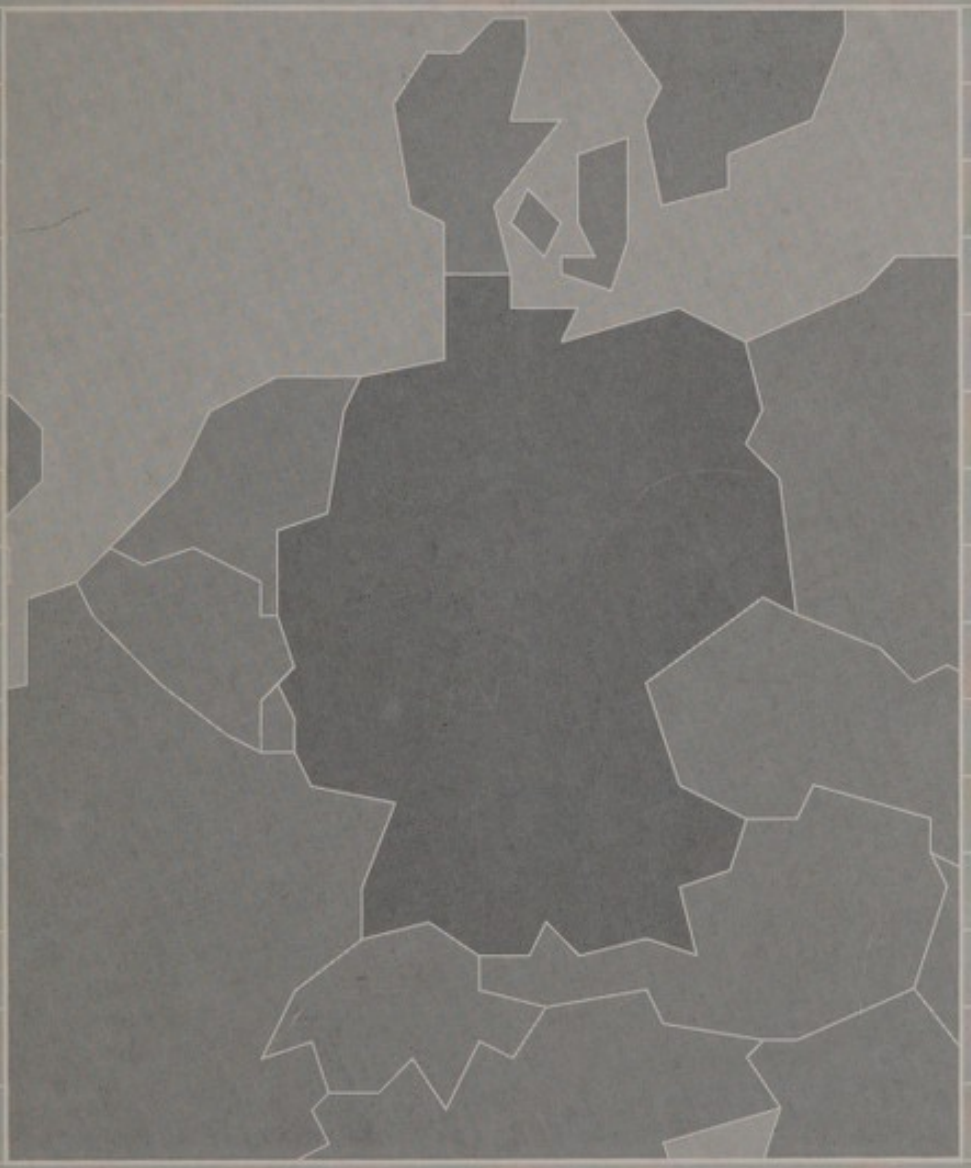
Report of the Federal Government on research 1993 : abridged version / Federal Ministry for Research and Technology.

Report of the Federal Government on Research 1993

Abridged Version



Federal Ministry for Research and Technology

REPORT OF THE FEDERAL GOVERNMENT ON RESEARCH 1993

Abridged Version

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Introduction

With the Report of the Federal Government on Research, the Federal Government informs the German Bundestag about the objectives and priorities of its research and technology policy at the national and international levels. The report also provides comprehensive information on the resources for science, research and development as well as for the major research organisations.

The Ninth Report on Research since the beginning of reporting on research in 1965 succeeds the Report of the Federal Government on Research 1988 and the Facts and Figures Update 1990. It comprises the following parts:

- Part I: Perspectives of the Federal Government's research and technology policy
- Part II: The resources for science, research and development in the Federal Republic of Germany and in international comparison
- Part III: Priorities in the Federal Government's promotion of research and development
- Part IV: Research and technology policy in the Länder – Presentations by the Länder
- Part V: European and international research and technology policy – International organisations and research institutions with German participation
- Part VI: Promotion organisations and research institutions in the Federal Republic of Germany
- Part VII: Statistics

This abridged version comprises the Foreword, Parts I and II, extracts from Part V as well as lists of addresses of research institutions and promotion organisations described in Part VI.

Foreword

With its Report on Research the Federal Government provides a comprehensive survey of research in Germany. This report documents the intention of the Federal Government to give high priority to the promotion of research and technological development as a long-term investment in Germany's future.

The Report of the Federal Government on Research emphasises the importance of research and technology for Germany's future: In the 1980s research- and technology-intensive areas had the highest growth rates in industry. Being a high-labour-cost country, Germany depends on obtaining above-average prices in the world markets for its exports of top-quality products. New innovative leaps are needed to maintain Germany's competitiveness vis-à-vis growing competition from low-labour-cost countries as well as products of increasing quality from South-East Asia. One must not lose sight of the vision of "growth from intelligence". In the current phase of structural change in industry, enhanced environmental protection requires the increasing implementation and enforcement of new environmentally compatible technologies. Even in times of tight budgets the results of basic research have to be acknowledged as cultural assets. Scientific continuity must be ensured.

Research has to cope with extensive tasks at a time when public research budgets have to contribute to consolidating public finances and corporate R&D budgets are coming increasingly under cost pressure. The lack of dynamism in industrial R&D expenditure is alarming. The current structural change in industry calls for great anticyclical commitment to research and development to maintain the high level of innovative dynamism of German industry.

The dominating feature of structural change in German research in the period reviewed by the Federal Government's Report on Research is the reorganisation of research in the new Länder. Developing efficient public and private research capacities is a prerequisite for mastering the economic and social change in the new Länder and hence for completing German unity. The R&D capacities in the new Länder enable research in the whole of Germany to upgrade its quality and establish a broader basis.

Within its own jurisdiction, the Federal Government has been greatly committed to restructuring non-university research. In spite of all transitional difficulties and persistent shortcomings, the development of non-university research in the new Länder has become a success story of research policy. Implementing the recommendations of the Science Council, the Federal Government and the new Länder had set up more than 100 new research institutions by January 1, 1992, thus securing about 12,500 jobs in research. The situation of research in industry in the new Länder, however, is still worrying. The labour force of about 86,000 persons in industrial research in the former GDR in late 1989 was reduced to about 24,000 persons in 1992. So far, it has not been possible to create an adequate basis for the production of independent innovative products by the companies in the new Länder. In 1992, the Federal Ministries for Research and Technology as well as of Economics allocated DM 600 million to various programmes designed to support corporate research and development in the new Länder. The range of promotion instruments and schemes will be extended further.

A review of the results of research policy since 1982 shows that international recognition of German scientific achievements has increased. Scientific publications received more notice and the number of awards for German researchers has risen. In the field of technological development, Germany has traditionally had strong points in many advanced technologies. With this specialisation of its range of goods Germany achieved excellent foreign trade results in the 1980s. But at present, important markets such as mechanical and automotive engineering are increasingly coming under competitive pressure. There are signs indicating that innovative dynamism in Germany is altogether slackening.

In a number of high-tech areas outstanding scientific achievements could not successfully be translated into innovative, marketable products. An international comparison shows that the Federal Republic of Germany is underrepresented in those technological areas which have the highest rates of increase in patents and rely most heavily on scientific results.

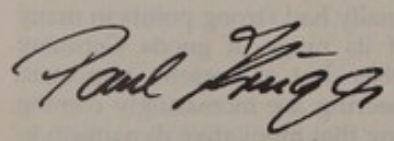
But in fact Germany is in a position to meet all the necessary requirements to make good for these deficits. It has a sophisticated and varied research system which, with its historically grown distribution of functions among the Federal and Länder governments and industry, has proved to be successful. In the years to come, the priority policy objective must be to take advantage of all possibilities to increase the efficiency of research in Germany. Leeway for shaping research has to be created by, among other things, clearly defining priorities and posteriorities in research. More than in the past, research promotion has to pursue the objective of applying and implementing research results as quickly as possible. Basic conditions for research and technology need to be improved especially with a view to reducing excessive regulation and raising the level of acceptance.

It is and will remain a priority function of research policy to identify young technology lines with a high technological and economic potential and translate them into products. There is no fail-safe method to achieve this. What is needed is an intensive dialogue between government and industry on strategies and priorities of private and public research at different technical levels, which can provide a basis for more efficient cooperation than in the past.

In 1992, with an R&D budget of DM 9.2 billion, the Federal Ministry for Research and Technology accounted for more than 50% of the Federal Government's R&D expenditure and for 11.5% of total spending on research and development in Germany. Most of these funds are earmarked for promoting medium- and long-term research projects. The Federal Ministry for Research and Technology uses its scope of action to improve the scientific and technical basis in research areas with a high technological and economic potential. Most of these research projects are likely to attract private-sector interest and commitment. Since corporate research funds are mostly spent on applied research and the development of products, it is obvious that the Federal Government's research and technology policy has a major impact on the priorities of medium- and long-term research in Germany. The challenge is now to do everything to live up to the ensuing responsibility in the years to come.

In our partner countries, the USA and Japan, research and technological competitiveness have a much higher ranking than in Germany. Since innovative dynamism plays a central role for the future of our country, we need more discussion and even controversy about the right methods to increase the efficiency of research.

The Report of the Federal Government on Research provides a detailed presentation of research in Germany. I hope that this comprehensive description of the priorities of research promotion may be useful in many ways.



Dr. Paul Krüger
Federal Minister for Research and Technology

REPORT OF THE FEDERAL GOVERNMENT ON RESEARCH 1993

Abridged Version

Structure[1)]

[1)] Each part is preceded by a detailed table of contents.

List of figures

Part I

Part II

Part I

Perspectives of the Federal Government's research and technology policy

Contents

1. *Outlines and current functions of research and technology policy*

1.1 Outlines

The Federal Republic of Germany has a broad-based and varied research sector. The level of research and technological efficiency constitutes an important basis for the industrial future of this country. It creates know-how and room for manoeuvre to safeguard and shape the environment in which we live. In addition, scientific results are important cultural achievements.

To guarantee and expand the development potential as well as the wealth and freedom of research is therefore a major objective of the Federal Government. The challenge of completing German unity, a dramatically changed international environment, safeguarding our natural resources and, not least, concern about Germany as a location for industry, increase the necessity of using the opportunities offered by research and technology.

Research and technology policy has to take into account the trends of scientific and technological change in the early 1990s:

It is obvious that as economic activities are becoming more and more global the research activities of the industrialised countries and some newly industrialised countries in South-East Asia continue to converge. The proportion of scientific publications published in international co-authorship has tripled over the past two decades. For Germany it amounts to almost 30 %. In the 1980s, private companies increased their worldwide direct investment considerably. Thus they have not only become actively involved in technology transfer, but they have also acquired foreign research potentials. Technological competition is becoming tougher as new states are joining this competition. New important markets emerged and continue to emerge in Japan, Korea, Taiwan, Indonesia and other dynamic industrialised countries in the Asian region. For Germany these countries are both strong competitors and important partners. They complement the increasing involvement of the Federal Republic of Germany within the European Community as well as the close and established cooperation with the USA. In view of the worldwide mobility of knowledge as well as the capital to be invested in research and development it is one of the central responsibilities of research and technology policy to maintain and increase the long-term attraction of Germany as a location for research and technology.

At the same time the importance of – often regional – research networks is growing: As a result of the increasing complexity of scientific and technological progress, the emergence of new, rapidly growing research areas at the fringes of traditional disciplines and corporate prioritiy activities, shorter innovation cycles and, in many areas, increasing costs of research and development, researchers depend more and more on the cooperation and the intensive exchange of knowledge with suitable partners in a flexible research environment. This is why established partnerships and the ability to develop new cooperative relations between the many different players in the research sector have to remain a primary advantage offered by this country to research and development.

One of the characteristics of technological development in the early 1990s is that most technological areas which have the highest patenting rates rely to an extraordinary extent on the most recent scientific results. Basic research which typically is a function of the state, and applied research and development which in a free market system have to be performed mainly by private-sector companies converge in these areas. For many high technologies, research stages do not follow one another from basic research in government research institutions to industrial application. As a technology matures the working steps rather overlap in many ways. Scientific results which today are developed in laboratories will tomorrow determine the success in new markets. Even at more advanced stages of technical development applied research falls back on results yielded by basic research. New technologies enable basic research to acquire more knowledge.

In view of these developments the search for varied and flexible forms of cooperation becomes a central task of public and private research management. Joint efforts by science, industry and government are required to speed up the translation of laboratory results into marketable products and processes, to acquire applicable know-how to safeguard the world in which we live, and to implement environmentally friendly production processes. This is why promoting the intensity of the dialogue between the partners from industry, science and society as well as furthering their willingness to engage in this dialogue are important elements of the Federal Government's research and technology policy.

Over the next few years at least, public budgets in the Federal Republic of Germany will have to operate under restrictive financial conditions. This is why government, industry, science and society have to arrive at the widest possible consensus in order to make use – on the basis of a division of labour – of opportunities to increase the efficiency of funds spent on research and development.

Basic conditions for research need to be improved further so that performance, creativity and scientific competition at the international level can be furthered. Regulating research is only justified in those cases where other societal goals are affected; such regulation must be limited to what is absolutely necessary. Research in humans must not exceed the limits set by ethics. The genetic heritage of the Earth has to be protected, creation to be cherished. In some areas, such as genetic engineering, practical experience gathered with

new legal regulations has identified considerable, partly unjustified obstacles to research which are now to be eliminated by swiftly amending the law. An important basic condition for research and development in Germany is their acceptance and appreciation by the general public. To this end an understandable description of the opportunities offered by research and new technologies is as necessary as the responsible handling of research results and technology as well as an unbiased, pragmatic dialogue.

Research, too, has to face up to the discussion about priorities and posteriorities. In the years to come instruments, mechanisms and priorities of research promotion will have to be developed in a dialogue between government, industry and science. In this process those research areas need to be strengthened which in the medium and long term can contribute to solving urgent problems concerning the future of this country. In the Federal Government's research promotion application-oriented basic research is gaining increasing importance. Priority has been given to the development of tools designed to accelerate the process of making the results of basic research into products and production processes for new markets. This implies that in the years to come it will no longer be possible to carry out every desirable programme or project in the area of purely knowledge-oriented basic research. Large-scale technology programmes such as space flight will be reduced to an adequate proportion of the total budget.

The complexity and pace of technological change call for a more intensive cooperation of public and private research in Germany. The dialogue on long-term technology trends and economic and technological potentials of technologies for the future is of great significance. This dialogue can increase the willingness of public and private research to develop long-term perspectives and embark jointly on long-term high-risk technology lines. The Federal Ministry for Research and Technology has started various initiatives in this area. It has initiated in-depth expert talks to reflect – at the beginning of the 21st century – the status of knowledge of technological and economic trends as well as new technologies important for the future of this country. In the years to come the Ministry will continue this dialogue at the expert level and draw conclusions regarding its promotional activities. This strategic dialogue between government, industry and science is complemented by analyses of technological change contributed by the government. One major element of this dialogue has to be the clear separation of the responsibilities of government and industry; the market and competition have to remain important driving forces of technical progress and structural change.

A review of research policy going back to 1982 shows that German research achievements have enjoyed growing international recognition. German scientific publications have received increasing international notice and the number of awards given to German researchers has risen. Germany has an excellent infrastructure, and its researchers have a high level of qualification and generally acknowledged capabilities. German unification will strengthen Germany in terms of research staff and their qualifications. The basis has become even wider now, thus improving the conditions for scientific diversity and quality. Institutes and working groups of the national research centres, the Fraunhofer Society, the Max Planck Society and the "Blue List" have started their work. The system of cooperative industrial research has been established in the new Länder (states), thus creating the basis for mastering the continual structural change in the Eastern part of the country.

In view of persistent extensive tasks, however, the slackening dynamism of public and private research expenditure in Germany in recent years is cause for concern. Although in terms of the share of GDP (gross domestic product) devoted to research and development efforts (1991: 2.7 %) Germany is still in the top group, it has fallen behind Japan (3 %) and the USA (2.8 %). Only a tidal change in the form of a stronger lasting commitment to investing in the future, making full use of the potential of increasing research efficiency, can secure Germany's position in the international environment.

1.2 Current functions

The Federal Government is focussing on the following elements of research and technology policy:

- Building up and expanding research in the new Länder
- maintaining the high level of basic research
- promoting strategic technologies at the precompetitive stage (especially information technology, biotechnology and materials research, transport and energy research)
- increasing the innovative strength of small and medium-sized enterprises
- further development of preventive research (especially ecology, health, climate and polar research)
- further development of research receiving basic funding
- intensifying international cooperation in R&D
- maintaining the technological basis for preventive security policy measures
- continuing long-term government programmes (fusion research, space research).

Building up and expanding research in the new Länder

In the new Länder the Federal and Länder governments and the science organisations have developed structures according to the established model of non-university research which is based on the freedom of science, extensive self-government of scientific institutions and competition as an incentive. Efficient potentials had to be maintained and reorganised appropriately. After the Treaty on German Unity had entered into force, one year of transition ending on December 31, 1991 was available for the basic restructuring process. Technical and organisational reorientation were based on the recommendations of the Science Council.

In spite of unfavourable conditions in the centrally planned economy of the former GDR research in some areas was up to international standards. The new research institutions to be set up could build on this basis in terms of substance, methodology and staff.

At short notice the Federal Government provided the funds required to implement the recommendations of the Science Council. As a result of the scientific independence and authority of the Science Council the implementing decisions were accepted also in those cases where dramatic changes to previous structures were required. In cooperation with the Länder governments the Federal Government has vigorously worked towards making the new institutions operational by quickly developing the technical and organisational structures, implementing the Science Council's recommendations regarding human resources and equipment as well as preparing and performing staff recruitment. Under the East German research sector reconstruction scheme more than 100 research institutions had been set up by January 1, 1992. Financial conditions and technical programmes required for efficient research and scientific work could be created newly for a total of about 12,500 scientists.

In keeping with the structures in the old Länder national research centres, "Blue List" institutions, institutes of the Max Planck Society and the Fraunhofer Society as well as research institutions of Federal Government departments and the Länder were set up. They have clear and assured perspectives in terms of both financial resources and programme orientation.

The Federal Government has allocated substantial funds (DM 610 million alone in 1992) to maintain efficient industrial research and development capacities in the new Länder; this measure is designed to support – during a transitional period – the profound restructuring process which is characterised, among other things, by a considerable decline of research potentials. A detailed survey is provided in section 2.

Maintaining the high level of basic research

The high quality of basic research is one of Germany's assets in the research and technology sector. It is important that this outstanding quality of basic research is also promoted in the future. It is becoming increasingly obvious that application-oriented basic research is becoming more and more common, i.e. research areas where the application of results is highly likely are increasing in scope and significance, e.g. in the biosciences. There is also a clear trend towards an interdependence of science and technology which in turn determines the progress made in those areas.

The financial position of basic research in Germany is as strong as ever: With a share of about 20 % in the research and development expenditure of government and industry it has received more support in this country since the end of the 1980s than in other large industrialised countries (USA 12 %, Japan 13 %). In recent years application-oriented basic research in the areas of materials research, information technology, physical technologies, biosciences and environmental research, could boast high growth rates in the budget of the Federal Ministry for Research and Technology (BMFT).

Since 1982 a great number of large-scale basic research projects has been carried out, including the Continental Deep Drilling Programme (KTB), the high-energy accelerators HERA in Hamburg and LEP at CERN in Geneva, the SIS/ESR Heavy Ion Facility in Darmstadt, the modernisation of the BER II Research Reactor in Berlin, ESRF in Grenoble, and the Very Large Telescope (VLT) of ESO. It has been decided to set up the BESSY II Synchrotron Radiation Source. In the future greater importance will be attached by an even more intensive utilisation of existing large-scale equipment. In the next few years the BMFT will not be able to finance any new large-scale equipment for knowledge-oriented basic research.

Science has to be organised in such a way that its constituent parts interact fruitfully, thus producing synergy effects and avoiding mutual separation tendencies. To this end more concepts for promoting interdisciplinary cooperation, e.g. in the form of innovation symposia, are being developed. A favourable climate for the development of science and for the promotion of young scientists is of paramount importance. But in view of scarce budget funds science and politics will have to endeavour more than ever before to give the general public an even clearer explanation than in the past of the purpose, benefits and importance of basic research by citing specific basic research projects.

Promoting strategic technologies

In the Federal Government's view strategic technologies, e.g. information technology, biotechnology, materials sciences, as well as systems technologies such as production and environmental engineering and transport and energy technologies are of special significance, because they are applied across all branches of industry and have a major impact on the competitiveness of German industry. Furthermore, they can contribute to the development of technologies which help save energy and natural resources in the production process, thus promoting a new quality of "growth from intelligence". This is why the Federal Government gives priority promotion to technology development in these areas. Outstanding examples of completely new research areas are the technology of new functional materials, nanotechnology to produce very small structures or bio-informatics. These new areas of knowledge can only be opened up in close cooperation between publicly funded research institutions and industry. This is why collaborative projects of science and industry are of particular importance. In addition, some areas require broader cooperation at the European level which, in information technology, is made possible by a EUREKA initiative, the JESSI project.

The promotion of strategic technologies goes hand in hand with numerous early technology identification schemes comprising studies of various disciplines such as production engineering, cross-disciplinary studies of strategic technologies at the beginning of the 21st century with a forecasting horizon of ten years, as well as Delphi surveys with a forecasting horizon of 30 years. All these studies aim to identify potential development lines in the research and innovation process and indicate priority tasks of technology policy for the benefit of all those concerned.

The transport of passengers and goods holds a key position in industry and society. It is important that in the years to come existing traffic routes are used in the most progressive way possible by means of new technologies, that private and public transport are better linked and scenarios for the future traffic situation in conurbations are developed. The leading objectives of transport research and technology are optimizing transport chains and safeguarding an environmentally friendly mobility.

Energy research focusses on the development of improved energy supply perspectives through higher safety of the use of nuclear energy, further development of renewable energies and an effective strategy to reduce CO_2 emissions.

Since from the technical point of view nuclear technology – with the exception of reactor safety and nuclear waste management research – is considered an established technology, the financial commitment of research and technology policy is declining strongly in this area. In the next few years, however, increasing sums will be dedicated to decommissioning nuclear facilities (cleaning up contaminated sites).

Increasing the innovative strength of small and medium-sized enterprises (SMEs)

The specific strong points of SMEs are in the area of application-oriented research and development; SMEs also play a central role in the dissemination of new key technologies. The Federal Government takes into account the specific circumstances of SMEs in the R&D area by providing special promotion conditions, thus enabling SMEs to keep abreast of the innovation process. The funds allocated by the BMFT to promoting research and development in these enterprises rose from DM 340 million in 1982 to about DM 580 million in 1992, although over the same period total resources for the promotion of research and development in trade and industry dropped from DM 3.2 billion to DM 1.6 billion. Consequently, small and medium-sized enterprises today receive more than 30 % of the total BMFT funds devoted to research and development promotion in trade and industry, compared with 10 % in 1982. In 1992 the Federal Ministry of Economics supported the research and development activities of SMEs with about DM 219 million.

The Federal Government has allocated substantial funds to promoting the development of innovative and competitive small and medium-sized enterprises in the new Länder through a number of specific schemes (cf. Part II, section 9).

In the 1990s the promotion of SMEs will be developed further. In future it will rely in particular on the following measures: Promotion under specialised programmes, research and development loans for innovative leaps, cooperative industrial research, new schemes to support cooperative research projects and improvement of technology transfer. In the medium term, R&D promotion in the new Länder has to be integrated into a pan-German R&D concept.

Further development of preventive research

The Federal Government is attaching increasing importance to preventive research (ecological research, research into global climate and environmental changes, environmental technology, health research, humanities and social sciences). By rising from 9.2 % in 1982 to 18.1 % in 1993 the share of funds allocated to preventive research in the BMFT budget has almost doubled (for an international comparison of government expenditure on environmental research see Figure I/1). Also in this area the policy applies that it has to be possible for scientific results and new technologies to be put into practice.

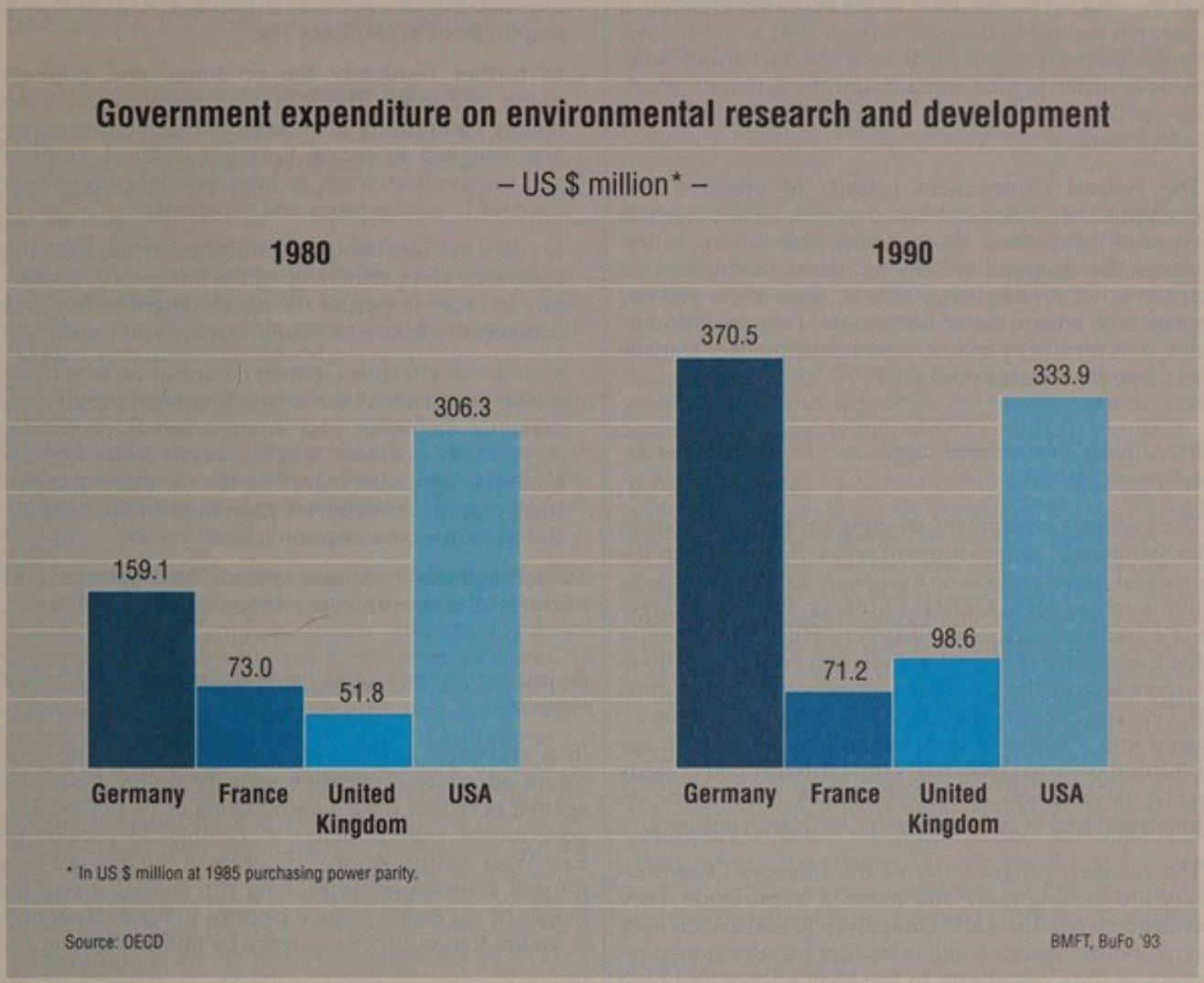
First and foremost, there is the analysis of the causes of environmental pollution and damage levels. This requires in-depth knowledge of stability conditions and pollution limits, especially with regard to natural ecosystems used by man such as forests, farmland and water bodies, as well as assessing the risks of relevant pollution and damage levels. Significant success could be achieved in some areas in the past. For example, research into forest damage has been able to identify fundamental mechanisms of action as well as causes of forest damage.

In addition to developing waste management technologies and advanced measuring and analytical methods, the promotion of environmental technology aims to contribute to closing the still large number of open material cycles in production. Research promotion here focusses on technical progress which by generating integrated solutions prevents the production of polluting residual or waste substances in the first place. SMEs in particular have the opportunity to participate in the future growth of this sector of economic activity by intelligently linking technical concepts and their industrial realisation. Of special importance is the development of environmental management concepts which guarantee the long-term utilisation of ecological systems while at the same time preserving them. In environmental technology, government research commitment is called for especially in those cases where the market does not independently generate technologies to implement advanced norms and standards.

In the area of health research, the Federal Government decided in April 1993 to continue and update its "Health Research 2000" programme. This programme zeroes in on elements designed to improve the structure of the health system, such as interdisciplinary centres for clinical research. One of its goals is to establish closer links between clinical research and medical practice. Specific research priorities of the programme include disorders of the immune system including AIDS as well as diseases of the nervous system and psychological disorders, especially drug and other addictions.

In spite of recent advances in understanding, the need for preventive research is as great as ever. Due to its original responsibilities, government has the special obligation to enable research to yield the results necessary for preserving a healthy and livable environment. This also includes the necessary correction of earlier research and development lines. Findings concerning

Figure I/1



the global hazards of CFC emissions, for example, have created the basis for a worldwide strategy to phase out CFCs. Here, German scientists have made major contributions.

Scientific and technical progress needs to be supported by evaluating research in the humanities and social sciences and has to be objectively substantiated by technology impact assessments. Scientific and technical findings alone cannot do justice to the direct and indirect social effects of scientific and technical change. Research in the humanities and social sciences helps to assess and integrate social change, thus creating the basis for problem-oriented action. Using special analyses, technology impact assessments highlight medium- and long-term ecological and economic results and consequences of research and hence form an integral part of research promotion schemes.

Further development of research receiving basic funding

The activities of German research institutions receiving basic funding complement each other.

The foundation of basic research consists of universities and higher education institutions whose basic funds are provided by the Länder governments. Top-level performance is only possible if there is a sufficiently broad basis for scientific activities as well as constant scientific innovation. Due to the teaching load of universities funds earmarked for research did not sufficiently grow in recent years. There is a need for improvement and for catching up, especially as regards the basic equipment of universities. It is the task of the Länder to make good this deficit.

On this basis the Federal and Länder governments jointly promote

- research projects at universities through the German Research Foundation
- top-level research at the Max Planck Society
- interdisciplinary and specially complex research at national research centres
- application-oriented research at the Fraunhofer Society
- cross-sectoral projects at the research institutions included in the Blue List
- construction of higher education institutions and provision of large-scale equipment at universities.

In this way a flexible response to new challenges is guaranteed.

In view of the tight budget and structural changes a ceiling was set for the total funds allocated to national research centres in the period from 1991 to 1994; however, a distinction was made between the various functions in order to take into account the different priorities of research projects conducted by national research centres.

The Federal Government intends to preserve and strengthen the characteristic features of the various types of institutions. At the same time it aims to improve the cooperation among these institutions in order to achieve synergy effects. One of its priority goals is to ensure faster utilisation of the institutions' research results by industry and their quicker translation into marketable products.

Intensifying international cooperation in research and development

The Federal Government strongly promotes European cooperation in many different ways. In addition to the classical organisations of European scientific cooperation such as ESA, CERN, EMBL or ESO, and large-scale facilities such as the ILL Very-High-Flux Reactor, the European Synchrotron Radiation Facility (ESRF) in Grenoble and the European Transonic Wind Tunnel (ETW) in Cologne, the EUREKA initiative has developed into a motor of technological cooperation in application-oriented research. With currently 550 projects since its inception in 1985, EUREKA has become an important tool of cooperation for European industry.

The research programmes of the European Community are gaining more and more in importance. They encourage scientists and companies to embark on joint cross-border research and introduce less developed regions of the Community to top-level science and high technology. The Federal Government is actively involved in determining the contents of the programmes with a view to supplementing national research promotion according to the principle of subsidiarity, supporting the development of European norms and standards, granting small and medium-sized companies better access to EC research funds and establishing transparent and efficient promotion procedures within the EC.

The development of technology policies in Europe is determined by new challenges. The emerging union in Western Europe, the high level of research and technology achieved here, and the smooth international cooperative relations are very important for the countries in Central and Eastern Europe. It is the responsibility not only of politics, but also of science in Western Europe to turn to Central and Eastern Europe and provide support. Germany in partic-ular is called upon to face up to this task.

Research policy and its international priorities have to be measured by the contribution they make to mastering the four great challenges of the 1990s. These are

- to secure – in the globalisation process of industry and science – Germany's position, especially in the high technology sector, as contributor to research and production in Europe and as part of the triade formed by South-East Asia, the USA and Europe, thus making an essential contribution to growth and employment in Germany itself;
- to further resolutely the economic and political union of Europe. The European research and technology community is an essential element of a policy designed to secure Europe's political, cultural and economic strength in international competition in order to ensure peace and prosperity;
- to offer the neighbouring countries in the East the assistance and partnership of the European Community in order to permit the development of free and democratic structures, also in science and industry;
- to make an effective German contribution to solving global problems in the areas of energy supply, climate development and environmental protection (key words: increase in CO_2, ozone hole, tropical ecology), also with regard to the developing countries, aiming at sustained growth without progressive resource consumption (closed cycles).

Mastering these challenges calls for the committed and resourceful cooperation of national research policies.

Research and technology for preventive security policy measures

In a changing world the Federal Government considers adequate preventive security policy measures against potential risks a cornerstone of its policy. The government expects that – in contrast to periods of East-West confrontation – progress in the defence sector will slow down in the long run so that it will no longer be necessary to give priority to funds designed to secure the country's existence by military means.

But due to the rather unpredictable proliferation practices of those countries whose most efficient industrial complex used to be their defence industry, German defence technology capabilities must not be neglected.

Within the framework of the alliances (NATO, WEU) as well as the United Nations and the Conference for Security and Cooperation in Europe the Federal Armed Forces have to make their own contributions and thus fulfil new functions.

One of the departmental responsibilities of the Federal Ministry of Defence (BMVg) is to maintain the technological and cooperative capabilities of German industry and research institutions required to ensure the adequate future equipment of the Federal Armed Forces; in doing so the ministry relies increasingly on civil technologies and close cooperation with partners in the alliances. The ministry's comprehensive research and technology concept focusses primarily on reconnaissance and command and control, long-distance transport and protection, non-technical studies and military medical research.

Sufficiently modern armed forces can only be kept if a defence production base is maintained which permits cooperation with partners in the alliances. This is why Germany must have a defence technology base whose focus on certain subject areas has to be coordinated with the partners in the alliances so as to complement

their activities. This requires the ability adequately to assess new developments in order to respond to long-term changes in the overall security situation.

Continuing long-term government programmes

Due to their complexity and the funds they require, long-term government programmes such as fusion and space research can actually only be implemented on the basis of worldwide cooperation, with collaboration within Europe being required in the first place. For example, Germany contributes to the worldwide preparations for the ITER large-scale project. Basic funding of nuclear fusion research in Germany is embedded in European cooperation.

European space research is finding itself in an ongoing phase of adjustment of the programmes to a tighter budget and a changed international environment. An important intermediate step in this direction was taken by the ESA Council at ministerial level in Granada in 1992.

As a result of the Granada meeting the long-term ESA plan will be given a new structure in terms of time and substance, which makes greater allowance for the changed economic situation in the member states. In keeping with the programmes adopted in Granada the German medium-term contribution is about one third below the plans, according to the full programme adopted in The Hague in 1987. The decision to launch a polar orbit observation mission (ENVISAT) highlighted the importance of environmental and climate research. There was unanimous agreement on the further development of cooperation with Russia which opens up perspectives of worldwide collaboration in the field of space research. A reorientation phase was introduced for the Hermes programme which will end in 1995 and, among other things, is to address the question whether it is possible and useful to cooperate with Russia in building a spaceplane.

New developments have been triggered by the decision of the US government to revise the plans for the FREEDOM Space Station to reduce costs. This is also welcomed by the German side. A revision of the concepts for the development and operation of the Space Station will have to result in an improved cost-benefit ratio – also with regard to the European contribution – as well as a convincing and updated utilisation concept and, not least, reduced operating costs at a later stage. It will also be necessary to examine possibilities of extending international cooperation by including Russia in the Space Station activities in order to give the whole exercise a more far-reaching, internationally uniting function.

Against this background and in view of the aggravated economic situation also in the other partner countries, intensive deliberations are going on at the ESA level concerning the various plans and national participations in individual programmes.

In general, space research policy and also the so-called national programme will focus more than before on the practical applications of space technology. Large-scale projects will no longer be carried out by Germany alone.

2. *Germany as a location for research and technology activities*

One of the most important advantages of Germany as a production location has traditionally been the outstanding infrastructure and the highly qualified manpower. In addition, there is a great scientific and technological potential.

Expenditure on research and technology, both on basic and on industrial research, is an investment in the future of this country. New technologies which are the upshot of the swift practical application of the results of today's basic research will tomorrow be among the major factors determining the competitiveness of our national economy. Today's findings of ecological research will tomorrow provide the basis for healthy and nature-preserving living conditions in this country.

The sophisticated system of publicly funded research institutions which is jointly supported by the Federal and Länder governments has proved its efficiency in its interaction with universities and private-sector industrial research activities (cf. Figure I/2). In view of increasingly tougher competition it is necessary to put basic research results swiftly into practice in future so that new technological developments can be taken up in time. This is why the Federal Government has intensified the research and technology dialogue between industry, science and government with a view to identifying promising technologies at an early stage. Then joint strategies will have to be developed to meet the technical and hence the scientific and economic challenges of the 21st century. To achieve this it is necessary to initiate early adjustments of the present research institutions in terms of structure and substance.

