population as a rationale for concern.

Scientific and technological cooperation by Member countries with developing countries is often put forward as important. Yet such statements are couched in general terms which as yet offer little in the way of concrete suggestions, and even less with respect to more active policies towards the Third World.

The report states that the ecologically oriented development of agriculture, pest control, adaption of conventional and industrial technologies suited to the needs of the developing countries, and assistance in establishing efficient infrastructures are appropriate endeavors.

SMALL & MEDIUM-SIZED BUSINESSES

Concern for small and medium-sized industry, which employs more than half of all industrial workers and wage earners in the FRG, has led to the establishment of some special programs. Small businesses have been given a greater share in promotional grants particularly in optics, measurement techniques, production engineering, application of electronic components, and improvement of work conditions. Research funds have been increased from DM95.8 million ($50.4M) in 1972 to about DM600 million ($316M) in 1979 for these industries by (1) the Ministry of Economics programs on innovation, for technical development of Berlin industries, for cooperative industrial research, for support of R&D personnel, for pilot programs on technology transfer, and for promoting external contract research, and (2) the Deutsche Wagnisfinanzierungs-gesellschaft (German Venture Financing Society).

Still there is criticism that the share of the R&T funding for small and medium-sized industries is too small. Some of the government programs, concentrating on a relatively small number of technologies with high R&D components, naturally tend to favor larger corporations because they have the resources adequate to the risks. This is especially true in nuclear, transport, space, and aircraft technologies. In fact several large companies have combined to carry out programs requiring distributed risks.

SECTORAL & REGIONAL BALANCE

In the funding of technologies on a priority basis by the FRG there is the danger of producing regional or industrial sector imbalance of funding. The report recognizes this problem but points out that industry itself shows similar potential for imbalance through its own expenditures and that government promotion cannot have the aim of equal regional distribution. On the other hand, new research and specialized information installations are being located so as to produce more geographical balance in R&D capacities.

The acceptance and assessment of technology is a rather new phenomenon and is duly recognized in the report. Assessment of both the beneficial and disadvantageous factors of the introduction/use of new technologies, particularly where far-reaching economic and social implications are anticipated, is deemed both appropriate and desirable. In the FRG there seem to be two groups, each about the same size: one shows fear and concern not only for future technical development but also even for the current influence of technology, the other regards technology as an essential prerequisite to maintenance and extension of the prosperity the FRG has already achieved.

IMPACT OF TECHNOLOGY

The report points out that assessment of the effects of a new technology, exhibiting as it frequently does considerable delay in its consequences, is very difficult even when the best of scientific projection methods are used.

IMPACT ASSESSMENT

A particular example is nuclear energy, which has caused major political conflict within the FRG in the past few years. This conflict has been fired by the feeling that the ever-increasing reliance on central energy supply systems has been planned by "anonymous authorities" and that the political decision-making should be made more public both in information concerning it and in the amount of public participation. The same feelings concerning participatory decision-making pertain also to the planning for local industrial centers, housing developments, and traffic routing.

NUCLEAR ENERGY CONFLICT

A new development touching many of the most industrialized OECD Member countries in recent years is growing demand for broader public participation in decisions relating to science and technology. The most obvious manifestation of this so-called "participatory phenomenon" has been in the area of nuclear energy policy.

The risk assessments made by scientists for the siting of nuclear power plants, as an example, have missed the mark as far as the fears of many citizens are concerned.

The factors behind the emergence of this phenomenon have a lot to do with the fact that traditional patterns of government decision-making have emphasized the role of experts. Decisions involving enormously complex technical considerations have usually been felt to be best handled by those having the necessary technical expertise. In those instances when the experts themselves have come to disagree, owing in part to insufficient scientific or technical evidence, the public at large has resorted to normative judgments. They have demanded greater public accountability. They have sought more direct involvement in governmental decision-making processes.

PUBLIC DISCUSSION NEEDED

The polarization of opinions on nuclear energy has forced the federal government to make its decisions only along lines that will get broad-based acceptance. It also has taught the lessons that polarization of opinion must be avoided by adequate public discussion well ahead of the introduction of new technologies and that the government must pay great attention to the consequences of technology and develop its own techniques for evaluation along with alternative technologies even though they may be less promising.

Government authorities have responded in a variety of ways. Some have seen the need to involve the public at the earliest stages of the decision making process when policy guidelines or issues are first formulated. Others have sought to improve the general level of public understanding of technical issues (as in the area of nuclear energy policy) by undertaking public information campaigns and promoting more open dialogues through national debate. Some governments have undertaken programmes designed generally to increase public understanding of science. Many governments have sought to ensure through new legislation greater public access to government information and the citizens' right to participate in government regulatory proceedings.

The issue of public participation does not stop only at technology's door. Increasing concern is being raised as to the public's right to intervene in science decision-making as well. Who should determine scientific research priorities? How will the results be used? What kinds of controls are necessary? These are some of the questions being asked in a number of countries and a variety of scientific disciplines, most notably in the life sciences and microbiology, but also in some of the social sciences.

FOUR AREAS FOR CONCERN

The report implies that protest similar to that on nuclear energy could conceivably develop in four new technology areas unless adequate preparations are made. The areas are:

- microelectronics—because of further industrial automation and changes in production engineering

- gene research and technology—because of the possibility of hereditary manipulation

- increased use of pharmaceuticals—because of unknown long-term and combinatorial effects

- comprehensive and interlinked data banks—because of privacy problems.

RESPONSE TO CONCERNS

For microelectronics and communications engineering the government is planning:

- to investigate the impact on employment and employment qualifications and to generate broad public discussion.

- to promote testing of new systems of news transmissions, particularly cable television.

- to investigate conditions necessary for successful employment of new information techniques in large and small enterprises.

For gene research, guidelines have been worked out with the cooperation of scientists and these are to be made binding by the enactment of new statutes.

For pharmaceuticals a program of R&D is to be implemented, and its results will form a basis for discussion with the manufacturers.

For large-scale data banks, data protection techniques will be investigated.

Structure of Research and Technology Support

The constitution of the FRG as well as those of the Länder (Federal States) governments specify that the arts, science and humanities, research and teaching must be unfettered. Science has thus enjoyed a great deal of self-administration, and the consequent structure of research is best described as diffuse. This is derived from the independence of the medieval universities. As problems of modern research and technology come now to require large amounts of funds available only through the federal government there has been an increase of late in governmental influence on research. Nevertheless, the principle is maintained as well as can be. Governmental direction of research has been restricted to augmentation of research funding and then for specific purposes, not the direction of research performed under traditional support. Figure 1 shows the total budget and sources for research and technology support in the FRG for 1978.