2.1 Research and development in industry

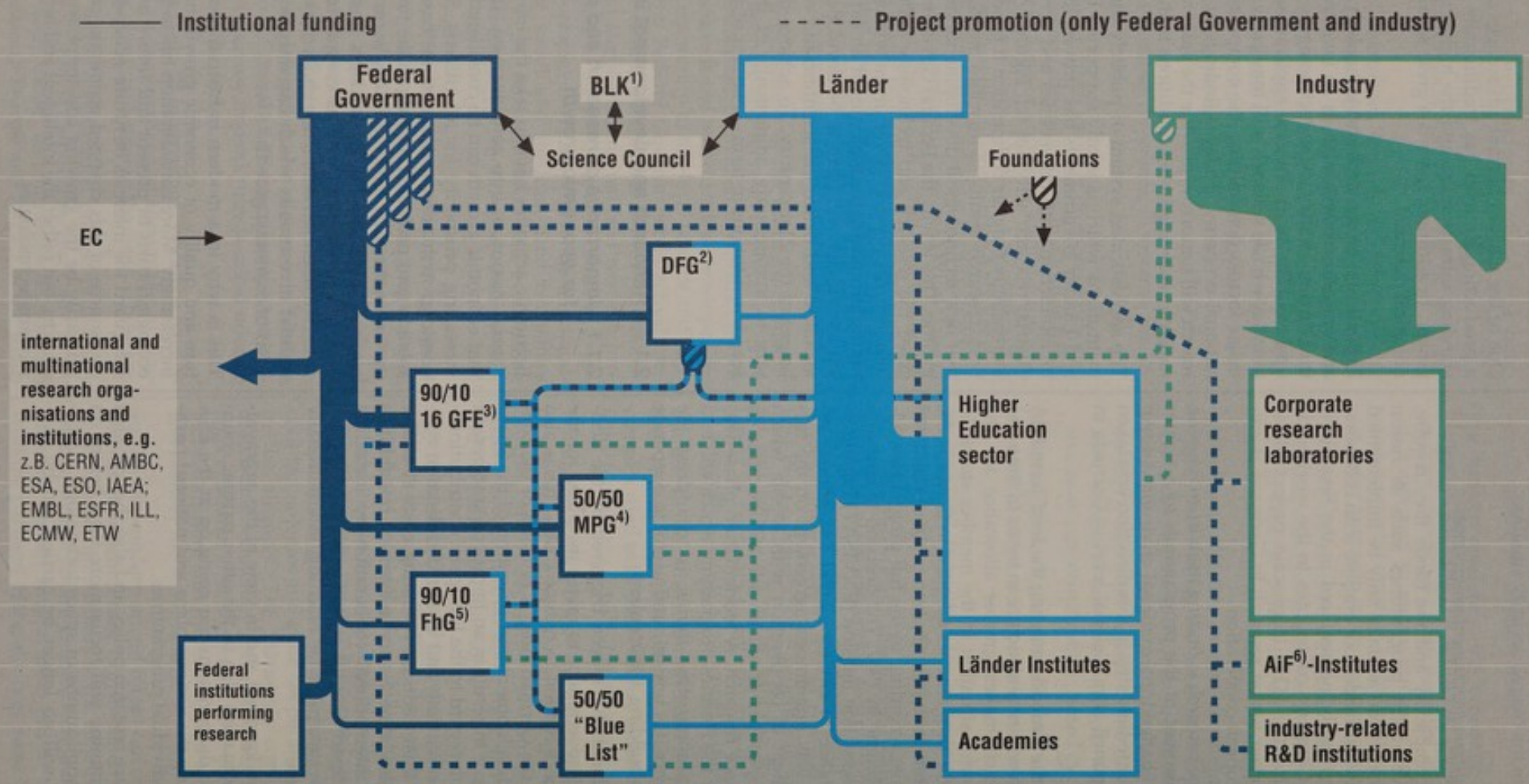
2.1.1 *Importance of research and development for economic growth*

Economic activities have to take the environment and natural resources into consideration. It is only then that economic growth can be considered the source of increasing prosperity for all citizens. Sustained economic growth creates the material basis required to solve urgent problems relating to the future. Cleaning up environmental problem sites, switching to more environmentally friendly products and cleaner production processes as well as conquering cancer and AIDS – to mention only a few challenges – require substantial investments which can only be made on the basis of economic growth.

This is why in a modern industrial society the structure and quality of economic growth have to change increasingly. More consideration has to be given to the ecological basis of present and future management to safeguard the interests of future generations. The crucial source of this changed economic growth will not primarily be the growing consumption of natural resources, but rather the intelligent and increasing use of modern technologies.

Figure 1/2

Structures of German research funding (simplified diagram)



1) Federal/Länder Commission for Educational Planning and Research Promotion
2) German Research Foundation
3) National research centres
4) Max Planck Society
5) Fraunhofer Society
6) Industrial Cooperative Research Association

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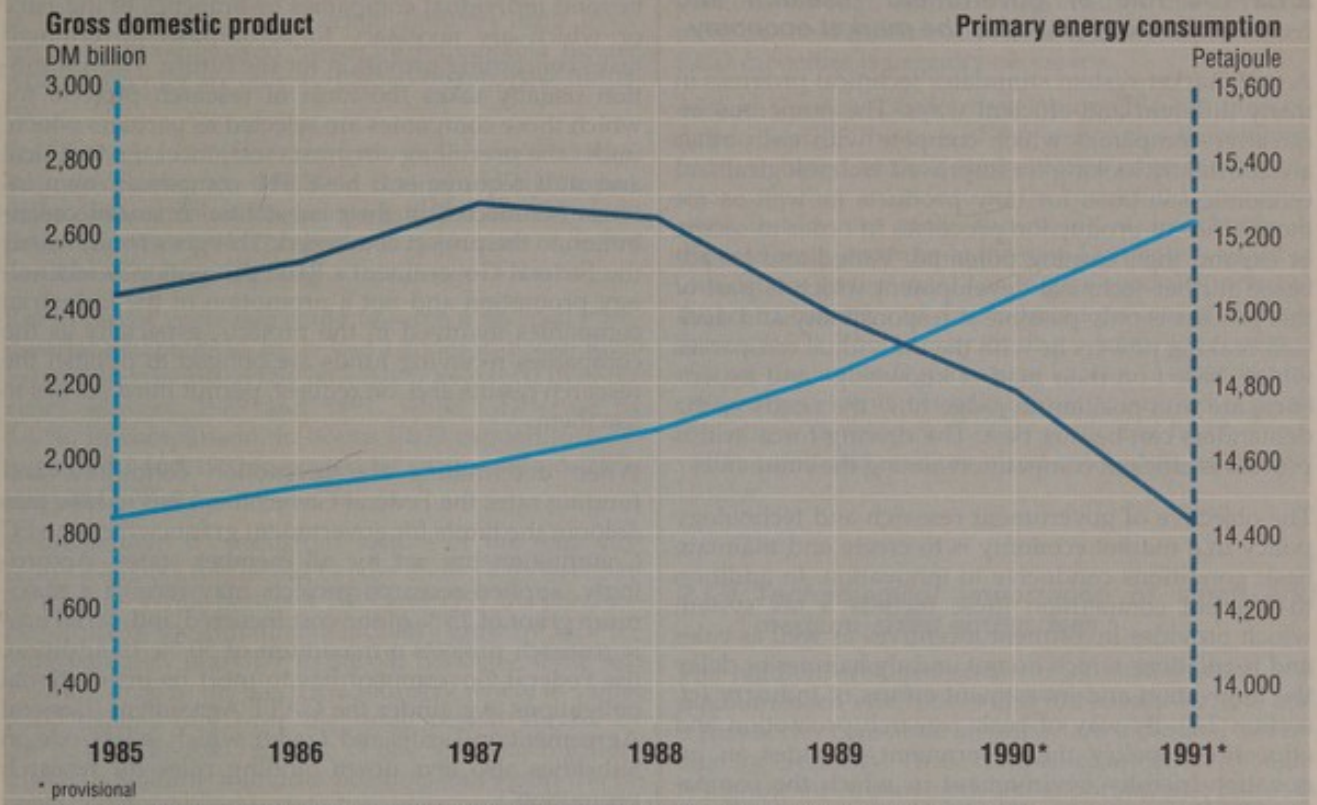
Figure I/3

Growth from intelligence, demonstrated by the decoupled development of energy consumption and economic growth in Germany



* provisional

Source: Federal Statistical Office; Arbeitsgemeinschaft Energiebilanzen; Deutsches Institut für Wirtschaftsforschung (DIW), Berlin; Institut für Energetik (IFE), Leipzig; BMWi.

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With world markets being open and accessible, foreign trade plays an important role in securing the prosperity and economic strength of Germany. The competition to which German industry is exposed in the world markets has become very stiff. Today it is no longer the country with the greatest mineral resources or the highest capital which has an economic advantage, but the country with the highest level of knowledge. This statement emphasizes the importance that science and research have for the position of a national economy in international competition and for the prosperity of a country's citizens.

Research and development are of critical importance for the international attractiveness of industry locations. The competitiveness of a national economy can be summarised as follows:

- The ability to offer products in the global markets that are competitive in terms of both price and quality ("high world market share").

- This has to be done under conditions which lead to an adequate economic growth permitting a higher standard of living for all citizens ("rising standard of living").

- It has to be ensured that the necessary "investment" can be financed from domestic savings ("no borrowed prosperity").

- These conditions have to be met on a lasting and long-term basis ("no haphazard successes in particular years").

Germany has neither appreciable raw materials nor increasing population figures which it could contribute to the international exchange of goods and services. Germany's wealth relies almost exclusively on its technological and industrial capabilities. This is why it is even more important for Germany than for other industrialised countries which are rich in raw materials to defend its technological and economic competitiveness. This challenge is even more formidable in the new Länder. Here research, technological development and innovations are of crucial importance for the successful restructuring of industry and for economic growth. A wide range of product and process innovations is indispensable for the future competitiveness of East German companies. Successful innovations require immaterial investment and entail material investment in replacement, rationalisation and expansion. This is why strengthening the innovative potentials of

industry and introducing international standards constitute a necessary investment for the future. Everything has to be done to prevent the R&D potentials of East German industry from declining any further. Starting from scratch would be much more expensive.

2.1.2 The role of government research and technology policy in the market economy

A free market system stimulates technical progress in many different and efficient ways. The numerous innovative companies which compete with each other are constantly looking for improved technological and economic solutions for new products as well as for more efficient production processes in order to secure or expand their earning potential. Varied and broad-based further technical development which is part of this process is only possible if responsibility and decision-making powers lie with the individual companies which, based on their market knowledge and experience, are in a position to judge how the needs of the demanders can be met best. The driving force in this process is efficient competition among the companies.

The objective of government research and technology policy in a market economy is to create and maintain basic conditions conducive to innovation. In addition to efficient competition these include a tax system which provides investment incentives as well as rules and regulations which do not unduly hamper or delay the innovation and investment efforts of industry (cf. section 2.3). By way of basic research promotion and educational policy the government provides an innovation-friendly environment in which the companies' R&D activities can flourish.

Government promotion of research and development in industry is based on the principle of subsidiarity. In the Federal Government's view the conditions for government research promotion in trade and industry are only met in those cases where companies are unable to develop certain technologies of considerable general economic importance on their own or where they cannot do so fast enough or to an adequate extent. Even then the government will generally limit itself to providing help for self-help.

Such initiatives may be justified when there are external effects, i.e. if also third parties can use research results and thus gain an economic advantage without paying the technology developer a fee. In such cases the incentive may be too weak for innovative companies to develop private R&D activities in these areas to the extent desirable if economic profitability considerations were included. A case in point is government promotion of basic research in those areas which are important for broad-based industrial application.

Another example is government promotion of preventive research benefiting "public assets" (e.g. water and air quality), for which there are no "markets" in the usual sense and where consequently incentives for private-sector R&D efforts need to be increased. Research and development projects which have long time horizons, a high economic risk and great financial needs and therefore are beyond the possibilities of individual companies, may also prompt the government to act and intensify the impetus generated by individual firms.

It is the objective of the Federal Government's R&D promotion in trade and industry to further and make accessible – in the interest of the national economy as a whole – those technologies whose significance goes beyond individual companies or branches of industry or which are necessary to accomplish government tasks concerning provision for the future. This promotion usually takes the form of research projects for which those companies are selected as partners which, under the prevailing circumstances, meet the technical and staff requirements best. The companies' own interest is reflected in their substantial financial contribution to the project concerned. This goes to show that the Federal Government's R&D promotion is technology promotion and not a promotion of the industrial companies involved in the projects, especially as the companies receiving funds are obliged to publish the research results and, on request, permit third parties to use them.

When determining the promotion conditions and funding rates the Federal Government has to take into account the limits for government grants which the EC Commission has set for all member states. Accordingly, applied research projects may receive a maximum grant of 25 % of the cost incurred, industrial basic research projects a maximum of 50 %. In addition, the Federal Government has to meet its international obligations, e.g. under the GATT Agreement (General Agreement on Tariffs and Trade), which in its Code on Subsidies also lays down binding rules for research promotion.

But mastering certain technologies is not the only factor determining the technological capabilities of a national economy. Research and technology policy also has to take into account the efficiency of innovation structures and of technology dissemination. This applies in particular with regard to the innovative strength of small and medium-sized enterprises. This is why, regardless of the technology concerned, the Federal Government furthers improved research cooperation among companies as well as between companies and research institutions, provides incentives for recruiting and keeping on scientific staff, supports the development of infrastructures for technology transfer, and stimulates the adoption of modern innovation management tools. In this context the development of public research infrastructure also plays a significant role. National research centres and the Fraunhofer Society provide important complements to corporate R&D capacities. Against payment they can solve problems which could not be solved on an individual basis, because it would be unprofitable or even impossible for many companies to provide the necessary in-house R&D capacities. At the same time they make a major contribution to closer cooperation between industry and science and intensify the exchange of knowledge and experience in both directions. Along these lines the Federal Government's testing institutions (Federal Institute for Materials Research and Testing, Federal Institute of Physics and Metrology) render important technical services to German industry.

2.1.3 Research and development in industry – the current situation

The most important players by far in the German research scene are companies in trade and industry. In 1992 they contributed about 59 % to funding the expenditure on research and development in Germany and performed as much as about 66 % of all R&D. At the same time, about 86 % of industrial R&D activities in 1992 were financed by German industry itself. In international comparison these are remarkable figures which currently are only surpassed by Japanese industry.

This is the result of a strong growth of industrial R&D activities during the 1980s. In that period the importance of research and development for German enterprises increased which shows that German industry has taken up the technological challenge of the time.

But in recent years one could observe a reversal in industrial R&D efforts. In the old Länder in-house R&D expenditure increased by only 3.4 % averaged over the years between 1989 and 1991, while GDP rose by 8.4 %. In comparison, in-house R&D expenditure between 1981 and 1989 increased by an annualised 7.1 %, with an GDP growth of 4.7 %.

A breakdown by industrial sectors of the data currently available for the old Länder shows a differentiated picture: While between 1989 and 1991 the R&D expenditure of the automotive industry grew by 14.1 % – approximately like GDP in the old Länder –, there was a severe drop in the electrical industry where in-house R&D expenditure over the same period shrank by 4.8 %. With an R&D growth of 3.4 %, the chemical industry is holding a middle position (but again the increase is disproportionately low compared with GDP).

Unification has expanded and strengthened industrial R&D capacities in Germany. The order of magnitude by which, for example, the number of qualified engineers and scientists available to industry has grown, corresponds to the capacity of a medium Western industrialised country. For the future development of pan-German market-oriented R&D capacities this should be of considerable importance, not least because prior to unification the lack of R&D staff in many areas had already impeded innovation considerably and because also our main competitors in the world markets expect a substantial reduction in R&D personnel by the end of the decade. It is imperative now to take advantage in the medium term of the opportunities which have opened up through the increase in R&D capacities as a result of German unification.

But at the moment market-driven R&D in the new Länder is undergoing a fundamental restructuring and adjustment process. The substance and priorities of R&D in the former GDR often did not comply with world market requirements, in many cases researchers were working on developments that paralleled Western technologies. By Western standards, many R&D institutions were considerably overstaffed, the result being a relatively low per capita efficiency of the personnel employed. Very serious obstacles for researchers in the former GDR were the difficulty to get access to modern high technologies from the West and the lack of latest research equipment.

The extent of the restructuring and adjustment process which industry-related R&D capacities in the new Länder are currently going through is also reflected in the fact that the number of personnel in this area has by now dropped to about a quarter (cf. Part II). Confronted with economic difficulties companies often began to cut costs first in this area which is so important for their future, and in many cases did so to a disproportionately high degree. A reversal of this development in the direction of increasing industry-oriented R&D capacities is urgently necessary.

Also in the new Länder developing efficient, market-driven R&D is the task of the companies themselves, because, based on their market knowledge and experience, only they are able to set the correct in-house priorities. But in view of the abrupt and radical change of the economic structure in the new Länder as a result of unification, government has to give special support to the restructuring and development process of market-driven R&D. This is why during a transitional period market-driven R&D in the new Länder is receiving increased government funding. Special support is given to the new development of dynamic and highly innovative small and medium-sized enterprises in the new Länder.

2.1.4 Technological importance of small and medium-sized enterprises

The highly developed sector of innovative small and medium-sized enterprises and not least the crafts and trades sector constitute an important locational advantage for Germany. These companies are not only highly significant employment and export factors, but with their extraordinary capacity to supply high-quality technology they often provide the crucial basis for the innovative strength of big high-tech companies. Being able to purchase a wide range of high-quality technological supplies in the domestic market is an invaluable advantage. Changed demand structures in favour of individual problem solutions and the possibility to meet these requests by using modern technology in many cases open up new development opportunities for small and medium-sized enterprises. Due to their strong points such as shorter decision-making processes, being closer to the customer and more flexible, SMEs can often make much better use of such opportunities than big companies.

In the 1980s small and medium-sized enterprises, too, upgraded their R&D efforts considerably. But when making important innovative contributions to the economy as a whole, SMEs have to fight specific disadvantages, e.g. in terms of acquiring information, getting access to the capital market or having fewer possibilities of spreading R&D risks.

The Federal Government's technology policy will continue to aim at improving the innovation opportunities of SMEs in order to push the broad-based application of key technologies and increase the innovative strength of the economy as a whole.

Small and medium-sized enterprises play an outstanding role in disseminating technologies. In order to make full macro-economic use of key technologies

new methods and processes need to find a wide range of applications as fast as possible. This can only be achieved if new technologies are used as soon as possible also by SMEs. The promotion of small and medium-sized enterprises under specialised BMFT programmes is therefore of considerable importance. Encouraged by special administrative simplifications such as the consolidation of cost unit rates into a lump sum, the firms are involved in technology development at a relatively early stage. They are also supported in quickly introducing new technologies by indirect specific promotion schemes. Such indirect specific tools are used in those cases where there are severe obstacles to technology dissemination and where financial support seems to offer a suitable approach to overcoming these impediments.

To remain successful in the increasingly tough and complex technology race SMEs depend more and more on R&D cooperation. The driving force is not only cost savings; more and more SMEs are only able to master new technologies by means of cross-sectoral cooperation. In the process of market globalisation transnational cooperation will also become more important for such firms. In the past, the Federal Government has already successfully encouraged such cooperations through various schemes such as cooperative industrial research, the promotion of contract research and development and the promotion scheme "Industry/science research cooperation". But in this respect small companies in particular are still suffering from major deficits in whose elimination they should be supported.

In assisting the rapid development of efficient market-driven industrial R&D capacities in the new Länder, special priority is on supporting highly innovative SMEs. Without such medium-sized structures industry in the new Länder will not be able to achieve the level of performance and innovative strength that industry in the old Länder has. Also, SMEs are indispensable for lastingly improving the employment and training situation in the new Länder.

The fact that in the former GDR small and medium-sized businesses had largely disappeared and that, consequently, no recent experience is available represents a specific challenge in the new Länder. Since SMEs can only survive in the long term if they are competitive at the national and international levels right from the beginning, they have to strive to reach the technological top. This is a major challenge for the R&D capabilities of these companies.

This is why particular importance is attached to founding new technology-based firms in the new Länder as well as to the infrastructure which technology centres provide for such companies. This also applies to the work of the agencies, to technology transfer and innovation promotion as well as to the innovation consultancy centres at the Chambers of Industry and Commerce. It is also necessary to establish a large-scale transfer of experience from the SMEs in the old Länder. An important starting point is the promotion of R&D cooperation between SMEs in East and West. But government promotion schemes can only accomplish this formidable task when they are supported by the determined commitment of small and medium-sized enterprises in the old Länder with their invaluable experience.

Also the traditionally close cooperation between Fachhochschulen and SMEs can help provide the SMEs with the impetus necessary to secure R&D capabilities. The Federal Government has therefore made great efforts to support the speedy establishment of Fachhochschulen in the new Länder.

2.1.5 *International interdependence*

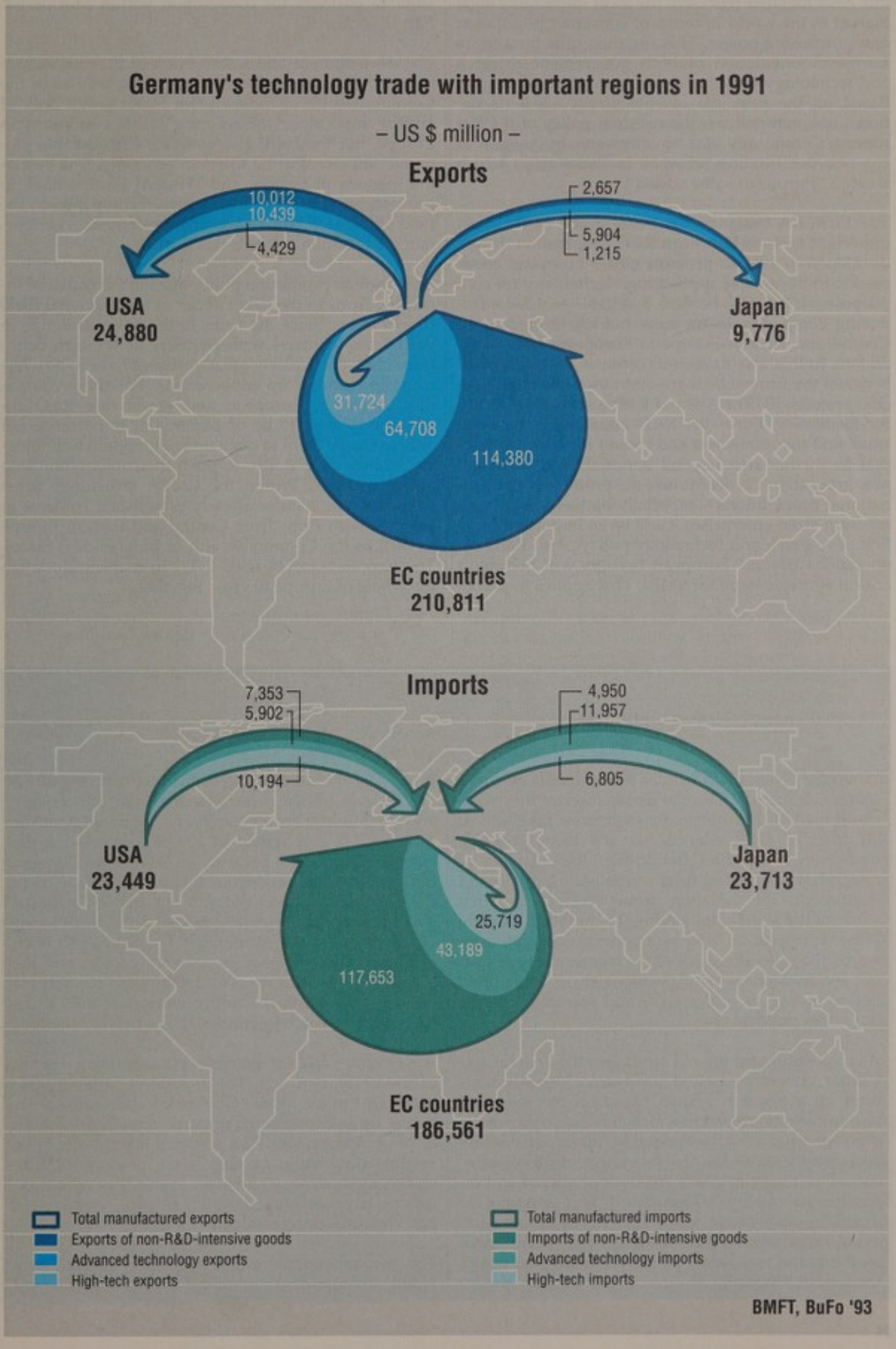
International trade has been one of the principal driving forces of economic growth in the past few decades. At the same time, there has been a radical qualitative change of the international exchange of goods and services. Today it is no longer raw materials or finished products alone that are exchanged. There is also an increasing flow of components and intermediates from all production levels between the various national economies. Since the mid-1980s this development has been accompanied by an extraordinary increase in transnational direct investment. This process was favoured by efficient transport systems and modern communication technologies which have made distance a negligible factor. Thus the internationalisation of trade was followed by the internationalisation of production. Often multinational companies are no longer characterised by transnational capital links alone, but also by a multinational or even global organisation of sequences of operations. The limits of national markets are playing an increasingly weaker role in terms of both sourcing and marketing (cf. Figure I/4).

At the next stage internationalisation is advancing more and more into the area of industrial research and development. The importance of so-called strategic alliances in this field has increased lately and aroused public interest. It is primarily companies from the triade Japan, the USA and Europe, in other words, the most highly developed economic regions, which engage in this form of cooperation. In addition to the R&D cooperations within individual economic regions, more and more alliances develop between companies based in two or all three of these regions. This also shows that people tend to think no longer in terms of economic blocs.

In future, companies will increasingly set up their research facilities in those parts of the world where the environment seems to be best suited. This development is described by the buzzwords "technology globalisation" and "international sourcing of technological resources". Because of its excellent research infrastructure Germany can offer favourable conditions for siting such international R&D facilities in this country. But even Germany – as a research location – was confronted with a drain of R&D capacities in the field of bioengineering and genetic engineering.

In view of the changed geopolitical situation it can be expected that internationalisation trends in all areas of economic activities will tend to increase.

Figure I/4


Germany's technology trade with important regions in 1991
– US $ million –
Exports
10,012
10,439
4,429
2,657
5,904
1,215
USA
24,880
Japan
9,776
31,724
64,708
114,380
EC countries
210,811
Imports
7,353
5,902
10,194
4,950
11,957
6,805
USA
23,449
Japan
23,713
25,719
43,189
117,653
EC countries
186,561
Total manufactured exports
Exports of non-R&D-intensive goods
Advanced technology exports
High-tech exports
Total manufactured imports
Imports of non-R&D-intensive goods
Advanced technology imports
High-tech imports
BMFT, BuFo '93

The European Single Market and the European Economic Area together represent the most important single market in the world in terms of consumer population and purchasing power. This situation calls for a more European orientation of both government research and technology policy and corporate R&D strategies. Based on the principle of subsidiarity vis-à-vis national research policies, the research policy of the European Community has to intervene by means of cross-border funding schemes in those areas which create a "European value added".

The EUREKA initiative has become one of the most important tools of European R&D cooperation. It was developed in 1985 to promote closer European cooperation in the area of applied high technology for civil purposes. It has also become a suitable tool for introducing companies in the new market economies of Central and Eastern Europe to European R&D cooperation. In this way numerous contacts are established between the firms which are often useful beyond specific projects. EUREKA is not least a successful forum for facilitating European R&D cooperation between small and medium-sized enterprises for which collaboration in this area beyond national borders is still new ground. In the near future the promotion of transnational cooperations – especially between small and medium-sized enterprises – will be an important function of research and technology policy. Also R&D cooperations beyond European borders will become a critical strategic issue for SMEs. This applies in particular to those firms or industries which cannot find any suitable partners for cooperation within Europe (cf. Part II, section 9).

The development and stabilisation of national economies in Central and Eastern Europe as well as in the Commonwealth of Independent States is not only of critical importance for securing stable conditions in Europe, but they will also generate considerable economic impetus for the German economy. The economic regions in Eastern and Western Europe have to grow together. Cooperation between companies in the field of research and development can make an important contribution towards this goal.

Government promotion policy aims in particular at including firms in the new Länder in transnational R&D cooperations. Since the firms in the new Länder have hardly any contacts with partners in Western countries, often particularly great obstacles have to be overcome in opening up cooperations. For these companies, however, European and worldwide R&D cooperations seem to be of paramount importance not only to enable them to catch up with modern technological standards, but also to push their integration into global markets. Within the CMEA structures, firms from the new Länder already established contacts in the past with firms from Central and Eastern Europe as well as the Commonwealth of Independent States. These contacts can be used today to enable industry in the whole of Europe to grow together.

The challenge of German unification

When the Federal and Länder governments began to reorganise the East German research sector they were confronted with problematic structures: Like almost all areas of GDR science, non-university research units were overstaffed. In addition, the efficiency of research was suffering from centralist control, lack of equipment, the isolation from Western research while at the same time tending to duplicate existing Western results, as well as a general orientation towards the self-sufficiency of the country in the product sector. Management positions were often filled not according to professional and scientific criteria, but rather political ones.

As a substitute for the old structures the Federal and Länder governments and the science organisations built up a research system based on the model of non-university research which has been proven in the Western part of the Federal Republic of Germany and complies with the federal system of this country as well as the principle of freedom of science and international quality standards. It was essential to maintain and restructure efficient potentials and avoid duplications. This technical and institutional reorientation was based on the recommendations of the Science Council.

In view of the dimensions of the restructuring effort the Federal Ministry for Research and Technology and the Minister for Research and Technology of the former GDR had agreed in 1990 to commission the Science Council to perform an overall evaluation. Reference to this procedure is made in Article 38 of the Treaty on German Unity. More than 200 national and international scientists assessed the institutions of the three former Academies. The Science Council evaluated the efficiency of research groups and the viability of research areas and submitted recommendations concerning the future work, size and structure of the research institutions to be newly founded.

A welcome – and for many people surprising – result of the evaluation was that in spite of unfavourable conditions in the former GDR research in some areas had – by international standards – reached a high level of performance. The research institutions to be set up could build on this basis in terms of substance, methodology and staff. In this way new institutions have developed which extend, complement and enrich German research as a whole.

The recommendations of the Science Council provided an important guideline for the Federal and

Länder governments; they could be implemented almost completely. The scientific independence and authority of the Science Council have furthered the acceptance of the decisions on implementation especially in those cases where radical changes to earlier structures were required. In the months after the evaluation had been completed the Federal Government, in cooperation with the Länder, ensured vigorously that founding committees or similar bodys were set up for all new research institutions in order to make the new facilities operational, develop technical and organisational structures quickly, implement the Science Council's recommendations regarding human recources and equipment as well as prepare and perform staff recruitment. The staff in the new institutions, which are jointly funded by the Federal and Länder governments, were selected in keeping with standard principles. In this respect, the science ministers of the new Länder followed a BMFT proposal. These standard principles are as follows:

- All management positions in the research institutions mentioned are to be newly filled; scientists of the former institutions may also apply and – in case of equal suitability and qualifications – have to be given preference.
- When R&D activities are continued staffing continuity is to be ensured; accordingly, such positions are only advertised internally. But in the interest of an appropiate staff composition up to 10 % of the scientists even at these institutions should come from the old Länder or Western countries.
- On the basis of these principles the selection committees in the new research institutions should make judgements especially according to professional criteria, at the same time taking into account the social background of the applicants (special consideration of seriously disabled persons, older staff members and single parents).
- Checking the applicants' integrity is based on principles applying to the public service according to the Treaty on German Unity or Länder provisions. On March 10, 1992 the Federal Constitutional Court ruled the regulations and the restructuring process pursuant to Article 38 of the Treaty on German Unity to be constitutional. The tremendous social effects of the restructuring process could be cushioned by transitional funding and job creation schemes.

Setting up new research institutions

Implementing the recommendations of the Science Council, the Federal Government and the new Länder – pursuant to Article 91b of the Basic Law (Constitution) – founded more than 100 non-university research institutions with effect from January 1, 1992. Within the BMFT's jurisdiction these include

- three new national research centres as well as eight branch offices of existing national research centres
- 24 new institutions to be included in the Blue List as well as four branch offices
- nine institutions and twelve branch offices of the Fraunhofer Society
- two institutes, 28 working groups at universities and a supporting organisation for the seven humanistic centres of the Max Planck Society as well as a branch office of a Max Planck Institute.

Some government departments (Federal Ministry of Food, Agriculture and Forestry; Federal Ministry of Economics; Federal Ministry of Labour and Social Affairs; Federal Ministry for Regional Planning, Building and Urban Development; Federal Ministry of Education and Science; Federal Ministry of Health; Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) have set up departmental research institutions, institutions included in the Blue List as well as branch offices of existing institutes in the new Länder. The new Länder, in turn, have founded their own research institutions. Under the scheme for the integration of scientists which helps bring scientists and research groups from the Academies back to the universities, a total of 1,920 applications for grants was accepted.

With the job opportunities in the new research institutions within the jurisdictions of the BMFT (about 7,200 jobs including the long-term humanistic projects in the programme of the Academies of Sciences) and the other federal ministries (about 2,300), at the Länder research institutions (approx. 1,170) as well as under the programme for the integration of scientists a total of about 12,500 jobs has been created in research. In addition, there are approx. 3,000 research-related jobs under employment creation schemes at the former Academies of Sciences.

Some of the new research institutions funded by the Federal Government are novel and unique in structural and technical terms. It is remarkable that relatively few and small theme-centred national research centres were created. The number of new institutions included in the Blue List is comparatively high. The Fraunhofer Society has made particular efforts to set up institutions at the interface of research and industry.

The Max Planck Society has decided to found or plan another ten institutes. As a first step it intends to set up one Max Planck Institute per Land, if possible. In terms of subject matter the research policy of the Federal Government and of the new Länder has triggered new and promising developments, be it in preventive research, basic research or application-oriented research. Examples:

- In view of the high pollution levels in Central Germany the Leipzig/Halle Environmental Research Centre and some Blue List institutions are developing the scientific basis for understanding the environmental problems of industrialised and urbanised regions, including their regeneration and clean-up as well as their reorganisation and long-term environmentally compatible development.

- New integrative concepts of diagnosis, therapy and prevention are developed and clinically tested at the Max Dellbrück Centre for Molecular Medicine in Berlin-Buch where molecular biological commonalities of different groups of diseases are studied.

- Basic research priorities are on geosciences (Geoscientific Research Centre Potsdam), microstructure physics, plasmaphysics, chemistry, biosciences and mathematics.

- New research institutions (institutes and branch offices of the Fraunhofer Society and Blue List institutions) perform application-oriented research with regard to new technologies in areas such as microelectronics, information processing, production technologies, materials research and biotechnology.

- The Federal Ministry for Research and Technology and the Federal Ministry for Labour and Social Affairs are funding the Committee for the Study of Social and Political Change in the New Länder (based in Halle).

- The Institute for Economic Research in Halle, a Blue List institution funded by the Federal Ministry of Economics, has already built up a reputation of its own with studies of the transformation processes in the new Länder.

- The departmental research institutions included in the Blue List that are funded by the Federal Ministry for Food, Agriculture and Forestry and the Federal Ministry for Regional Planning, Building and Urban Development continue agricultural and building research activities in new structures and have embarked on new projects.

- Traditional and new humanistic research projects are carried out in particular under the programme of the Academies and at research centres supported by the Max Planck Society.

The fact that the Federal Government has given priority to the new Länder is also reflected in the volume of research promotion: In the 1993 BMFT budget alone about DM 730 million are earmarked for basic funding and approx. DM 750 million for project promotion; in addition, DM 188 million are being appropriated for the programme for the integration of scientists and for reducing the burden of the new Länder in financing Blue List institutions. From 1993 to 1996, a total of DM 266.6 million will be allocated to construction and restoration schemes as well as to purchasing equipment for non-university research institutions; the Federal Government will contribute 75 % to this special investment programme. Problems will be solved step by step: improving the infrastructure as well as the working and living conditions of scientists, joint appointments, cooperative agreements with universities, collaborative projects with industry as well as the integration into universities of persons supported under the programme for the integration of scientists.

Renewal of university research

The renewal of university research is part of the restructuring of universities in the new Länder. This renewal process is based on recommendations of the Science Council concerning the technical restructuring of universities in the new Länder and the establishment of Fachhochschulen. These recommendations are implemented by means of existing instruments of science promotion and university construction, supplemented by the University Renewal Programme which provides specific assistance for renewal. The Programme for the Renewal of Higher Education and Research in the New Länder of July 1991 was revised in July 1992, as agreed, and supports restructuring with funds amounting to DM 2.427 billion which the Federal Government and the new Länder provide on a 75:25 basis.

The objectives of this programme include the renewal of universities in staffing and technical terms, strengthening basic research by integrating scientists and working groups from the Academies in universities or in research institutions jointly funded by the Federal and Länder governments, as well as securing the infrastructure in the science sector. The promotion of young scientists comprises varied schemes for "Habilitationsförderung" (support of scientists doing research for securing the right to lecture in a particular subject at a German university), for post-doctoral promotion in Germany and abroad as well as for postgraduate promotion; young scientists engaged in postgraduate studies including preparatory activities are eligible for assistance, too. Funds are also available for qualification courses for the scientific staff and for developing follow-up and distance study courses as well as for establishing Fachhochschulen.

With the revised University Renewal Programme the Federal Government contributes to developing a competitive and efficient academic and research sector in the new Länder which is integrated into the national and international science systems.

R&D in industry

The responsibility for developing efficient market-driven R&D capacities in the companies of the new Länder lies primarily with industry itself, because based on their experience and market knowledge the firms alone are able to set the right priorities for their own work. But in the difficult phase of economic change the government has to support the restructuring process in the new Länder by means of temporary intensified R&D funding schemes. Since mid-1990 the Federal Ministries of Economics (BMWi) and for Research and Technology have provided assistance in a great many cases through a number of coordinated schemes. Promotion focusses on four priorities:

- Developing an R&D-supporting infrastructure

  Setting up of agencies for innovation promotion and technology transfer by the BMWi; BMFT pilot

project "Innovation consultancy centres for Chambers of Industry and Commerce; setting up of centres for demonstration, consultancy and technology transfer in new technology areas by the BMFT; specialised information transfer centres as well as information retrieval from databases supported by BMWi and BMFT.

- Developing and increasing the technological competitiveness of East German companies

  Funding of cooperative industrial research by the BMWi; easier access to BMFT project promotion under specialised programmes; temporary special promotion of R&D projects at industry-oriented research institutions by the BMWi and the BMFT under the joint scheme "Upswing East".

- Promoting new technology-based firms (NTBFs)

  BMFT pilot project for the promotion of new technology-based firms as well as for the establishment and expansion of technology parks.

- Technology-related promotion of small and medium-sized enterprises

  Grants towards R&D payroll costs and innovation promotion scheme by the BMWi; funding for additional R&D staff and for two types of contract research promotion by the BMFT.

In 1992 alone the BMWi and BMFT appropriated some DM 607 million (of which the BMWi provided approx. DM 250 million and the BMFT about DM 357 million) for the maintenance and expansion of efficient industrial R&D capacities in the new Länder. Included in this sum are approx. DM 195 million from the joint scheme "Upswing East".

With its privatisation and reorganisation policy Treuhandanstalt also plays a considerable role in maintaining these necessary R&D capacities of industry. It has to identify viable new corporate units which have the necessary R&D potential to serve their purposes, and separate them from the former collective combine structures.

Many centralised R&D capacities were hived off into independent "Research GmbHs" (limited liability companies), a process which led to special problems. These institutions had accounted for a considerable part of the total industry-related R&D capacities of the former GDR. It was necessary in the restructuring and privatisation process to find new funding bodies for these industrial research units which at first had remained in the possession of Treuhandanstalt. In joint efforts by the Federal Government, Treuhandanstalt and the new Länder solutions could be found for the majority of these R&D institutions which were privatised or made into non-profit-making organisations. Federal funds allocated to these institutions in 1992 amounted to about DM 130 million.

Due to their special mandate and profile, the 21 Fachhochschulen which have meanwhile been founded at 26 locations in the new Länder offer great opportunities for promoting research and development in industry, in particular in cooperation with small and medium-sized firms.

New research structures in Germany

German research has been complemented, expanded and enriched by the institutions and potentials of the new Länder. This has not only augmented the technological capabilities of German research in international competition, but has also increased the obligation vis-à-vis the international community to use this potential to help solve global problems. The growth of research in East Germany should now help trigger a review of the entire German research programmes and research policy. Such a complete review is necessary in order to reconsider, from the aspect of new qualities, the structures, priorities and research strategies as well as the distribution of research locations over all of Germany and to open up new fields and tasks of research.

2.2 Government-funded research infrastructure

Compared with other countries, German research institutions are characterised by a particularly high degree of variety. An important influencing factor can be traced through the various periods of the history of German science. In the 19th century, for example, Reich institutes were founded, in 1911 the Kaiser Wilhelm Society for the promotion of sciences was set up, followed in 1920 by the Emergency Association of German Science as a precursor of the German Research Foundation. After the Second World War these institutions were joined by the Fraunhofer Society and the national research centres as new organisational forms of science in the Federal Republic of Germany.