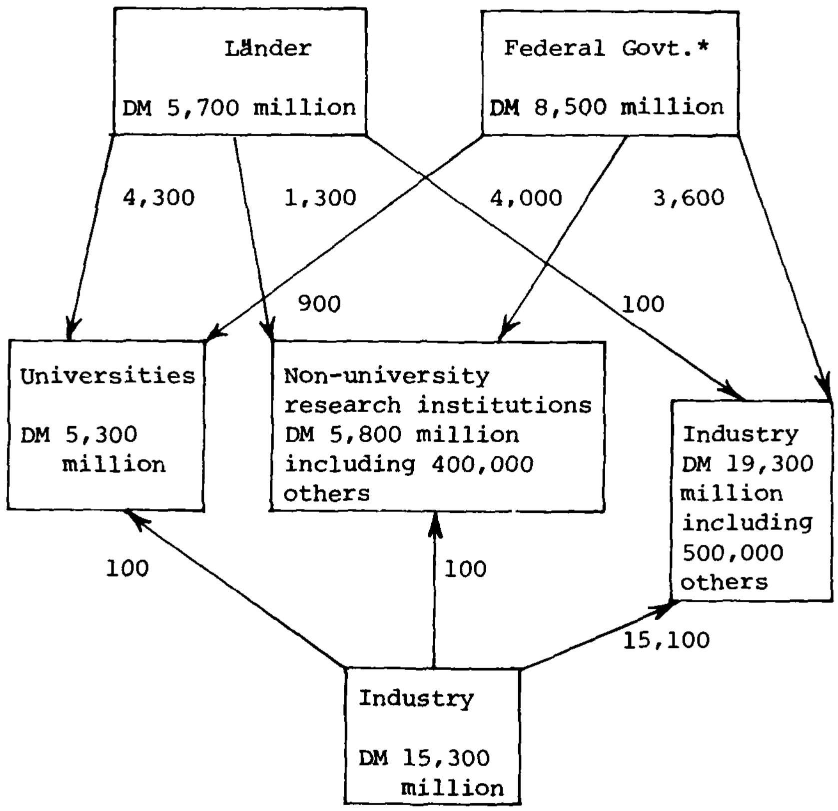
The general tendency is to make science and technology policy a part of general government policy and apply the same operating rules as to other areas of government policy. The euphoria of unrestricted expansion has been replaced by a target-planning, utilitarian attitude. This is an important change; it is no longer a matter of merely stimulating R&D, but of making its results usable and ensuring that they are really put to suitable use.

This is first naturally evident in government R&D, which is subject to reappraisal in terms of both government objectives and methods of management. The aim is to improve the

TOTAL BUDGET FOR RESEARCH AND DEVELOPMENT

IN THE FEDERAL REPUBLIC OF GERMANY (1978)

Total: DM 30,400 million



*including the estimated R&D share in university construction financing by the Federal Government (DM 285 million)

Figure 1

effectiveness of government research and increase its contribution to the national economy and to the community as a whole. Yet so far this new line of conduct seems not to have resulted in any radical transformation of government R&D centres, their programmes, or their organizational charts.

The new fact, pointed out earlier, is the attempted application of some criterion of social relevance and responsibility towards the community to university research, regardless of its method of financing.

UNIVERSITIES

Universities carry out research in all of the disciplines. The Länder finance the universities for teaching and for some, but not all, of the research. The universities receive third-party funds from the Deutsche Forschungsgemeinschaft (German Research Society), the Bundesministerium für Forschung und Technologie - BMFT (Federal Ministry for Research and Technology), as well as from other Federal and Länder ministries, foundations, and industry. Research planning at universities is done mainly on a decentralized basis within the specialized disciplines or individual institutes of the universities.

PROJECT MANAGEMENT ORGANIZATIONS

Project management organizations such as the Max-Planck Society (MPG) (see Appendix III) for basic research, the Fraunhofer Society (FhG) (see Appendix IV) for applied contract research, and the Berlin Science Center (WZB) for applied social research concentrate their research in priority areas. The allocation of funds to disciplines, institutes, and projects is largely left to the expert scientists. The Fraunhofer Society has an additional incentive to solicit funding from industry and reflects industrial interest in its research programs.

BIG SCIENCE NATIONAL RESEARCH CENTERS

National research centers which are financed mainly by the Federal Government combine basic research with applied research in priority subjects. Some of the national research centers conduct exclusively basic research with the aid of large-scale facilities. These require a special infrastructure. Examples are DESY (German Electron Synchrotron) and GSI (Society for Heavy Ion Research) (see Appendix II). These research centers also allow the use of their facilities by other institutions. The programs are planned in a formal manner, and there is a working association of these centers (AGF) to promote cooperation among them.

There are also research establishments serving the individual ministries of both the Federal and Länder governments. They support the ministries and carry out both basic and applied research. Some have been given national mandates such as, for example, measurement and calibration.

UNIVERSITIES

University research is primarily governed by the initiative and qualifications of the researcher. As shown by a model scheme of the Bund/Länder commission for educational planning and research promotion at the Free University of Berlin, commissions for research planning can promote this initiative but cannot replace it. Such commissions especially when supported by outside experts are able to contribute to internal research planning, establishment of priorities, and facilitation of contacts with governmental administration and supraregional research establishments.

Some of these initiatives are by no means favourably regarded by the scientific community. Members of University circles, in particular, are apt to be highly critical of government action. Public authorities are either accused of not doing enough to support university research, or else of doing too much by unduly emphasizing criteria of social relevance.

The unsatisfactory situation of university research is spreading and worsening. The main reason is unquestionably the backlash which followed the "explosion" in higher education: the rapid growth of student numbers, the inadequacy and disorganized transformation of university structures, and the imbalance between teacher and student numbers, or between education and research functions.

The framework Act for Higher Education requires the recipients of third-party funds to notify their university of these funds [!]. The university may impose restrictions and prohibit the use of its staff, resources, and equipment if the university tasks are adversely affected.

Some countries indicate that the difficulty might be mitigated to a certain degree by increasing the "second flow of funds," i.e. resources flowing through research councils and other bodies responsible for promoting research. Such funds must however first be made available.

PRIORITY RESEARCH

The Länder university laws and regulations, although differing considerably, do contain provisions relating to third-party funds and may have major impact on staff employment contracts. Most of the Länder university laws already have or will contain provisions by which priority research areas are assigned to a central university board. The priorities in research form part of the university development plans and are incorporated in the Länder overall university plans. The German Research Society and the Science Council have adopted rules which will simplify the recognition and granting procedures for priority research areas.

RESEARCH MANPOWER

Staffing of both universities and other research establishments continues to be of major concern. The number of positions for scientific and technical staff quadrupled between 1960 and 1974 while the non-university research staffs nearly doubled. During that period the vacancies were largely filled with young people, causing a major change in the traditional age structure. With a balanced age structure an annual replacement rate of 4-5 percent could be expected, but the present rate, which is also the one projected for the 1980's, is between 1 and 2 percent. Restricted opportunities outside the universities and research establishments have compounded the problem to cause a lack of mobility among scientific personnel.

To this must be added problems relating to changes in the teaching profession itself: rigid stratification, an age structure offering few career opportunities for young scientists, and heavier teaching and administrative duties at the expense of research.

The average age of university staff members is continuously rising. At the national research centers, reflecting the same trend, the average age of scientists was 37 years in 1975 and 40 in 1977. By 1990-1995, the average age is projected to be 45 years. These trends are debilitating for qualified young scientists. Also, they present serious problems for adaptability within the research community insofar as research specialization over the years leads to problem anging to new research tasks and programs. Retraining is thought to be indispensable, and exchange of personnel among universities, research centers, and industry will be encouraged.

HEISENBERG PLAN

The "Heisenberg Program," adopted by the Federal and Länder governments in 1977, is intended to prevent at least some of the highly qualified young scientists from leaving research. Under this program, the German Research Society annually awards up to 150 scholarships covering several years to young scientists from all disciplines for lecturing or research. Between 4 November 1977 and 31 December 1978, 87 such scholarships were awarded from more than 350 applicants.

COOPERATION BETWEEN FEDERAL & LÄNDER GOVERNMENTS

The Federal and Länder governments cooperate in the promotion of supraregionally significant research establishments and projects not specifically covered by departmental and industrial research. The cooperation is governed by general agreements adopted in 1975 and later amplified. Under these agreements the Federal Government and all Länder governments jointly decide on research policy and financing of the German Research Society, the Max-Planck Society, as well as 10 supraregional research establishments. The Bund/Länder commission for education planning and research promotion (BLK) prepares positions, and the fundamental decisions are made by the heads of governments. The following institutions are jointly promoted by the Bund and those Länder in which the institutes are located:

- the Fraunhofer Society

- 12 national research centers

-36 independent research institutions (of supraregional significance)

- 67 individual projects primarily in the humanities coordinated by the Conference of the Academies of Science.

Exchange of information is maintained between the Federal and Länder governments on all programs. Berlin is a special case and the Federal Ministry for Research and Technology cooperates with the Berlin Senate in establishing priorities.

FEDERAL INTERDEPARTMENTAL COORDINATION

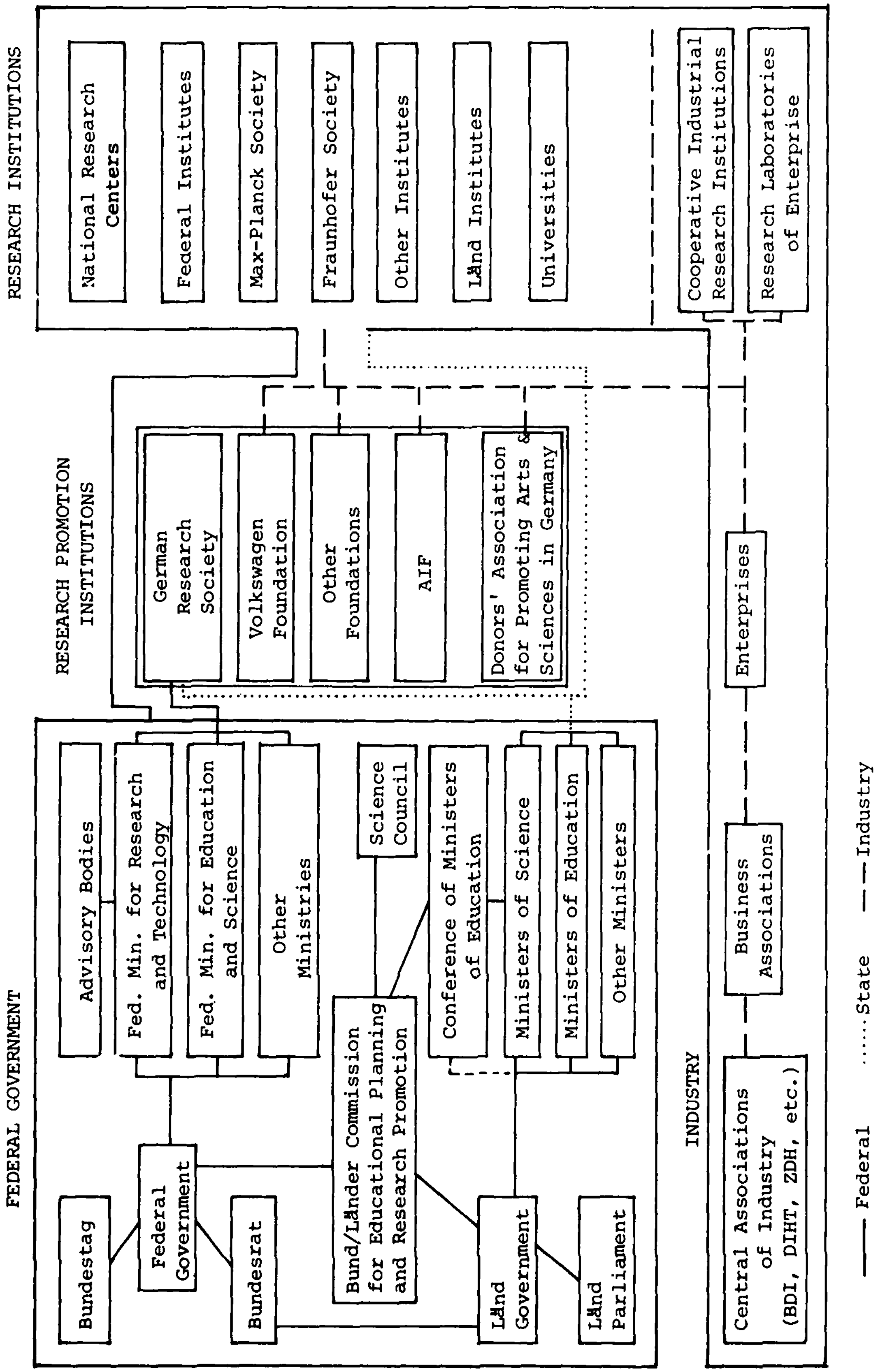
Ten of the 17 Federal Ministries spend more than DM10 million ($5.3 million) per year on R&D. Coordination of these programs is the responsibility of the Federal Ministry for Research and Technology. Law requires the departments to coordinate their activities under their own initiative. To this end, special instruments of information are produced—statements of planned or in-place activities and program budgets. (A data bank called DAKOR has been established to assist information flow.) Figure 2 describes some of the activities.

Co-ordination is certainly the most sensitive science policy function. However, whether in regard to governmental objectives, tasks, or programmes, no satisfactory formula seems to have been found. Here again, the desire for centralization prevails in some countries, whereas in others the proliferation of new mechanisms for co-ordination is the mark of change. But the need for more efficient, dynamic co-ordination is increasingly felt to be all the more urgent since resources allocated to R&D remain stationary or decrease in relation to other categories of public expenditure.

Due to this situation, the functions of bodies whose task is to promote R&D activities in their respective areas of responsibility also need to be revised. Such an overhaul of research promotion institutions has been undertaken in several Member countries. Usually this consists in reallocating duties in such a way as to make it easier to monitor programmes and see that funds are appropriately used. In other cases, new measures have been taken to standardize methods of allocation by public bodies and make their procedures for selecting R&D programmes or projects more consistent.

TECHNOLOGY TRANSFER

In order to improve products, processes, and services and to create conditions favorable for innovation, the FRG thinks it important to transfer research results to industry and the public domain as quickly as possible. This transfer,



RESEARCH AND TECHNOLOGY IN THE FEDERAL REPUBLIC OF GERMANY

Figure 2

it is noted, takes place first of all by personal contacts between scientists and users. The report points out:

- Scientific findings have their own value and market in technical journals and among experts all over the world.

- Scientific publication is not necessarily compatible with protection of proprietary rights—a condition often required by industry.

- The amount of R&D information frequently overwhelms absorptive capacity and information requirements.

- User and research establishment interchange is frequently hindered by claims of confidentiality and the "not-invented-here" syndrome.

- R&D results often require additional problems-oriented development up to the prototype stage in order to determine exploitability. Frequently that development is impaired by research mentality or by administrative regulations.

INFORMATION CENTERS

The FRG, the report states, has over the past few years established new transfer processes. Specialized information centers and agencies to disseminate technical information are being set up for the storage, evaluation, and transfer of the technological information available. Different methods are evolved in this process.

PATENTS

INFORMATION TRANSFER

The Federal government together with the Länder governments and industry is trying to establish better access conditions by extending the 16 specialized information systems and special purpose information centers. In the long term it is intended to link the patent publications agencies with the work group for patent exploitation (ARPAT) of the Fraunhofer Society (FhG), which documents publicly promoted patents for industry, and with the FhG patents department for German research, which assists private inventors in applying for and exploiting patents. The exploitation departments of the national research centers have been expanded. These centers may now use part of their earned income, whereas before such income would result in a corresponding cut of government subsidies. Some Federal research institutes such as the Physical-Technical Federal Institute (PTB) or the Federal Institute for Materials Testing (BAM) are extending their activities in information and further education. The publicly supported research establishments show their products at fairs such as the Hanover Fair and Interkama. Universities are increasing their efforts to produce prototypes based on their research. The research and technology policy for small and medium sized companies contains measures to improve information and technology transfer, notably the advisory agencies for innovation and technology. On large-scale projects such as energy and transportation, cooperative agreements and contracts on the exploitation of research results between the national research centers and industry play a significant role in information transfer. Techniques are being examined to provide remuneration to the national research centers for their contributions to industry. Joint development companies have been and are being established to develop the advanced high-temperature and fast breeder reactor systems as well as fuel reprocessing.