Another factor is Germany's federal structure: According to the Basic Law (Article 30) the discharge of governmental functions is incumbent on the Länder in so far as the Basic Law does not otherwise prescribe or permit.

In the area of research promotion the Federal Government has increasingly fulfilled tasks whose accomplishment exceeded the financial strength of the Länder. The incorporation into the Basic Law of research promotion as a joint task (Article 91b) in 1969 defined the substance and limitations of the Federal Government's contribution: The Federal and Länder governments may cooperate in the promotion of institutions and projects of scientific research of supraregional importance.

In 1969 the Federal Government was authorised to promulgate framework regulations concerning the general principles underlying the higher education system. At the same time the construction of institutions of higher education was made a joint task. For the rest, however, it is the Länder which are responsible for universities (higher education institutions) and university research.

There are also research institutions funded independently either by the Federal Government or by the individual Länder governments.

Based on Article 91b of the Basic Law the Federal Government makes major contributions to funding the Max Planck Society, the Fraunhofer Society, the institutes included in the Blue List and the national research centres. Institutes abroad and Federal research institutes are exclusively financed by the Federal Government.

Institutional variety has turned out to be a strong point of German research. It ensures that different organisations, complementing the universities, can display their particular capabilities. There are

- the Fraunhofer Society with its market-orientation;
- the Max Planck Society with its free and independent basic research which is exclusively committed to scientific performance;
- the national research centres, handling complex interdisciplinary research projects which require a large number of staff and a high level of funding;
- the Blue List institutions with their wide variety of themes and specific individual orientation;
- the Federal Institute for Materials Research and Testing, the Federal Institute of Physics and Metrology and the Federal Research Centres in the sector of food, agriculture and forestry with their department-specific research activities.

The further organisation of non-university research has to link up to the development of recent years which in the old Länder was characterised by differing degrees of expansion (in brackets increase in basic funding between 1982 and 1992):

- Intensive expansion of the Fraunhofer Society (+ 250 %) as a contract research institution;
- continuous development (+ 55 %) at the Max Planck Society, whose high level of performance was acknowledged in recent years when several of its researchers were awarded Nobel prizes;
- new priorities at the national research centres (+ 60 %), e.g. through the development of polar research, biotechnology, non-nuclear energy research, and considerable additional spending on new large-scale equipment for basic research;
- further development of Blue List institutions according to their specific orientations.

The different types of research institutions are adequately distributed. The regional distribution in the old Länder is the result of many years of development determined by subject-related arguments and reflecting the different degrees of commitment, financial and otherwise, of the various Länder governments in the past.

Based on the large variety of the German research scene, the Federal Government aims to achieve optimum results. This is why it promotes cooperation among the different institutions as well as between these institutions and universities and industry, and cooperation at the international, especially the European level.

As the building of Europe advances, European research policy is gaining increasing importance. This is why the programmes of the research institutions have to intermesh with the programmes of the European Community and why cooperation with European partner organisations is necessary. The research institutions are called upon to get involved in the EC research programmes right from the point of inception. They also have to make sure that they raise more funds from EC coffers.

The Federal Government supports cooperation with European partner organisations under specific programmes and in utilising large-scale equipment. It does not see any need for new European R&D institutions. Institutionalised cooperation structures may be created in those cases where they are required for a specialised programme or where they are necessary to defend the European position in global competition.

In cooperation with industry the Fraunhofer Society will continue to play its successful role as an institution of contract research. But the transfer of knowledge to industry, especially from national research centres, has to be accelerated. The national research centres whose structures are basically geared to long-term projects must also adopt innovation in industry as their goal. The Federal Government will moderate the dialogue between research institutions and industry.

In addition to the classical forms of technology transfer such as technology centres and licensing the Federal Government supports new ways of cooperation. These may include privatising individual areas or pooling public and private research capacities for temporary, target-oriented cooperations.

In keeping with the 1991 recommendations of the Science Council the Federal Government supports close cooperation between non-university research institutions and universities. The joint appointment of professors is quite common, and universities make intensive use of the national research centres' equipment; special research programmes and postgraduate courses are run jointly.

The Federal Government welcomes the cooperation of research institutions in theme-centred groups. Taking up a BMFT initiative, groups have formed to work in the areas of solar energy, environmental research and biomedical research.

In order to improve the coordination of the research institutions' activities the Science Council, taking up a proposal of the Federal Government, has begun a series of assessments of individual subject areas in the research sector. Currently it is working in the field of environmental research. According to the decisions taken by the Conference of the Federal and Länder governments at their research policy meeting on December 14, 1992 other subjects will follow, e.g. materials research, health research, biotechnology, energy research and information technology. The Federal Government hopes to receive further recommendations concerning an improved division of labour between the institutions, the efficient use of funds and the determination of qualititave priorities.

In the Federal Government's view the technical guidance provided for ongoing research programmes as well as their concurrent evaluation are important elements of quality control in research.

2.2.1 University research

Importance of universities in a differentiated research system

The unity of research and teaching is an important characteristic of German universities. Universities provide a broad basis for research; in many areas they do top-level research; they ensure the training of young scientists and hence the constant renewal of research personnel.

The universities have such a wide range of research in a variety of disciplines that it is possible to change priorities and respond quickly to societal developments and issues. By the same token, the freedom of science within the autonomy of the universities, as guaranteed by the Basic Law, safeguards the research interests of scientists irrespective of non-scientific considerations of their relevance and regardless of offers of external funds from clearly defined research programmes. Accordingly, the financial and organisational conditions for university research have to be designed in such a way that the freedom of research remains untouched.

Especially in this century the dynamism of scientific development has led to an interlinkage of basic research on the one hand, and applied research and development on the other hand, with the distinction often being blurred. Of particular importance is the technology transfer to the regional environment of universities which also plays a part in the structurally motivated promotion of small and medium-sized enterprises. In this application-related research area Fachhochschulen, too, have a central function.

The relation between university research and non-university research institutions

In its "Recommendations Concerning the Perspectives of Universities in the 1990s" published in 1988 as well as in its "Recommendations Concerning the Cooperation of National Research Centres and Universities" published in 1991, the Science Council addressed the relation between university research and non-university research institutions.

In its analysis the Science Council notes that publicly funded non-university research institutions expanded over the last ten years, while the universities were just about able to maintain their resources. It is true that universities continue to have a wide range of interdisciplinary research capacities not existent in other institutions. But there are indications in some areas, especially the technologically relevant ones, that the universities are losing their competitiveness vis-à-vis non-university research institutions and industry, because basic funding by the Länder is not increasing as required and because on the teaching side universities have to cope with a constantly growing number of students. If these development trends continue, the Science Council feels that in the long term

- new research institutions will be primarily set up outside the universities, especially in the expanding application-oriented disciplines, so that

- the close link between research and teaching which is characteristic of German universities is loosened, because institutes specialising in research operate outside the universities and the universities themselves lack the resources needed to create competitive research conditions for academic researchers.

Since for many years the Länder governments have not provided sufficient funds for academic research, quick and extraordinary efforts are needed to meet the pent-up demand. Research promotion through external funds must be able to build on adequate basic funding of the universities. This applies in particular to promotion by the German Research Foundation which, being the largest provider of external funds for universities, plays a particularly important part in research promotion, and it is also true for project promotion by the BMFT.

Dynamism in research also requires institutional dynamism. Nevertheless non-university research institutions continually check whether planned in-house activities could not be carried out just as well, or even better, at the universities.

Cooperation between non-university and academic research is quite extensive and takes place in many different forms. In addition to the direct promotion of university research through federal project funds (about DM 890 million in 1992) the universities also benefit from other federally financed services such as the utilisation of large-scale equipment and other services whose value is currently estimated at approx. DM 1 billion per year.

The better part of these funds goes into providing large-scale equipment at the national research centres. All national research centres cooperate with the universities, in particular those in their regional vicinity. The joint appointment of professors has now become common procedure, especially at the institutions in the new Länder. There is good cooperation between spe-

cial research programmes and postgraduate courses. In many cases the institutions commission the universities to carry out research activities. Finally, non-university research institutions provide a large number of services for universities.

The universities benefit from the involvement of scientists from university research institutions in teaching and in the complementary training of young scientists, especially in those cases where the non-university institutes specialise in areas which are not, or cannot be, equally established at the universities.

Research and development as a responsibility of Fachhochschulen

In recent years Fachhochschulen have played an increasingly important role in technology transfer, in qualified consultancy for industry, in further training as well as in creating a link between regional requirements and applied research and development. They have become important contacts and providers of information, especially for small and medium-sized enterprises.

With their performance in application-oriented research and development the Fachhochschulen can complement and enrich university research. But unfortunately the funding of Fachhochschulen is lagging behind the qualitative and quantitative increase in their functions. Often the necessary equipment is not adequate. Research and development at the Fachhochschulen largely depend on external funds and technology transfer revenues. It is therefore necessary to improve or even create the conditions for a greater involvement of the Fachhochschulen in projects of applied research and development in all disciplines taught there.

University research promotion by the European Community

A major instrument in the European Community's research and technology policy is represented by the four-year Framework Programmes as well as the detailed programmes in various disciplines which build on them. Universities and national research promotion organisations are prepared for active participation in these programmes.

The universities are increasingly participating in EC research and development programmes. Especially universities with a technical and scientific orientation have benefited from the promotion opportunities of the Second Framework Programme (1987 to 1991). Priorities of participation were industrial and materials technologies, information and communication technologies as well as non-nuclear energies and environmental research. German universities also took advantage of the programmes designed to stimulate the cooperation and the exchange of European researchers. Concerning the Third Framework Programme, the universities have expressed great interest in biomedicine, biotechnology and non-nuclear energies.

Cooperation between Federal and Länder governments in research promotion

Responsibilities in the area of research promotion are divided between the Federal Government and the Länder governments according to the federal structure laid down in the Basic Law. Pursuant to Article 30 of the Basic Law, the exercise of governmental powers and the discharge of governmental functions – including government research promotion – shall be incumbent on the Länder in so far as the Basic Law does not otherwise prescribe or permit.

According to the distribution of powers laid down in the Basic Law, and within the framework of concurrent legislative powers, the Federal Government is responsible for the promotion of scientific research (Article 74 No.13 of the Basic Law). It has not, however, made use of its power to promulgate a general research promotion law. The power of the Federal Government to issue framework regulations concerning the general principles governing higher education (Article 75 No.1a of the Basic Law) is also of relevance for university research. It is on this power – as well as on other legislative powers of the Federal Government (such as the one already mentioned according to Article 74 No.13 of the Basic Law) – that the Framework Act for Higher Education is based which also contains provisions relating to research (sections 22 to 26 of the Framework Act for Higher Education).

Pursuant to Article 91a of the Basic Law, the Federal Government participates in the discharge of Länder responsibilities relating to the expansion and construction of institutions of higher education including university hospitals. In performing this joint task the Federal Government bears half the cost. The procedure for cooperation regarding joint framework planning and financing is defined in detail by the federal University Construction Act. Co-financing by the Federal Government of large-scale equipment for universities with a purchasing price of more than DM 150,000 is particularly important for research; in recent years this co-financing scheme has gained increasing significance.

Pursuant to Article 91b of the Basic Law, the Federal and Länder governments may, on the basis of agreements, cooperate in educational planning and in the promotion of institutions and projects of scientific research of supraregional importance. On this basis several agreements have been concluded between the Federal and Länder governments. These agreements

are relevant to the promotion of research outside the universities, and also – especially through the promotion of the German Research Foundation – to academic research. They include

- the administrative agreement between the Federal and Länder governments on setting up a joint Commission for Educational Planning and Research Promotion of June 25, 1970, as amended on December 17/21, 1990;
- the framework agreement on joint research promotion pursuant to Article 91b of the Basic Law of November 28, 1975, last amended on October, 25 and November 13, 1991, which defines the group of research institutions and projects eligible for joint promotion as well as the coordination procedure to be applied;
- additional and implementing agreements filling in the details of this framework.

Federal research promotion is also affected by the unwritten responsibilities of the Federal Government (laid down in detail in a draft agreement on the delineation of powers and responsibilities). In this context, the responsibility of the Federal Government for departmental research is important. It is on this basis that federally funded departmental research institutions are set up in areas such as agriculture, environment, health and defence.

According to the distribution of powers as laid down in the Basic Law, the Länder are responsible for the remaining functions in the area of research promotion. Payroll and current costs of the universities are borne by the Länder.

On the basis of the framework agreement on research promotion pursuant to Article 91b of the Basic Law, the Federal and Länder governments promote the German Research Foundation, the Max Planck Society, the Fraunhofer Society, 16 national research centres, currently 82 Blue List institutes as well as 151 projects of the Academies of Sciences. In 1992 this required a total of about DM 7 billion to which the Federal Government contributed approx. DM 5 billion. The framework agreement on research promotion and the pertinent implementing agreements (cf. Part II, section 7) as well as the descriptions of the individual institutions lay down which Länder contribute to a specific funding project and how the financial burden is shared by the Federal and Länder governments.

The most important body for joint research promotion as well as for mutual coordination and information is the Federal/Länder Commission for Educational Planning and Research Promotion (BLK). In addition to discussing and deciding on specific issues, especially regarding the financing of jointly promoted research institutions, the Commission has also acted as a forum for research policy discussions since 1983. In these talks subjects of mutual interest are discussed by representatives of the Federal and Länder governments as well as of the organisations and institutions involved. The Federal Government and the Länder not only share information on joint research promotion, but also inform each other about the promotion principles and procedures they apply and about research institutions and major projects they fund on their own, as well as about plans for new institutes and new projects. There is unanimous agreement within the Commission that the system of joint research promotion as laid down in Article 91b of the Basic Law has been successful.

The Federal and Länder governments instituted the Science Council as early as 1957. The Council's function is to prepare recommendations for the thematic and structural development of universities, science and research. At the request of the Federal and Länder governments it also comments on specific institutes, developments or plans. Important examples are recommendations for university construction and comments on the higher education situation as a whole, appraisals of jointly promoted research institutions included in the Blue List as well as comments and recommendations concerning specific disciplines. Since its members are high-ranking representatives of science and government who have to undergo certain appointment procedures, this advisory body enjoys an excellent reputation. 32 members were appointed by the Federal President; 24 of them were jointly proposed by the German Research Foundation, the Max Planck Society, the German Rectors' Conference and the Association of National Research Centres and eight were nominated by the Federal and Länder governments. Another 22 members were delegated by the Federal and Länder governments.

Contract research at the universities is subject to the regulations of the Framework Act for Higher Education. These regulations were revised by the third amendment to the Framework Act for Higher Education in 1985; this amendment facilitates the performance of contract research and increases the incentives for raising external funds.

2.2.2. *Non-university research institutions*

2.2.2.1. National research centres

The national research centres are a central element of the German research scene. Their specific strong points are

- the provision of large-scale equipment for research, e.g. particle accelerators, research reactors, research vessels and supercomputers,
- the management of sophisticated technical infrastructures,
- concentrated capabilities for handling complex interdisciplinary issues.

The national research centres are therefore particularly qualified

- to cooperate with universities in important areas of basic research;
- to handle central national programmes in international cooperative projects, e.g. in polar research, nuclear fusion and space research;
- to investigate central issues of environmental and preventive research for the benefit of the general public, e.g. climate research, protection of the atmosphere, soil and ground water protection, contaminated sites, as well as health research including questions of molecular medicine and biotechnological research;
- to contribute to technology development focussing on selected areas which are of great public interest such as environmentally friendly energy supply and key technologies of long-term economic importance (biotechnology, information technology).

To meet worldwide economic challenges national research centres need to use their particular abilities to increase Germany's attraction for industry. The time which elapses between the development of scientific results at the research centres and the development of marketable products has to be shortened. This calls for an intensified dialogue between science and industry.

To accelerate the innovation process new forms of cooperation will have to be considered which will join the classical instruments of technology centres and licensing. One possibility seems to be the pooling of research capacities of research institutions and industry to carry out a project that is limited in time ("temporary initiative"); it also seems conceivable to hive off some units from research institutions into independent operations. This will permit private-sector organisations to co-finance projects and assume economic responsibility. The form of cooperation should be geared to the requirements of the individual case.

European industry is responding to the Single European Market with different forms of cooperation. The national research centres also need to become more European in their outlook. But this process of Europeanisation should not focus on new institutional structures. This would only be opportune in individual areas where European industry, too, is institutionally interlinked. Here, national research centres can make a contribution towards global competitiveness.

The process of building Europe has also increased the importance of the European Community's research policy. It has to be linked with the German national research policy and the research programmes of the various institutions. This implies that the research institutions contribute their specific knowledge to the EC research programmes right from the point of inception. EC research programmes, national programmes and the programmes of the research institutions have to complement each other. EC funds will then be complementary parts of the institutions' budgets.

The BMFT has submitted a funding concept for the development of national research centres up to and including 1995. The national research centres in the old Länder cannot expect their funds to grow before 1994. The BMFT concept distinguishes between different research areas. This is why from 1994 onwards some national research centres will receive more funds due to priority functions in the operation of large-scale equipment or due to other new requirements, e.g. in arctic or cancer research. Others will have to limit their range of subjects and hence will be forced to restructure and cut costs (e.g. nuclear and subsea technology).

2.2.2.2 Max Planck Society

The institutes and other research facilities of the Max Planck Society for the Advancement of the Sciences (MPG) which are distributed over the whole of Germany constitute an essential element of research in this country. The Max Planck Society is currently operating 62 research facilities (of these 57 institutes) in the old Länder as well as 39 research facilities (two institutes, two branch offices of institutes, 28 working groups and seven humanistic centres) in the new Länder. The MPG tends to concentrate on basic research in selected areas of the sciences and humanities. In particular, it takes up new promising research subjects which have not yet been adequately integrated in the universities or cannot be integrated there, e.g. because of their interdisciplinary character or because of the higher level of funds and effort they require. An indispensable prerequisite for introducing new research projects is the possibility to recruit researchers and scientists with outstanding scientific qualifications. Many MPG facilities are enjoying an excellent international reputation which in recent years has been reflected in the fact that several MPG scientists were awarded the Nobel Prize.

The MPG cooperates with the universities, making its large-scale equipment (e.g. telescopes) available to academic research as well.

The Federal Government welcomes the cooperation between the MPG and the universities. A case in point is the cooperation of Max Planck Institutes and univer-

sities in several special research programmes and in developing joint basic research priorities in the field of genetic engineering. There are similar cooperative projects in clinical research.

After German unification the MPG has also started activities in the new Länder. It intends to create as many institutes in the new Länder in the medium term as there are in the old Länder. In doing so it will be guided by the time-tested principles which have made its work so successful in past decades.

2.2.2.3 Fraunhofer Society

In jointly funding the Fraunhofer Society (FhG) the Federal and Länder governments are aiming to promote the practical application of scientific findings in the area of applied research. The Fraunhofer Society is an important partner of industry because it performs contract research, offers information and services relating to new technologies, products and processes and provides initial and further training courses for qualified personnel.

The FhG makes important contributions towards the *innovative strength of German industry*:

- It identifies innovation potentials at an early stage by closely watching technological development;
- it meets the demand of industry for specific long-term contract research;
- it can adapt its tools and abilities to meet the requirements of the research market.

In addition, it performs research work for public-sector clients.

The Federal and Länder governments have given sustained support to the strong growth of the FhG over the last ten years. There is no other research institution which has grown as much over that period.

It is characteristic of this specific financing model that unlike other publicly funded research facilities the FhG receives only little basic funding and has to cover its costs primarily by using revenues from contract research and services performed for private and public clients. Public funding also depends on the total amount of revenues. Since 1986 basic financing has mostly developed in parallel with the revenues.

The FhG financing model was reviewed and updated by the Federal/Länder FhG Committee in 1982 and 1986 and on September 30, 1992. The Committee agreed that by the end of 1995 revenues would cover one third of the cost of the contract research service sector and that from then on this proportion would increase even further. Basic financing will also be provided in the future in order to ensure the necessary in-house and pre-competitive research required for the transfer of scientific findings to industry.

The pioneering efforts of the FhG in the new Länder deserve a special mention. The local Fraunhofer facilities currently have a staff of 1,000, complementing the range of research activities of the institutes in the old Länder. They are to be expanded steadily.

It will be important in the future to enhance the role of the FhG as a "producer of productivity" which was successful in many areas, especially production technologies. This calls for an even closer cooperation with industry in determining the thematic orientation of the individual institutes and in setting priorities in the selection of industry-related research areas. With the support of the BMFT, the FhG will address new issues relating to the technologies of the 21st century, and continue to make active use of its institutes' potential, created by the FhG model, for the dynamic development of industry and research in Germany.

2.2.2.4 Research institutions included in the Blue List

According to Article 2, para. 1, Nos. 5 and 6 of the framework agreement on joint research promotion concluded pursuant to Article 91 b of the Basic Law between the Federal and Länder governments on November 28, 1975, independent research institutions and facilities having a service function for research as well as organisations supporting research institutions are funded in addition to national research centres, the Max Planck Society and the Fraunhofer Society, provided they are of supraregional importance and national scientific interest. They are registered in the Blue List, an annex to the implementing agreement on research institutions of May 5/6, 1977 whose first edition was printed on blue paper.

Until 1991, the Blue List comprised 48 institutions in the old Länder with a staff of about 4,800. In the wake of German unification and as a result of the ensuing development of a new pan-German research sector, the Blue List – in keeping with the recommendations of the Science Council – was extended in 1992 to include another 34 institutes in the new Länder. 82 institutions are currently listed. They differ very much in terms of function, size, location and legal structure.

In addition to university research, MPG, FhG, national research centres and departmental research, the Blue List institutions constitute one of the cornerstones of German research. Together with the host Länder they have identified research priorities of supraregional importance so that they can be considered a major instrument of federal research policy.

The Blue List institutions have so far been organised in eight sections: humanities and social sciences, economic sciences, education sciences, medicine, biology, other natural sciences, information and documentation as well as museums (only their research activities).

Following the great expansion as a result of the restructuring of the science and research sector in the new Länder, the Blue List has moved into the focus of

science policy considerations concerning the further development of the German research system. This is why in 1992 the Science Council set up a working group to reorganise the Blue List. The working group's mandate is to examine the science policy function and future organisation of the Blue List. It will concentrate in particular on issues of future performance assessment and the control of Blue List institutes by research policy.

2.2.3 Young scientists

Scientific and technological progress is not possible without qualified and motivated young scientists. The quality of junior scientists determines the value of German research and technology. In order fully to tap the existing innovation potential in science and research young qualified female scientists need to be promoted much more than has hitherto been the case.

The training as well as the continuous integration of young scientists into the research process are tasks to which the Federal and Länder governments – within the framework of their responsibilities – give particular attention. This is all the more urgent as the career opportunities of young scientists in basic research, especially at universities, have dramatically deteriorated since the early 1980s. The main reason is the unfavourable age structure which has developed as a result of the expansion of universities and scientific institutions during the 1960s and 1970s.

In the 1990s this has led to changed conditions with considerably increased needs for replacement and renewal at universities and non-university research institutions:

- About half of the professors and more than one third of the scientists at non-university research institutions will retire over the next ten years. As a result, the career opportunities of young scientists will improve, especially from the mid-1990s onwards; however, there will be differences between the various disciplines. It is now of critical importance to train a sufficient number of highly qualified scientists in order to meet this future demand. In this process special consideration is to be given to women who so far have been greatly underrepresented in the higher education sector.

- Career opportunities for young scientists in basic research are also opening up in the new Länder. The renewal that has been started there involves institutions and especially staff and provides young scientists with a large number of additional opportunities. Great efforts have to be made to offer suitable junior staff from the new Länder the possibility to qualify locally. Career perspectives need to be opened up to prevent qualified scientists from leaving the new Länder.

The Federal Government greatly welcomes the commitment of industry to promoting young scientists. But at the same time it is convinced that opportunities for qualified junior scientific staff have to be opened up also in non-industrial areas. To this end the Federal and Länder governments and research institutions initiated a number of schemes in recent years, especially in response to changed basic conditions. The following activities are relevant to the higher education sector:

- In response to a memorandum by the science organisations on "Safeguarding the Efficiency of Academic Research and Promoting Young Scientists" the Länder have established additional professorships which from the mid-1990s onwards will be cut down again since regular positions will then become vacant ("Fiebiger Plan"). A total of about 800 professorships is being created under this programme.

- In 1977, the Federal and Länder governments adopted the "Heisenberg Programme" for the promotion of highly qualified young scientists and entrusted the German Research Foundation with its implementation. This programme has been successful. The Second Special University Programme includes a modified Heisenberg Programme which is also financed by the Federal and Länder governments on a 50:50 basis and makes it possible from 1991 onwards to apply for and grant not only scholarships, but at the same time also the staff and equipment required for the research project in question. A special concern is the increased promotion of women in science.

- Since 1985 the Federal Ministry of Education and Science has provided the German Research Foundation with special funds for a post-doctoral programme. It is designed to enable particularly well qualified young post-doctoral researchers to participate in basic research, especially at universities and abroad, for up to three years immediately after obtaining their doctorate.

- Foundation professorships of the kind promoted since 1985 by the Donors' Association for the Promotion of Sciences and Humanities in Germany under a special programme also contribute to reducing the effects of the unbalanced age structure at the universities on the career opportunities of young scientists.

- An important new structural element of the promotion of junior scientists is constituted by the postgraduate courses suggested by the Science Council which offer doctoral candidates the opportunity to prepare their thesis within a major coherent research project and at the same time enroll in systematic postgraduate studies. On December 21, 1989, after an experimental phase including pilot projects and based on ongoing experience gathered with foundation-funded courses, the Federal and Länder governments adopted a scheme for promoting postgraduate courses and entrusted the German Research Foundation with its implementation. By the end of 1992 the German Research Foundation had selected and included in the promotion scheme almost 200 postgraduate courses from all disciplines, including also some courses in the new Länder, in which 4,000 to 5,000 doctoral candidates and up to 400 post-doctoral researchers receive basic research training.

In order to reform the structure of academic studies it is intended to expand postgraduate studies and establish postgraduate programmes in major subjects.

- The Second Special University Programme adopted on October 2, 1990 by the heads of the Federal and Länder governments is a milestone in improving the promotion of young scientists. For the decade from 1991 to the year 2000 the Federal and Länder governments will provide another DM 4 billion in the old Länder which will mainly be spent on promoting junior scientists at universities and non-universitiy research institutions. One programme priority is the specific promotion of female scientists and the creation of conditions conducive to improving the compatibility of scientific qualification on the one hand and family care on the other. The promotion of women is to be increased to such an extent that their number at the next higher level of qualification corresponds to the number they had already reached at the lower level; for example, the aim of this scheme is to ensure that the number of female doctoral candidates corresponds to that of female students having graduated from a study course.

  The University Renewal Programme for the new Länder also serves the interests of junior scientists through its differentiated schemes for "Habilitationsförderung" (support of scientists doing research for securing the right to lecture in a particular subject at a German university), for post-doctoral promotion as well as postgraduate promotion including postgraduate courses. The Federal Government funds 60 % of the Second Special University Programme and 75 % of the University Renewal Programme.

With their laws on postgraduate promotion the Länder also make a direct contribution towards the training of qualified young scientists. In 1992, about 2,100 doctoral candidates benefited from this type of promotion.

Equally important is the funding of the nine nationwide organisations for the promotion of young talent by the Federal Ministry of Education and Science. In 1992, the ministry appropriated some DM 122 million for these schemes for the benefit of more than 12,000 students and about 2,000 doctoral candidates.

In the past few years the non-university research institutions also initiated special schemes similar to those of the universities. It is important to note that since the universities are overcrowded, the non-university research institutions are much more called upon than before to contribute – in keeping with their size and importance – towards the qualification of young scientists. The following measures have been taken:

- About 4,300 jobs for doctoral candidates have been created at non-university research institutions. Under the Special Programme II funds are earmarked for a total of another 2,800 doctoral candidates over ten years in addition to those 2,500 whom the institutions provide with scientific jobs anyway.
- The national research centres employ 600 post-doctoral researchers under permanent promotion programmes.
- The Max Planck Society offers two-year scholarships for 140 German and 340 foreign post-doctoral scientists. In addition, there are another 450 post-doctoral places at Max Planck Institutes, which are funded from other sources. Based on the "Fiebiger Plan", a programme is underway for the promotion of highly qualified young scientists under which another 50 scientists are employed for a period of ten years.
- Under the Second Special University Programme funds will be earmarked over a period of 10 years for an additional 1,000 post-doctoral scientists to qualify at non-university research institutions for a period of three years each.

Supporting young scientists will remain a central challenge for research and science policy. This and the number of students to be expected call for measures to be taken with regard to the size and the structure of the higher education system. It is expected that in the new Länder the number of new students will have doubled by the year 2000 which of course will have an effect on the total number of students; an increased demand for study places is also expected in the old Länder. This is a development which can also be observed in other industrialised nations. Planning has to take account of this new dimension of the demand for university training and scientific qualification, especially as regards scientific personnel. At the same time, academic research performance and hence the training of researchers have at least to maintain their current high level. This objective cannot be attained with bridging and temporary measures alone; it also calls for structural, organisational and thematic university reforms. To this end, the Federal Ministries of Education and Science and for Research and Technology submitted an education and research policy paper to which the Federal Cabinet consented on February 3, 1993.

Scientific innovations and a high level of efficiency can only be ensured and developed further if all existing resources are adequately tapped. A major potential for science which so far has not been exhausted is academically qualified women. In spite of the substantially increased number of women in highly qualified educational courses women are still heavily underrepresented in the research and science sector. This applies in particular to top positions and especially to professorships and directorates of research bodies and institutions.

When female managers as a role model are rare or even non-existent in science, this has a negative effect on the involvement of young women and their motivation to select a study course and take up a scientific career. In the Federal Government's view the specific promotion of women in the science sector is an essential contribution towards improving the quality of research and science. This is why the hitherto successful research instruments, e.g. the various scholarship schemes, were complemented by specific women- and family-friendly offers such as extended basic promo-

tion periods and part-time scholarships, scholarships for postgraduate refresher courses and for re-entry into university, as well as funds for job contracts for female students and differentiated child care allowances.

2.3 Creating an innovation-friendly climate

It is a priority objective of the Federal Government's research and technology policy to create and maintain conditions that are conducive to innovation. Debureaucratisation and deregulation are permanent tasks in general, and in particular for research and technology policy. When removing obstacles to innovation, such as legal regulations and bureaucratic procedures, the Federal Government will also have to tackle regulations for whose existence it shares responsibility.

A case in point is the law on genetic engineering. The consequences of the hyperbureaucratic provisions of this law have considerably complicated research and production in the genetic engineering sector in Germany in recent years. Until 1992, only two genetically modified plants were released in Germany, compared with a total of 858 in the OECD states. This is why the Federal Government prepared an amendment to the law in order to improve conditions governing research and development in genetic engineering; this amendment was adopted by the Cabinet in May 1993. In addition, the Federal Government will advocate an amendment to the pertinent EC directives.

The same applies to the law on the protection of animals: An amendment which has been prepared at the Länder level would complicate conditions for scientific research even further. The Federal Government aims to improve the research conditions by consistently supporting the development of methods which could replace animal experiments while at the same time making all necessary efforts to maintain the possibility of animal experiments where they are absolutely necessary.

Fiscal policy has a great impact on the R&D commitment of German industry. It has to be of a long-term nature, aiming at strengthening the forces of growth. In view of the international environment it is particularly necessary to improve company taxation. In recent years the most important industrialised countries have considerably improved fiscal conditions for businesses. Consequently, the relative competitive position of Germany has deteriorated. With the law to maintain and improve the Federal Republic of Germany as a location for business, investment, production, research and development the Federal Government is aiming at noticeably improving company taxation. Germany is the only major industrialised country which does not offer any tax incentives for research and development. In view of the current budgetary situation and its future overall concept for a company tax reform the Federal Government therefore intends to examine revenue-neutral tax models for research and development as well.

Technology-oriented basic conditions have to ensure that businesses have adequate financial strength to undertake innovation efforts that are of macro-economic interest. The high equity ratio of German industry is a favourable prerequisite. Setting up new technology-based firms, however, remains particularly difficult. The Federal Government's second pilot project for the promotion of new technology-based firms aims to encourage the provision of direct-investment capital of DM 300 million in the period from 1989 to 1994, and hence the development of a risk capital market in Germany.

In important technological areas, e.g. in information and communication technology, standardisation is an integral part of technical development. It must always begin before incompatibilities between concurrent standards occur, because experience has shown that these can only be eliminated with great difficulty and financial sacrifices. Standardisation within the EC that runs parallel to development is meant to help ensure that new products and processes are developed not only for the national market. This will save costs and increase the competitiveness of European industry – especially in high-tech markets with their ever shorter product cycles – vis-à-vis countries with large domestic markets like the USA and Japan.

Databases and technical communication networks increase the efficiency of information transfer and offer the possibility of mastering rapidly growing global knowledge. Access to scientific and technological information plays an important part in the competition of countries eager to be locations for research and technology.

This is why the BMFT supports the development of, and access to, scientific and technical databases. Of particular importance are specialised information centres which not only have their own supply of data, but also act as nodes in international science and research networks. Through the expansion of an integrated chemical information system in late 1992, STN Karlsruhe, which connects the Karlsruhe specialised information centre with the Scientific and Technical Information Network (STN International), became one of the globally leading providers of factual information.

Improving these important basic conditions for research and development can often support the implementation of innovations more effectively than the use of public funds.

3. International cooperation in research and technology

3.1 Basic elements

The improvement and intensification of international cooperation pose a special challenge to all those who are involved in the process of research and technology development in Germany. To create the necessary conditions for this and to further and support cooperation is one of the priorities of the Federal Government's research policy.

There are many reasons for international cooperation in research and technology which in different ways also define the role the government has to play in this collaboration:

- The exchange of knowledge from scientist to scientist beyond national borders has always fertilised science and permits an international division of labour as well as specialisation.

- Cross-border issues which, for instance, arise in environmental sciences and geosciences can obviously only be solved in international and, more recently, often global cooperation.

- Some new lines of research, such as genome research, are so complex that they can only be tackled successfully if the intellectual resources available worldwide are pooled.

- In some areas (e.g. high-energy physics, fusion, space flight) the costs of large-scale equipment and research infrastructure have reached dimensions which exceed the financial strength of individual states.

- In the area of industrial research and development worldwide competition can force businesses to pool their resources across national borders. Also with regard to standardisation issues it is very important that other countries are involved in technological projects at an early stage.

- International cooperation in research and development contributes to attaining overriding political objectives, e.g., by supporting change in Central and Eastern Europe or by providing assistance to the Third World.

Research policy, too, is committed to securing world peace which must be the ultimate objective of any policy. The Federal Government is aware that this might result in barriers to international cooperation in research and technology. In many areas today, science and technological development provide a high measure of knowledge which can be abused for the development and production of weapons of mass destruction and therefore must not be disseminated without any control. Recognising these dangers and checking them, if necessary, by limiting the transfer of technologically useful knowledge requires each and every researcher to be on his guard and show responsibility. This is obviously also a task of government which has to balance – very carefully and bearing in mind the freedom of science as prescribed by the Constitution – the desirability of an unimpeded cross-border exchange of scientific knowledge and the necessity of preventing the proliferation of weapons of mass destruction. In this context, the Federal Government has taken a number of measures in recent years which are constantly examined in the light of current developments for their necessity and effectiveness and, if necessary, complemented. The exchange of views and experience as well as the consultation with other countries are very important, because the proliferation of weapons of mass destruction can only be countered effectively through the agreed cooperation of all those states which posess the pertinent knowledge and technologies.

3.2 Priorities

The challenges confronting German research policy in this decade determine the priorities of international cooperation. Of special importance are

- the completion of the European research and technology community within the framework of the European Communities,

- assistance for the countries in Central and Eastern Europe including the successor states of the Soviet Union,

- increasing commitment in worldwide cooperation in the high-technology sector and to protecting life and the environment in the global process of change,

- intensified cooperation with developing countries, especially newly industrialised countries,

- cooperation with industrialised countries, especially the USA, Japan, France, the United Kingdom and Israel.

3.2.1 Completion of the European research and technology community

Scientists, institutes and companies in many areas take intensive transfrontier cooperation in research and technology within Western Europe so much for granted that government support or bilateral agreements between the governments are needed only in a few exceptional cases. This is why the function of government can be limited to national measures, which often fall under the responsibility of the Länder, such as the removal of bureaucratic obstacles and the provision of adequate funds for travel and scholarships.

On the other hand, international and supranational organisations as well as multilateral initiatives are gaining increasing importance for cooperation in Western Europe. The Federal Republic of Germany is a member of, and one of the most important contributors to, most European research institutions, e.g. in the areas of space research, high-energy physics, neutron and synchrotron radiation, molecular biology, as well as astronomy and weather forecasting. This is why cooperation is more and more shaped by participation in the consultative and decision-making bodies of these organisations. The Federal Government acknowledges this by participating actively in, and contributing numerous initiatives to, the international discussion and decision-making process in these bodies. In the dialogue with its partners it is constantly aiming at improving the conditions for a meaningful division of labour between national and international research institutions.

The European Community is in the centre of European research and technology cooperation. In recent years its research and technology policy has gained so much significance that even in the bigger member states it has become an independent factor in research promotion and technology development, appearing side by side with national policies. In some areas EC promotion has achieved particular importance, e.g. in fusion research, where it coordinates – and to a considerable extent also finances – all activities in the member states. The EC contributes a large part to the publicly funded promotion of industry-related information technologies, also in Germany.

The Treaty on European Union (Maastricht Treaty) gives Community research and technology policy greater weight: The previous objective of strengthening the scientific and technological bases of Community industry and encouraging it to become more competitive at international level remains unchanged. In addition, a further objective is formulated in the Treaty, viz. "promoting all the research activities deemed necessary by virtue of other Chapters of this Treaty" (Article 130f). This had been foreshadowed by recent developments: For several years Community research and technology policy has covered subjects which in part only indirectly support the objective of strengthening European industry, such as medical research, environmental research and the exchange of scientists. In the Federal Government's view it is particularly important that in this respect Community research and technology policy should be subsidiary to national policies.

Due to its linkage with industrial policy which has now been included in the Treaty, Community research and technology policy has assumed a new feature: The industrial policy of the Communities now also comprises the "encouragement of a better utilisation of the industrial potential of policy in the areas of innovation, research and technological development." Under no circumstances can it be the function of government industrial policy to tell businesses what road and direction to take for a necessary structural adjustment or to intervene in investment and innovation processes by means of subsidies and protectionist measures.

Community research and technology policy has always served other Community objectives as well. This applies in particular to the policy for the promotion of economic and social cohesion within the Community, the so-called objective of cohesion. It aims to narrow the gap between the R&D capacities of the various regions in the Community.

Community activities in the area of promoting scientific and technical cooperation with non-EC countries are also gaining more and more importance. Specialised programmes were opened up for participation of third countries and measures were created for cooperation with developing countries. The scheme for supporting cooperation with Central and East European countries initiated in 1992, involvement of the EC in the International Science and Technology Centre in Moscow as well as the foundation of the International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union deserve a special mention. The Federal Government supports these activities.

In late 1992, the ongoing Third Framework Programme was upgraded considerably. It provides the basis for the Community's specific programmes for research and technology promotion.

In its memorandum of February 1992 the Federal Government made proposals for the future organisation of the EC's research and technology policy, some of which were included in the plans for the Fourth Community Framework Programme in the area of research and technological development (1994 to 1998). These proposals encompass

- greater focussing of specific programmes, and within these programmes concentration of funds on priority areas in order to increase efficiency,
- concentration on programmes for pre-competitive application-oriented research, including standardisation and preventive research, which applies in particular to environmental and medical research, renewable sources of energy, as well as fusion and safety research,
- integration of climate research based on the model of fusion research, i.e. the leading climate research centres are invited to develop, in cooperation with the Commission, a homogeneous programme for the entire EC which is to be based on a division of labour,
- increased EC participation in EUREKA projects,
- improved terms and conditions for the participation of small and medium-sized enterprises in Community programmes,
- decentralised administration of the Commission's programmes.

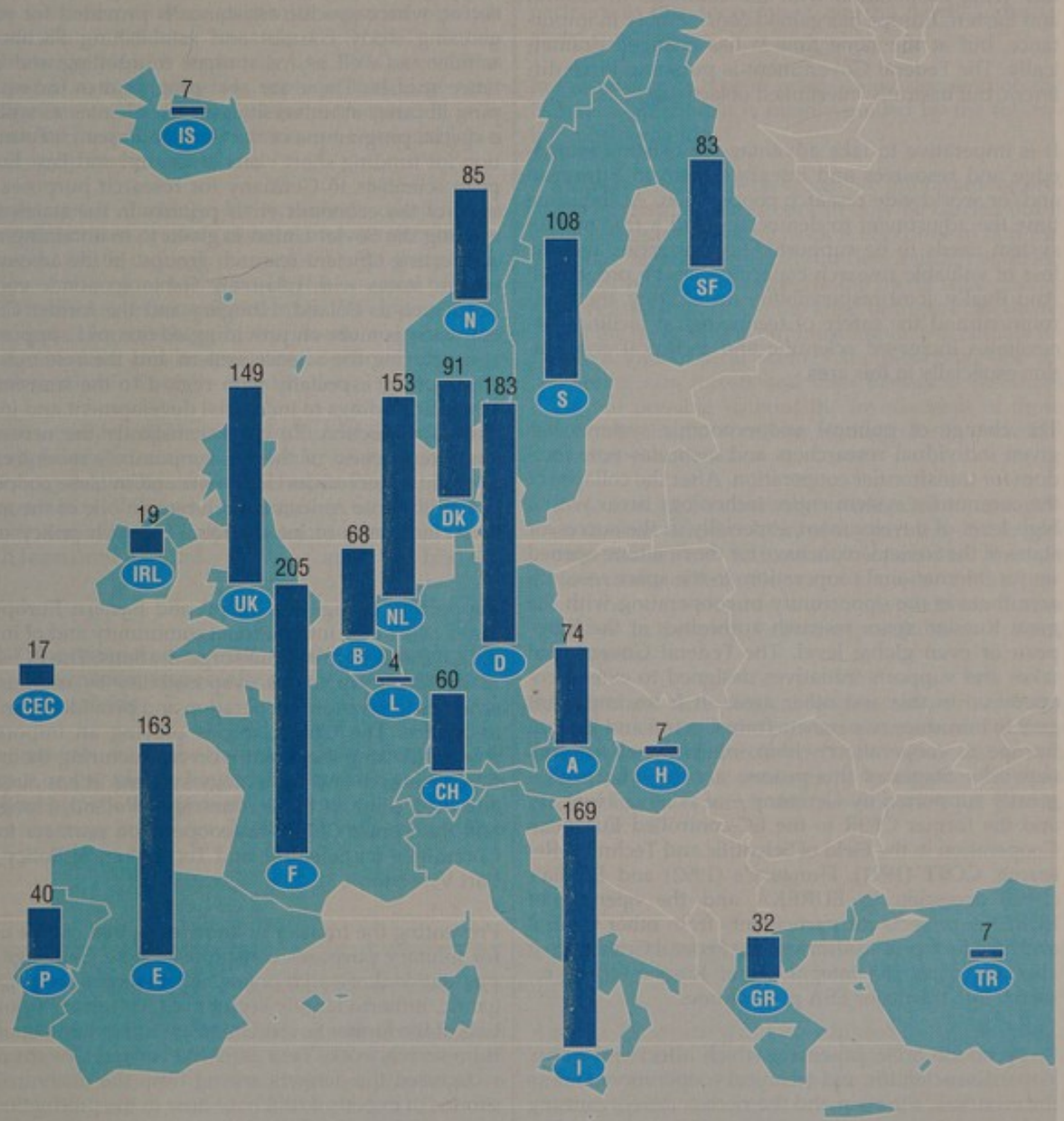
In view of the increased importance of EC research promotion, the major self-government organisations of German science are striving to gain a greater influence on the conception and implementation of EC programmes. They are involved in a dialogue with the science organisations of other member states, with the EC Commission as well as German government agencies.

Apart from direct EC promotion EUREKA is the most important instrument for creating a European research and technology community. With its large group of participants, its flexible project-related approach and its basic openness for the participation of third countries EUREKA is particularly instrumental to creating a "greater Europe". The Federal Government is endeavouring to enhance the role of EUREKA by initiating "flagship" projects in specific high-tech areas (cf. Figure I/5 as well as Part II, section 9 and Part V, section 1).

Figure I/5

EUREKA and Europe

1992 Project participation of EUREKA members



As of October 15, 1992

Source: EUREKA Secretariat, Brussels

BMFT, BuFo '93

3.2.2 Assistance for Central and East European countries including the successor states of the former Soviet Union

The revolutionary changes in Central and East European countries which obviously also affect their science systems offer great opportunities for intensifying scientific and technical cooperation. But at the same time they entail the task for the research policies of the Western states as well as of the EC and the international organisations to provide the necessary assistance. Due to the political reform process of the past few years cooperation with the countries in Central and Eastern Europe has gained considerably in importance, but at the same time it has changed dramatically. The Federal Government is pursuing three different, but basically interlinked objectives:

It is imperative to take advantage of existing knowledge and resources and integrate them in European and/or worldwide research cooperation. At the same time the adjustment to democracy and a free market system needs to be supported so that crises and the loss of valuable research capacities can be prevented. And finally, joint responsibility for ecology, the environment and the safety of technological facilities necessitates increased scientific and technical cooperation especially in this area.

The change of political and economic systems has given individual researchers and institutes new freedom for transfrontier cooperation. After the collapse of the communist system entire technology areas with a high level of development, especially in the successor states of the Soviet Union, have for the first time opened up for international cooperation. In the space research area there is the opportunity of cooperating with the great Russian space research authorities at the European or even global level. The Federal Government takes and supports initiatives designed to extend cooperation in this and other areas. It is an important goal to introduce researchers from Central and Eastern Europe to cooperation within international research networks. Stages of this process are the admission – greatly supported by Germany – of Poland, Hungary and the former CFSR to the EC-controlled European Cooperation in the Field of Scientific and Technical Research, COST (1991), Hungary's (1992) and Russia's (1993) accession to EUREKA and the opening of EUREKA projects for participants from other Central and East European countries. The Federal Government also advocates the integration of Russian space research into the major ESA programmes.

Problems do arise, however, which affect and partly jeopardise scientific and technical cooperation. Due to the economic situation and the necessary reorganising and restructuring processes the partly excellent scientific and technical potential is threatened with irreversible damage, especially by the exodus of qualified scientists to non-scientific areas or other countries. The states in the West are thus facing the task of supporting the inevitable restructuring of the research and technology system in the Central and East European countries including the successor states of the Soviet Union by word and deed as well as of making financial contributions during a difficult transitional period in order to maintain efficient research and technology potentials.

The Federal Government is meeting this challenge with a host of measures which are realised within its "Overall concept for counselling on establishing democracy and social market economy in the states of Central and Eastern Europe and the CIS". The activities in the area of research and technology comprise a wide range of different individual measures. They are complemented by schemes in the higher education sector, where specific assistance is provided for reorganising study courses and establishing Fachhochschulen, as well as for student counselling and distance studies. There are also programmes for equipping libraries at universities and academies as well as a special programme of the German Research Foundation for funding short visits of Central and East European scientists to Germany for research purposes. In view of the economic crisis priority in the states succeeding the Soviet Union is given to maintaining and supporting efficient research groups. In the advanced reform states with relatively stable economic conditions such as Poland, Hungary and the former CSFR emphasis is more on providing advice and support in restructuring the science system and the research infrastructure, especially with regard to the transfer of scientific findings to industrial development and innovative production. To check constantly the necessity and effectiveness of these – temporary – measures in the light of recent developments and in close cooperation with those concerned will remain one of the most important tasks of international research policy over the next few years.

Supporting change in Central and Eastern Europe is also a task of the international community and of international and supranational organisations. The EC is already facing up to this responsibility by organising schemes to promote cooperation and provide technical assistance. The OECD, too, is playing an important role in advising these states on restructuring their national research and technology systems. It has already admitted some of these countries – Poland, Hungary and the former CSFR – as cooperation partners to its Committee for Scientific and Technological Policy (cf. Part V, section 1.3).

Preventing the transfer of knowledge that can be used for military purposes constitutes a new challenge for international research policy. It is essential that the gigantic, hitherto largely secret military research potentials of the former Soviet Union are integrated in peaceful research work. Very early the Federal Government recognised the dangers arising from the uncontrolled exodus of experts with know-how in the production of weapons for mass destruction; together with others it has therefore initiated the foundation of the "International Science and Technology Centre" in Moscow by the EC, Japan, the USA and Russia, which is intended to create new civil employment opportunities for the experts in their own country. Through the EC the Federal Government will continue to be actively involved in the work of the Centre.

3.2.3 Worldwide cooperation in high technology and environmental research

Some of the current scientific and technological challenges are so complex that they can only be mastered in worldwide cooperation, coordinating and pooling all available intellectual and material resources irrespective of geographical or political borders. Since the political blocs no longer exist, the conditions for this cooperation seem to be as favourable as never before. Intensifying worldwide cooperation will therefore be one of the priorities of the German international research policy over the next few years. Major potentials have been identified in particular in space research (Space Station), fusion research (ITER/NET) and in high-energy physics (especially at CERN) as well as the need in these areas for sophisticated large-scale equipment and technological infrastructure. It is in particular the potential integration of Russia which is opening up new perspectives.

Another great challenge for worldwide coordination is research into global climate and environmental changes, which can only be realised with the participation of all regions of the world. It is essential to build up suitable research capacities in the developing countries and integrate them in worldwide research. The United Nations and its specialised agencies appear to be most suitable for these coordination activities.

Cooperation among the major industrialised nations in the sophisticated areas of molecular biology and neurobiology is stimulated by the Human Frontier Science Programme (HFSP) which is based in Strasbourg and run by a number of European countries in cooperation with Japan and the USA.

3.2.4 Increased cooperation with developing countries, especially newly industrialised countries

The imperilment of the natural basis of continued existence on our planet, limited resources as well as population growth and poverty in the developing countries are more and more developing into great global problems which will become even more severe in the future. Since they are directly interactive, all attempts at solutions are being complicated even more.

The United Nations Conference on the Environment and Development which took place in Rio de Janeiro in June 1992 has made this abundantly clear; it called upon the international community to make every effort to harmonise the requirements of economic growth with the preservation of our natural recources. To make a contribution towards this goal is the intention of the Federal Government's scientific and technical cooperation with developing countries; the main partners in this cooperation are the newly industrialised countries.

In this particular type of international cooperation the Federal Government is mainly guided by the following considerations:

- Many research projects which are important for preserving natural recources can only be carried out if the necessary scientific work is also done in non-European regions, especially in developing countries. This applies, for example, to the use of solar energy as well as to studies in the areas of tropical medicine and the geosciences. But most important, climate research and tropical ecology for preserving the remaining rain forests and their biological resources are not possible without the involvement of those countries in the Southern Hemisphere that are immediately affected.

- Project-related cooperation is intended to strengthen the scientific capability of the partners and to prepare them for industrial cooperation through the transfer of technology and know-how, thus paving the way towards a technology-driven future that is in keeping with the possibilities of these countries.

Scientific and technological cooperation with developing countries serves the primary objectives of the Federal Government's foreign policy: to secure peace and safeguard economic interests by establishing a close partnership in research and development (cf. Part V, section 3).

The impact of the UN Conference in Rio on research policy

The United Nations Conference on the Environment and Development (UNCED) held in Rio de Janeiro in June 1992 initiated the worldwide reorientation of ecological and economic development. The Rio Declaration encompasses important principles of environmental and development policy, such as the right of all countries to development while preserving their political and cultural identity, as well as the obligation of countries to apply the polluter-pays principle and the principle of preventive action and to integrate environmental protection into all areas of politics.

Agenda 21, which was also adopted in Rio, is a development and environmental policy action programme for the next century which was jointly drafted by the industrialised countries and the developing countries and defines a host of important research and development tasks. The latter also applies to the Framework Convention on Climate Change which was signed by 162 states and aims to protect the Earth's atmosphere and especially to stabilize the atmospheric concentration of greenhouse gases on a level where a dangerous man-made perturbation of the climate system can be prevented. To

attain these objectives important research issues need to be solved.

The Convention on International Trade in Endangered Species which was signed by 160 states can only be implemented if adequate biotopes are preserved for the various animal and plant species. As these biotopes compete with the space claimed by the growing human population, intensive research has to help find a viable compromise satisfying both claims. Until then the protection of biotopes and hence the protection of species have to be handled very strictly in order to preserve the species that still exist and not expose them to any greater danger.

The "Conceptual Framework for Research on Global Change" adopted in April 1992 reflects the research policy conclusion that the Federal Government has drawn from the environmental changes that are currently taking place or are foreseeable today. The UNCED resolutions have confirmed the appropriateness of this concept.

The major tasks resulting from the Conceptual Framework for Research and the UNCED resolutions relating to research activities in the next few years can be divided into three groups.

System studies

The gaps in our understanding of the system Earth need to be closed so that the type and scope of future environmental changes can be forecast with greater accuracy. Research efforts are focussing on

- climate system research, with special attention being given to the hydrological cycle, the cycle of trace substances, natural climate variability and signal analysis;
- a better understanding of stratospheric processes contributing to ozone depletion;
- changes in the oceans and ice regions;
- the peril to sensitive land ecosystems;
- atmospheric research.

Impact studies

This type of research studies the impact of system changes with regard to

- the potential economic and far-reaching social consequences of global environmental changes, especially the greenhouse effect, for the various countries and for sensitive regions (e.g. rising sea level, shifting climate zones, losses in agricultural production);
- the consequences for natural ecosystems.

Studies of possible action

Existing technologies need to be made more environmentally compatible, and at the same time socio-economic research has to be carried out to provide a basis for an environmental policy strategy. This research is intended to alert international policy-makers to action that needs to be taken and to identify options which can ensure sustained and viable development.

The research tasks primarily include

- research concerning the perception of global environmental problems and environmental awareness so as to further the acceptance of necessary action for viable developments;
- research with a view to the environmentally compatible change of economic structures.

3.3 German research policy in international comparison

National research policy receives important impulses from the numerous links with the research policies of our partner countries as well as from the international exchange of views and experience concerning questions of research and technology policy, which is conducted within the OECD and the European Community as well as on a bilateral basis.

Whereas the general development trends of research policies often display remarkable parallels, there are considerable differences in the institutional structure of research promotion, the ratio of public to private research funding as well as the interpretation of the role of government.

A comparison between German research policy and the policies of France, the United Kingdom, Japan and the USA highlights the following major differences:

When the total of public and private expenditure on research and technology is expressed as a percentage of the gross domestic product, Germany, the USA and Japan are the leaders among the major industrialised countries. Whether Germany can keep this top position cannot be predicted in view of the declining expenditure by industry (cf. Figure I/6).

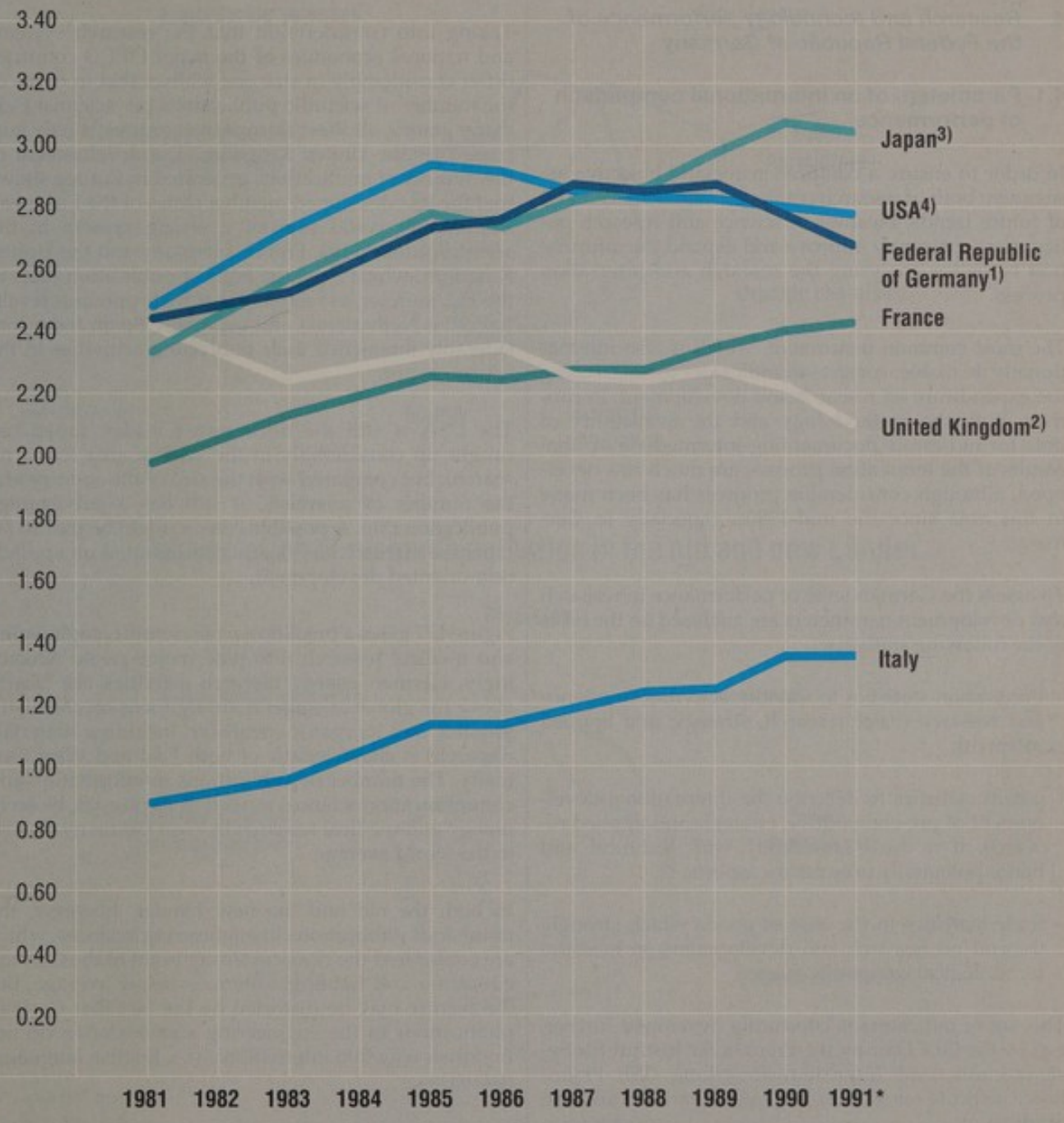
A breakdown by funding sources, however, shows that the share of industry, which in Germany amounts to almost two thirds of the expenditure, is even higher in Japan, with the share of public funds obviously being lower. In the USA – like in France and the United Kingdom – a particularly high proportion of public expenditure is accounted for by defence research, whose share is even smaller in Japan than it is in Germany. However, a trend has recently emerged in the USA towards increased public funding of civil research.

The comparison of research structures shows first of all that in France central agencies play a leading role

Figure I/6

Gross domestic expenditure on research and development (GERD) in selected OECD countries, 1981 to 1991

– as % of GDP –



* Provisional OECD data, based partly on national estimates, partly on OECD estimates.
1) 1987 break in series with previous years; 1986 and 1988 estimates, 1990 and 1991 revised estimates.
Up to and including 1990 former West Germany, 1991 Germany as a whole.
2) 1991 data provided by Central Statistical Office, London (March 31, 1993)
3) R&D expenditure overestimated.
4) Excludes most or all capital expenditure.

Source: OECD (1992/1) and BMFT calculations.

BMFT, BuFo '93

which facilitates the concentration of resources on priorities and a more flexible and clearer definition of focal points. In Japan the broad-based consensus between government, science and industry on policy questions is of special importance. The British system is characterised by the marked tendency to leave the funding of research and technology, with the exception of basic research, primarily to market forces.

4. *Research and technology performance of the Federal Republic of Germany*

4.1 Parameters of an international comparison of performance

In order to ensure a comprehensive and objective assessment both of research results already achieved and of future trends, businesses, science and research policy must constantly improve and expand the information bases for analysing the research and innovation process.

The most common instrument, which is also internationally available, consists in indicators for measuring the expenditure on research and development. In contrast, both the methodology and the availability of data for indicators documenting intermediate or final results of the innovation process, are much less developed, although considerable progress has been made in this area since the mid-1980s, especially in Germany.

To assess the German level of performance in research and development parameters are analysed on the basis of the following statistics:

- Publication statistics to identify activities in science and research (basic research, strategic and applied research);
- patent statistics to describe the international development of pre-competitive, strategic and applied research, if it deals specifically with technical and hence potentially proprietary aspects;
- trade statistics in the case of goods which strongly depend on research and development, to measure technological competitiveness.

This set of indicators is constantly developed further, e.g. by the OECD or by the Fraunhofer Institut für Systemtechnik und Innovationsforschung (ISI; Fraunhofer Institute for System Engineering and Innovation Studies).

4.2 Research performance according to publication statistics

The assessment of the research performance of a country is based on two criteria:

- How many scientific papers are published to document research results obtained? ('Supply')
- How often are these results being used by way of citation? ('Demand')

4.2.1 Number of scientific publications

Taking into consideration that the research systems and national economies of the major OECD countries differ considerably in size one realises that in terms of the number of scientific publications per scientist Germany among all West European countries is only surpassed by the United Kingdom. The development of the number of publications generated in Europe shows that the less developed member states of the European Community could register a strong growth in the scientific area. While France, Germany and the United Kingdom, which have the highest publication rates in the EC, more or less remained at their previous levels, Italy, the Netherlands and especially Spain have considerably intensified their publishing acitivities in the science sector.

The USA is still the uncontested leader. Japan has caught up considerably in the science area (basic research), but compared with the size of the country and the number of scientists, it still has a sub-average publication rate. A possible reason might be that so far Japanese research has clearly concentrated on application-oriented development.

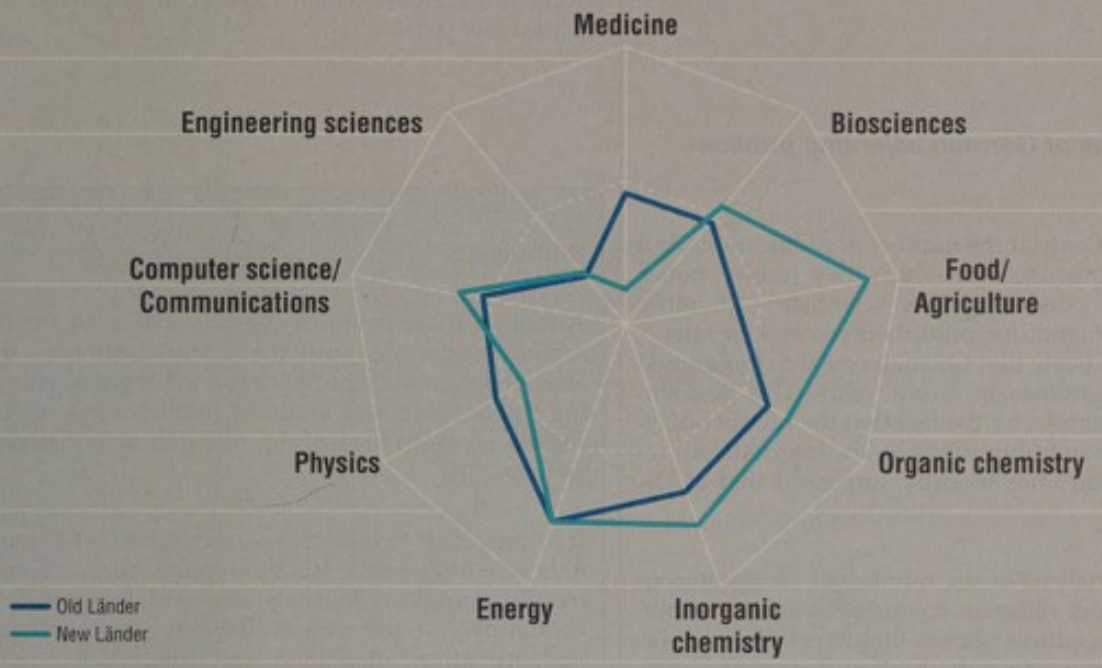
Figure I/7 gives a breakdown of scientific, engineering and medical research into nine major areas. Accordingly, German energy research activities are clearly above the global average. A strong focus on chemistry (organic and inorganic chemistry, including materials research) is characteristic of both East and West Germany. The number of publications in information and communication sciences as well as in physics, biotechnology and medical research in West Germany is close to the world average.

In both the old and the new Länder, however, the number of publications in engineering sciences, which are considered the classical strong point of the German education and training system, is below average. But the picture may be distorted by the fact that German publications in the engineering sciences often do not find their way into international (i.e. English language) databases.

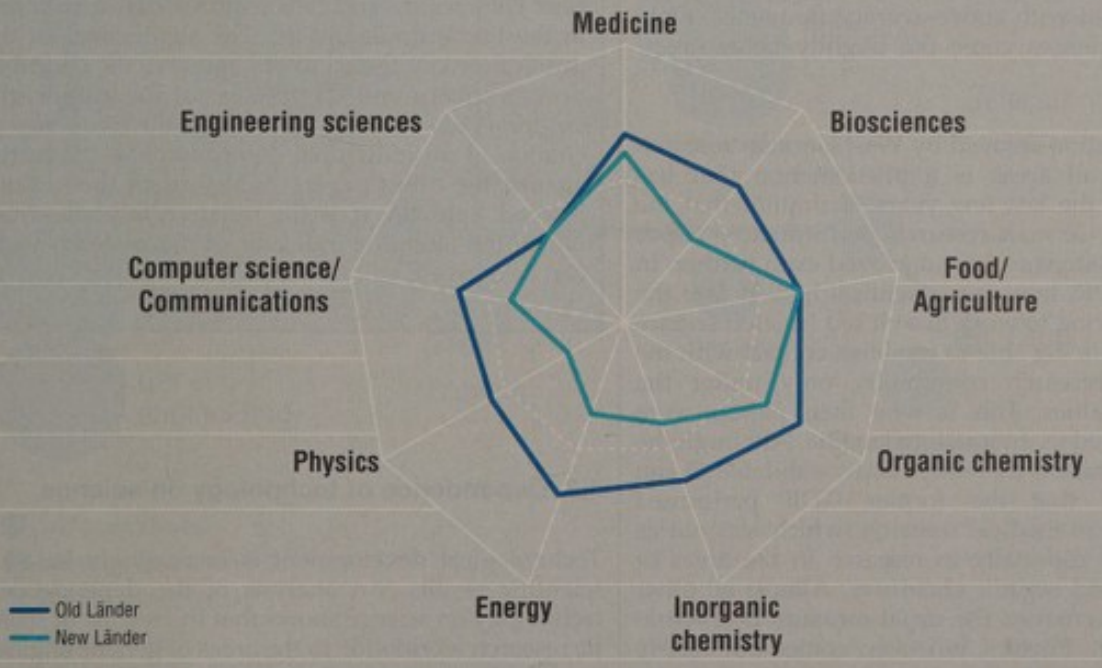
A number of interesting international trends can be identified: Between 1981 and 1990 the number of international scientific publications increased most in biotechnology and applied microbiology (300 %). This applies to a lesser extent to a number of other molecular biology and medical areas. Communication and computer sciences are also characterised by a high level of growth. Materials research ranks third among the major areas.

Figure I/7

Research activities in the old and new Länder



Appreciation of research activities in the old and new Länder



Publications or citations resp. with address of the first author in former West Germany or the former GDR; publications assigned to nine subjects according to focal point of research. Activity and appreciation indices are derived from the mean publication or citation rate of publications by German authors compared with the mean publication or citation rate resp. worldwide of all publications in the same technical journals. The dashed reference line represents the global mean; the other lines represent sub-average and above-average relative values for Germany.

Source: ISSRU database, based on SCI, FhG-ISI.

BMFT, BuFo '93

Germany largely followed this global trend in both biotechnology and materials sciences, with the high increments being particularly conspicuous in environmental sciences (only in the old Länder). Information and communication sciences, however, show a negative deviation from the global trend; the level reached in the early 1980s was just about maintained.

4.2.2 Citations of German scientific publications

If one looks not only at the number of publications, but also at the frequency with which they receive notice from, and are cited by, other scientists – in other words, the 'demand' for published research results –, the statistics indicate that German research has gained increasing importance in recent years. This is documented, for example, by the fact that the number of citations of German publications by the international research community has recently surpassed that of UK publications.

The detailed analysis of the number of citations from publications from different countries by means of bibliometrical procedures shows that West German organic chemistry receives the highest degree of notice. This also applies to medical research, biotechnology and the food sciences. Publications in the areas of energy research, inorganic chemistry including materials research, as well as research in the fields of information and communication technology and physics are also cited with above-average frequency. Only engineering sciences come out slightly below average.

The great attention enjoyed by West German research in practically all areas is a phenomenon that has emerged over the last few years. It implies that the level of West German research performance, which had been high anyway, has improved even further. In the former GDR, however, scientists had to face the problem of having to work in a closed isolated science system and of being able to establish contact with the international research community only under the greatest difficulties. This is why their papers were hardly published in international media. Although the available database is therefore hardly validated, it can be concluded that the former GDR performed above average in medical research (which was not as extensive) and especially in research in the areas of food science and organic chemistry. Almost all other research areas enjoyed the usual measure of international attention. Physics, however, comes out clearly below average.

The increasing dependence of industrial innovative strength on the availability of the latest scientific results leads to more and more cooperation between universities and businesses. In addition, companies intensify certain basic-research activities in their in-house laboratories. Quantitative measurements show that the number of scientific publications based on industrial research results is increasing. In qualitative terms, this new pattern of cooperation is supported by the growing number of scientists from industrial laboratories which have in recent years been awarded the Nobel Prize. In the further development of science and research the Federal Republic of Germany can build on strong foundations which have even improved over the past few years.

Bibliometry

Although there is still a considerable need for research in this area and the harmonisation of the analysed data sources requires a lot of work, counting publications and citations (bibliometry) nevertheless gives an idea of the research activities carried out.

It is important to take into consideration what journals scientists select for their publications. Some, mainly American journals, are widely spread in East and West, they are available in many libraries and are more often read and cited than others, mostly technical journals published in the respective national language. Frequently cited journals are considered internationally renowned; the contributions accepted for publication by these journals after reviewing are addressed to the international peer community and hence more often mentioned in the literature databases. The significance of the publication in terms of its quality, its contribution to science and the renown of the author (the authors) only becomes clear when the frequency of citation of an individual contribution is measured against the other papers published in the various learned journals. It is this relative measure from which the attention indicator of the research work can be derived.

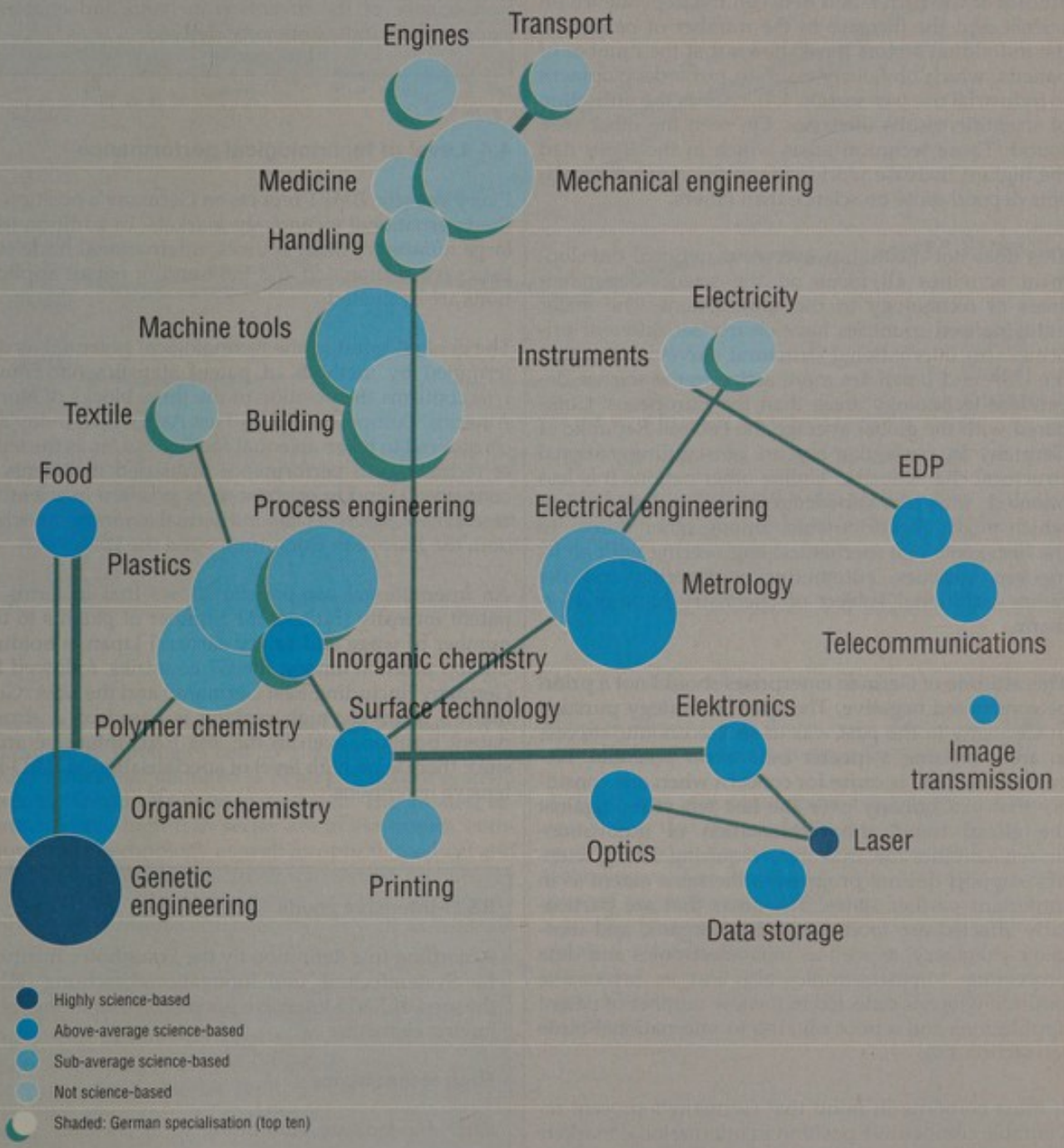
4.3 Dependence of technology on science

Technological development is increasingly based on scientific results. An analysis of the dependence of technology on science shows that the results of scientific research worldwide in the areas of genetic engineering, pharmacy and laser technology are those that are used most intensively for product development (cf. Figure I/8).

They are followed, at a considerable distance, by a number of technology areas which more or less belong to the information technology sector. These are telecommunications, microelectronic components, infor-

Figure I/8

Interlinkage of technological development areas



Relatedness of technological development areas based on multiple classification in European patent applications. Short connecting lines indicate frequent multiple classification, i.e. closely related technological areas, while long connecting lines indicate rare multiple classification. Areas with strong German innovative activities are shaded.

Source: EPAT and WPI databases, FhG-ISI, CWTS. 1987 data.

BMFT, BuFo '93

mation storage and data processing, image transmission as well as metrology and sensor technology. These modern technology areas which are exceptionally dependent on science also comprise optics, surface engineering, organic and inorganic chemistry including new materials and superconduction, as well as food technology. It is interesting that also from the competitive point of view these areas, which were selected from a patent statistics series, are often referred to as industrial sectors with a "strategic" importance for the national economy.

Studies of the correlation between the dependence on science and the increase in the number of patents in the individual sectors have shown that the number of patents, which obviously claim to put a development to industrial use (see section 4.4), rises as the utilisation of scientific results increases. Or, seen the other way round: Those technical areas which in the 1980s had the highest increase worldwide in the number of patents depend more on science than others.

This does not mean, however, that national development activities all focus on the science-dependent areas of technology to the same extent. The major industrialised countries have clearly set different priorities. An international structural survey shows that the USA and Japan are more active in the science-dependent technology areas than the Europeans. Compared with the global average the Federal Republic of Germany in particular has an outstanding national structural characteristic: Unlike other nations it is less oriented towards knowledge-based sectors, a fact which might be attributable, among other things, to the firm roots that mechanical engineering with all its modern varieties, automotive engineering and the rather traditional subject of chemistry have in Germany.

This attitude of German enterprises should not a priori be considered negative. The specific strategy pursued in Germany in the past was to seek economic success in areas offering a greater innovation potential. Nevertheless, there is cause for concern when one considers that in Germany over the last ten years, against the global trend, the reorientation of innovation-driven activities towards areas requiring strong scientific support did not progress to the same extent as in important partner states. The areas that are particularly affected are food technology, organic and inorganic chemistry, as well as microelectronics and data processing. Microelectronics also lost its favourable position which is reflected in the low number of patent applications and a poor ranking in international trade (cf. section 4.4).

It must be borne in mind that Germany's present favourable competitive position in international markets for technological goods is based on the achievements of earlier years. It is therefore not the lower level of involvement in today's science-dependent technologies, but rather the unfavourable trend of our time that gives cause for concern. The data show that this applies in particular to information technology which is based on microelectronics.

Measuring the dependence on science

In order to determine statistically the dependence on science of a technological area, the officials at patent offices, when examining patent applications, have to check up on the prior state of the art. This is usually described in earlier patent documents. If necessary, the patent examiners resort to scientific literature and list appropriate references. The frequency of such references to scientific literature in patents provides an indication of the dependence on science of the invention in hand and enables appropriate indicators to be derived.

4.4 Level of technological performance

Every year the BMFT reports on Germany's position in the international technology markets. In addition to a large number of other sources, international trade statistics (cf. section 4.5) and the trend of patent applications are evaluated.

The general trend of the technological potential as determined by methods of patent statistics (cf. Figure I/9) confirms the position of the three blocks of North America, Europe and South-East Asia which today are considered to be on an equal footing. As far as the level of technological performance measured in patents is concerned – and in contrast to its position in scientific research – Japan as an individual country matches both the European Community and the USA.

An international comparison shows that in terms of patent intensity (ratio of the number of patents to the number of wage and salary earners) Japan is holding the top position among the G7 countries, followed by Germany (including East Germany) and the USA. Germany's relatively high ranking is based on a strong patent position, even in the less R&D-intensive area, since there is no high level of specialisation in R&D-intensive inventions.