The promotion of R&T in industry has been under discussion in FRG for some years.

In most Member countries, the main purpose of government support for industrial R&D is to encourage R&D activities leading to the establishment or expansion of technology-intensive industries. Fears of technology lag and of an irretrievable loss of competitiveness have the effect of favouring identical branches of industry, and hence of exacerbating international competition in advanced sectors.

METHODS FOR R&T SUPPORT FOR INDUSTRY

There are two concepts which form the central issue in these discussions and they can be characterized as the direct or the indirect methods of research promotion. The direct method relates to certain R&D projects proposed by industry which fit into formulated governmental priority programs. Subsidies are provided to the industries at a suitable rate after careful examination and approval. The indirect method provides support based on measures of the amount of R&D performed by industry such as the number of people employed in R&D or on capital expenditures for R&D. The pros and cons of each method are debated widely. The direct method is criticized for government's interference with industrial policy. The indirect method is criticized as a pork barrel.

Meanwhile, rather than direct intervention, several countries seem to prefer novel methods of action. Among these, one can mention the refinement and broadening of contractual procedures, which are applied to individual projects, team research and multidisciplinary programmes. These are often of a pluri-annual nature.

The report argues that the two methods are not necessarily incompatible, but rather mutually complementary. Which method should be used is thought to depend on the type of problems to be solved and on the effect government funding will have on the recipient industry. Three aims for government support are identified:

- to stimulate industrial R&D in general

- to relieve small and medium-sized industry of the "base load" of R&D

- to concentrate R&D on foreseeable technology needs.

Table II shows instruments for promoting R&D.

CONSENSUS DEVELOPMENT

Project-related (or the direct method) support for R&D is thought appropriate, for recognized technology needs supporting economic and social development. This approach requires a broad-based process of consensus development. Consequently the FRG uses this method for projects within the scope of special priority programs.

The consensus required for selection and implementation of these programs is determined by industrial expertise, market analysis and experience, and by inputs from trade unions and associations as well as from scientific advisors. For these projects, as a matter of principle, the R&D projects supported remain within the province of the industries in their prosecution and even more so in their commercialization.

Prior to any governmental support, a thorough examination must be made to ascertain whether industry with its own resources could initiate and carry out the projects. Three conditions might dictate governmental support:

- Scientific, technical and economic risk is too high.

- Financial requirements are too large for industry in question.

- Project is so long-term that profits cannot be expected within foreseeable time.

In addition to these considerations, there are areas such as reactor safety research or public goods and services which by their nature have genuine public interests at stake.

The report points out that formulation and prosecution of programs can have only limited range and precision. Consequently, the FRG relies on a broad-based consensus-forming process, and it requires that the recipient industry assume part of the risk. Also, the FRG will deliberately support competing technological approaches until one proves itself to be preferred. Additionally, continuous monitoring of programs is done to avoid de facto permanent subsidation.

SMALL BUSINESS

During periods of economic difficulty, there is a tendency, particularly for the small and medium sized industries, to reduce R&D expenditures, thereby causing problems for employment in R&D but also for long-term health of the industry. An expenditure-oriented approach to R&D support tailored to

Innovation phase / Instruments for promoting R&D	Innovation Process						
	Basic Research	Applied Research	Experimental Development	Functional, Pilot, Demonstration & Reference Models	Commencement of Production	Opening up of Markets	Diffusion
	General Promotion of Research						
	Information & Documentation (*scientific & technical info*) *as an across-the-board function*						
The Federal Government's Priority Areas of R&D Promotion	Energy Research & Technology						
	Raw Materials Research & Research on Iron & Steel						
	Marine Research & Technology						
	Information Technologies (D.P.) & Technical Communication						
	Electronics, other Key Technologies, Innovation						
	Space Research & Technology						
	R&D in the Service of Health						
	R&D in the Service of Nutrition						
	Humanization of the Working Environment						
	Environmental Planning & Engineering (Environmental Protection, Area Planning & Urban Development)						
	Transport & Traffic Systems						
	Defense Engineering Research & Development						
Research Measures at R&D Establishments	Universities						
	Max-Planck Society						
		Major Research Establishments					
		Fraunhofer Society					
		Other Non-university R&D					

TABLE II/a

<table>
<tr><th rowspan="2">Innovation phase / Instruments for promoting R&D</th><th colspan="7">Innovation Process</th></tr>
<tr><th>Basic Research</th><th>Applied Research</th><th>Experimental Development</th><th>Functional, Pilot, Demonstration & Reference Models</th><th>Commencement of Production</th><th>Opening up of Markets</th><th>Diffusion</th></tr>
<tr><td rowspan="5">Special measures of production</td><td colspan="3">Cooperative Research (AIF*)</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">R&D personnel subsidies to enterprises</td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Contractual Research</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Initial innovations program</td><td></td><td></td></tr>
<tr><td></td><td></td><td colspan="3">Technical Development in Berlin</td><td></td><td></td></tr>
<tr><td rowspan="4">Promotion by Tax Incentives</td><td colspan="4">Art. 4 of Investment Allowance Law</td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Art. 4a of Investment Allowance Law</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Art. 7 of Income Tax Law (environment)</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td colspan="2">Housing Modernization Law</td></tr>
<tr><td rowspan="3">Own capital funds
and capital from outside sources</td><td></td><td></td><td></td><td colspan="4">Venture Financing Society</td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">ERP funds for business promotion</td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td colspan="2">ERP funds for environment</td><td></td></tr>
<tr><td>Government procurement services</td><td></td><td></td><td></td><td></td><td></td><td colspan="2">Government demand</td></tr>
<tr><td rowspan="2">Information & guidance assistance, technology transfer</td><td></td><td colspan="5">R&D results, patents, exploitation</td><td></td></tr>
<tr><td colspan="5">I&D, management assistance/guidance (IHK/RKW/ISI)**</td><td colspan="2">Market & structural studies</td></tr>
</table>

* Union of Industrial Research Associations

** IHK = Chamber of Industry & Commerce
RKW = Board for Rationalization of the German Economy
ISI = International Statistical Institute

TABLE II/b

the specific industrial firm seems desirable from the point of view of governmental efficiency and from the point of avoiding concentration of support funds in a few large corporations.

The policy of the FRG is thus to promote through a number of coordinated measures which include both the project-oriented (direct method) measures and those measures producing broad effects in support of industrial R&D. Within the scope of the resolutions adopted by the government in July 1978 on economic and growth policy, the FRG has emphasized the promotion of R&D for the small and medium-sized producing industries. This is over and above previous measures specified in previous governmental policy.

For most Member countries, such structural changes mean that innovative efforts must be extended and increased for the benefit of small and medium-sized firms, which often are seedbeds of new ideas and forceful action. So far, statements of intention have been followed by few really effective measures and the possibilities of an R&D policy for such firms have yet to be fully investigated.

R&D PERSONNEL COSTS

From 1979 a budget in the amount of DM300 million ($158 million) has been made available by the Federal Ministry of Economics through the Union of Industrial Research Associations (AIF) for subsidizing R&D personnel costs.

In 1978 improvements were made for small and medium-sized industries through the investment allowance (Art. 4 of the Law on Investment Allowances). They include:

- R&D investment allowance for the first DM1,500,000 ($263 million) spent on R&D was increased from 7.5 percent to 20 percent

- extension of promotion to cover buildings used for R&D to an extent between 1/3 and 2/3's

- provision for acquisition of intangible assets such as purchase of usufructuary rights and inventions under costs. This encourages the use of outside R&D results.