R&D-intensive goods

According to a definition by the Fraunhofer Institut für Systemtechnik und Innovationsforschung (ISI) the area of R&D-intensive goods consists of the following elements:

High technologies

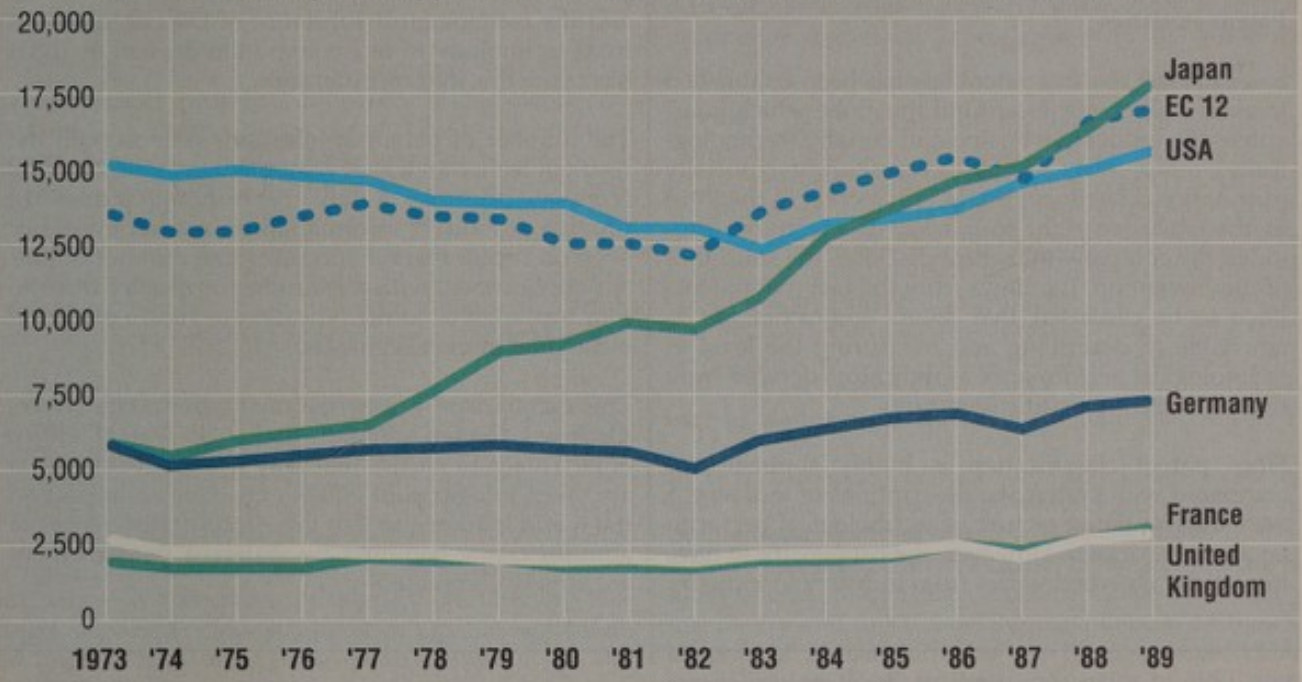
R&D expenditure amounting to at least 8.5 % of turnover.

Advanced technologies

R&D expenditure between 3.5 and 8.5 % of turnover.

Figure I/9

Patents relevant to world market, broken down by countries of origin



Inventions with patent applications in the USA, Japan and Western Europe and patents already granted at least in the USA. National assignment of patent documents according to the country where the patent application was filed first. Years indicated are years of first application (priority year or year of invention). 1988 and 1989 data are extrapolated.

Quellen: USPTO, WPI database, FhG-ISI. BMFT, BuFo '93

Just under 40 % of patents granted can be assigned to advanced technologies and 25 % to high technologies. This implies that about 65 % of all patents are granted on inventions in R&D-intensive areas. The greatest activities in the high-tech sector are in electronics, communication technology as well as optical, medical and measuring instruments. In the advanced technology area emphasis is on textile, paper and printing technology (special industry machinery) as well as on business machines.

When in an international comparison of patent intensity the focus is on high technology alone, Japan again has a good technological position which, however, could not be built in the 1980s. By this weighted standard and considering the much greater US national economy, Germany is not far behind the USA.

The picture is completely different in the advanced technology sector where among the G7 countries Germany and Japan have the highest levels of patent intensity, with Japan having taken the lead over Germany in recent years; it was even able in the 1980s to intensify its above-average specialisation.

A closer look at patents granted in the R&D-intensive area shows that the acceleration of technical change is more marked in the high-tech sector than in advanced technologies. The increase in the number of patents granted in pharmacy, turbines and plastics was particularly dynamic compared with previous years. The classical areas of the chemical industry whose patent indicator had been declining for many years are now again showing a slight growth. Strong growth in high technology can be identified mainly in areas based on microelectronics, e.g. at the high-tech level of electrical engineering which also includes inventions in the field of laser engineering and energy-saving light bulbs. The number of patents issued in the areas of communications and electronics is growing by almost 9 % a year, while the volume of patents granted on so-called service machines, such as cash dispensers, is rising by more than 5 %.

When one looks at the industrial sectors in Germany which excel by their technological strength it is quite

striking to note that, compared with the past, there is an increasing specialisation in those areas on which West German companies had already focussed in the past few years. These are in particular the aerospace industry, the entire sector of mechanical engineering as well as vehicles construction. On the other hand, patent activities in those areas where Germany had always been underrepresented continued to decline substantially. This applies, for example, to data processing and home electronics.

Patent statistics

Since the last century patent law has been established in almost all countries around the globe which guarantees the innovative business materially (technologically), temporarily (up to 20 years) and territorially (one national territory) limited protection in the form of the exclusive right to market its invention, provided the company in its turn discloses the substance of that invention. It follows from the fact that patents have to be disclosed that patent indicators are as amenable to describing and measuring the level of technological performance as indicators derived from the statistics of scientific literature.

Since patent classification is highly sophisticated compared with systematic descriptions of industry, a very differentiated picture of technological performance can be drawn. However, the propensity to have inventions patented varies from industry to industry and the technological substance of the patent varies from technology to technology; the present analysis has taken this into consideration.

The number of patent applications reflects both the result of technological development activities and the economic priorities of industry. Although it does not provide any direct information on market events or even on future market successes, the number of patent applications, with a lead time of usually three to four years, gives some indication of future events in individual market segments.

This comparison of international patent data covers disclosed foreign patents of the US Patent Office only. This is to ensure that only those developments are taken into account which may have an impact on the world market and that the effects of differences in administrative handling by different patent offices are largely eliminated.

4.5 Germany's position in international technology markets

From 1990 to 1991 the world trade volume of manufactured goods rose by 2.26 %. The growth of R&D-intensive goods even amounted to 4.85 %. This is an increase in the share of R&D-intensive goods in total world exports by one percentage point to 44.6 % over the same period. The largest exporter of such goods in 1991 was Japan with 19.6 %, followed by Germany and the USA with 18 % each. Unlike its two main competitors, Germany suffered a major decline of 0.9 % – compared with previous years – in its share of R&D-intensive goods in world trade. It is alarming that this seems to continue a long-term trend in the market position of German industry which in the late 1980s used to be the largest exporter of R&D-intensive goods ahead of Japan and the USA.

The united Germany specialises to a high degree in the export of technology-intensive goods; thus it achieves an export surplus with R&D-intensive goods which is way above average. But this degree of specialisation is lower than that of industry in the old Länder. Compared with its former territory, Germany – with the same order of rank – has a different position vis-à-vis the most important other supplier countries of R&D-intensive products. Among the major industrialised countries Germany – even after enlarging its territory – still has the highest level of specialisation worldwide in exporting R&D-intensive goods behind Japan and ahead of the UK and the USA (which changed places between 1990 and 1991).

The Federal Republic of Germany, however, was not able to hold its position in the world markets for R&D-intensive products. German R&D-intensive exports rather stagnated in value terms between 1990 and 1991. In contrast, German exporters of "non-R&D-intensive products" could raise their export level by 1.5 % in nominal terms, thus considerably surpassing the corresponding total world market growth. Compared with the old territory, today's Germany is much more lagging behind Japan, while its lead over the other major suppliers of technology products has shrunk considerably. This change is exclusively attributable to a lower level of specialisation in the field of advanced technology.

4.5.1 Structure of German exports of R&D-intensive goods

In 1991, 48 % of German exports (DM 307 billion) of manufactured products and 39 % of imports (DM 210 billion) were accounted for by R&D-intensive goods. In value terms, more than 70 % of exported technology goods and just under 60 % of imports were based on advanced technologies. The share of R&D-intensive products in total exports was about 46 % and in total imports 34 %.

This goes to show that within the group of R&D-intensive products the Federal Republic of Germany – also after unification – is mainly specialising in advanced technologies. Regarding high technologies, however, the balance is slightly negative. This specialisation in advanced technology products, which are much more important in terms of sales volume than high-tech goods, is shared by Japan. This clearly shows that also for the united Germany Japan will remain the main competitor in the world market.

With 25 %, machines had the largest export share in R&D-intensive products, followed by passenger cars (almost 20 %), chemical products (17 %) and electrical goods (12 %). In imports, passenger cars represent the largest individual item, with 18 %, followed by chemical products (14 %), electrical goods and machines (about 12 % each) as well as aircraft and spacecraft (a good 11 %). It has to be borne in mind, though, that in the last category parts and components for Airbus assembly have to cross national borders several times.

Even in the united Germany specialisation in high technologies is mostly below average. This is due, among other factors, to the unfavourable export/import ratio in the relatively important aircraft sector and in the industries based on microelectronics. Most other high-tech product groups are characterised by above-average German specialisation. These include all chemical high-tech products including biotechnology products, as well as electrical high-tech goods, optical instruments, measuring and control technology and power plants.

In the group of advanced technology products pan-German specialisation is less pronounced than was the case in former West Germany, due to the above-average rise in imports, but negative figures are still exceptional. In some areas unification even seems to have contributed to improving the position. This applies to almost all chemical products based on advanced technology where in 1991 the new Länder exported above-average quantities of R&D-intensive chemical goods, compared with the total of manufactured products, but imported only an average amount of these articles. Also the producers of metal working machines, power distribution equipment and high-performance ceramics in the new Länder show a positive specialisation.

In several areas (e.g. automotive industry) specialisation is still positive, but less marked than in former West Germany. In more consumption-oriented areas most of this effect can certainly be ascribed to the reorientation of trade towards the new Länder as well as to increased imports. In statistical terms, this reorientation of trade and German unification have caused a 'structural disruption' whose consequences cannot yet be assessed. But in view of the gain of additional export capacities in the new Länder and the still weak demand for capital goods there in 1991, one would have expected improved specialisation levels in the capital goods sector.

German R&D-intensive industry not only has a large number of strong points in advanced technologies, but also some weak points. As in high technology, these can be identified especially in the areas of microelectronics, power distribution equipment as well as in photo/optics.

4.5.2 Position of the new Länder

In 1991, 2.5 % of all exports of R&D-intensive industries came from the new Länder. This level has dropped considerably, compared with the previous year.

In 1991, total exports of R&D-intensive goods by companies based in the new Länder fell by almost 60 %, compared with the previous year. This setback is almost exclusively due to the fact that Eastern markets ceased to exist and new markets could not be opened up to compensate for this loss, due to the still existing competitive disadvantages vis-à-vis Western competitors. Particularly dramatic drops in export were registered in photo/optics, motor vehicles, communications engineering, "Other electrical appliances etc." as well as business machines/data processing.

In 1991, the export of R&D-intensive goods from the new Länder comprised above-average contributions by the manufacturers of rail vehicles, ships as well as aircraft and spacecraft, inorganic chemistry products, medical and pharmaceutical products, special industry machinery and metal working machines. With the exception of special industry machinery, pan-German specialisation levels in these industries in 1991 were more favourable than the corresponding figures for former West Germany in 1990. In 1991, industry in the new Länder hardly contributed towards the export of motor vehicles, especially passenger cars.

4.5.3 Position of the old Länder

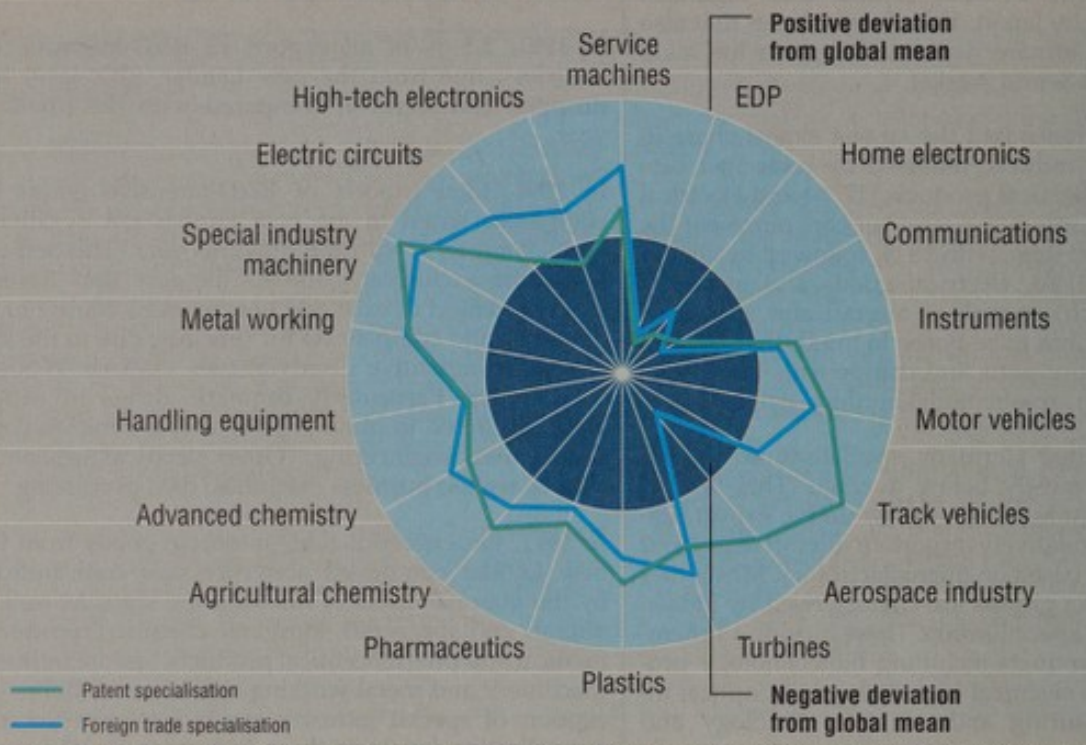
In value terms, industrial exports by the old Länder of R&D-intensive products remained more or less at the 1990 level. But structural shifts can be identified within the export pattern. Increments attained in the areas of rail vehicles, aircraft and spacecraft, medical and pharmaceutical products as well as "Other electrical appliances etc." were higher than the average. Export rates were clearly lower in most product areas of the chemical industry as well as for special industry machinery and motor vehicles. The specialisation levels for motor vehicles are again clearly below the figures of the previous year, which today can certainly no longer be explained alone by the redirection of potential exports to the new Länder.

4.5.4 Long-term trends in German trade with technology-intensive goods

There are some important structural developments which need to be pointed out with regard to both the German trade position concerning manufactured goods as a whole and the trade with R&D-intensive goods (cf. Figure I/11):

Figure I/10

Germany's export and patent specialisation



Foreign patents disclosed by the US Patent Office and dating back to the invention years 1986 to 1988 are compared with the 1990 foreign trade results, with the corresponding standardised specialisation levels being reflected. Considering the different periods or points in timr resp. is meaningful, because – as experience has shown – patent activities precede the effect on trade by about 4 years.

Source: ISI / NIW 1992

BMFT, BuFo '93

- As in recent years, the increase of the total German export of goods, at 2 % in real terms, remained clearly below the growth registered for the trade of OECD countries (a total of 4.5 %).
- Between 1990 and 1991, there were quite considerable shifts in the export structure of German industry. Although the export of manufactured goods increased at a rate of just below 0.7 %, this development is mainly due to the export of non-R&D-intensive products. In the category of R&D-intensive goods Germany's export in 1991 was even lower (– 0.2 %), in nominal terms, than in the previous year.
- The supply structure of West German industry has clearly shifted in the 1980s. Especially in those areas where microelectronics plays an important role such as data processing equipment and home electronics, it is becoming obvious that German industry suffered substantial losses.

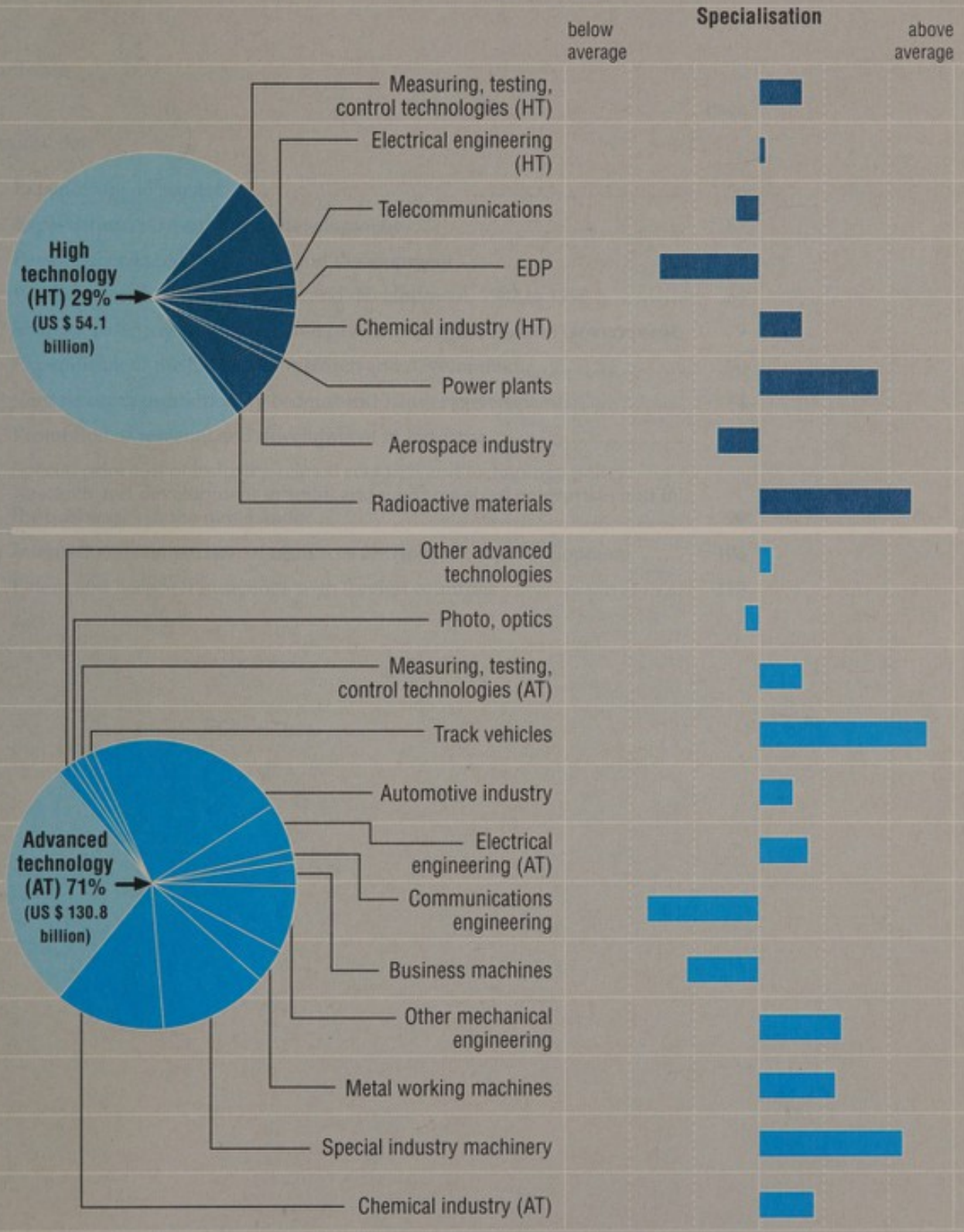
  Here Germany has clear specialisation disadvantages. Although this might be considered a reflection of the international division of labour which, from the economic point of view, is not negative in itself, the generic importance of microelectronics for a large number of other sectors must not be neglected.
- In spite of the present difficulties of the capital goods industry the development trend in mechanical engineering and vehicles construction was positive during the 1980s. Germany is clearly one of the dominant suppliers in the world market.
- In recent years the supply of R&D-intensive products in German industry has increasingly shifted towards areas whose growth rates are below the industrial average. At the same time, their specialisation in areas such as telecommunications technology, which in recent years enjoyed above-average growth, has become weaker. It must also be borne in mind that in those areas where German industry is weak already today, patent statistics, too, suggest sub-average invention activities.
- As far as microelectronics is concerned, it may be assumed that German activities in scientific research in this area are also less intensive.

The above considerations clearly show that only increased commitment by science, industry and government can revise and improve the sub-average position in some fields of science and technology.

Figure I/11

German exports and specialisation pattern of R&D-intensive goods in 1991

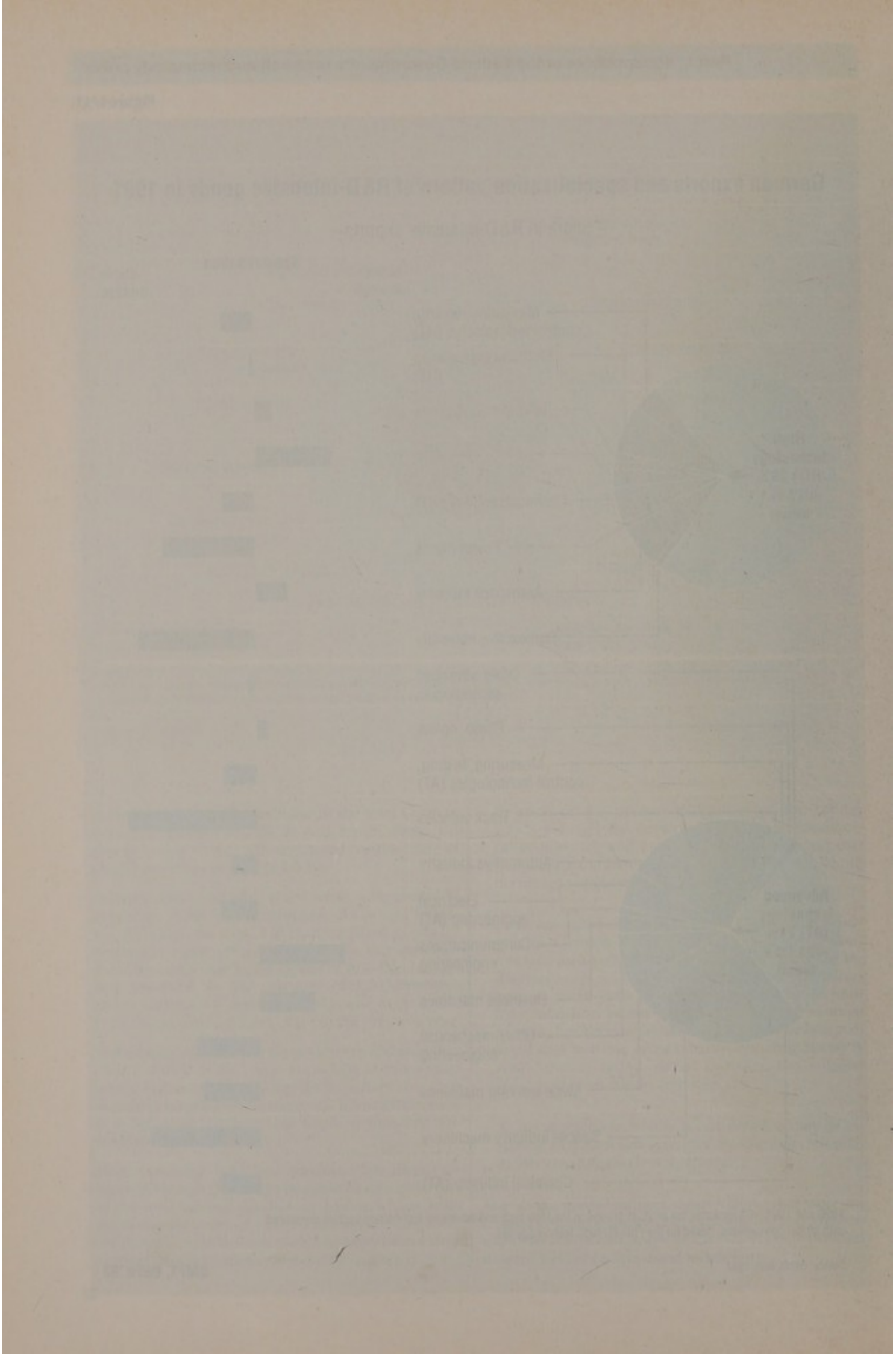
– Share in R&D-intensive exports –



1990 and 1991 RCA indicator for product groups in the high-tech and advanced technology sectors compared with global competitors, based on the FhG-ISI high technology list.

Source: OECD, NIW, 1992.

BMFT, BuFo '93



Part II

Resources for science, research and development in the Federal Republic of Germany and in international comparison

Contents

Introduction

Quantitative indicators have turned out to be useful instruments for describing the research sector. Science and technology indicators still have a high value in assessing the level of performance of scientific research and the competitiveness of a country. It is in particular the informative value and the international comparability of the data which are of interest to research policy. The agreements resulting from the work of the Organisation for Economic Cooperation and Development (OECD) in particular have helped improve the methodological validation of the data and make them more reliable and up-to-date.

This report deals with both traditional input statistics, which relate basically to financial and human resources and which are the prime focus of attention in this report, and with output or impact statistics, which are designed to provide information on the efficiency of research and research policy.

At the national and international levels, the Federal Government supports the development of methodology related to science and technology indicators. Improved tools of research statistics permit extended and detailed reporting on research and will thus contribute to objective information and debate on science and research.

1. Expenditure on science

In 1990, the last year for which actual figures are available for all sectors – all related to former West Germany –, the expenditure of the Federal Republic of Germany on science amounted to DM 83.3 billion. This is a rise of 5.0 % over 1989 (DM 79.3 billion) and 67.6 % over 1981 (DM 49.7 billion) and corresponds to a mean annual rate of increase of 5.9 %.

According to the data available for 1991 and 1992, which relate to the united Germany and are in part still based on estimates, science expenditure in those years reached almost DM 100 billion; at DM 99.4 billion in 1992 it is up 5.3 % on 1991 (DM 94.4 billion).

The increment between 1990 and 1991 is 13.3 %; it is estimated that less than half of this increase can be attributed to German unification (cf. Table II/1).

The share of science expenditure in 1991 and 1992 in the gross national product is still 3.3 %, in 1981 it was 3.2 %. In the 1980s, this indicator peaked at 3.6 % in 1987.

Science expenditure comprises not only funds for research and experimental development, but also resources for scientific teaching and training as well as for other related scientific and technological activities.

Compared with previous reports, it has to be taken into consideration that the concept of science expenditure has been modified: The science expenditure (net expenditure) of the Länder which is mostly channelled to universities was reduced by direct Länder revenues (in particular revenues from patient care in hospitals) in order to eliminate the highly distorting influence of expenditure on patient care at university hospitals.

Compared with previous reports, there is a clear shift in the level of science expenditure by the Federal Republic of Germany as a result of the new concept which was applied to the entire period under review (downward shift: e.g. by DM 10 billion in 1987). This change of concept also affects the financing structure of science expenditure.

The contribution by public authorities to financing the science expenditure of the Federal Republic of Germany in 1990 amounted to 48.2 % (actual), that of industry was 51.8 %. This ratio was reversed during 1991 and 1992. In 1992, the contribution by public authorities was

Table II/1

Science expenditure of the Federal Republic of Germany by financing sources*)
– in % –

	1981	1983	1989	1990	1991	1992
1. Public authorities	54.8	53.2	47.3	48.2	50.5	51.6
1.1 Federal Government (including ERP)	23.8	23.9	20.5	20.9	21.1	21.4
1.2 Länder and local governments [1])	30.1	28.0	24.8	25.2	27.5	28.4
of which new Länder (without East Berlin)	–	–	–	–	3.5	3.9
1.3 Private Non-Profit organisations	0.9	1.3	2.0	2.2	1.9	1.8
2. Industry	45.2	46.8	52.7	51.8	49.5	48.4
Total	100.0	100.0	100.0	100.0	100.0	100.0
DM million	49,705	55,372	79,333	83,312	94,360	99,398

*) Up to and including 1990 former West Germany, from 1991 onwards the whole of Germany.

[1]) In contrast to previous publications, science expenditure of the Länder is no longer based on net expenditure, but on "basic funds" which are left after deduction of direct receipts (especially Länder revenues from patient care in university hospitals).

Source: BMFT

51.6 %, that of industry 48.4 %. The causes underlying this change are the growth rate of industry's science expenditure, which was lower than in previous years, and the sharp increase in the science expenditure by the Federal Government (in particular due to additional spending related to building up the pan-German research sector) and by the Länder (especially due to the corresponding expenditure by the new Länder).

As a result, the share of industry which had been increasing up to 1989 (52.7 %) is declining again for the first time and that of public authorities, which in 1989 reached its lowest level in this decade at 47.3 %, has begun to increase again. In 1981 the respective shares were 54.8 % (public authorities) and 45.2 % (industry).

While the Federal Government's science expenditure is mainly channelled into the non-university sector, the better part of the Länder expenditure benefits the higher education sector. It is especially in connection with building up the research sector in the new Länder that the share of the Federal Government's science expenditure which is appropriated to higher education institutions and which gained in importance already in the 1980s, increased substantially (cf. section 4). A detailed description of the flow of funds and the interlinkages between the individual sectors is provided in the following sections.

2. Expenditure on research and development

From 1981 to 1989, the last year for which actual data are available for all sectors, the expenditure of the Federal Republic of Germany on research and development (R&D) (total research budget) rose from DM 39.9 billion to DM 66.1 billion. According to data that are in part still provisional the 1990 R&D expenditure of former West Germany reached a level of DM 69.2 billion (up 4.7 % on 1989).

In the period under review, the total research budget of the Federal Republic of Germany rose by 73.7 % in nominal terms. When applying GNP deflators, this corresponds to a real growth of 35.8 %.

The mean annual growth rate thus amounts to 6.3 % in nominal terms and 3.5 % in real terms.

The 1991 total research budget which now covers the whole of Germany is estimated at DM 77.3 billion. When looking at the rate of change of 11.6 % from 1990 to 1991, the territorial changes in Germany need to be taken into account as well. According to early estimates, R&D expenditure for 1992 amounts to DM 80.7 billion; this corresponds to an increase of 4.4 % over 1991. Over the entire period under review, 1981 to 1992, the total research budget of the Federal Republic of Germany has slightly more than doubled (cf. Table II/2).

The structure of the research budget in terms of the contributions made by individual sectors to funding and performing research and development is shown in Tables II/2 and II/3 as well as in Figures II/1 and II/2 (for interlinkage of funding cf. Figure II/3).

The change in the research budget and its structure in terms of funding and performing sectors in the years from 1989 to 1992 is a result of the restructuring of the research sector in Germany, which was started immediately after unification in late 1990. Consequently, the government increased its funds substantially, especially in 1991, and again in 1992. But while the Federal and Länder governments increased their R&D expenditure at an above-average rate compared with earlier years, the dynamism of expenditure growth in the industrial sector (also in the old Länder) slackened.

It is important to note that the process of restructuring the research scene differs in the various R&D-performing sectors. In 1992, the process of building up the non-university sector was largely completed, the establishment of the higher education sector was completed at least in part. Restructuring the industrial sector in the new Länder has turned out to be more difficult and protracted than expected. In 1992 this process was characterised by opposite developments: Although there was an increasing number of new R&D-performing companies – some of which had been hived off from existing organisations –, the total number of R&D personnel and hence R&D capacities continued to decline, because many companies which so far had been active in R&D either hived off or closed down their R&D departments. These very different situations in the performing sectors have greatly influenced the structure of the research budget. In conjunction with the weakening dynamism of industry in the old Länder it has brought about a considerable structural change.

The greater part of Germany's R&D expenditure is financed by industry. Its contribution, which between 1981 and 1989 had risen from 55.4 % to 62.3 %, declined – according to the data available – over the last years under review; it dropped from 61.4 % in 1990 to 59.6 % in 1991. For 1992, it is estimated at 58.9 %. Two factors have contributed to this development. On the one hand, the increases in funds declined, which had been characteristic of the R&D expenditure by industry in former West Germany and which until 1989 had been above average with double-digit increase rates for both the total research budget and the gross national product. On the other hand, the Federal and Länder governments had increased their R&D expenditure over the last three years at an above-average rate, in particular by providing funds for establishing a pan-German research sector.

German industry stepped up its R&D expenditure between 1989 (former West Germany) and 1991 (Germany) by a total of 11.8 % (over the same period – and also considering unification – the gross national product rose by 25.7 %). In comparison, the total R&D expenditure of the Federal Government (+ 20.7 %) and of the (old and new) Länder (+ 32.6 %) rose at an above-average rate. The data for 1992 which are still of a provisional nature seem to confirm this trend: The R&D expenditure by industry rose by 3.2 % over 1991, that of the Federal and Länder governments by 5.6 % and 7.0 %, respectively.

Even with the changed structure of the research budget, private non-profit institutions and the "Abroad" sector could maintain or even slightly increase their contributions. The contribution by private non-profit institutions has been an unchanged 0.5 % since 1989, while the contribution from abroad which was 2.2 % in 1989 is now 2.4 % (1992). Foreign R&D expenditure contributing to the total research budget includes in

Table II/2

**Total research budget of the Federal Republic of Germany*)
– R&D expenditure of the Federal Republic of Germany by financing sectors and as % of GNP[1]) –**

Financing sectors[2])	1981	1987	1989	1990	1991	1992
I. Federal Government [3]) – DM million ...	10,363	13,144	13,956	15,150	16,850	17,790
Index 1981 = 100	100	127	135	146	163	172
% of total R&D expenditure	*26.0*	*22.1*	*21.1*	*21.9*	*21.8*	*22.1*
II. Länder [3])[4]) – DM million	6,898	8,550	9,157	9,630	12,140	12,990
Index 1981 = 100	100	124	133	140	176	188
% of total R&D expenditure	*17.3*	*14.4*	*13.9*	*13.9*	*15.7*	*16.1*
III. Industry – DM million	22,082	36,831	41,197	42,500	46,045	47,520
Index 1981 = 100	100	167	187	192	209	215
% of total R&D expenditure	*55.4*	*61.9*	*62.3*	*61.4*	*59.6*	*58.9*
IV. Private Non-Profit institutions						
(PNP) – DM million	155	238	325	355	390	415
Index 1981 = 100	100	154	210	229	252	268
% of total R&D expenditure	*0.4*	*0.4*	*0.5*	*0.5*	*0.5*	*0.5*
Total R&D expenditure financed by						
domestic sectors – DM million	39,498	58,763	64,635	67,635	75,425	78,715
Index 1981 = 100	100	149	164	171	191	199
% of total R&D expenditure	*99.1*	*98.8*	*97.8*	*97.7*	*97.6*	*97.6*
in % of GNP [1])	*2.6*	*2.9*	*2.87*	*2.77*	*2.67*	*2.60*
V. Abroad – DM million	363	738	1,465	1,590	1,830	1,935
Index 1981 = 100	100	203	404	438	504	533
% of total R&D expenditure	*0.9*	*1.2*	*2.2*	*2.3*	*2.4*	*2.4*
Total R&D expenditure – DM million .	39,860	59,501	66,100	69,225	77,255	80,650
Index 1981 = 100	100	149	166	174	194	202

*) Up to and including 1990 former West Germany, from 1991 onwards Germany as a whole.
[1]) GNP: Gross national product.
[2]) Estimated in some cases, actual figures for Federal Government up to and including 1991, Länder up to and including 1990, industry up to and including 1989.
[3]) Federal institutions included only with their R&D shares; Länder institutions included only with their R&D shares from 1985 onwards.
[4]) A new computing procedure for research and development (affecting Länder R&D expenditure) was introduced in the higher education sector by the 1987 survey; the data of earlier years were revised here accordingly so that Länder R&D expenditure deviates from the data in previous publications.

Source: BMFT

Rounding error

particular funds by the European Communities and other international organisations as well as resources made available by companies abroad to various domestic sectors for research and development projects (as far as they were included in surveys).

The share of R&D expenditure funded by domestic sectors has changed only slightly over the last few years; in 1992 it amounted to 97.6 % (1989: 97.8 %).

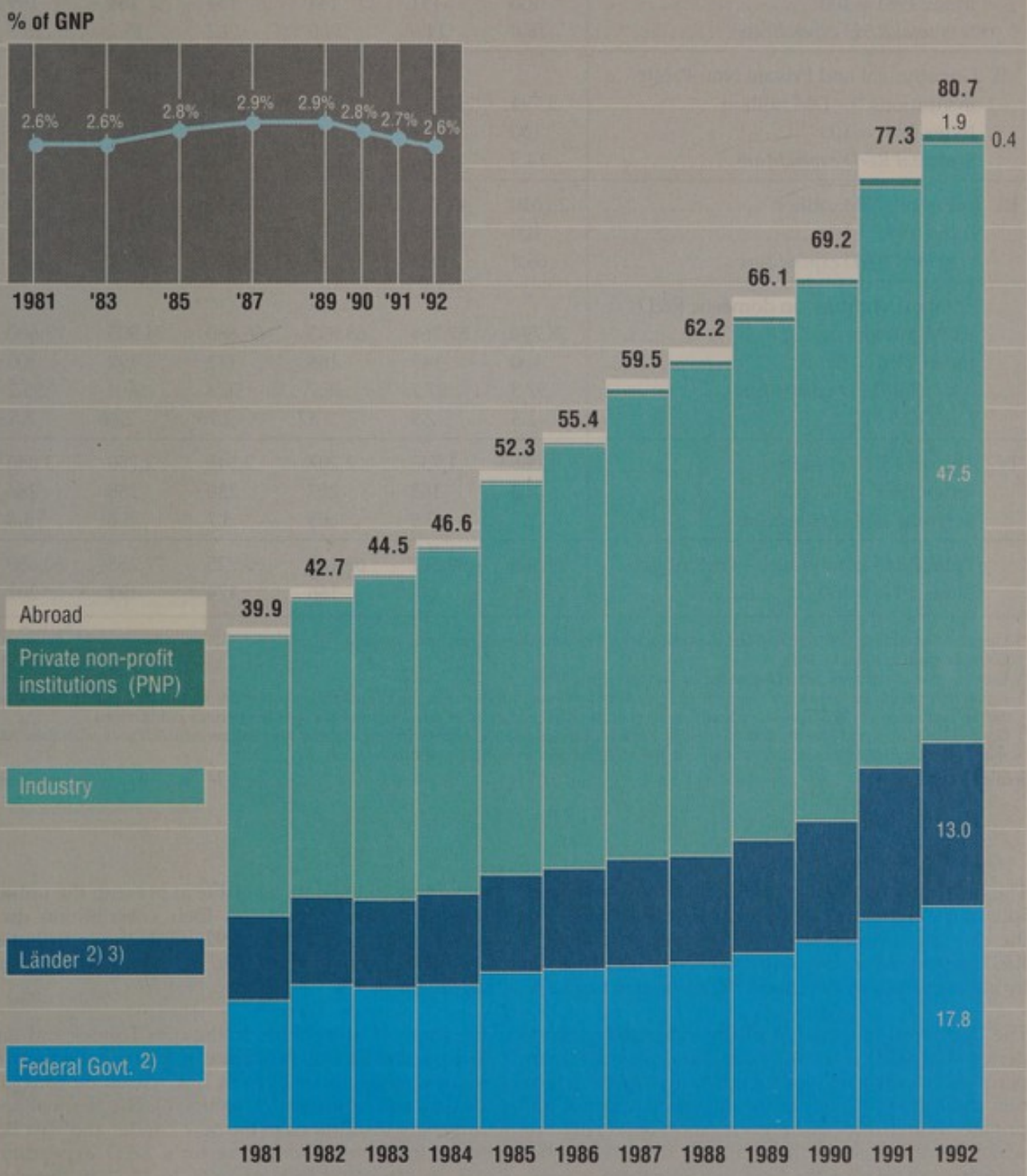
When the R&D expenditure funded by domestic sectors is expressed as a percentage of the gross national product (GNP: the total value of the Federal Republic of Germany's output of goods and services produced by nationals), it becomes apparent that between 1989 and 1991 this ratio fell from 2.87 % to 2.67 %. According to the data available it was only 2.60 % in 1992 (cf. Table II/2).

A breakdown of the total research budget by research-performing sectors also highlights the clear structural change that has taken place in the period under review (1981 to 1992). As on the financing side, the contribution by industry is shrinking here, too. In 1989, it was just under 70 %, then dropped by more than four percentage points and in 1992 was 65.6 % (estimated) (cf. Table II/3). The share of the new Länder and East Berlin in intramural R&D expenditure in the industrial sector was an estimated 4 % in 1992.

Figure II/1 (cf. Table II/2)

Total research budget

R&D expenditure of the Federal Republic of Germany* by **financing** sectors[1)]
– DM billion –



* Up to and including 1990 former West Germany, from 1991 onwards Germany as a whole.
1) Estimated in some cases, actual figures for Federal Government up to and including 1991, Länder up to and including 1990, industry up to and including 1989.
2) Federal institutions only included with their R&D shares, Länder institutions only included with their R&D shares from 1985 onwards.
3) A new computing procedure for research and development (affecting Länder R&D expenditure) was introduced in the higher education sector by the 1987 survey; the data of earlier years were revised here accordingly so that Länder R&D expenditure deviates from the data in previous publications.

Source: BMFT

BMFT, BuFo '93

Table II/3

Total research budget of the Federal Republic of Germany*)
– R&D expenditure of the Federal Republic of Germany by research – performing sectors and as % of GDP [1]) –

Research-performing sectors[2])	1981	1987	1989	1990	1991	1992
I. Higher Education sector [3]) – DM million	6,390	8,339	9,227	9,850	11,760	12,730
Index 1981 = 100	100	131	144	154	184	199
% of total R&D expenditure	*16.0*	*14.0*	*14.0*	*14.2*	*15.2*	*15.8*
II. Government and Private Non-Profit institutions [4]) – DM million	5,794	7,714	8,476	9,030	11,425	11,980
Index 1981 = 100	100	133	146	156	197	207
% of total R&D expenditure	*14.5*	*13.0*	*12.8*	*13.0*	*14.8*	*14.9*
III. Industry – DM million	26,610	41,715	46,190	47,800	51,320	52,890
Index 1981 = 100	100	157	174	180	193	199
% of total R&D expenditure	*66.8*	*70.1*	*69.9*	*69.1*	*66.4*	*65.6*
Total expenditure on domestic R&D – DM million	38,794	57,768	63,893	66,680	74,505	77,600
Index 1981 = 100	100	149	165	172	192	200
% of total R&D expenditure	*97.3*	*97.1*	*96.7*	*96.3*	*96.4*	*96.2*
% of GDP [1])	*2.5*	*2.9*	*2.87*	*2.76*	*2.66*	*2.58*
IV. Abroad – DM million	1,066	1,733	2,207	2,545	2,750	3,050
Index 1981 = 100	100	163	207	239	258	286
% of total R&D expenditure	*2.7*	*2.9*	*3.3*	*3.7*	*3.6*	*3.8*
Total R&D expenditure – DM million	39,860	59,501	66,100	69,225	77,255	80,650
Index 1981 = 100	100	149	166	174	194	202

*) Up to and including 1990 former West Germany, from 1991 onwards Germany as a whole.
[1]) Gross domestic product (GDP).
[2]) Estimated in some cases, actual figures up to and including 1989.
[3]) A new computing procedure for research and development was introduced in the Higher Education sector by the 1987 survey; the data of earlier years were revised here accordingly so that Länder R&D expenditure deviates from the data in previous publications.
[4]) Government: (Research) institutions owned by Federal, Länder and local governments. Federal institutions included only with their R&D shares, Länder institutions included only with their R&D shares from 1985 onwards.

Source: BMFT

Rounding error

The "self-financing ratio of industry", a ratio characteristic of the industrial sector, has not been affected by the changes described: As in 1989, the proportion of R&D performed in the industrial sector and financed by industry itself in 1991 and 1992 amounted to 85.8 %.

The declining contribution of the industrial sector to performing R&D over the period under review compares with increasing contributions by higher education institutions as well as the government sector and private non-profit institutions (non-university research institutions). In the course of the 1980s, when industry's share rose, the importance of these two sectors for the total research budget had declined continuously. This trend has been reversed since 1989. The higher education institutions' contribution rose from 14.0 % (1989) to 15.2 % (1991), while the non-university research institutions stepped up their contribution even more from 12.8 % (1989) to 14.8 % (1991).

According to the data available at present, the universities have again increased their contribution quite substantially to 15.8 % in 1992, while the contribution by non-university research institutions rose only slightly to 14.9 %.

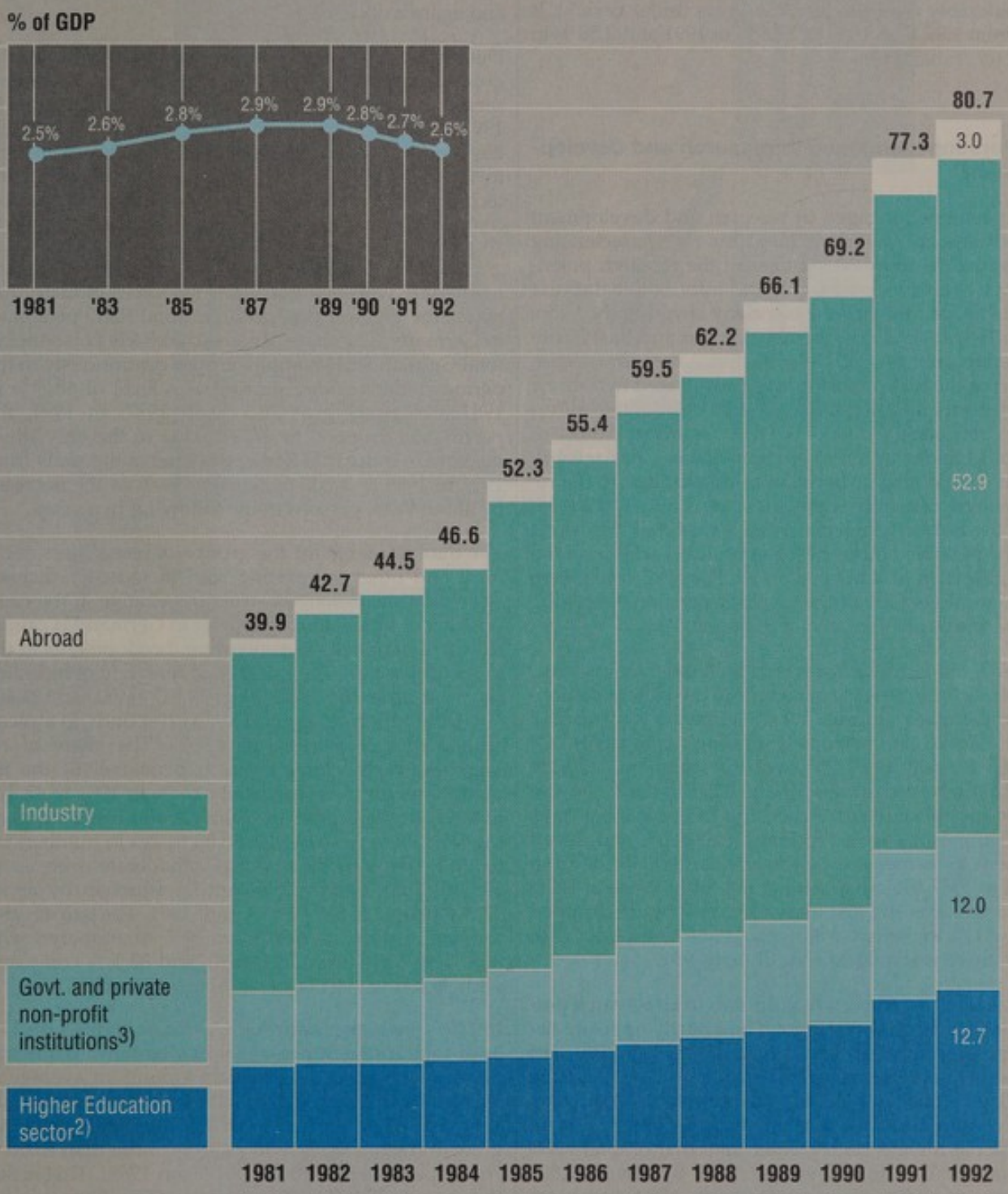
The share of universities in the new Länder and East Berlin in the R&D expenditure of the higher education sector totalled about 12 % in 1992, based on provisional data and estimates (cf. section 6). The share of non-university institutions in the new Länder and East Berlin in the non-university sector's R&D expenditure was an estimated total of 16 % to 18 % in the same year.

There has also been a marked increase in the R&D expenditure channelled abroad by domestic sectors. A major proportion of these funds is accounted for by contributions which the Federal Republic of Germany

Figure II/2 (cf. Table II/3)

Total research budget

R&D expenditure of the Federal Republic of Germany* by **performing** sectors[1]
– DM billion –



* Up to and including 1990 former West Germany, from 1991 onwards Germany as a whole.
1) Estimated in some cases, actual figures up to and including 1989.
2) A new computing procedure for research and development was introduced in the higher education sector by the 1987 survey; the data of earlier years were revised here accordingly so that they deviate from data in previous publications.
3) Government: (Research) institutions owned by Federal, Länder and local governments; federal institutions only included with their R&D shares, Länder institutions only included with their R&D shares from 1985 onwards.

Source: BMFT

BMFT, BuFo '93

has undertaken to make to international research and development. The R&D funds spent by German companies abroad are also included here. The share of the sector "Abroad" was 3.8 % in 1992, in 1989 it was 3.3%.

When R&D performed by domestic sectors alone is expressed as a percentage of the gross domestic product (GDP: the total value of goods and services produced in Germany), it becomes apparent that also this ratio – like the one related to GNP – has decreased considerably over the last few years under review: It fell from 2.87 % in 1989 to 2.66 % in 1991 and 2.58 % in 1992 (cf. Table II/3).

3. Personnel engaged in research and development

The personnel engaged in research and development constitutes an important indicator for characterising the structure and development of the research potential of a country. Comparable and informative data are available for former West Germany covering the years from 1981 to 1991. For the new Länder and East Berlin there are only the 1991 results. Since the surveys underlying the R&D statistics were introduced in the new Länder only recently, there are still considerable differences between the data of the new Länder and those of the old Länder in terms of completeness and reliability. It should also be borne in mind that due to the restructured research scene the new Länder data for 1991 are not very informative. It is expected that it will not be possible before 1993 to provide a well-founded quantification of R&D personnel. For 1992, a tentative estimate was made of the research personnel working in the whole of Germany (cf. Figure II/4).

In 1989, the last year for which final data are available for all sectors, the R&D personnel in the Federal Republic of Germany (former West Germany) comprised a total of 426,446 persons (full-time equivalent). Of these, 176,402 (41.4 %) were researchers, 120,326 (28.2 %) were technical staff and 129,718 (30.4 %) were other supporting staff. According to provisional data, 424,546 persons were working in research and development in former West Germany in 1991. While from 1983 to 1987 the mean annual rate of increase in R&D personnel was still just under 4 %, this figure dropped below 1 % in the two following years. Compared with 1989, there was a decline of 0.4 % in 1991.

This stagnating trend which applies to all research personnel is the result of different and partly opposite developments of the groups of researchers, technical staff and other supporting staff which together make up the R&D personnel. In the 1980s the number of researchers rose continuously at a mean annual rate of 4 %; this increase has always been greater than that of total R&D personnel. The decline of the latter by almost 2,000 persons in 1991, as compared with 1989, compares with an increase in the number of researchers by about 14,500; this corresponds to a rise of 8 %. Up to 1987, the technical staff also had positive growth rates which, however, were lower than that of the group of researchers. In 1989, the headcount of the technical staff had dropped by 2,000 persons. According to the 1991 data for technical and other supporting staff, there was a decline by at least 15,500 persons in both groups taken together, as compared with 1989, so that it can be assumed that this negative trend affecting technical R&D personnel is continuing beyond 1989. In the period under review, the development of the number of other supporting staff was not homogeneous: In 1983 (121,701) there was a slight decline, compared with 1981 (123,006), followed in the years up to 1987 by an increase to 131,134 persons (up 7.8 % on 1983) and again a decrease in 1989.

Due to these differences in development between the group of researchers and the other two groups of personnel the structural composition of R&D personnel in 1991 diverges considerably from that in 1981: While the proportion of researchers rose from 36.4 % in 1981 to 41.4 % in 1989 and the corresponding figure for the technical staff remained more or less constant, the percentage of other supporting staff fell from 34.9 % to 30.4 % over the same period.

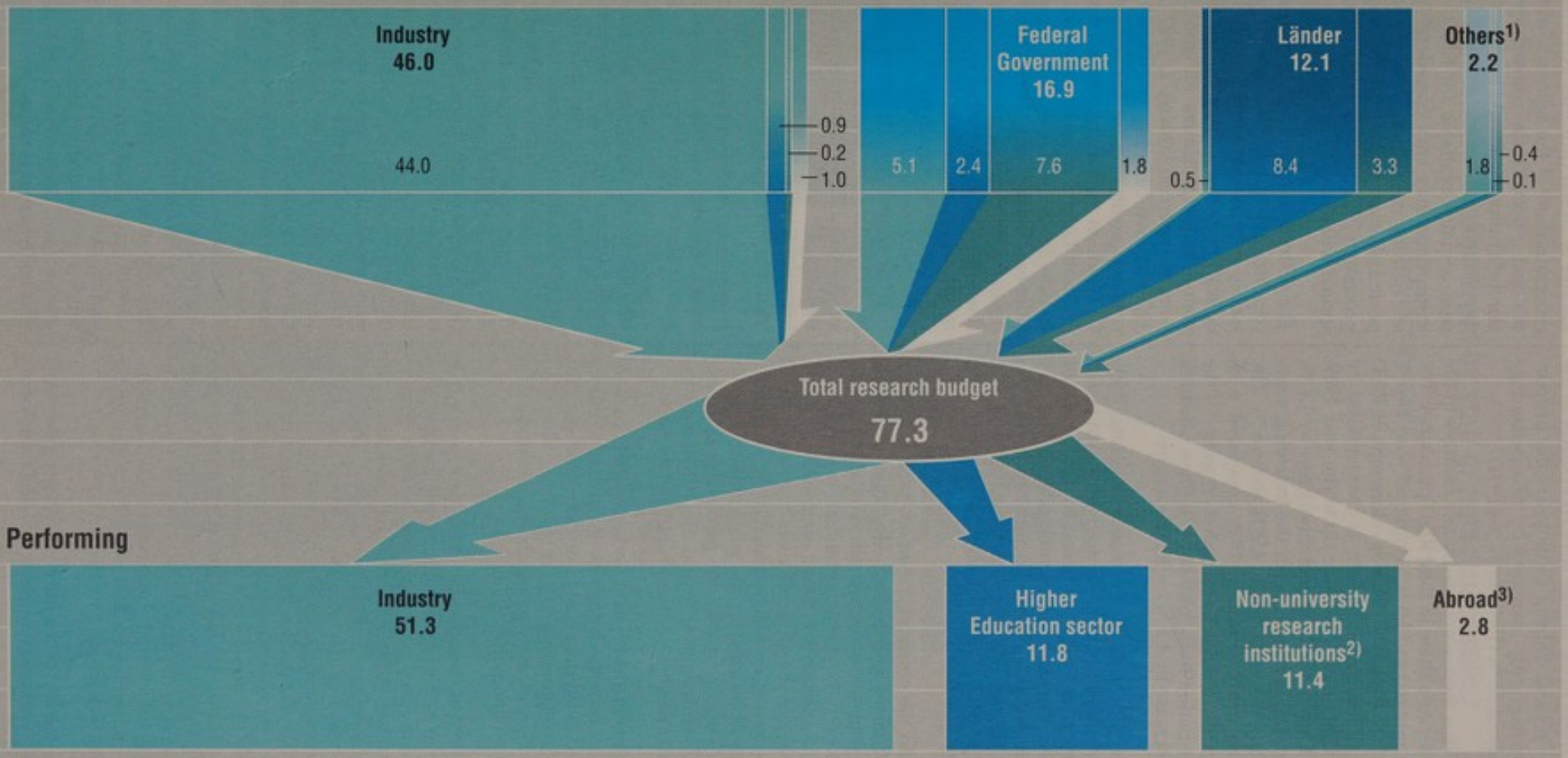
In keeping with financial R&D resources industry has by far the greatest proportion of total R&D personnel in Germany. The share of industrial R&D personnel in total German R&D manpower rose continuously in the period under review, starting at a level of 68.7 % in 1981 and peaking at 70.5 % in 1987. In 1991, the percentage dropped to 67.7 %, due to the only slight increase in industrial R&D personnel in the years from 1987 to 1989 (+ 1,200 persons) as well as the decrease by about 9,000 persons in the following two years.

The data available for the groups of researchers, technical and other supporting staff in industry demonstrate that the described structural change in the composition of total R&D manpower in Germany is primarily attributable to corresponding developments in the industrial sector: The number of researchers in industry went up in the 1980s from 77,017 (1981) to 121,400 (1991), in absolute terms. This corresponds to a mean annual rate of increase of 4.7 %. The share of researchers in the total research personnel of the industrial sector thus rose from 31.7 % in 1981 to 42.3 % in 1991. In the groups of technical and other supporting staff there were moderate increases in numbers up to 1987, followed by an equally moderate decrease in 1989 (– 5,000) and a substantial reduction by about 17,300 people in the period until 1991. The percentages for both groups in 1989 were 29.7 % compared with 30.1 % in 1981 (technical staff), and 32.1 % compared with 38.1 % in 1981 (other supporting staff).

In 1991, the higher education sector accounted for 17.9 % of total research personnel in Germany. While this percentage varied only slightly around an average of 16.3 % in the period from 1981 to 1989 (maximum 1983: 16.7 %; minimum 1985: 15.9 %), R&D personnel grew in the following two years by more than 6,000 to 76,000 persons in 1991 (up 9.1 % on 1989). This raised the share to 17.9 %, while corresponding figures in the industrial sector decreased at the same time. Also in the higher education sector the increase rates for the group of researchers is clearly higher than those of other personnel. The numbers of technical and other supporting personnel in the higher education sector – unlike the industrial sector and all sectors together –

Total research budget 1991*

– DM billion (estimate) –



* Germany as a whole after unification on October 3, 1990.
1) Own funds of private non-profit institutions.
2) Government institutions and private non-profit institutions.
3) Including international organisations.

Rounding error

Source: BMFT-

BMFT, BuFo '93

Figure II/3

increased (slightly) until 1991. There have been no structural changes in the higher education sector in the period under review. During those years the proportion of researchers only increased by two percentage points from about 55 % (1981) to 57 % (1991).

During the 1980s there were hardly any changes in the government sector's share in total R&D personnel: The 1991 share amounted to 13.9 %, compared with 13.6 % in 1989 and 12.9 % in 1987. The development of R&D personnel in this sector, however, is characterised by steadily growing rates of increase up to the year 1989: Between 1981 and 1983 R&D personnel grew by 1.4 %, the corresponding percentages for the following years (two-year intervals) were 3.6 %, 4.9 % and 6.6 %. The relatively high increase rate in 1989 compared with 1987 is in part attributable to extended coverage of the survey. In the period from 1989 to 1991, there was only a moderate increase by 1.6 % to 58,805 persons.

Also in this sector the share of researchers in total R&D personnel rose steadily, but less markedly than in the industrial sector: In 1981 it amounted to 36.1 %, in 1991 to 42.6 %. This increase was accompanied by equally large losses in the two other personnel groups. From 1981 to 1989, the percentage of technical staff dropped from 33.1 % to 31.3 %, that of other supporting staff from 30.8 % to 28.8 %.

Information on the number of women is also available for the government and higher education sectors; at least for the group of researchers, the data are complete. From 1981 to 1991, the number of female researchers in the higher education sector almost doubled (+ 95 %). In 1981, their share in the group of researchers was about 11 % and has now risen to just under 16 %. The corresponding rate of increase in the government sector is much lower (+ 64 %). In 1981, the percentage of female researchers there was 13.6 %, and in 1991 – as in the higher education sector – it was slightly below 16 %.

As mentioned previously, the number of R&D personnel in the new Länder is largely based on early estimates. Compared with provisional or estimated data for 1991 for the corresponding sectors in former West Germany, those figures involve much greater uncertainties so that their comparability is limited.

As early as 1990, a considerable reduction in research personnel set in in the industrial sector of the new Länder which continued, undiminished, in 1991. Also in 1992 there was a decline in research personnel, although the process has clearly slowed down. This is apparently the result of the establishment of new R&D-performing companies; another contributing factor is probably that R&D-performing units were hived off from their parent companies into independent operations. In 1991, the numbers of research personnel declined by one third: At the beginning of the year there were still 40,000 working in research and development, by the end of the year this figure had dropped to 27,000 so that the annual mean was 34,560 persons. The figure expected for the end of 1992 was just under 24,000 persons (full-time equivalent).

Based on the survey of full-time university personnel for 1991, the estimated number of R&D personnel working in the higher education sector of the new Länder is 18,800 (full-time equivalent). In view of the reorganisation of the research sector in the new Länder and especially the restructuring of higher education institutions it should be noted that, depending on department, university or Land, the number of persons actually available for R&D in higher education institutions may vary considerably so that these data are nothing more than a first approximation. It is expected that as a result of the ongoing restructuring process in 1992, the basic data for university R&D personnel will change.

The restructuring process of the non-university sector (research institutions that are completely or predominantly government-funded) – unlike that of the higher education sector – may be considered almost completed by 1992. Almost all institutions in this sector were founded on January 1, 1992 (cf. Part I, section 2). The data available for 1991 therefore relate mainly to research institutions of the former Academies of the GDR which receive transitional funding from the Federal and Länder governments and which, according to Article 38 of the Treaty on German Unity, ceased to exist on December 31, 1991. Differentiated data based on standard surveys are not yet available for 1992. For this sector, as for the other sectors, the 1992 data were tentatively estimated on the basis of data for the united Germany (cf. Figure II/4).

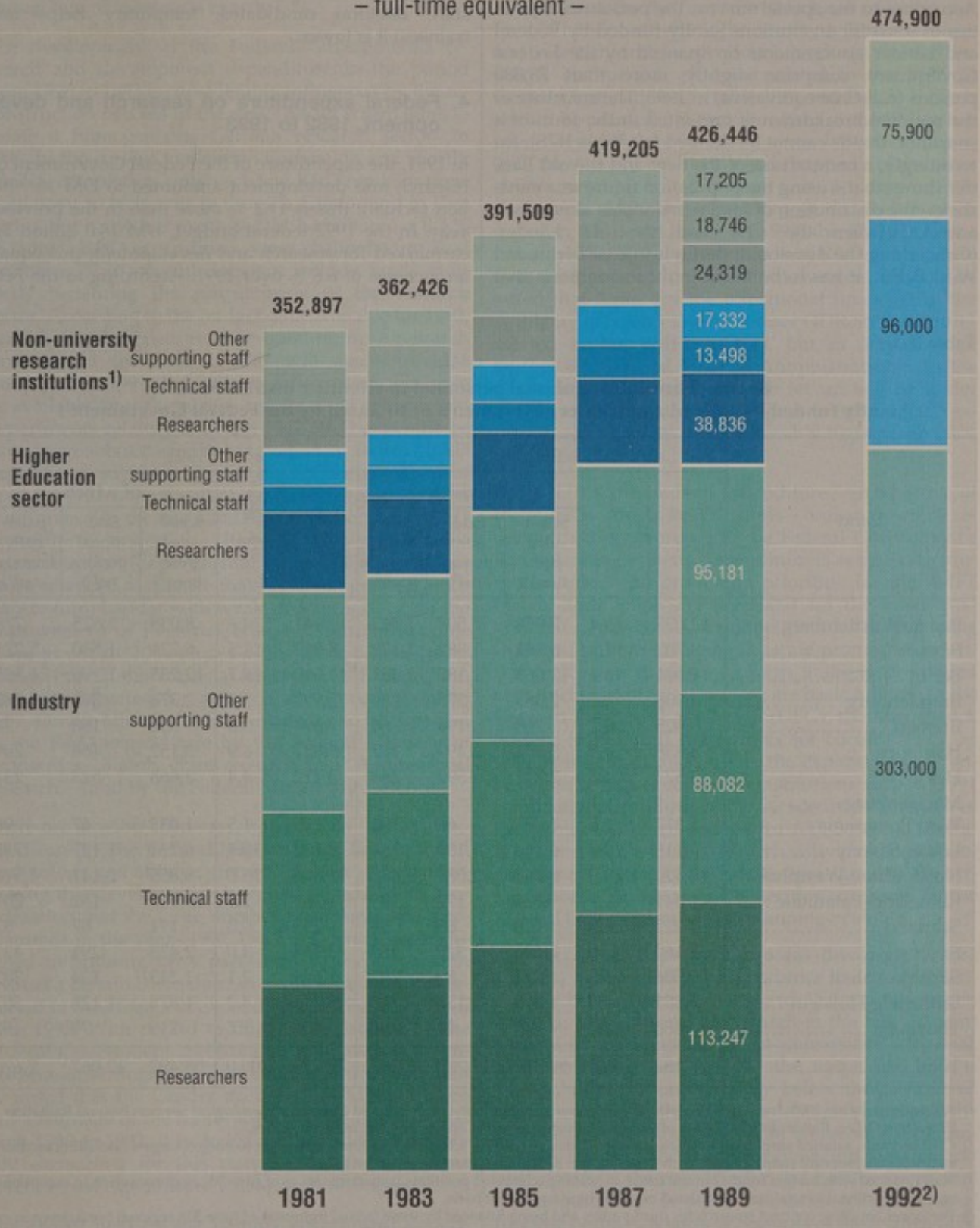
In order to gather early information on the structure of the non-university sector in the new Länder, a special survey was conducted which focussed in particular on the regional breakdown of the total staff working at federally financed science institutions. This survey also included the scientific institutions in the old Länder.

It should be noted in this context that in recent years regional aspects clearly increased in importance in the assessment of research resources. Accordingly, there is a growing need for regional breakdowns of the financial and human resources for science and R&D. Such presentations are highly sophisticated in statistical and methodological terms; they require data that are broken down to great detail. The corresponding statistical presentations of former West Germany in this report were enlarged considerably: For the first time data on R&D personnel are broken down by Länder. Since regional information is usually related to actual data alone, only data for 1990 and hence for the old Länder and West Berlin are available on the basis of regularly prepared R&D statistics. In order to gain some early information on the regional structure of the research scene in the new Länder as well, a special survey was conducted for 1992 and 1993 covering the regional breakdown of **total expenditure** and **total personnel** of all research institutions jointly funded by the Federal and Länder governments pursuant to Article 91b of the Basic Law (i.e. MPG, FhG, national research centres and Blue List institutions), as well as of federal science institutions performing research functions. This report thus covers the better part of the non-university sector. Not included were only the Länder research institutions and private research institutions funded predominantly neither by industry nor by the government; their share in the personnel of the non-university sector is rather low, anyway.

Figure II/4

R&D personnel broken down by staff groups and sectors*

– full-time equivalent –



* Up to and including 1989 former West Germany, 1992 Germany as a whole.
1) Government and private non-profit institutions.
2) BMFT estimate.

Rounding error

Source: BMFT, Federal Statistical Office, SV-Wissenschaftsstatistik GmbH

BMFT, BuFo '93

The total figures given in Table II/S are considerably higher than corresponding data of R&D personnel, due to differences in the methodological and technical approach and the coverage of this report, and especially due to the fact that total science expenditure and total science personnel were included and not only the proportions accounted for by R&D.

According to the special survey, the personnel capacities of scientific institutions jointly funded by Federal and Länder governments or financed by the Federal Government comprise slightly more than 78,000 persons (full-time equivalent) in 1993. The structure of the regional breakdown is presented in the form of a snapshot, trends cannot be derived (cf. Table II/S). Interestingly, a comparison of the new and the old Länder shows that – using the population figure as a yardstick – the distribution of total personnel is almost balanced between the new and the old Länder. (Concerning the division of Berlin into East Berlin and West Berlin, it has to be taken into consideration that in some cases the regional breakdown had to be estimated). In terms of the targeted number of positions and the personnel financed by third-party funds (including the personnel financed from the BMFT temporary personnel augmentation fund), the share of the new Länder including East Berlin is slightly higher than the corresponding population figure, in the case of additional staff (i.e. scientific and student auxiliary staff, doctoral candidates, temporary helps and trainees) it is lower.

4. Federal expenditure on research and development, 1982 to 1993

In 1991, the expenditure of the Federal Government on research and development amounted to DM 16,9 billion (actual); this is 11.2 % more than in the previous year. In the 1992 federal budget, DM 18.0 billion are earmarked for research and development; this equals an increase of 6.6 % over 1991. According to the Fed-

Table II/S

Regional breakdown of total personnel in scientific institutions jointly funded by Federal and Länder governments or financed by the Federal Government[1])

Land	1992					1993				
	Total	%	of which			Total	%	of which		
			Scheduled positions[2])	Additional personnel[3])	Externally financed staff[4])			Scheduled positions[2])	Additional personnel[3])	Externally financed staff[4])
Baden-Württemberg	12,027	*15.4*	7,956	2,509	1,562	11,441	*14.6*	8,038	2,625	778
Bavaria[5])	8,702	*11.1*	6,141	1,382	1,179	8,972	*11.5*	6,221	1,530	1,221
Berlin	14,384	*18.4*	12,067	1,187	1,131	14,610	*18.7*	12,235	1,190	1,185
Brandenburg	2,908	*3.7*	2,385	273	250	2,997	3.8	2,374	341	282
Bremen	525	*0.7*	268	194	64	594	*0.8*	332	188	74
Hamburg	3,838	*4.9*	3,152	499	187	3,827	*4.9*	3,152	466	209
Hesse	3,573	*4.6*	2,712	592	268	3,422	*4.4*	2,668	523	231
Mecklenburg-West Pomerania	1,217	*1.6*	1,057	66	94	1,178	*1.5*	1,035	47	96
Lower Saxony	8,116	*10.4*	6,194	1,139	784	8,102	*10.4*	6,231	1,137	735
North Rhine-Westphalia	12,420	*15.9*	8,843	2,089	1,488	12,506	*16.0*	8,855	2,141	1,511
Rhineland-Palatinate	1,341	*1.7*	980	172	189	1,360	*1.7*	997	162	201
Saarland	222	*0.3*	100	68	54	255	*0.3*	111	87	57
Saxony	3,160	*4.0*	2,436	320	405	3,155	*4.0*	2,433	291	431
Saxony-Anhalt	1,506	*1.9*	1,171	83	252	1,649	*2.1*	1,213	134	302
Schleswig-Holstein	3,331	*4.3*	1,860	1,158	313	3,313	*4.2*	1,878	1,128	307
Thuringia	866	*1.1*	745	41	80	850	*1.1*	719	79	52
Total	78,132	*100.0*	58,065	11,770	8,297	78,229	*100.0*	58,492	12,067	7,670

[1]) All institutions are 100% included. Exceptions: Museums included in the Blue List and German Meterological Service, Federal Radiation Protection Office, Rationalisation Board of German Industry included only with their research shares.
[2]) Civil servants, salaried employees and wage earners listed as holding scheduled positions according to budget targets (including auxiliary staff with civil servant status as well as civil servants on probation (actual figures as of June 30)).
[3]) Staff financed with budget funds, but not listed as holding scheduled positions (actual figures as of June 30); regionalisation in exceptional cases proportional to total staff; calculated on a full-time equivalent basis.
[4]) Personnel handling contract research for third parties and being financed by these (actual figures as of June 30); regional breakdown in exceptional cases proportional to total staff. Including personnel financed by the BMFT temporary personnel augmentation fund; calculated on a full-time equivalent basis.
[5]) Including central administrations of MPG and FhG.

Source: BMFT

Rounding error

eral Governments's budget draft for 1993, the same amount, i.e. about DM 18 billion will be appropriated to R&D. Over the period from 1982 to 1991 the Federal Government raised its R&D expenditure by about 46 % which corresponds to a mean annual rate of increase of 4.3 %. The increase over 1981 amounts to 62.5 % (in this approach the basic effect of the 1982 supplementary budget is neglected). Here the mean annual rate of increase is exactly 5 %.

The development of the Federal Government's research and development expenditure in the period from 1990 to 1993 is considerably influenced by the reconstruction process in the new Länder which aims to create a homogeneous German research sector. In 1990, in the run-up to German unification and shortly after its completion, only very few R&D funds or none at all went to recipients in the new Länder and in East Berlin. But in 1991 as much as DM 1.4 billion, i.e. 8.3 % of federal R&D expenditure, were channelled to East Germany. This amount does not include funds indirectly benefiting the restructuring of the research sector. According to the budget data available for 1992, R&D funds designed to serve building up a research structure in the new Länder will again increase sharply over 1991. But reliable information will only be available after the survey results of all government departments relating to actual 1992 R&D expenditure have been submitted. The stagnation of federal R&D expenditure suggested by the data of the government draft for 1993 is the result of opposite developments in some areas: On the one hand, there is a decline in R&D expenditure under the item of General Finance Administration (departmental budget 60), mainly because financial assistance that had been granted since 1989 to (old) Länder with weak structures (Law on the Improvement of Regional Economic Structures) pursuant to Article 104a para 4 of the Basic Law is being phased out. Of this financial assistance DM 190 million had been targeted for research and development in 1992. On the other hand, major cuts are to be expected in the R&D expenditure by the Federal Ministry of Economics – mainly in the research area "Aeronautical research" – and by the Federal Ministry of Defence.

There are sizeable increases, however, in the R&D expenditure by the Federal Ministries for Research and Technology and of Education and Science. When interpreting this development, it should be taken into consideration that the large number of schemes and programmes in the years 1991 and 1992, which were devoted to building up a pan-German research sector, created a certain basic effect in many areas which is reflected in the change of expenditure in 1993 compared with 1992. With regard to financial assistance by the Federal Government according to the Law on the Improvement of Regional Economic Structures it should be noted that the Länder do not seem to have taken full advantage of the funds appropriated in the period from 1989 to 1992, thus reducing the funds provisionally earmarked for this purpose; but by the same token, actual expenditure will arise in 1993 as well.

The shares held by the various government departments in federal R&D expenditure differ widely. In addition to the Federal Ministry for Research and Technology (BMFT) which accounts for about half of the funds, the Federal Ministries of Defence (BMVg), of Economics (BMWi) and of Education and Science (BMBW) receive major shares. Between 85 % to 90 % of the total federal R&D expenditure is accounted for by these four ministries; the shares of other ministries have shown an upward tendency. For the years from 1989 onwards departmental budget 60 (General Finance Adminstration) will be extremely important, because it contains the funds for structural assistance for the old Länder as well as the resources for universities and research and for projects of industry-related research institutions, all appropriated in the light of German unification (cf. Table II/4 and Figure II/5). It should be pointed out that the share of the BMVg has been decreasing substantially since 1991. In contrast, both the share of the BMBW and the shares of the other government departments have gone up, especially in connection with the development of the research sector in the new Länder. In 1991, the BMFT had the lowest share, at 49 %, in the federal R&D expenditure over time, as a result of structural changes. It should be noted that funds for the transitional financing of the Academy of Sciences of the former GDR are not appropriated in the BMFT budget, but in departmental budget 60 (General Finance Administration). As the new research institutions to be set up will be under BMFT jurisdiction, the BMFT share in federal R&D expenditure will again be considerably higher than 50 % from 1992 onwards.

Table II/5 shows federal expenditure – irrespective of the ministry providing the funds – broken down by research themes according to the Federal Government's R&D planning system. Expenditure is assigned to promotion areas and promotion priorities; for the BMFT this is done at project level and for the other government departments at budget item level. Departing from this pattern are some separate promotion priorities which are grouped to form a single promotion area. Included in this grouping are basic funding of the German Research Foundation (DFG), the Max Planck Society (MPG) and the Fraunhofer Society (FhG) as well as the funds allocated to the expansion and construction of higher education institutions and – in 1991 – transitional funding of the Academy of Sciences of the former GDR (promotion area A4). Based on the national research centres' research activities, federal institutional funding of the centres is assigned to the various promotion areas and priorities according to the Federal Government's R&D planning sytem.

Among the civil promotion areas the largest share (15.2 %) in federal R&D expenditure in actual 1991 figures is held by the promotion area "Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities". In 1990, this percentage was 11.2 %; the target for 1992 is 14.9 %, which is only slightly below the 1991 level. Elements causing this increase in expenditure are the funds earmarked for the Special University Programmes for the old Länder and for financing research and universities in the new Länder and East Berlin as well as, in particular in 1991, resources for transitional funding of the Academy of Sciences of the former GDR for which a separate promotion priority was defined. Second place is held by the promotion area "Space research and space technology" with a share of 9.2 %,

Table II/4

Shares of ministries in the Federal Government's R&D expenditure
– DM million –

Departmental budget	1982	1987	1989	1990	1991	1992	1993
	Actual					Budget	Govt.draft
Federal Ministry of Economics ..	1,038.5	913.8	964.9	1,051.3	1,217.3	1,253.7	1,069.6
Federal Ministry of Defence	1,695.5	2,921.0	3,155.5	3,419.3	3,192.7	3,137.1	3,034.4
Federal Ministry for Research and Technology[1])	6,869.8	7,216.0	7,324.7	7,756.1	8,256.3	9,209.3	9,448.0
Federal Ministry of Education and Science	939.0	1,022.5	1,121.5	1,199.3	1,551.9	1,680.5	1,933.7
General Fiscal Administration[2]) .	14.4	19.7	293.5	411.2	1,139.7	859.9	537.3
Other ministries	992.9	1,059.1	1,176.1	1,311.8	1,494.7	1,828.6	1,916.2
Total	**11,550.1**	**13,152.2**	**14,036.2**	**15,149.0**	**16,852.6**	**17,969.2**	**17,939.2**
	– %–						
Federal Ministry of Economics ..	*9.0*	*6.9*	*6.9*	*6.9*	*7.2*	*7.0*	*6.0*
Federal Ministry of Defence	*14.7*	*22.2*	*22.5*	*22.6*	*18.9*	*17.5*	*16.9*
Federal Ministry for Research and Technology[1])	*59.5*	*54.9*	*52.2*	*51.2*	*49.0*	*51.3*	*52.7*
Federal Ministry of Education and Science	*8.1*	*7.8*	*8.0*	*7.9*	*9.2*	*9.4*	*10.8*
General Fiscal Administration[2]) .	*0.1*	*0.1*	*2.1*	*2.7*	*6.8*	*4.8*	*3.0*
Other ministries	*8.6*	*8.1*	*8.4*	*8.7*	*8.9*	*10.2*	*10.7*
Total	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***	***100.0***

[1]) Excluding global expenditure reduction (1992 DM 180 million, 1993 DM 180 million).
[2]) Including financial assistance pursuant to Art. 104a para 4 of the Grundgesetz to Länder with a weak structure in order to invest in the promotion of research and technology (1989 to 1992) and including from 1991 onwards – as a result of German unity – resources for higher education institutions and research as well as for industry-related research institutions.

Source: BMFT

Rounding error

with the promotion area "Energy research and energy technology" being third with 7.2 %. This means that the share of energy research is down 1.1 percentage points on 1990. With a share of 9.2 % in 1991, space research could maintain its 1990 level. While space research could consolidate its position in the 1992 budget, the share of energy research continues to shrink. The latter development is mainly attributable to the steady decrease of funds for "Nuclear energy research". In 1992, a separate research priority was created for activities related to the decommissioning of nuclear facilities and pertinent risk sharing by the Federal Government.

The next few places are held by the promotion areas "Large-scale equipment for basic research", "Environmental research; climate research" and "Information technology (including production engineering)" with shares between 5 % and 6 % and a slightly upward tendency. All in all, civil promotion areas benefited from the declining share of the promotion area "Defence research and technology", which dropped from 22.4 % in 1990 to 18.8 % in 1991.