DIRECT VS INDIRECT SUPPORT

These measures have to some degree reduced the argument on direct versus indirect methods for support. The funds used for direct support have continuously risen since 1978 whereas the indirect methods sustained a setback in 1965. Depreciation allowances for R&D investment which were started in 1965 ended in 1974. It had been renewed until 1974 even though the original intention had been to abandon this tax privilege along with the introduction of the allowance for R&D investments in 1970. Since the rate of support for the investment allowance was simultaneously reduced from 10 percent to 7.5

percent and since, at the same time, R&D investments decreased because of market conditions, the total amount of allowance granted for R&D likewise showed a down-turn in 1975. The overall financial outlay, consequently, for these two indirect methods decreased from DM358 million ($188 million) to DM85 million ($45 million) within 12 months. It is necessary to point out, though, that the amounts attributable to special depreciations only represent deferred tax payments and not a final absolvement of the corresponding tax. Accordingly, the ratio between indirect and direct methods of R&D support changed from 1 to 3.6 in 1974 to about 1 to 20 in 1975. Since 1975, the business associations have called for a return to the previous, higher ratio.

In 1978 and 1979 the ratio of indirect to direct support was increased and is thought to be about 1 to 3. This change was due to three factors: (1) the increase of the R&D investment allowances as provided for under Article 4 of the Law on Investment Allowances and Article 19 of the Berlin Promotion Law (1978), (2) the rise in subsidies for cooperative research (from DM 51 million ($27 million) in 1977 to DM67 million ($35 million) in 1978), and (3) the introduction of staff cost subsidies in 1979. The expenditure and tax revenue shortfalls attributable to indirect R&D support is expected to be at least DM750 million ($395 million) in 1979.

Between the direct and indirect methods, there is a group of overlapping measures. These are referred to as "indirect specific" or "indirect selective" measures. They include governmental risk-sharing in the German Venture Financing Society, the promotion of external contract research, investment allowances for energy conserving investments, and special depreciation of goods needed in environmental protection.

Small and medium-sized business support requires, according to the report, especially designed techniques and considerations. The priorities identified are:

- intensified direct (project-related) support with a view to application and advancement of technological innovation

- use of indirect support to encourage applications-oriented R&D

- intensified cooperation with external research institutions to improve technology transfer

- improved information concerning technology developments and market changes by extended information and advisory services

- facilitation of allocation of funds for introduction of new products and processes to the market.

Table III outlines the instruments.

RESEARCH AID FOR SMALL BUSINESS

Experience has shown that it is not economical for many small businesses to increase their research capabilities. Consequently increased cooperation with external research institutions is desired. The 25 institutes of the Fraunhofer Society for the Promotion of Applied Research (FhG) provide both industry and government-owned agencies with R&D capacity. R&D contracts with small and medium-sized industries can be supported from 40 to 60 percent of the contract value with funds from the Federal Ministry of Research and Technology. Also R&D contracts awarded to third parties have been supported since 1978 with a subsidy of 30 percent of the contract value up to a maximum of DM120,000 ($63,000). This program is carried out through the Union of Industrial Research Associations (AIF) with funds provided by the Federal Ministry for Research and Technology.

The Federal Ministry for Research and Technology promotes technology-related advisory services, under pilot projects with various Länder groups of the Board for Rationalization of the German Economy (RKW) and several chambers of industry and commerce, with professional associations, with the technology mediating agency in Berlin, and with IG Metall (Metal Workers' Trade Union).

ADVISORY SERVICE

A new advisory service has been established in Berlin. It is called the Association of German Engineers (VDI) and offers advice on applications of microelectronics and "physical" technologies.

VENTURE FINANCING

To help small and medium-sized businesses to introduce new products and processes to the market, the German Venture Financing Society (WFG) has raised its capital stock to DM30 million ($16 million). Over a startup period of 15 years the FRG has agreed to cover the WFG losses by repayable loans. By the end of 1978 WFG had 20 undertakings, 7 of which were new company starts. Early in 1979 the FRG started a special equity capital aid program.

ADMINISTRATIVE IMPROVEMENTS

The administration by the FRG of these programs for R&D in small and medium-sized businesses has been criticized and attempts to improve the administration are under way. Outside experts are now reviewing procedures and results will be incorporated as appropriate. The main criticisms have been:

- Application requirements are too extensive.

- Examination of applications takes too much time.

- Project promotion
  - Direct promotion of R&D projects within the scope of technological promotion priorities
  - Initial innovations program
  - Technical development in Berlin
- Indirect promotion of R&D
  - 40 or 25 p.c. subsidy for expenditure on R&D personnel via AIF
  - Promotion of R&D investments by means of tax incentives
- Investment & innovation aids for foundation & expansion of enterprises
  - German Venture Financing Society (WFG)
  - Aid program on capital from own sources for business promotion
  - Long-term loans involving reduced interest rates (ERP programs)
  - Promotion for introducing energy-conserving technologies and products to the market
- Contract research
  - 30 p.c. subsidy towards the cost of external contract research via AIF
  - Fraunhofer Society (FhG)
- Cooperative industrial research
  - Union of Industrial Research Associations (AIF)
- Technology transfer
  - I&D specialized information systems
  - Patents/exploitation of R&D results (Patents Dept. of German Research, ARPAT)
  - Information transfer from national research centers, universities and federal research institutes
  - Technology and information guidance
  - Fairs and exhibitions
  - Standardization/public procurement

TABLE III

- Too much scientific depth is required of projects whereas their innovative significance for the company is understated.

INTERNATIONAL COOPERATION

The basis of international R&D cooperation is through the exchange of scientists and information occasioned by conferences, visits and joint projects. In the FRG there are scientific organizations promoting joint projects—Alexander V. Humboldt Foundation, German Research Society, German Academic Exchange Service, to name a few. The report recognizes three trends in international R&D cooperation:

(1) Increase in international cooperation is needed to achieve goals. Examples are:

- FRG/France cooperation on advanced nuclear reactors
- Joint European Torus
- CERN
- EEC commission and focus on energy, raw materials, agriculture, food, environment, medicine, urban planning.

(2) FRG intensifying its cooperation with countries exporting raw materials and oil:

- cooperation with the PRC on research on coal, oil, steel and non-ferrous metals
- cooperation with Australia for testing coal liquefaction plant
- cooperation with Venezuela on tar sands oil recovery.

(3) FRG opening new paths for scientific and technological cooperation with developing countries.

INTERNATIONAL INFLUENCES

POLAR EXPLORATION

International developments could influence the R&D policy of the FRG. The United Nations Conference on Maritime Law is expected to influence exploitation of the sea and the seabed. The FRG acceptance of the Antarctic Treaty in 1979 will influence a German polar exploration institute, to erect a stationary research facility in the Antarctic, and to build a polar research and supply ship. The adoption of the "International Nuclear Fuel Cycle Evaluation Program" (INFCE) in 1977 is expected to influence German nuclear R&D.

The report also includes some OECD figures for R&D expenditures of some leading industrial nations. See Table IV.

TABLE IV

R&D Expenditure [1)] and its Share in the Gross Domestic Product (GDP) of Selected Countries, 1969 to 1975

Country	National Currency	1969		1971		1973		1975	
		*	GDP share	*	GDP share	*	GDP share	*	GDP share
Federal Republic of Germany	DM	10,400	2.0	15,600	2.1	18,200	2.0	21,800	2.1
France	FF	13,900	1.9	16,300	1.9	19,400	1.9	25,700	1.8
Great Britain	£	1,000	2.3	1,000	2.3	1,300	2.1	2,100	2.1
Italy	Lira	433,900	0.8	572,000	0.9	713,900	0.9	1,080,900	0.9
Japan	Yen	933,200	1.5	1,345,900	1.6	1,980,900	1.9	2,621,900	1.7
USA	US $	26,600	2.8	26,700	2.6	30,400	2.4	34,600	2.3
Canada	Can $	1,000	1.1	1,200	1.2	1,300	1.1	1,700	1.0

1) OECD classification (excluding the humanities and social sciences)

* R&D expenditure in million national currency

Source: OECD

Epilogue

Since the publication of "Bundesbericht Forschung VI" the Minister for Science and Technology (BMFT), Dr. Volker Hauff, has been replaced by Dr. Andreas von Bülow. This is the first ministerial appointment for Dr. von Bülow who since 1976 has been the Undersecretary of State for Defense. *Nature* (*Nature*, Vol. 288, No. 5788, P. 206, 20 Nov 1980) reports that Dr. von Bülow has not yet had time to form his policies for the BMFT but is expected to lean more to the right than Hauff who had been trying to use the ministry as an instrument of economic policy. Hauff, according to *Nature*, was becoming impatient with the research community, especially the big science institutions like the Karlsruhe nuclear research center and others grouped into a powerful lobby called the Arbeitgemeinschaft der Grossforschungs-einsichtungen (AGF). The ministry controls a budget around DM6 billion ($3 billion) representing the bulk of federal support for R&D in Germany. The BMFT along with the Länder governments supports the institutes of the AGF, the Max-Planck Gessellschaft, the Deutsche Forschungsgemeinschaft (which funds university research projects), the Fraunhofer Gesellschaft, and other research supporting bodies.

APPENDIX I

The Deutsche Forschungsgemeinschaft (DFG) (the German Research Society) can trace its roots back to 1920 in the Totgemeinschaft der Deutschen Wissenschaft (Emergency Association of German Science) which was set up to correct the poor condition of German science after WWI. The DFG is an autonomous, self-governing organization serving all branches of science. Funds for the DFG are received from the federal and state (Länder) governments, from industry, and from private donations. Other institutions also receive funds from the same sources, but the DFG is by far the largest and most important. The function of the DFG is to finance research projects, to further cooperation among researchers, and to support the training of young scientists. Insofar as the US has a counterpart, it would be the NSF.

The DFG channels money mainly through the Normalverfahren (Normal procedure grants) and the Schwerpunktverfahren (Priority procedure grants). Individual scientists can apply for support. The applications are examined by assessors who are elected every four years. The Hauptausschus (main committee) decides on the proposals taking into account the assessors' evaluation. Proposals may be too small for DFG consideration, and those proposals could be sent to other foundations for support by the proposers. The Priority procedure grants relate to research projects deemed by the Senate of the DFG as being in fields which need particular emphasis.

Since about 1970 Special Areas of Research (Sonderforschungsbereiche [SFB]) have been established at universities. SFBs are for long-term but non-permanent research programs most frequently of an interdisciplinary nature, and both universities and non-university research establishments can jointly carry out an SFB grant. The DFG is responsible for evaluation of these programs, and the Science Council makes the final decisions.

The DFG does not have its own research centers. Rather it supports existing institutes and has supported their expansion and has sponsored the founding of new institutes. It also administers the Heisenberg Program. The DFG established the Ausschus für angewandte (Committee for Applied Research) to promote cooperation among industry, administration, and science.

To give some idea of the funds handled by the DFG, 1977 figures showed by source:

	DM in Millions	($ in Millions)
Federal Government	382.2	(201)
Länder	282.3	(149)
Donors Assoc. & others	3.6	(1.9)
	DM768.1	

Grants made by DFG in 1977

	DM in Millions	($ in Millions)
Normal Procedure Grants	368.2	(194)
Priority " "	125.6	(66)

Special Areas of Research	220.1	(116)
Auxiliary Research Institutes	12.3	(6.4)
Special Units	17.4	(9.2)
Computers & Equipment	23.9	(12.6)
Libraries (Scientific)	13.1	(6.9)
Foreign Scientific Relations	12.9	(6.8)
	DM793.5	

APPENDIX II

The Grossforschungseinrichtungen (Big Science Establishments) were established either jointly or separately by the Federal and Länder governments. They are publicly financed (90% Bund and 10% Land in which located) but are legally independent, not state institutions. They perform mainly state-subsidized programs in nuclear research, aeronautics and space research, data processing, environmental protection, exploitation of the sea and coastal areas, biology, and medicine. They frequently participate in international programs established by the government. The 1978 budget for all the establishments was DM1,350 million ($711 million). A list of the establishments follows:

German Electron Synchrotron	Deutsches Elektron-Synchrotron (DESY)
German Aerospace Research Center	Deutsches Forschungs- und Versuchsanstalt für Luft- und Raumfahrte V. (DFVLR)
German Cancer Research Center	Deutsches Krebsforschungs-zentrum (DKFZ)
Institute for Biotechnological Research	Gesellschaft für Biotechno-logische (GBF)
Marine Nuclear Propulsion Corporation	Gesellschaft für Kernenergie-verwertung in Schiffbau und Schiffahrt mbH (GKSS)
Mathematics & Data Processing Research	Gesellschaft für Mathematik und Datenverarbeitung mbH (GMD)
Radiation & Environmental Research Corporation	Gesellschaft für Strahlen- und Umveltforschung mbH München (GSF)
Heavy Ion Research Corporation	Gesellschaft für Schwerionen-forschung mbH (GSI)
Hahn Meitner Institute of Nuclear Research	Hahn-Meitner Institut für Kern-forschung Berlin GmbH (HMI)
Max Planck Institute for Plasma Physics	Max-Planck-Institut für Plasmaphysik (IPP)
Jülich Nuclear Research Establishment	Kernforschungsanlage Jülich GmbH (KFA)
Karlsruhe Nuclear Research Center	Kernforschungszentrum Karlsruhe GmbH (KfK)

APPENDIX III

The Max-Planck-Gesellschaft zur Föderung der Wissenschaften e.V. (MPG) (Max Planck Society for the Advancement of Science) is the largest research organization in the FRG. Its function is to carry out research in fields the universities cannot easily undertake, such as fields of interdisciplinary research or ones requiring specialized employment or resources. The MPG runs 49 research institutes, 38 of which carry out research in the natural sciences. The natural sciences emphasized are biochemistry, biology, plasma physics, nuclear physics, space research, astronomy, radioastronomy, solid state physics, meteorology, and social and educational sciences. Most of the institutes have scientific advisory councils. For research having a political orientation research planning is done by a special MPG Senate Committee, and the Chairman of the British Science Research Council (SRC) and the Director General of the French Centre National de la Recherche Scientifique (CNRS) are represented on this committee.

Recently research into new fields has been initiated in Projektgruppen (units). These units could develop into new Max Planck Institutes, into DFG Sonderforschungs-bereiche (Special Areas of Research, see Appendix I) or into other institutes. This approach has been taken to avoid some of the risk that would be involved in setting up a new institute immediately; a new institute requires a commitment of between DM3 and 5 million per year for an average period of twenty years.

The MPG is interested in exploiting research results especially from its own institutes. In 1970 it established, as an example, Garching Instrumente GmbH which operates mainly from the sale of licenses derived from the research.

Funding for MPG comes 90% from the Federal and State governments and about 10% from donations, membership fees, inheritances, and patents.