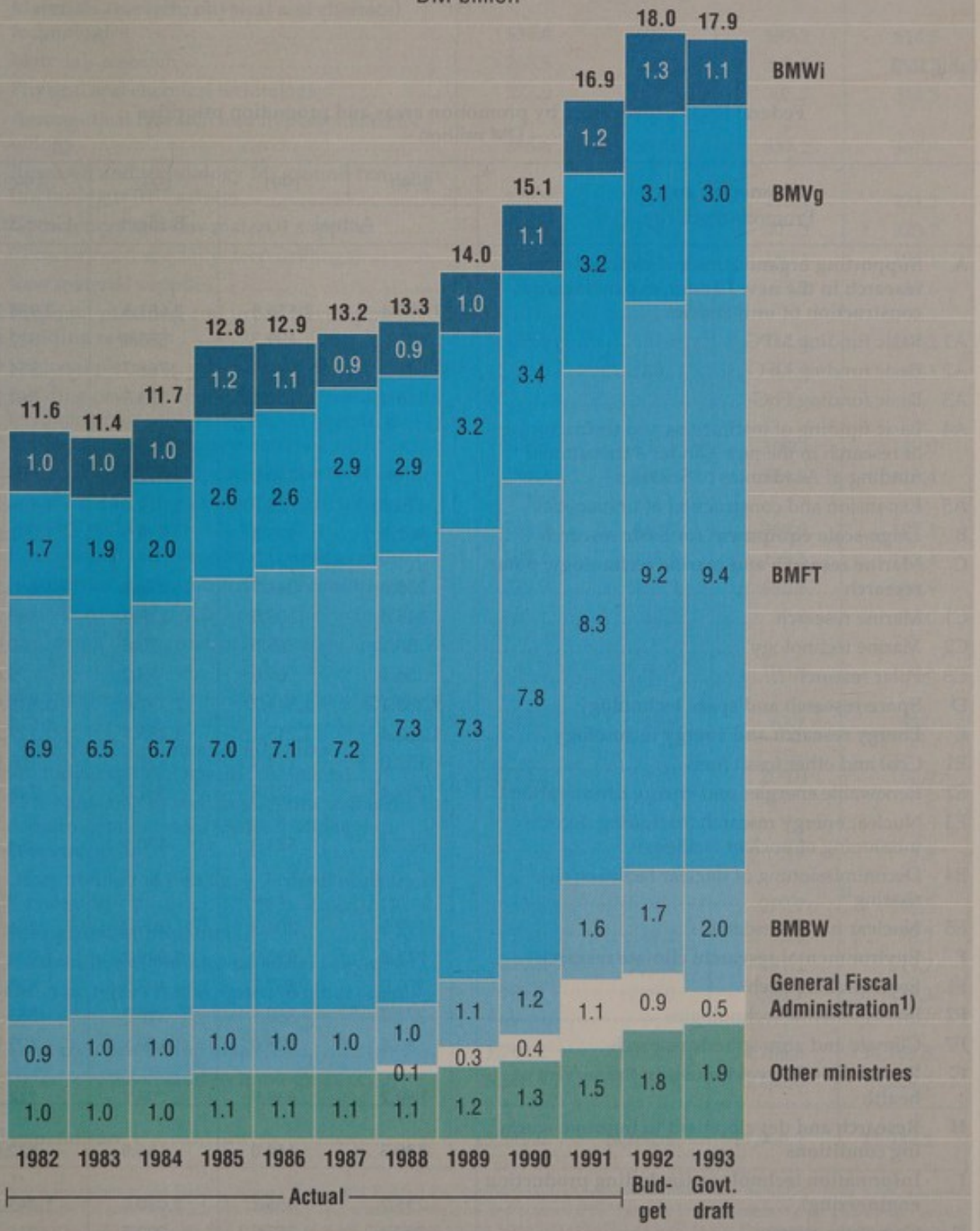
According to the government draft for 1993, the shares of the promotion areas mentioned above will continue to grow. The shares of "Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities" and "Space research and space technology" will increase again (to 16.5 % and 10.1 %, respectively). Expenditure on the research area "Aeronautical research and hypersonic technology" will drop by 1.5 percentage points to 3.2 %, and funds for "Other activities not assigned to other sectors" will go down by 0.6 percentage points to 2.6 %. Federal assistance for Länder with weak structures for which the Federal Government's draft budget for 1993 – as mentioned above – does not provide funds anymore, has been assigned to the latter research area. But according to recent information the targeted amounts of previous years will not be fully utilised so that also in 1993 there should be actual expenditure.

The development of R&D expenditure on the various promotion areas between 1990 and 1991 was greatly influenced by German unification. Especially those promotion areas have above-average growth rates

Figure II/5 (cf. Table II/4)

Shares of ministries in the Federal Government's R&D expenditure, 1982 to 1993

– DM billion –



1) Including financial assistance pursuant to Art. 104a para 4 of the Grundgesetz to Länder with a weak structure in order to invest in the promotion of research and technology (1989 to 1992) and including from 1991 onwards – as a result of German unity – resources for higher education institutions and research as well as for industry-related research institutions.

Source: BMFT

BMFT, BuFo '93

which received funds to provide transitional financing for the Academies of the former GDR (Academy of Sciences, Building Academy and Academy of Agricultural Sciences) as well as special funds for the new Länder. The promotion area "Research and development in agriculture, forestry and fishery" could boast the largest relative growth, at 90.1 %, followed by "Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities" (+ 50.8 %) and "Innovation and improved basic conditions" (+ 48.4 %). With an increase of 25.9 % "Environmental research; climate research" is also enjoying substantial growth, followed by "Regional planning and urban development; building research" (+ 24.8 %) (cf. Table II/5).

Table II/5

Federal R&D expenditure by promotion areas and promotion priorities
– DM million –

	Promotion area Promotion priority	1990	1991	1992	1993
		Actual		Budget	Govt.draft
A	**Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities**	**1,695.4**	**2,556.9**	**2,681.5**	**2,958.2**
A1	Basic funding MPG	471.0	499.3	555.0	622.8
A2	Basic funding DFG	638.1	697.1	766.7	834.9
A3	Basic funding FhG	166.0	182.0	333.3	364.3
A4	Basic funding of institutions and restructuring of research in the new Länder – transitional funding of Academies of Sciences –	—	450.0	12.0	—
A5	Expansion and construction of universities[1]	420.3	728.5	1,014.6	1,136.2
B	**Large-scale equipment for basic research**	**962.9**	**973.3**	**999.5**	**1,051.2**
C	**Marine research and marine technology; polar research**	**230.3**	**241.7**	**276.1**	**261.7**
C1	Marine research	115.8	103.5	129.4	130.2
C2	Marine technology	58.1	68.5	73.5	60.9
C3	Polar research	56.4	69.6	73.2	70.6
D	**Space research and space technology**	**1,388.1**	**1,544.7**	**1,797.0**	**1,815.9**
E	**Energy research and energy technology**	**1,262.4**	**1,215.1**	**1,188.7**	**1,127.2**
E1	Coal and other fossil fuels	153.0	114.9	122.2	108.5
E2	Renewable energies and energy conservation	289.4	322.6	391.0	348.1
E3	Nuclear energy research (excluding decommissioning of nuclear facilities)	627.4	573.3	470.1	454.9
E4	Decommissioning of nuclear facilities; risk sharing[2]	—	—	—	9.7
E5	Nuclear fusion research	192.5	204.3	205.4	206.1
F	**Environmental research; climate research**	**711.8**	**895.9**	**1,049.2**	**1,071.1**
F1	Ecological research	354.2	407.7	493.2	515.3
F2	Environmental technologies	271.2	360.1	396.3	383.1
F7	Climate and atmospheric research	86.4	128.0	159.8	172.7
G	**Research and development in the service of health**	**589.2**	**638.9**	**703.7**	**744.1**
H	**Research and development to improve working conditions**	**130.5**	**140.0**	**136.9**	**132.8**
I	**Information technology (including production engineering)**	**735.7**	**855.1**	**1,030.6**	**1,045.2**
I1	Computer science	207.4	232.5	209.7	215.3
I2	Basic information technologies	355.9	395.8	542.7	553.4
I3	Application of microsystems (including microelectronics and microperipherals)	64.8	98.4	140.3	140.6

Table II/5

Promotion area / Promotion priority		1990	1991	1992	1993
		Actual		Budget	Govt. draft
I4	Production engineering	107.6	128.5	137.9	136.0
K	**Biotechnology**	**266.7**	**278.2**	**333.4**	**366.9**
L	**Materials research; physical and chemical technologies**	**536.4**	**602.3**	**597.2**	**614.5**
L1	Materials research	263.5	294.9	291.5	299.7
L2	Physical and chemical technologies	272.9	307.5	305.7	314.8
M	**Aeronautical research and hypersonic technology**	**898.6**	**881.8**	**837.2**	**567.9**
N	**Research and technology for ground transport (including traffic safety)**	**220.9**	**224.0**	**215.1**	**221.2**
O	**Geosciences and raw material supplies**	**160.7**	**190.4**	**207.3**	**223.7**
O1	Geosciences (especially deep drillings)	127.4	155.8	180.1	196.1
O2	Raw material supplies	33.3	34.6	27.2	27.6
P	**Regional planning and urban development; building research**	**145.5**	**181.6**	**212.2**	**174.2**
P1	Regional planning, urban development, housing	36.0	48.7	48.9	45.1
P2	Building research and technology, research and technology for preserving the architectural heritage; road building research	109.5	132.9	163.3	129.0
Q	**Research and development in the food sector**	**94.5**	**100.5**	**124.6**	**116.4**
R	**Research and development in agriculture, forestry and fishery**	**231.8**	**440.7**	**360.6**	**397.2**
S	**Educational and vocational training research**	**109.1**	**123.6**	**135.5**	**143.4**
T	**Innovation and improved basic conditions**	**278.9**	**413.8**	**680.6**	**602.9**
T1	Indirect funding of R&D personnel in industry	65.1	32.2	32.0	33.0
T2	Improving the transfer of technology and knowledge	46.5	60.9	106.0	104.5
T3	Sharing the innovation risk of technology-based firms	40.2	45.9	61.1	83.0
T4	Other indirect promotion measures (excluding indirect specific measures)	112.2	199.8	200.0	180.0
T8	Rationalisation as well as scientific and technical departmental services (Federal Ministry of Economics)	3.2	4.4	3.9	3.9
T9	Other promotion measures (Federal Ministry of Economics)	11.8	70.6	277.7	198.5
U	**Specialised information**	**74.0**	**84.2**	**82.0**	**78.7**
V	**Humanities; economic and social sciences**	**327.2**	**391.2**	**491.1**	**519.7**
W	**Other acitvities not assigned to other sectors**	**709.7**	**709.0**	**566.7**	**475.3**
A-W	**Total civil promotion areas**	**11,760.2**	**13,682.8**	**14,706.6**	**14,709.5**
X	**Defence research and technology**	**3,388.8**	**3,169.8**	**3,262.6**	**3,229.7**
Total expenditure		**15,149.0**	**16,852.6**	**17,969.2**	**17,939.2**

[1]) Including universities of the Federal Armed Forces and Federal Fachhochschule for Public Administration; including, from 1989 onwards, the programme for ensuring academic efficiency and access to overcrowded courses (HSP I), from 1991 onwards the programme for ensuring the efficiency of universities and research and for promoting young scientists (HSP II) as well as the Programme for the Renewal of Higher Education and Research in the new Länder and East Berlin.

[2]) Without prorata expenditure of national research centres (for the time being still included in the expenditure of promotion priority E3).

Source: BMFT

Rounding error

From 1992 onwards, after important activities in the restructuring process of non-university research in the new Länder had been completed, federal funds for the new Länder which in 1991 had mainly been appropriated to priority activities, could be allocated more specifically to promotion areas and priorities. While in 1991 transitional funding of the Academy of Sciences had been allocated as a lump sum to the promotion priority "Basic funding of institutions and restructuring of research in the new Länder (without MPG, FhG) – transitional funding of Academy of Sciences", basic funding of institutions has been provided from 1992 onwards in a more specific way according to the research priorities of the newly founded research institutions. As indicated by the data of the Federal Government's draft budget for 1993, substantial growth rates can be expected for the promotion areas "Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities" (+ 10.3 %) and – after a drastic cut of expenditure in 1992 – "Research and development in agriculture, forestry and fishery" (+ 10.1 %) and "Biotechnology" (+ 10.0 %). Other sizeable increases can be registered in the promotion areas "Geosciences and raw material supplies" (+ 7.9 %), "Educational and vocational training research" and "Humanities; economic and social sciences" (+ 5.8 % each) as well as "Research and development in the service of health" (+ 5.7 %). A declining trend can be observed for the promotion areas "Aeronautical research and hypersonic technology" (– 32.2 %) and – after sizeable growth in previous years – "Regional planning and urban development; building research" (– 17.9 %), "Other activities not assigned to other areas" (– 16.1 %) and "Innovation and improved basic conditions" (– 11.4 %) (cf. Table II/5).

In 1990 and 1991, the trend of R&D expenditure by the Federal Ministry for Research and Technology (Table II/6) deviated from that of federal expenditure. With an increase in expenditure of 32.2 % the promotion area "Environmental research; climate research" ranks first, followed by "Geosciences and raw material supply" (+ 28.4 %), "Information technology (including production engineering)" (+ 13.6 %) and "Specialised information" (+ 12.0 %). The funds allocated to "Space research and space technology" and "Building research" went up by 11.3 % each. It is worth noting that funds for the research areas "Humanities; social sciences" and "Research and development in the service of health" grew at above-average rates of 10.8 % and 10.7 %, respectively. The trend of the 1992 target deviates from the actual 1991 figures; for instance, the promotion area "Other activities not assigned to other areas" which also includes the programme for ensuring efficiency at universities and in research and for the promotion of young scientists (+ 41.6 %) and the promotion areas "Innovation and improved basic conditions" (+ 32.7 %) and "Supporting organisations" with the promotion priorities of basic funding of MPG and FhG (+ 30.4 %) are in the top group. A comparison of the R&D expenditure by the BMFT targeted for 1992 and projected in the Federal Government's draft budget for 1993 shows that the promotion areas mentioned above will again enjoy above-average growth. The increase rates of R&D expenditure on "Information technology (including production engineering)" and "Space research and space technology", on the other hand, will remain below average. Regarding the trend of the BMFT expenditure data targeted for 1992 as well as the figures in the government draft budget for 1993, it should be noted that the global reduction of expenditure (DM 180 million in both 1992 and 1993) could not yet be taken into account.

Table II/6

R&D expenditure of the Federal Ministry for Research and Technology by promotion areas and promotion priorities
– DM million –

Promotion area / Promotion priority		1990	1991	1992	1993
		Actual		Budget	Govt. draft
A	**Supporting organisations**	**635.4**	**679.6**	**886.5**	**987.4**
A1	Basic funding MPG	471.0	499.3	555.0	622.8
A3	Basic funding FhG	164.4	180.3	331.6	364.3
A4	Basic funding of institutions and restructuring of research in the new Länder – transitional funding of Academies of Sciences –	—	—	—	—
B	**Large-scale equipment for basic research**	**962.0**	**972.3**	**999.0**	**1,051.2**
C	**Marine research and marine technology; polar research**	**221.7**	**230.5**	**263.1**	**248.3**
C1	Marine research	115.6	103.3	129.1	129.9
C2	Marine technology	49.7	57.6	60.7	47.8
C3	Polar research	56.4	69.6	73.2	70.6
D	**Space research and space technology**	**1,388.1**	**1,544.7**	**1,797.0**	**1,815.9**
E	**Energy research and energy technology**	**1,199.0**	**1,143.5**	**1,106.3**	**1,039.6**
E1	Coal and other fossil fuels	152.5	114.1	121.6	107.8
E2	Renewable energies and energy conservation	289.4	322.6	391.0	348.1
E3	Nuclear energy research (excluding decommissioning of nuclear facilities	564.5	502.5	388.3	367.9
E4	Decommissioning of nuclear facilities; risk sharing[1]	—	—	—	9.7
E5	Nuclear fusion research	192.5	204.3	205.4	206.1
F	**Environmental research; climate research**	**445.5**	**588.9**	**689.4**	**713.4**
F1	Ecological research	191.8	215.3	268.1	288.3
F2	Environmental technologies	171.6	251.2	268.7	260.0
F7	Climate and atmospheric research	82.1	122.3	152.6	165.1
G	**Research and development in the service of health**	**365.7**	**404.8**	**477.6**	**512.1**
H	**Research and development to improve working conditions**	**97.5**	**95.5**	**88.7**	**83.5**
I	**Information technology (including production engineering)**	**732.9**	**832.3**	**1,000.7**	**1,014.9**
I1	Computer science	207.4	214.3	185.6	192.5
I2	Basic information technologies	353.1	391.1	536.9	545.8
I3	Application of microsystems (including microelectronics and microperipherals)	64.8	98.4	140.3	140.6
I4	Production engineering	107.6	128.5	137.9	136.0
K	**Biotechnology**	**248.0**	**266.6**	**303.3**	**296.9**
L	**Materials research; physical and chemical technologies**	**462.8**	**507.2**	**491.3**	**514.6**
L1	Materials research	233.3	259.2	250.5	258.3
L2	Physical and chemical technologies	229.5	247.9	240.8	256.3
M	**Aeronautical research and hypersonic technology**	**220.2**	**238.3**	**211.3**	**203.1**
N	**Research and technology for ground transport (including traffic safety)**	**190.1**	**183.8**	**169.1**	**169.1**
O	**Geosciences and raw material supplies**	**66.1**	**84.8**	**120.9**	**129.9**
O1	Geosciences (especially deep drillings)	61.3	81.3	118.4	129.0

Table II/6

Promotion area / Promotion priority	1990	1991	1992	1993
	Actual		Budget	Govt. draft
O2 Raw material supplies	4.8	3.5	2.5	0.9
P Building research	**40.0**	**44.5**	**41.4**	**35.0**
P2 Building research and technology, research and technology for preserving the architectural heritage	40.0	44.5	41.4	35.0
T Innovation and improved basic conditions	**140.0**	**123.6**	**164.1**	**187.0**
T1 Indirect funding of R&D personnel in industry	59.9	30.3	32.0	33.0
T2 Improving the transfer of technology and knowledge	39.9	47.4	71.0	71.0
T3 Sharing the innovation risk of technology-based firms	40.2	45.9	61.1	83.0
U Specialised information	**62.9**	**70.4**	**69.1**	**65.5**
V Humanities; economic and social sciences	**93.1**	**103.1**	**129.7**	**138.1**
W Other activities not assigned to other sectors	**185.3**	**141.9**	**200.9**	**242.9**
Total expenditure	**7,756.1**	**8,256.3**	**9,209.3[2])**	**9,448.0[2])**

[1]) Without prorata expenditure of national research centres (for the time being still included in the expenditure of promotion priority E 3).
[2]) Excluding global reduction of expenditure (1992 DM 180 million, 1993 DM 180 million).

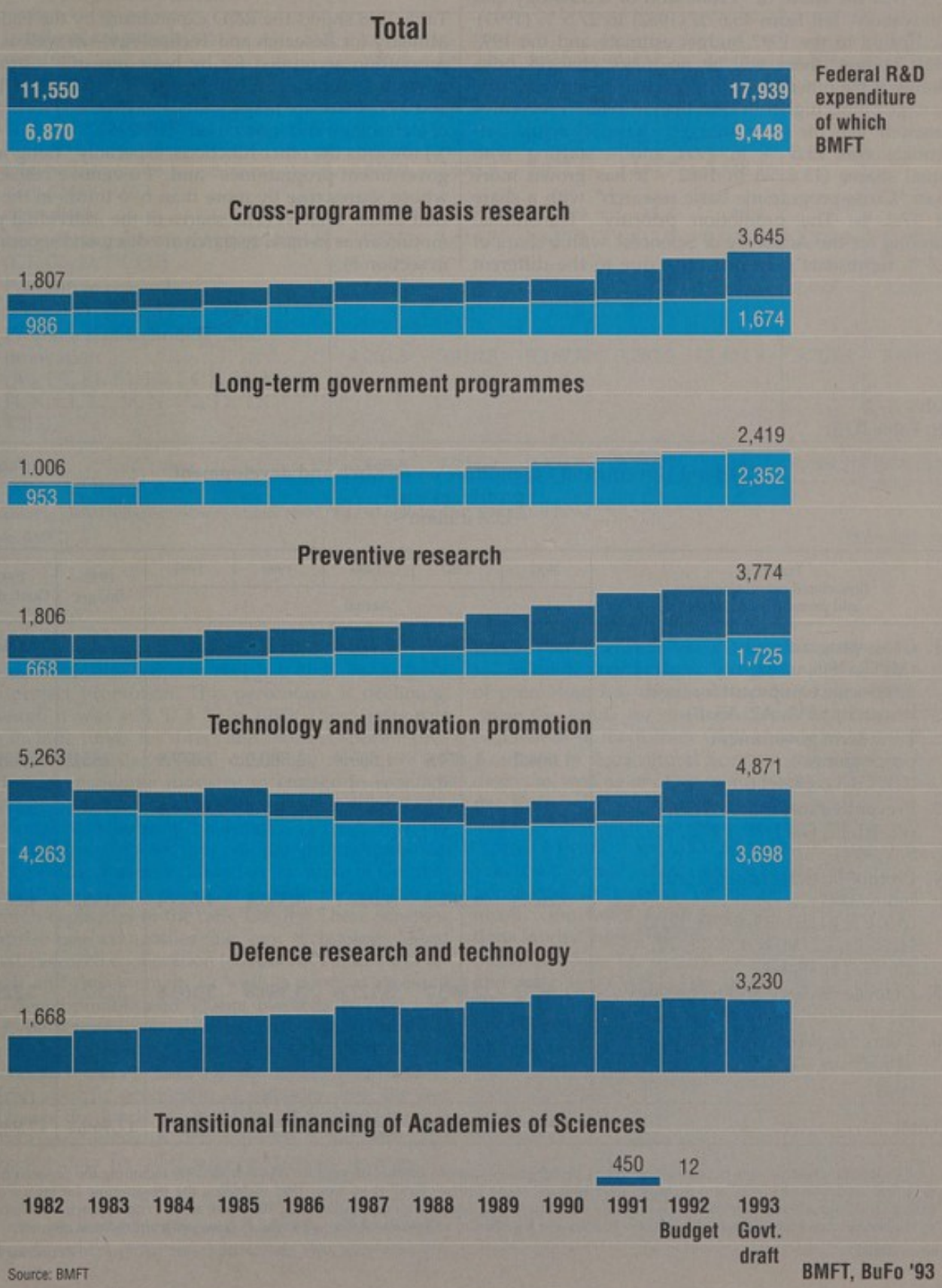
Source: BMFT

Rounding error

Figure II/6 (cf. Table II/7 and 8)

R&D expenditure of the Federal Government and the BMFT

– 1982 to 1993 profile (DM million) –



Source: BMFT

BMFT, BuFo '93

In the profile review the R&D expenditure on individual promotion areas and priorities is grouped to form functions, thus permitting a better overview – when R&D funds are appropriated – of the trend of priorities of recent years as well as current priorities (cf. Figure II/6).

It can be seen from Table II/7 which shows the profile structure of federal R&D expenditure from 1982 to 1993 that the share of "Promotion of technology and innovation" fell from 45.6 % (1982) to 27.5 % (1991). According to the 1992 budget estimate and the 1993 draft budget, there will be no major changes here. Shares of the other civil functions will be almost 5 percentage points higher in 1993 than in 1982. "Preventive research" has the second largest share; its actual percentage was 21.5 % in 1991 and – starting with equal shares (15.6 %) in 1982 – it has grown more than "Cross-programme basic research" with a share of 17.2 %. The promotion prioritiy "Transitional funding for the Academy of Sciences" with a share of 2.7 % represents a special case; due to the different research subjects addressed by the Academy institutes, it could not be assigned to any of the other functions and was therefore made a function in its own right.

A positive trend of the function "Cross-programme basic research" is reflected both in the target data for 1992 and in the Federal Government's draft budget for 1993, while the shares of the other functions do not change compared with actual expenditure for 1991.

Table II/8 shows the R&D expenditure by the Federal Ministry for Research and Technology – as well as the proportion accounted for by basic research – broken down by functions. It can be seen that between 1982 and 1991 there are major shifts away from "Promotion of technology and innovation" (1982: 62.1 %, 1991: 41.2 %) towards the other functions, especially "Long-term government programmes" and "Preventive research" whose shares rose by more than two thirds in the period under review. (The shares of the individual promotion areas in basic research are discussed separately in section 5).

Table II/7
(cf. Table II/5)

Federal Government expenditure on research and development
– profile review –
– DM million –

Function (associated promotion areas and promotion priorities)	1982	1987	1989	1990	1991	1992 Budget	1993 Govt. draft
	Actual						
1. Cross-programme basic research .. (MPG, DFG, university construction; large-scale equipment for basic research)[1]) (A1, A2, A5, B)	1,807.2	2,340.3	2,435.9	2,492.2	2,898.2	3,335.8	3,645.1
2. Long-term government programmes ..... (C1, C3, D, E5, O1)	1,006.2	1,471.6	1,689.8	1,880.2	2,077.9	2,385.0	2,418.9
3. Preventive research ..... (F1, F2, F7, G, H, P1, P2, Q, R, S, V, W1)	1,805.8	2,164.3	2,685.8	3,049.3	3,621.3	3,780.5	3,774.2
4. Promotion of technology and innovation ..... (A3, C2, E1, E2, E3, E4, I1, I2, I3, I4, K, L1, L2, M, N, O2, T1, T2, T3, T4, T8, T9, U)	5,263.3	4,282.3	4,097.1	4,338.4	4,635.4	5,193.3	4,871.3
5. Defence research and technology .. (X)	1,667.7	2,893.7	3,127.6	3,388.8	3,169.8	3,262.6	3,229.7
6. Transitional funding of Academy of Sciences ..... (A4)	–	–	–	–	450.0	12.0	–
Total	**11,550.1**	**13,152.2**	**14,036.2**	**15,149.0**	**16,852.6**	**17,969.2**	**17,939.2**

[1]) Unlike specific presentations of basic research this profile review assigns promotion priority A5 (as from 1989 including the programme on ensuring academic efficiency and access to overcrowded study courses (HSP I), as from 1991 including the programme for ensuring the efficiency of higher education institutions and research and for promoting young scientists (HSP II) as well as the Programme for the Renewal of Higher Education and Research in the new Länder and East Berlin) and promotion area B in full to cross-programme basic research.

Source: BMFT

Rounding error

Table II/8
(cf. Table II/6)

Expenditure of the Federal Ministry for Research and Technology on research and development
– profile review –
– DM million –

Function (associated promotion areas and promotion priorities)	1982	1987	1989	1990	1991	1992 Budget	1993 Govt. draft
	Actual						
1. Cross-programme basic research ..... (MPG; large-scale equipment for basic research) (A1, B)	986.4	1,413.8	1,415.3	1,433.0	1,471.6	1,554.0	1,674.0
basic research covered by functions 2 to 4	*831.6*	*1,272.1*	*1,537.2*	*1,751.7*	*1,867.2*	.	.
total basic research	*1,818.0*	*2,685.9*	*2,952.5*	*3,184.7*	*3,338.8*	.	.
% of BMFT R&D expenditure	*26.5*	*37.2*	*40.3*	*41.1*	*40.4*	.	.
2. Long-term government programmes (C1, C3, D, E5, O1)	952.7	1,416.7	1,630.2	1,813.9	2,003.1	2,323.2	2,351.5
3. Preventive research ..... (F1, F2, F7, G, H, P2, V, W1)	667.5	974.7	1,091.4	1,227.0	1,378.7	1,627.7	1,725.1
4. Promotion of technology and innovation ..... (A3, C2, E1, E2, E3, E4, I1, I2, I3, I4, K, L1, L2, M, N, O2, T1, T2, T3, U)	4,263.3	3,410.8	3,187.8	3,282.3	3,402.8	3,704.4	3,697.5
Total	**6,869.8**	**7,216.0**	**7,324.7**	**7,756.1**	**8,256.3**	**9,209.3**[1])	**9,448.0**[1])

[1]) Excluding global reduction of expenditure (1992 DM 180 million, 1993 DM 180 million).

Source: BMFT

Rounding error

The breakdown of federal R&D expenditure by types of promotion shows that in 1991 half of the funds went into project promotion. This percentage is declining, although it was still 54.3 % in 1990. These resources also include funds for direct and indirect specific promotion (without tax-related measures) which are intended to encourage industry to engage in research and development. After the previous scheme on R&D-personnel costs subsidy for small and medium-sized firms had been phased out, similar programmes are now being increasingly funded in the wake of German unification which are intended to maintain or build up research capacities in the new Länder. These schemes comprise new companies (e.g. new technology-based firms), research cooperation (cooperative industrial research and development as well as contract research and development) and grants towards payroll cost (R&D-personnel costs subsidy East, BMWi, and research-personnel increase promotion, BMFT) (cf. Part II, sections 8 and 9). After a sharp decline in direct and indirect specific promotion of industry over the last few years the funds for this type of promotion were raised considerably in 1991 (up 24.6 % on 1990). The budgeted data for 1992 suggest another increase by about 32 %.

In 1991, almost 41 % of federal R&D expenditure is accounted for by institutional funding; this includes the R&D expenditure of federal scientific institutions listed in the federal budget. The percentage of this type of promotion has increased (up 36.8 % on 1990), because the funds for the transitional financing of the Academies of the former GDR (Academy of Sciences, Academy of Agricultural Sciences and Building Academy) as well as of other institutions in the new Länder financed or co-financed by the Federal Government were allocated to this category, in particular to "Other Private Non-Profit institutions" and "Higher Education sector". After the restructuring process of non-university research in the new Länder has been mostly completed, funds have been shifted to institutions funded jointly by the Federal and Länder governments (such as the organisations promoting research and science) as well as to institutions named in the "Blue List". The share of national research centres, however, dropped considerably from 15.8 % in 1990 to 14.3 % in 1991. The reason is that from 1991 to 1994 the institutional funding of the 13 national research centres in the old Länder will not be increased in nominal terms – with a distinction being made at the same time between the specific subjects addressed by the individual centres. The data of the government draft budget for 1993 suggest that there will be a slight increase again (15.1 %) after a stagnation in 1992 (budgeted); this increase is mainly accounted for by the new national research centres set up in the new Länder.

In 1991, the share of "International cooperation" in federal R&D expenditure amounted to 8.7 % and, according to the 1992 budget data, is approaching the 10 % mark.

The outlook for 1993 shows that the share of "Project promotion" (45.7 %) will continue to decline in favour of "Institutional funding" (44.2 %) and "International cooperation" (10.0 %).

The breakdown of the Federal Government's R&D expenditure by recipient groups provides an overview of the distribution of federal funds channelled to individual sectors of the national economy for performing R&D or earmarked for financing their R&D. The trend of actual expenditure from 1982 to 1991 shows that the funds for "Industry" dropped quite sharply from 47.3 % to 30.1 %, while some of the other recipient groups enjoyed sizeable increases.

In 1991, government institutions (institutions of Federal, Länder and local governments including higher education institutions) received about DM 3.7 billion which is just under 22 % of federal R&D expenditure. This sum does not include funds appropriated to the German Research Foundation for the benefit of higher education institutions; in this survey these funds – due to the system applied – fall into the category of scientific non-profit organisations.

Higher education institutions and university hospitals received the following federal R&D funds, including the funds channelled to them via the German Research Foundation:

1989 (Actual)	DM 1.7 billion
1990 (Actual)	DM 1.9 billion
1991 (Actual)	DM 2.3 billion
1992 (budgeted)	DM 2.4 billion
1993 (government draft)	DM 2.5 billion.

There are several factors which help explain why federal funds for university research have increased considerably, especially between 1990 and 1991: In addition to federal project funds which had risen substantially over the last few years, the Federal and Länder governments' Special University Programmes (HSP) for ensuring academic efficiency and access to overcrowded courses (HSP I) as well as for promoting young scientists (HSP II) contributed greatly to this increase. Furthermore, from 1991 onwards, after German unification, higher education institutions in the new Länder and East Berlin received additional federal funds under the University Renewal Programme. It should be noted that only an average R&D share of 30 % of the functional federal funds allocated to universities is included in this consideration.

In 1991, the share of non-profit scientific organisations – including the German Research Foundation and collaborative research centres ("Sonderforschungsbereiche") – rose to 37.4 %; these organisations have thus become the largest group of recipients. The better part of funds in this group goes to national research centres which in 1991 received about DM 2.7 billion as basic funding and for project promotion. The large decline in the share held by this recipient group in 1991 is explained by the decision not to increase the basic funding of the 13 national research centres in the old Länder in nominal

Table II/9

Shares of recipient groups in the Federal Government's R&D expenditure
– in % –

Recipient group	1982	1987	1989	1990	1991	1992 [1] Budget	1993 [1] Govt. draft
	Actual						
Local authorities	15.4	17.1	19.8	20.2	21.8	21.3	21.6
of which:							
Federal Government-owned institutions	7.5	8.3	8.4	7.7	8.3	9.3	10.0
Länder and local government institutions including universities [2]	8.0	8.9	11.4	12.5	13.6	12.0	11.5
Private Non-Profit institutions [3]	29.9	35.1	35.3	34.5	37.4	37.7	40.0
Industry	47.3	37.8	34.7	34.2	30.1	29.7	26.8
Abroad	7.3	9.9	10.3	11.0	10.7	11.4	11.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**
DM million	*11,550*	*13,152*	*14,036*	*15,149*	*16,853*	*17,969*	*17,939*

[1]) Estimated.
[2]) Excluding DFG institutional funding and special research programmes.
[3]) Including DFG institutional funding and special research programmes.

Source: BMFT

Rounding error

terms before 1994 (with a distinction being made between the subjects addressed by the centres).

Other non-profit scientific institutions whose share more than doubled in 1991, compared with 1990, enjoyed the largest relative increase. The funds for the transitional financing of the Academy of Sciences, Academy of Agricultural Sciences and Building Academy of the former GDR were almost totally allocated to this group of recipients. Still provisional and partly estimated, this breakdown of expenditure by recipient groups as budgeted for 1992 suggests that even after the research restructuring process has been completed a large number of institutions in the new Länder will still be in this group (cf. Table II/9).

Also the recipient group "Abroad" enjoyed a substantial increase over the past few years. Its share rose from 7.3 % in 1982 to 10.7 % in 1991 and will continue to increase in 1992 (cf. Table II/9).

A breakdown of the recipient group "Industry" by industrial sectors shows that, with a share of 78.1 % (1991), the companies in the manufacturing industry (without building industry) received by far the highest percentage of federal funds. Within this branch of industry expenditure focussed on "Steel construction, mechanical engineering and vehicle construction" and "Electrical engineering, fine mechanics and optics" which together accounted for about 70 % of federal R&D expenditure on industry. While the share of the manufacturing industry (without building industry) has hardly changed compared with 1982 (80.3 %), that of "Utilities and mining" shrank by more than 50 %. In contrast, the share of "Services rendered by private businesses and the liberal professions" soared by 50 % in the period under review.

In 1991, almost 11 % of federal R&D funds was channelled to international scientific organisations; this percentage has hardly changed compared with the previous year. The better part went to international scientific organisations and research institutions in the form of membership fees. The European Space Agency (ESA) and the European Organisation for Nuclear Research (CERN) received the predominant share of these funds.

5. Share of basic research in research promotion by the Federal Government

After substantial annual increases of the funds allocated to basic research in the 1980s its share in federal R&D expenditure stagnated after 1989 at a level of about 28 %. Nevertheless expenditure on this type of research rose more sharply (89.7 %) between 1981 and 1991 than total expenditure on research and development (62.5 %) (cf. Table II/10). The trend of basic research after 1989 was influenced by the various special programmes which were aiming not so much at increasing basic research, but rather at maintaining research capacities, especially at the higher education institutions. Among these programmes are the programme for ensuring academic efficiency and access to overcrowded courses (HSP I) and the programme for ensuring efficiency at universities and in research and for promoting young scientists (HSP II) as well as financial assistance, pursuant to Article 104a, para 4 of the Basic Law, to (old) Länder with weak structures for investment in research and technology (1989 to 1992). 1991 was characterised by special developments in the wake of German unification, because funds appropriated to universities and research as well as industry-related research institutions in the new Länder primarily served to maintain science and research capacities and improve the research infrastructure. Apart from these specific aspects the share of basic research was also influenced by capital outlay for large-scale projects in the period under review.

Table II/11 shows the share of basic research in the Federal Government's R&D expenditure in 1991, broken down by promotion areas. The promotion areas "Large-scale equipment for basic research" (almost 100 %), "Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities", "Marine research and marine technology; polar research" and "Biotechnology" (more than 50 % each) all hold above-average shares. Below this level, but still above average (28.1 %) are the shares held by the promotion areas "Geosciences and raw material supply" (47.0 %), "Humanities; economic and social sciences" (34.1 %), "Research and development in the service of health" (35.3 %) and "Space research and space technology" (29.1 %).

If only civil promotion areas are included in the assessment, it becomes apparant that more than one third of federal R&D funds are allocated to basic research. The share of basic research in the R&D expenditure by the Federal Ministry for Research and Technology is indicated in Table II/8. It shows a substantial increase of

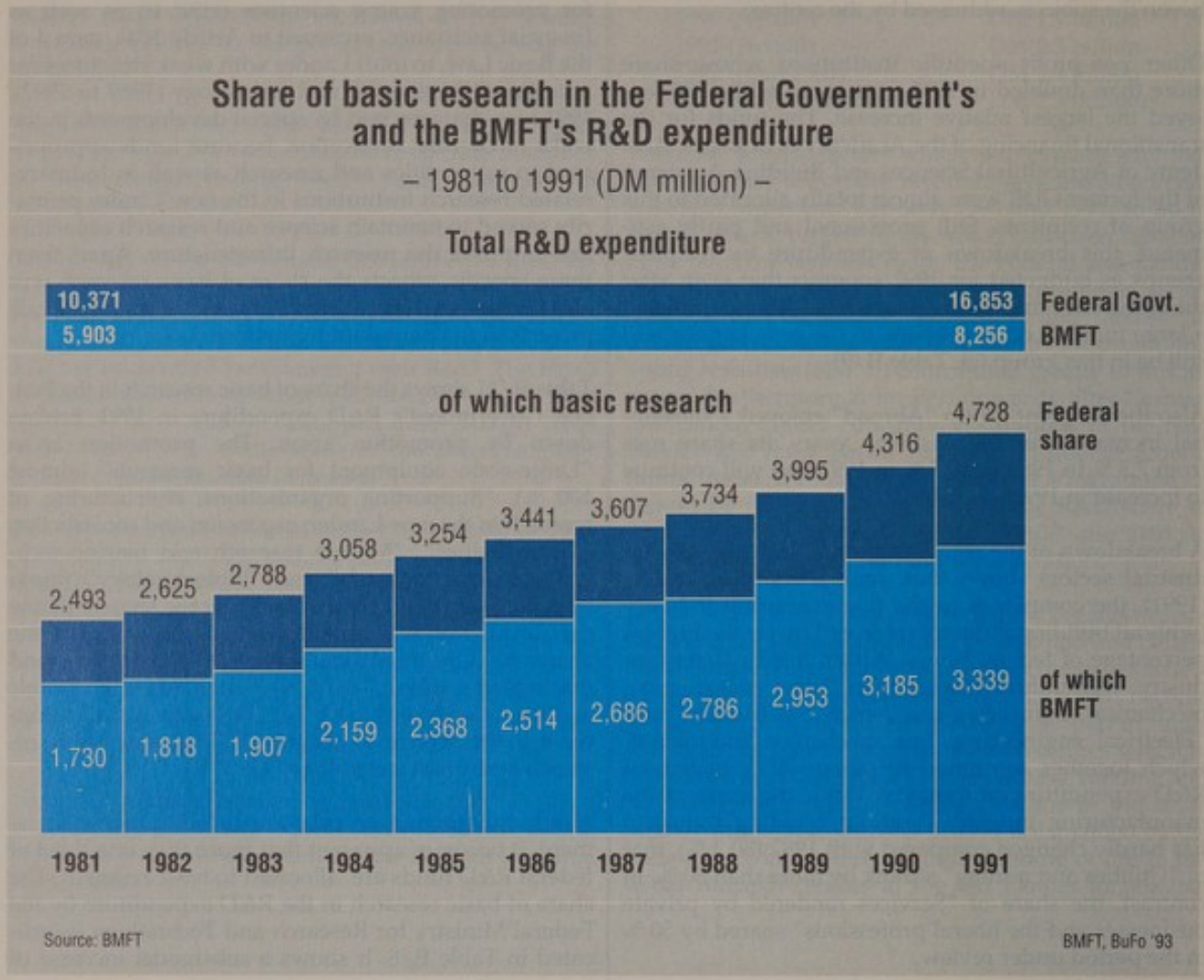
Table II/10

Share of basic research in the Federal Government's R&D expenditure

Year	R&D expenditure of Federal Government	Share of basic research	
	DM million		%
1981	10,371.0	2,492.6	24.0
1982	11,550.1	2,624.9	22.7
1983	11,438.8	2,788.0	24.4
1984	11,739.4	3,058.1	26.0
1985	12,766.9	3,254.4	25.5
1986	12,896.9	3,440.6	26.7
1987	13,152.5	3,606.8	27.4
1988	13,265.4	3,733.6	28.1
1989	14,036.2	3,995.4	28.5
1990	15,149.0	4,315.6	28.5
1991	16,852.6	4,728.0	28.1

Source: BMFT

Figure II/7 (cf. Table II/10)



basic research from 26.5 % in 1982 to 40.4 % in 1991. Compared with 1990, however, there is a slight drop. Apart from "Cross-programme basic research" the shares of the other functions in basic research also increased considerably.