Max Planck Institutes and Units:

Biological-Medical Section

Max-Planck-Institut für Biochemie (biochemistry)
Max-Planck-Institut für Biologie (biology)
Max-Planck-Institut für Biophysik (biophysics)
Max-Planck-Institut für Ernährungsphysiologie (nutrition physiology)
Max-Planck-Institut für molekulare Genetik (molecular genetics)
Max-Planck-Institut für Hirnforschung (brain research)
Max-Planck-Institut für Immunbiologie (immunology)
Max-Planck-Institut für physiologische und klinische Forschung (William G. Kerckhoff-Institut) (physiological and clinical research)
Max-Planck-Institut für biologische Kybernetik (biological cybernetics)
Max-Planck-Institut für Limnologie (limnology)
Max-Planck-Institut für experimentelle Medizin (experimental medicine)
Max-Planck-Institut für medizinische Forschung (medical research)
Friedrich-Miescher-Laboratorium für biologische Arbeitsgruppen in der Max-Planck-Gesellschaft (biological working groups)

Max-Planck-Institut für Psychiatrie (Deutsche Forschungsanstalt für Psychiatrie) (psychiatry)
Forschungsstelle für Psychopathologie und Psychotherapie in der Max-Planck-Gesellschaft (psychopathology and psychotherapy)
Max-Planck-Institut für Systemphysiologie (systems physiology)
Forschungsstelle Vennesland (relationship between nitrate utilization and photosynthesis)
Max-Planck-Institut für Verhaltensphysiologie (behavioral physiology)
Max-Planck-Institut für Virusforschung (virology)
Max-Planck-Institut für Zellbiologie (cell biology)
Max-Planck-Institut für Züchtungsforschung (Erwin-Baur-Institut) (animal breeding)

Chemical-Physical-Technical Section

Max-Planck-Institut für Aeronomie (aeronomy)
Max-Planck-Institut für Astronomie (astronomy)
Max-Planck-Institut für Chemie (Otto-Hahn-Institut) (chemistry)
Max-Planck-Institut für biophysikalsche Chemie (Karl-Friedrich-Bonhoeffer-Institut) (biophysical chemistry)
Max-Planck-Institut für Eisenforschung GmbH (iron metallurgy)
Max-Planck-Institut für Festkörperforschung (solid state physics)
Gmelin-Institut für anorganische Chemie und Grenzgebiete in der Max-Planck-Gesellschaft (inorganic chemistry and related fields)
Fritz-Haber-Institut der Max-Planck-Gesellschaft (physical chemistry and electro-chemistry, solid state physics, and electron microscopy)
Max-Planck-Institut für Kernphysik (nuclear physics)
Max-Planck-Institut für Kohlenforschung (coal research)
Projektgruppe für Laserforschung (laser research)
Max-Planck-Institut für Metallforschung (metals research)
Max-Planck-Institut für Meteorologie (meteorology)
Max-Planck-Institut für Physik und Astrophysik (physics and astrophysics)
Max-Planck-Institut für Plasmaphysik (plasmaphysics)
Max-Planck-Institut für Radioastronomie (radioastronomy)
Max-Planck-Institut für Strömungsforschung (fluid dynamics)

Humanities Section

Bibliotheca Hertziana (Max-Planck-Institut) (history of Roman art)
Max-Planck-Institut für Bildungsforschung (educational research)
Max-Planck-Institut für Geschichte (history)
Max-Planck-Institut zur Erforschung der Lebensbedingungen der wissenschaftlich-technischen Welt (research on living conditions of the scientific-technical world)
Max-Planck-Institut für ausländisches und internationales Patent-, Urheber- und Wettbewerbsrecht (foreign and international patent, copyright, and competition law)
Max-Planck-Institut für ausländisches und internationales Privatrecht (foreign and international private law)
Projektgruppe für Psycholinguistik (psycholinguistics)
Max-Planck-Institut für ausländisches öffentliches Recht und Völkerrecht (foreign public law and international law)

Max-Planck-Institut für europäische Rechtsgeschichte (history of European law)
Projektgruppe für internationales und vergleichendes Sozialrecht (international and comparative social law)
Max-Planck-Institut für ausländisches und internationales Strafrecht (foreign and international criminal law)

APPENDIX IV

The Fraunhofer-Gesellschaft zur Föderung der angewandten Forschung e.V. (FhG) (Fraunhofer Society for the Advancement of Applied Research) was founded in 1949 by representatives of industry, science, and the state as a nonprofit organization. It carries out applied research in the natural sciences and engineering. Its research work is carried out in its institutes which can be divided up in two ways: either into three divisions (contract research, defense research, and services) or into six sections (solid state electronics and information processing, systems engineering and technology transfer, materials in construction and installations, building and construction (timber technology), production technology and automation, and environmental research and technology.

The contract research division has sixteen institutes and is financed mainly by contracts undertaken for companies and business associations and for the state. Basic financial support is provided by the federal and state governments in amounts dependent on contract funding.

The defense research division is supported exclusively by project and sustaining funds from the Bundesministerium der Verteidigung (BMVg) (Federal Ministry of Defense). It has six institutes and emphasizes research in solid state, materials, propellants and explosives, ballistics, hydroacoustics, and military engineering trend analysis.

The services division receives sustaining and project funds from the federal and state governments. It includes the IRB (Information on regional planning and construction), the DZW (documentation on water), and the PSt (Patent Office for German research).

The ISI (Institute for systems engineering and innovation research) which comes under the Systems Engineering and Technology Transfer section was set up in 1972 to extend the FhG's interests by work in the interface areas of technology, industry, and society. The ISI principally covers technological and research planning, systems engineering, innovation research, and technology transfer.

The 1977 budget for the FhG was just over DM150 million ($79 million).

Institutes of the Fraunhofer Society are as follows:

Solid State Electronics and Information Processing

Institut für angewandte Festkörperphysik (IAF) (applied solid state physics)
Institut für Festkörpertechnologie (IFT) (solid state technology)
Institut für Informationsverarbeitung in Technik und Biologie (IITB) (information processing in technology and biology)
Institut für Physikalische Weltraumforschung (IPW) (physical space research)

Systems Engineering and Technology Transfer

Institut für Systemtechnik und Innovationsforschung (ISI) (systems engineering and innovation research)
Institut für Naturwissenschaftlich-Technische Trendanalysen (INT) (systems engineering of weapons and concepts of defense)
Patentstelle für die deutsche Forschung (PSt) (Patent Office for German Research)

Materials in Constructions and Installations

Institut für angewandte Materialforschung (IfaM) (applied materials research)
Institut für Festkörpermechanik (IFKM) (solid state mechanics)
Laboratorium für Betriebsfestigkeit (LBF) (structural fatigue)
Ernst-Mach-Institut (EMI) (shockwave research and ballistics)
Institut für Silicatforschung (ISC) (silicate research)
Institut für zerstörungsfreie Prüfverfahren (IzfP) (non-destructive testing)

Building and Construction, Timber Technology

Institut für Bauphysik (IBP) (construction engineering)
Wilhelm-Klauditz-Institut für Holzforschung (WKI) (wood research)
Informationsverbundzentrum Raum and Bau (IRB) (information on regional policy, town planning and construction)

Production Technology and Automation

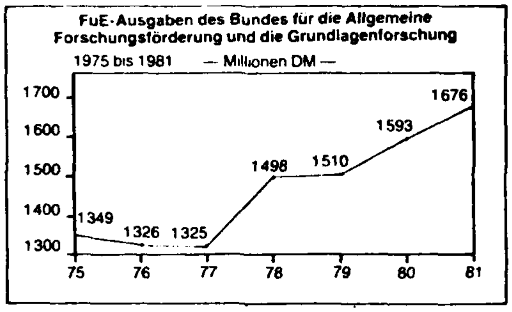
Institut für Produktionstechnik und Automatisierung (IPA) (production technology and automation)
Institut für Chemie der Treib- und Explosivstoffe (ICT) (chemistry of propellants and explosives)
Institut für Lebensmitteltechnologie und Verpackung (ILV) (food technology and packaging)
Institut für angewandte Mikroskopie, Photographie und Kinematographie (IMPK) (applied microscopy, photography and cinematography)
Institut für Grenzflächen- und Bioverfahrenstechnik (IGB) (interface technology and bio-processing technology)

Environmental Research and Technology

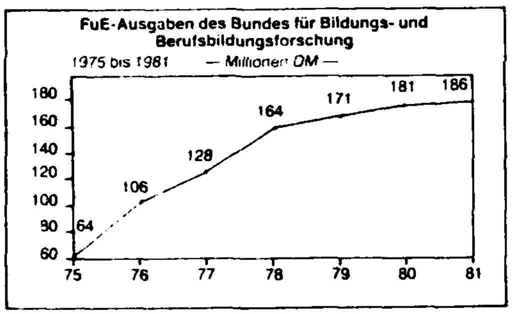
Institut für Aerobiologie (IAe) (aerobiology)
Institut für Atmosphärische Umweltforschung (IAU) (physical and bioclimatic research)
Institut für Hydroakustik (IHAK) (hydro-acoustics)
Dokumentationzentrale Wasser (DZW) (documentation on water)

APPENDIX V

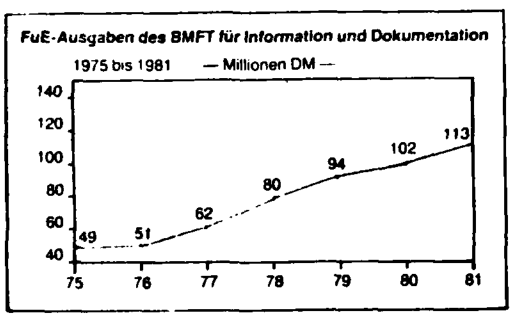
Funding profiles 1975 through 1981 for various sectors of German research and development are given herein. They are taken from Bundesbericht Forschung VI.



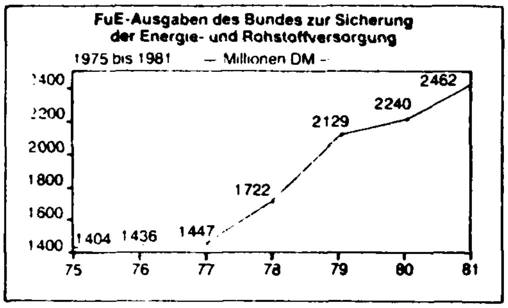
R&D Federal Expenditures for Basic Research and Research Support



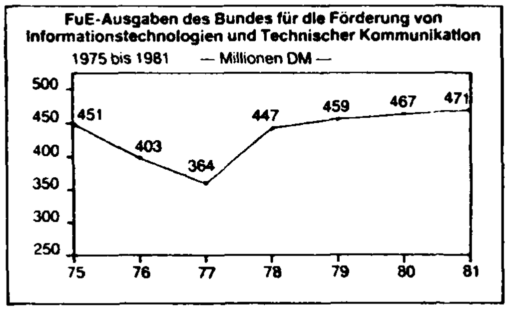
R&D Expenditures for Education and Vocational Research



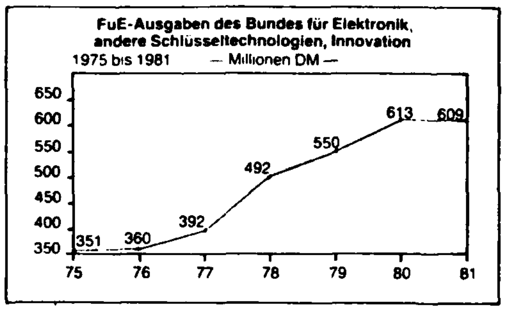
R&D Expenditures of BMFT for Information and Documentation



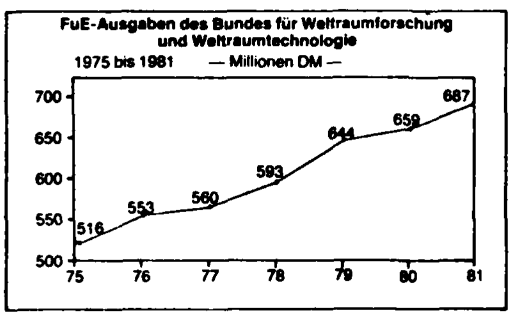
R&D Federal Expenditure to Insure Energy and Raw Material Supply



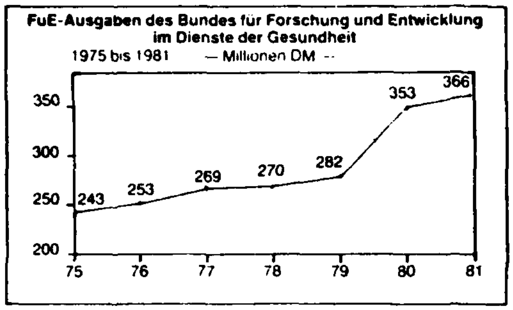
R&D Federal Expenditure for Support of Information Technology and Technical Communication



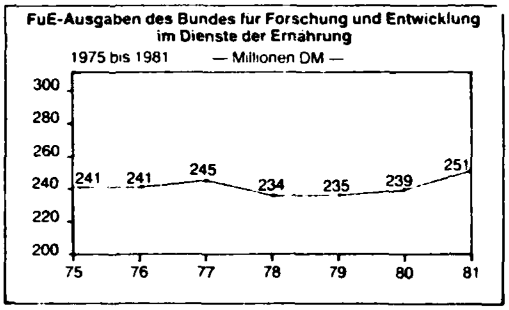
R&D Federal Expenditure for Electronics and Other Key Technology Innovation



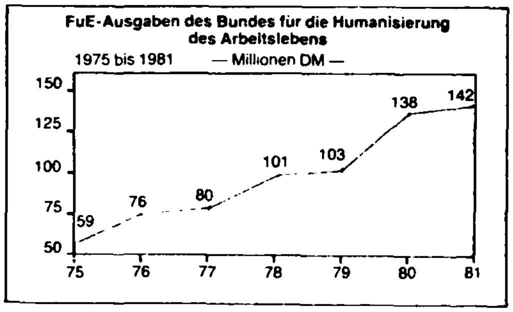
R&D Federal Expenditure for Space Research and Space Technology



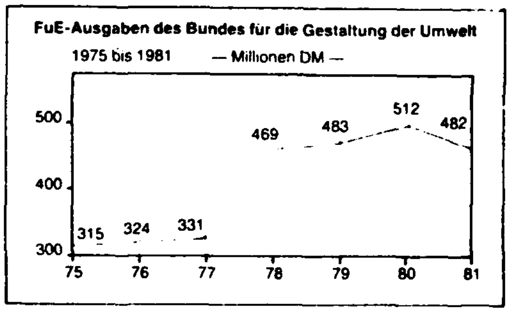
R&D Federal Expenditure for Research and Development in Health Services



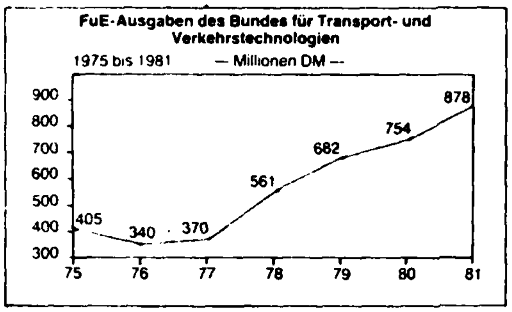
R&D Federal Expenditures for Research and Development in Nutrition



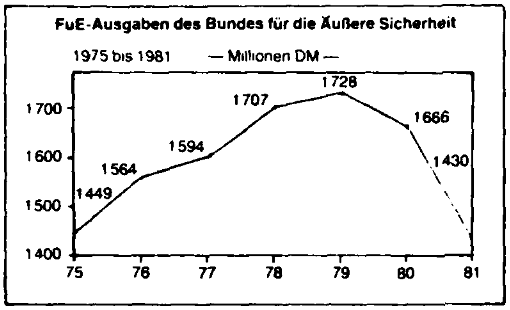
R&D Federal Expenditure for Working and Living Conditions



R&D Federal Expenditure for the Environment



R&D Federal Expenditure for Transport and Highway Technologies



R&D Federal Expenditures for Defense

LMED

8