6. Expenditure of the Länder on research and development

In 1990, the last year for which mostly actual data are available, the expenditure of the Länder governments on research and technology amounted to DM 9.6 billion, that is about 5.2 % up on the 1989 figure (DM 9.2 billion) and about 40 % up 1981 (cf. Table II/12).

R&D expenditure in 1991 and 1992 for the first time includes data for the new Länder and East Berlin. Since during those years the science expenditure of the old Länder (including East Berlin) from which the R&D expenditure is derived, is based on actual data, while that of the new Länder is based on provisional figures, this information can only be considered an estimate. In 1991, the R&D expenditure of the old and new Länder totalled DM 12.1 billion, in 1992 about DM 13.0 billion; this is an increase of 7 %.

Basic funds allocated to science by Länder and local governments which cover R&D expenditure as well as expenditure on R&D-related activities, especially teaching at universities, amounted to about DM 21.0 billion (actual) in 1990, and hence were up 6.6 % on 1989 and 40.1 % on 1981.

While reporting has so far relied on the concept of science expenditure, i.e. the net expenditure by Länder and local governments in the areas "Higher Education institutions including university hospitals" and "Non-university science and research", 'basic funds for science' are based on net expenditure (in the various areas) adjusted for direct Länder revenues. The new concept was applied consistently to the entire period under review. The reason for using this modified indicator is that the level of science expenditure in the higher education sector used to be increasingly determined by expenditure on patient care in university hospitals. In 1990, direct revenues in the higher education sector amounted to more than DM 10 billion, thus accounting for more than one third of "science expenditure". These were mainly revenues from patient care in university hospitals.

The concept of 'basic funds' has therefore brought about a considerable change in the order of magnitude

Table II/11

Share of basic research in the Federal Government's R&D expenditure by promotion areas in 1991

	Promotion area	R&D expenditure 1991	of which basic research	Share of basic research
		DM million		%
A	Supporting organisations; restructuring of research in the new Länder; expansion and construction of universities	2,556.9	1,570.0	*61.4*
B	Large-scale equipment for basic research	973.3	972.3	*99.9*
C	Marine research and marine technology; polar research	241.7	144.7	*59.9*
D	Space research and space technology	1,544.7	449.2	*29.1*
E	Energy research and energy technology	1,215.1	184.2	*15.2*
F	Environmental research; climate research	895.9	224.4	*25.0*
G	Research and development in the service of health	638.9	225.6	*35.3*
H	Research and development to improve working conditions	140.0	13.9	*9.9*
I	Information technology (including production engineering)	855.1	192.9	*22.6*
K	Biotechnology	278.2	155.7	*56.0*
L	Materials research; physical and chemical technologies	602.3	133.2	*22.1*
M	Aeronautical research and hypersonic technology	881.8	11.8	*1.3*
N	Research and technology for ground transport (including traffic safety)	224.0	3.7	*1.6*
O	Geosciences and raw material supplies	190.4	89.4	*47.0*
P	Regional planning and urban development; building research	181.6	4.7	*2.6*
Q	Research and development in the food sector	100.5	24.1	*24.0*
R	Research and development in agriculture, forestry and fishery	440.7	23.3	*5.3*
S	Educational and vocational training research	123.6	4.0	*3.2*
T	Innovation and improved basic conditions	413.8	0.3	*0.1*
U	Specialised information	84.2	3.1	*3.6*
V	Humanities; economic and social sciences	391.2	133.6	*34.1*
W	Other activities not assigned to other sectors	709.0	161.9	*22.8*
A-W	Total civil promotion areas	13,682.8	4,725.8	*34.5*
X	Defence research and technology	3,169.8	2.2	*0.1*
Total federal R&D expenditure		**16,852.6**	**4,728.0**	***28.1***

Source: BMFT

Rounding error

Table II/12

Basic funds*) allocated by Länder and local governments to sciences
– DM million –

Land	1981	1987	1989	1990	1991	1992
	Actual				Budget	
Baden-Württemberg	2,332.5	2,968.9	3,230.3	3,415.7	3,787.3	3,972.3
Bavaria	2,217.6	2,835.4	3,274.0	3,595.9	3,957.6	4,257.7
Berlin [1]	1,381.8	1,634.4	1,772.4	1,882.0	2,356.9	2,569.6
Brandenburg	–	–	–	–	.	.
Bremen	180.0	212.4	266.5	287.4	287.6	301.6
Hamburg	595.1	748.1	786.2	804.5	861.7	1,020.4
Hesse	1,413.9	1,706.9	1,824.3	1,982.1	1,960.2	2,165.0
Mecklenburg-West Pomerania	–	–	–	–	.	
Lower Saxony	1,583.8	2,015.6	1,944.0	2,068.5	2,154.0	2,356.8
North Rhine-Westphalia	4,115.6	4,390.2	4,650.6	4,933.8	5,184.2	5,538.3
Rhineland-Palatinate	557.0	774.8	874.2	944.9	953.0	1,014.2
Saarland	164.9	273.0	340.6	314.6	369.3	329.7
Saxony	–	–	–	–	.	.
Saxony-Anhalt	–	–	–	–	.	.
Schleswig-Holstein	420.0	642.6	712.8	741.1	804.0	831.7
Thuringia	–	–	–	–	.	.
Total	**14,963.0**	**18,202.6**	**19,676.3**	**20,970.6**	**25,995.8**	**28,217.3**
of which						
Old Länder and East Berlin	14,963.0	18,202.6	19,676.3	20,970.6	22,675.8	24,357.3
New Länder without East Berlin [2]	–	–	–	–	3,320.0	3,860.0
of which						
R&D expenditure of Länder [3]	*6,898[4]*	*8,550*	*9,157*	*9,630*	*12,140*	*12,990*

*) Basic funds: net expenditure minus direct revenues (especially revenues from patient care in university hospitals).
[1]) As from 1991 including East Berlin.
[2]) Estimated on the basis of provisional results of higher education finance statistics and budgets.
[3]) Estimated in some cases; based on actual figures up to and including 1989. As from 1985, only R&D shares of Länder institutions included.
[4]) Revised.

Source: Federal Statistical Office, BMFT

Rounding error

of the indicator under consideration, which must be taken into account. Other minor structural shifts result from the fact that not all Länder have universities with associated hospitals (e.g. Bremen).

Including the new Länder and East Berlin, basic funds totalled DM 26.0 billion in 1991 and DM 28.2 billion in 1992. The five new Länder (without East Berlin) account for DM 3.3 billion and DM 3.9 billion, respectively (cf. Table II/12 and Figure II/8).

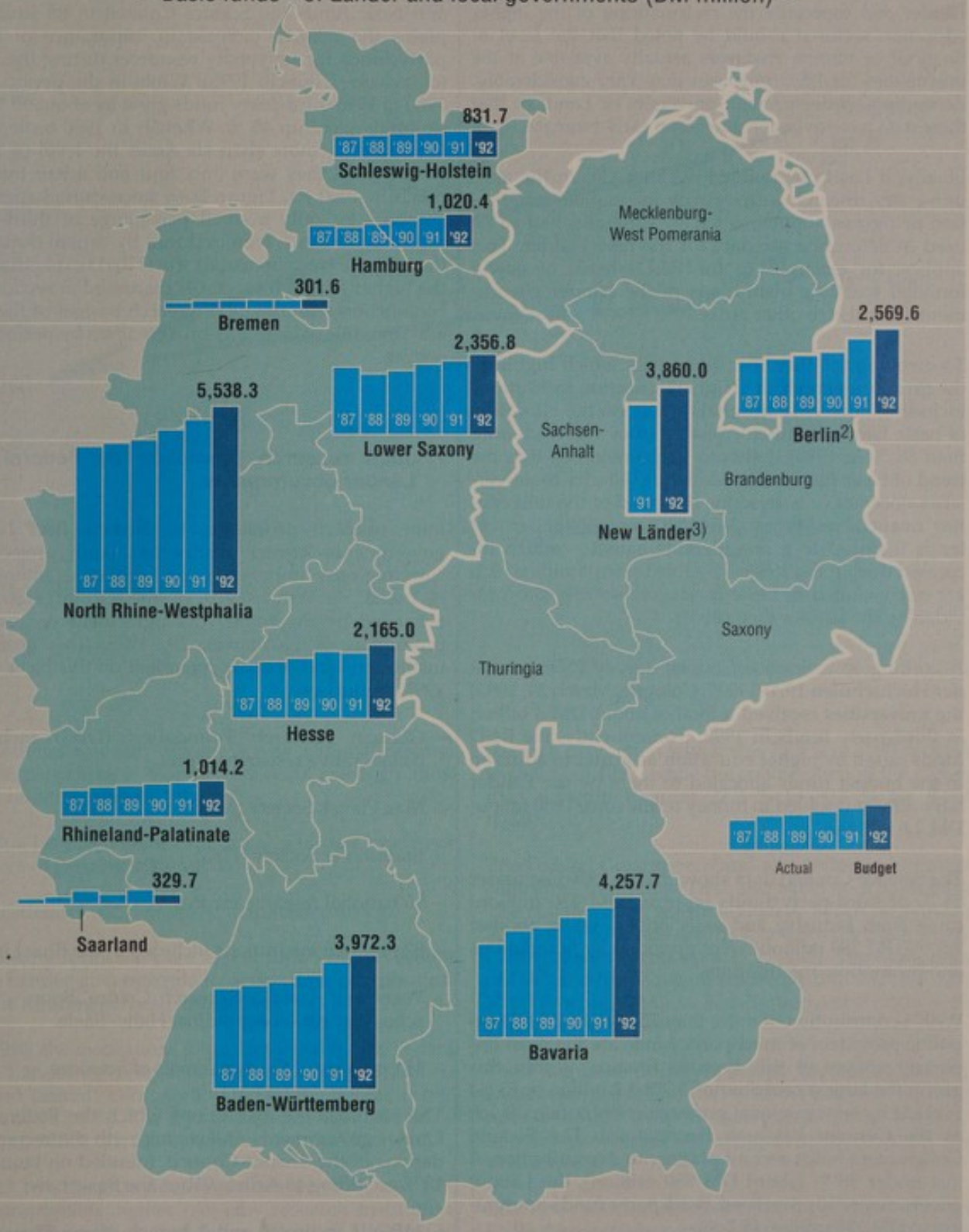
Like basic funds for science, the R&D expenditure of the Länder mainly goes to the higher education sector whose share in 1990 was about 73 %. Including the new Länder, their share in 1991 is estimated to amount to 69 %. In 1990, the non-university sector accounted for approx. 23 % of the Länder R&D expenditure; due to the inclusion of the new Länder and East Berlin, this share also changed slightly, rising to about 27 % in 1991. The share of R&D funds which the Länder spent on promoting research and development in industry was just under 4 % in 1990; according to an early estimate for 1991 the figure is also 4 % for the old and new Länder together.

When interpreting the data relating to the R&D expenditure by the Länder, the following special features need to be taken into consideration: As described in detail in earlier reports, the R&D expenditure of universities is determined by means of a computing procedure based on R&D coefficients. The basis of this computation consists of data related to expenditure of higher education institutions broken down by subjects, in conjunction with data or assumptions concerning specific activities of scientific personnel.

Figure II/8 (cf. Table II/12)

Science expenditure of Länder and local governments

– Basic funds[1] of Länder and local governments (DM million) –



1) Basic funds: net expenditure minus direct revenues (especially Länder revenues from patient care in university hospitals).
2) As from 1991 including East Berlin.
3) Estimated on the basis of provisional results of university finance statistics and budgets.

Source: Federal Statistical Office, BMFT.

BMFT, BuFo '93

Since these data were not available for the new Länder when this report was completed, the R&D expenditure of universities in the new Länder and East Berlin was computed on the basis of the average R&D coefficient of the old Länder. The 1991 and 1992 R&D expenditure by the new Länder determined in this way is DM 1.2 billion and DM 1.6 billion, respectively. In view of the reorganisation of the research scene in the new Länder and especially the restructuring of the higher education sector it should be noted that the level of financial or human resources actually available at the universities for R&D purposes may vary considerably, depending on department, university or Land, so that these data have to be considered an early estimate.

Finally, it has to be pointed out that also in the non-university research sector partly incomplete information or figures supplemented by estimates had to be used to determine the data for the new Länder. This applies, for example, to the R&D shares of newly founded scientific institutions of the Länder governments, but also to other areas.

To complement these considerations which highlight the great impact which "Higher education institutions including university hospitals" have on the allocation of basic Länder funds for science (they received more than 88 % in 1990) it should be pointed out that the trend of basic funds allocated by the Länder to universities does not fully describe the trend of the universities' financial resources. University research in particular is financed to a considerable extent – which increased during the 1980s – by third-party funds which are not included in basic funds, unless they are provided by the Länder themselves.

According to a Science Council survey ("Drittmittel der Hochschulen 1970-1990", Cologne, March 24, 1993) the universities received a total of about DM 3 billion in third-party funds in 1990. Consequently, the R&D funds raised by higher education institutes in addition to the budget funds allocated to them by the Länder have almost doubled in money terms since 1980 (about DM 1.6 billion).

The Science Council data show that in 1990 just under 15 % of third-party funds (approx. DM 430 million) came from industry and associations, while another 9.5 % (DM 280 million) were provided by foundations and promotion organisations.

With a contribution of more than 75 % (DM 2.2 billion) public providers of third-party funds are the most important source of this type of finance. Within this group the largest contribution (DM 1.2 billion or 53 %) is made by supraregional promotion institutions (such as the German Research Foundation). The Federal Government holds second place with a contribution of just under 38 % (about DM 850 million); the Länder governments appropriated third-party funds amounting to DM 130 million (5.7 %).

In the period from 1980 to 1990, the mean annual rate of increase of third party funds was 6.6 %. Third-party funds allocated by the Federal Government and by industry rose at disproportionately high rates (of about 9 % each). In the case of industry this figure resulted from above-average increase rates in the first half of the 1980s, while the Federal Government's contribution had especially high growth rates from 1985 onwards.

By comparing the trends of externally provided funds and basic funds the Science Council in its study explains the relative increase in importance of third-party funds for university resources during the 1980s (cf. Science Council, 1993): While in the period from 1980 to 1990 third-party funds grew by about 90 %, basic funds went up 40 %. Whereas in 1980 basic funds amounted to more than six times the level of third-party funds, they were only four and a half times as much in 1990 (cf. Figure II/9; since capital spending accounts for only a small percentage of third-party funds, basic funds were reduced by capital outlay for the purpose of comparison). Total R&D expenditure of the higher education sector is discussed in section 2 in conjunction with the total research budget of the Federal Republic of Germany broken down by performing sectors.

7. Joint research promotion by Federal and Länder governments

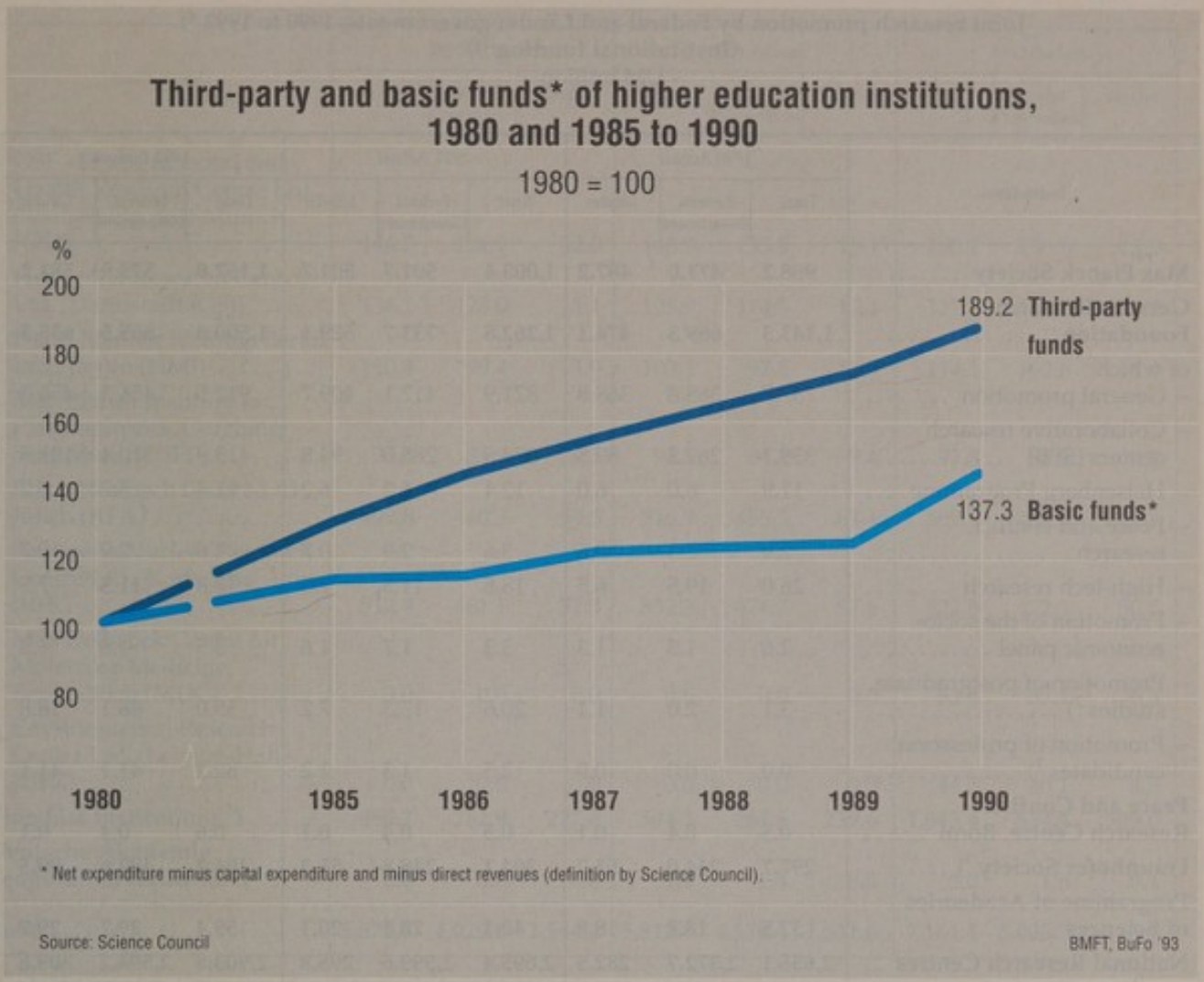
Joint research promotion by Federal and Länder governments covers institutions and projects of supraregional importance and national interest. It is based on Article 91b of the Grundgesetz and regulated by the framework agreement on research promotion of November 28, 1975. The group of institutions and projects promoted on this basis (as of 1992) comprises

- German Research Foundation (DFG) including collaborative research centres
- Max Planck Society (MPG)
- Fraunhofer Society (FhG)
- 16 national research centres
- 82 research institutions included in the Blue List
- Peace and Conflict Research Centre, Bonn – Deutsche Akademie Leopoldina, Halle/Saale
- 151 projects of the Academies of Sciences.

This includes the institutions which the Federal and Länder governments, in keeping with the recommendations of the Science Council, founded on January 1, 1992 according to Article 91b of the Basic Law:

- MPG: 2 institutes and 1 branch office; 28 working groups as well as a supporting organisation for the 7 humanistic centres proposed by the Science Council
- FhG: 9 institutions and 12 branch offices

Figure II/9



- National research centres: 3 new national research centres as well as 8 branch offices of existing national research centres
- Blue List: 34 new institutions as well as 4 branch offices of existing institutions
- Academies of Sciences: 50 long-term projects.

Financing formulae were agreed upon by the Federal and Länder governments to define their contributions to the funding of these institutions.

In 1990, the institutions jointly financed by the Federal and Länder governments received a total of DM 5.6 billion (actual), compared with DM 5.3 billion in 1989 (actual) (+ 5.2 %). The 1991 budget provides for DM 5.8 billion, which is a 4.3 % increase over the 1990 level.

At 23.2 %, the growth of funds between 1991 and 1992 is considerably higher. As new research institutions were set up in the new Länder, the funds allocated by the Federal and Länder governments to joint research promotion rose to a total of DM 7.2 billion. The Federal Government contributed DM 5.0 billion, the Länder DM 2.2 billion. Hence, the federal contribution to joint research promotion which was 72.3 % in 1990 dropped to 69.9 % in 1992, while the contribution of the Länder rose accordingly from 27.7 % to 30.1 % (cf. Table II/13).

The Federal Government and all Länder governments contribute to funding DFG and MPG on a 50:50 basis. The collaborative research centres which account for 30 % of DFG funds are financed by the Federal and Länder governments on a 75:25 basis. The total shares of DFG and MPG in joint research promotion fell from 37.7 % (actual 1990) to 37.1 % (budgeted 1992) in the period under review.

The Fraunhofer Society is jointly funded by the Federal Government and the 11 host Länder of the institutes on a 90:10 basis. Its share in joint research promotion has grown over the years; it amounted to 5.3 % in 1990 and 6.9 % in 1992.

Like FhG, national research centres are financed by the Federal government and the host Länder on a 90:10 basis. The total share of national research centres in the basic funding of institutions was 47.6 % in 1990 (actual) and, due to the changed composition of institutions receiving joint research promotion, 40.5 % in 1992.

Table II/13

Joint research promotion by Federal and Länder governments, 1990 to 1992 *)
(Institutional funding [1]))
– DM million –

Institutions	1990 Actual			1991 Actual			1992 Budget		
	Total	Federal Government	Länder	Total	Federal Government	Länder	Total	Federal Government	Länder
Max Planck Society	**958.2**	**471.0**	**487.2**	**1,003.4**	**501.7**	**501.7**	**1,157.0**	**575.9**	**581.2**
German Research Foundation	**1,143.3**	**669.3**	**474.1**	**1,262.8**	**733.7**	**529.1**	**1,500.8**	**865.5**	**635.3**
of which:									
– General promotion	737.7	368.8	368.8	821.9	412.1	409.7	912.5	456.3	456.3
– Collaborative research centers (SFB)	359.1	269.3	89.8	379.8	285.0	94.8	413.9	310.4	103.5
– Heisenberg Programme	11.9	6.0	6.0	12.4	6.2	6.2	11.4	5.7	5.7
– Peace and conflict research	2.9	2.3	0.6	3.6	2.9	0.7	3.6	2.9	0.7
– High-tech research	26.0	19.5	6.5	18.8	11.3	7.5	18.8	11.3	7.5
– Promotion of the socio-economic panel	2.6	1.3	1.3	3.3	1.7	1.6	3.5	1.8	1.8
– Promotion of postgraduate studies [2])	3.1	2.0	1.1	20.6	13.3	7.2	55.0	36.1	18.8
– Promotion of professorial candidates [2])	0.0	0.0	0.0	2.5	1.3	1.2	82.2	41.1	41.1
Peace and Conflict Research Centre, Bonn	**0.5**	**0.4**	**0.1**	**0.5**	**0.4**	**0.1**	**0.6**	**0.4**	**0.1**
Fraunhofer Society [3])	**297.7**	**244.0**	**53.7**	**304.1**	**248.8**	**55.3**	**494.1**	**403.6**	**90.5**
Programme of Academies of Sciences	**37.5**	**18.8**	**18.8**	**40.1**	**20.1**	**20.1**	**59.4**	**29.7**	**29.7**
National Research Centres	**2,655.1**	**2,372.7**	**282.5**	**2,695.4**	**2,399.6**	**295.8**	**2,903.8**	**2,594.2**	**309.6**
of which:									
– Alfred Wegener Institute for Polar and Marine Research, Bremerhaven (AWI)	82.1	72.9	9.2	98.2	88.3	9.9	105.3	94.6	10.6
– German Electron Synchrotron, Hamburg (DESY)	269.6	246.8	22.8	258.5	232.4	26.1	258.9	233.0	25.9
– German Aerospace Research Establishment, Cologne (DLR)[4])	394.3	340.0	54.3	390.7	327.0	53.7	410.1	356.8	53.3
– German Cancer Research Centre, Heidelberg (DKFZ)	140.0	126.0	14.0	152.6	137.3	15.3	144.6	130.1	14.5
– Biotechnological Research Company Ltd., Braunschweig-Stöckheim (GBF)	54.0	48.6	5.4	56.9	51.2	5.7	62.7	56.4	6.3
– Geoscientific Research Centre, Potsdam (GFZ)	0.0	0.0	0.0	0.0	0.0	0.0	49.3	44.3	4.9
– GKSS-Geesthacht Research Centre, Ltd., Geesthacht (GKSS)	95.8	86.2	9.6	97.8	88.0	9.8	121.9	109.7	12.2
– Mathematics and Data Processing Company Ltd., St. Augustin near Bonn (GMD)	120.9	108.8	12.0	120.6	108.5	12.1	127.1	114.4	12.7

Table II/13

Institutions	1990 Actual			1991 Actual			1992 Budget		
	Total	Federal Government	Länder	Total	Federal Government	Länder	Total	Federal Government	Länder
– GSF - Environmental and Health Research Centre Ltd., Neuherberg near Munich (GSF)	144.5	131.7	12.8	148.3	135.2	13.1	150.1	136.8	13.3
– Heavy Ion Research Centre Ltd., Darmstadt (GSI)	136.1	125.0	11.1	125.9	114.5	11.4	121.8	109.6	12.2
– Hahn-Meitner Institute Berlin Ltd., Berlin (HMI)	110.4	99.4	11.0	103.1	92.8	10.3	114.1	102.6	11.4
– Max Planck Institute for, Plasmaphysics, Garching near Munich (IPP)	95.4	85.9	9.5	93.5	84.2	9.4	97.8	88.0	9.8
– Jülich Research Centre Ltd., Jülich (KFA)	499.8	440.3	59.5	516.9	455.5	61.4	509.5	448.4	61.1
– Karlsruhe Nuclear Research Centre Ltd., Karlsruhe (KfK)	512.4	461.1	51.3	532.3	474.7	57.6	522.8	472.1	50.7
– Max Delbrück Centre for Molecular Medicine, Berlin-Buch (MDC)	0.0	0.0	0.0	0.0	0.0	0.0	63.4	57.1	6.3
– Environmental Research Centre Ltd., Leipzig-Halle (UFZ)	0.0	0.0	0.0	0.0	0.0	0.0	44.5	40.1	4.5
Blue List Institutions [5]	**480.7**	**252.9**	**227.8**	**504.3**	**264.6**	**239.6**	**1,043.4**	**534.4**	**509.0**
Deutsche Akademie Leopoldina, Halle/Saale	**0.0**	**0.0**	**0.0**	**1.4**	**1.4**	**0.0**	**2.0**	**1.6**	**0.4**
Total	**5,573.1**	**4,029.0**	**1,544.1**	**5,812.0**	**4,170.4**	**1,641.6**	**7,161.1**	**5,005.2**	**2,155.9**

*) Up to and including 1991 former West Germany, as from 1992 Germany as a whole.
[1]) The above sums also include funds provided on the basis of special agreements between Federal and Länder governments; this leads to deviations from the financing formulae laid down in the framework agreement on research promotion pursuant to Art. 91b of the Grundgesetz.
[2]) Including special funds from the Special University Programme II and the University Renewal Programme.
[3]) Not including institutional funding by the Federal Ministry of Defence as the institution is not subject to joint funding by Federal and Länder governments.
[4]) Not including a DM 24 million lump-sum payment by the Federal Ministry of Defence as the institution is not subject to joint funding by Federal and Länder governments.
[5]) All data budgeted.

Source: Economic plans as printed in Federal Budgets 1991 to 1993, Federal/Länder Commission for Educational Planning and Research Promotion, and BMFT calculations.

Rounding error

The new structure of institutions jointly promoted by Federal and Länder governments is best reflected in the research institutions included in the Blue List: Their number rose from 48 to 82, their share in total promotion increased from 8.6 % (1990) to 14.6 % (1992). The service institutions among them are funded by the Federal Government and all Länder governments (based on different financing formulae), while the other institutions are financed by the Federal Government and the respective host Land on a 50:50 basis.

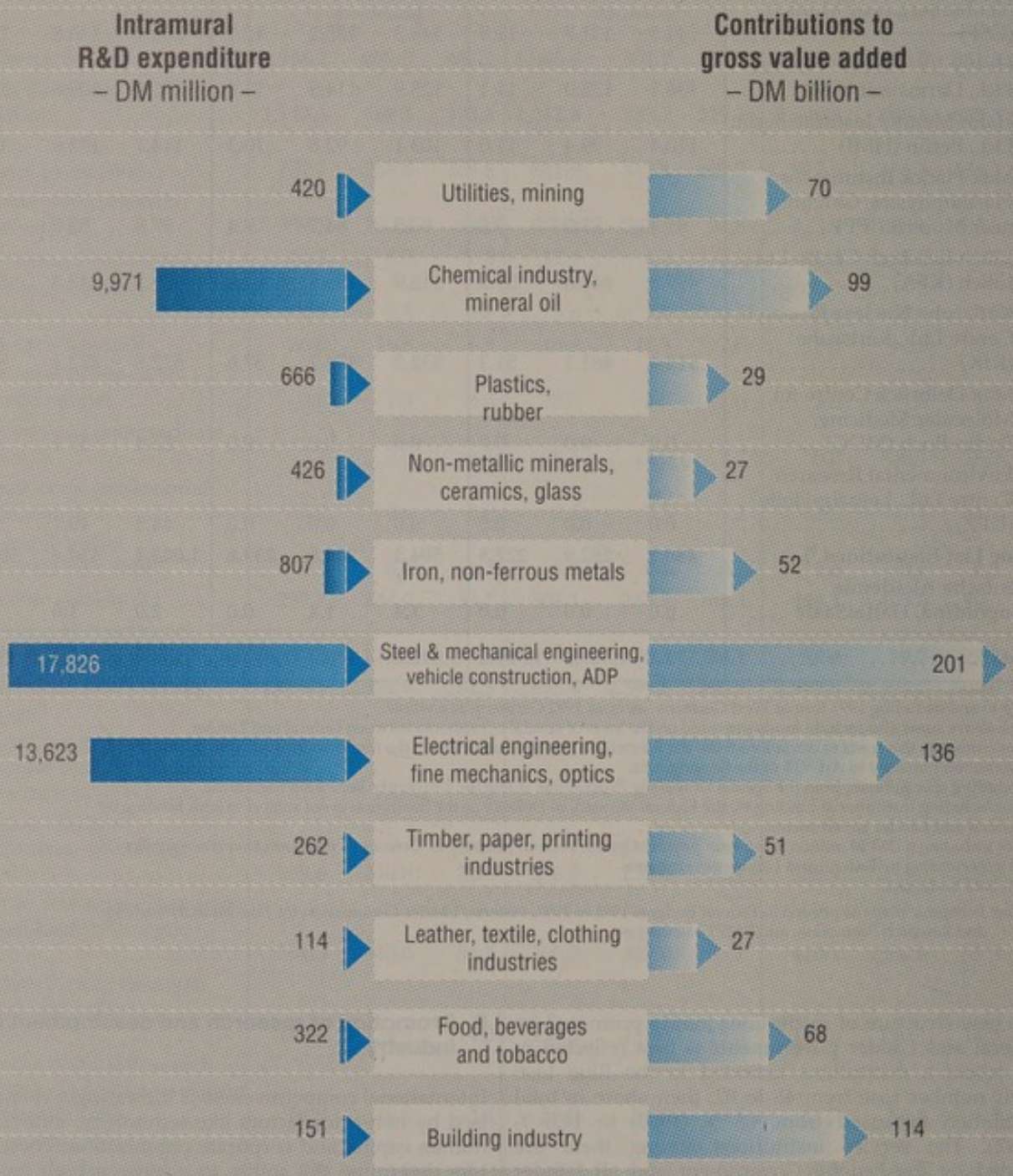
Finally, joint promotion also includes the Peace and Conflict Research Centre, Bonn, the Deutsche Akademie Leopoldina, Halle/Saale and the 151 projects of the Academies of Sciences.

8. Promotion of research and development in industry

International competitiveness is increasingly characterised by non-price factors like technology, innovation, human capital and corporate organisation. These factors determine the ability to achieve a high level of productivity. Over the last 30 years West German exporters could raise their prices considerably in the international markets, due to improved product properties. Consequently, Germany's world market share of 13 % hardly changed over this period, at constant prices and exchange rates, but the value share in the goods exports of all OECD countries, which is measured in dollars at the current exchange rate, rose by 4 %.

Figure II/10

Gross value added and intramural R&D expenditure of companies by industrial sectors, 1989



Intramural R&D expenditure by goods-producing industry:
DM 44.6 billion = 97.9% of total intramural R&D expenditure by industry in 1989

Contribution of goods-producing industry to gross value added:
DM 874.0 billion = 42.4% of gross value added in 1989 (provisional result)

Source: Federal Statistical Office
SV-Wissenschaftsstatistik GmbH

BMFT, BuFo '93

Germany has a competitive advantage with those products which excel by their special quality in terms of design and technical perfection and whose manufacture requires highly qualified manpower and a high level of scientific, technical and organisational know-how. The competitiveness of industry, a high level of qualification as well as basic conditions conducive to innovation are the critical factors which will determine whether Germany can keep and improve its position in the high-growth market segments of sophisticated technology products.

Strong impetus for growth from technology-intensive industries in the 1980s

During the phase of economic recovery in the early 1980s technology-intensive industries played an outstanding role. In the highly industrialised economy of the old Länder they became the driving force of production and employment growth. The upswing was characterised by the companies' determination to shape their own future by committing themselves more and more to research, development and innovation.

While the contributions by the Federal and Länder governments to the national research budget grew by about one third between 1981 and 1989, the funds allocated to research and development by industry increased by 87 %, thus clearly surpassing the growth of the gross domestic product (GDP). The firms' decision to increase their R&D efforts massively created the basis for a technology- and innovation-induced expansion of businesses. German industry thus provided a critical thrust for the strong growth in the second half of the 1980s.

Investment in innovations, which was also reflected by the considerable increase in the number of patents filed, led to above-average growth of production and employment, especially in technology-intensive industries: While in the period from 1980 to 1991 net production of the entire manufacturing industry grew by 2.4 % per year, it increased by 3.4 % in those industries whose products rely heavily on research and development (cf. also Figure II/10).[1])

Research- and technology-intensive goods play an essential role for German exports. In 1991, Germany's surplus in the trade with R&D-intensive goods amounted to more than DM 85 billion, thus surpassing by far the total trade surplus of DM 22 billion. Without the trade in R&D-intensive products Germany would have had to put up with a book-value trade deficit. This highlights the vital importance of highly competitive technology goods for the German economy which is greatly dependent on foreign trade.

Slackening dynamism in the early nineties

The fact that since 1989 the R&D expenditure of industry has grown much less than the gross domestic product and that the percentage of non-R&D-intensive products is increasing again in the product range of many manufacturers is a cause for worry. This slackening innovation dynamism is also reflected by the fact that between 1989 and 1991 intramural R&D expenditure of industry in the old Länder increased by an annualised 3.4 % while GDP grew by 8.4 %. In contrast, intramural R&D expenditure by industry between 1989 and 1991 went up 7.1 % per year on average, while the average GDP growth rate was 4.7 %.

Between 1989 and 1991, the total R&D expenditure of German companies in East and West rose by only 11.8 %, while GDP went up almost 26 %. The situation is no better when one looks at the old Länder only. There industrial R&D expenditure increased by about 7 % between 1989 and 1991, while GDP rose by 17.5 %.

The comparison of the rates of change of GDP with the changes in intramural R&D expenditure by various industries appears to be quite informative. The 1989 figures obviously relate to former West Germany. Consequently, one is not looking at a statistical update of a fixed system, but rather at the comparison of two different statistical survey units. In 1991 GDP (unified Germany) was almost 26 % higher than in 1989 (former West Germany). On average, the change in intramural R&D expenditure by individual industries remained below this level. A high increase in R&D investment was in the automotive industry (20.7 %). At 3.6 %, electrical engineering was considerably below the mean increase rate of R&D expenditure by the manufacturing industry as a whole (11,3 %).

The trend in the numbers of R&D personnel in industry tends to follow the same pattern as R&D expenditure. Thus, in the old Länder R&D personnel in industry decreased by 3.1 % between 1989 and 1991 (provisional data for 1991). Considerable declines were registered in particular in electrical engineering, plastics production, metal production and metal working.

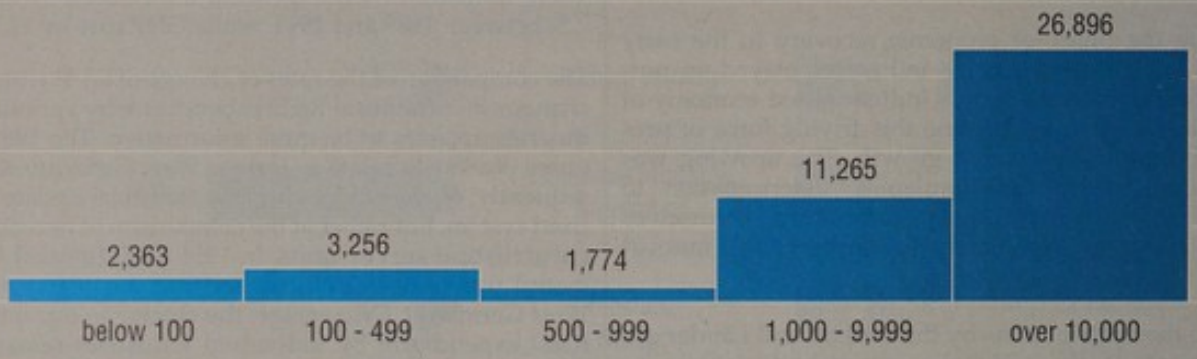
A look at international economic development shows that between 1989 and 1991/92 Germany's most important competitors in the world market for technology goods also had to face a considerable slowdown in the growth of industrial gross domestic expenditure on research and development. Between 1990 and 1991, the R&D expenditure of the Japanese industry increased only 3.2 % in real terms, after growth rates had been between 10 % and 12 % per year between 1987 and 1990. From 1990 to 1991, the contribution of Japanese industry to funding the national gross expenditure on R&D dropped by 0.4 percentage points to 72.7 %. In the USA – as in Germany – industrial research and development expenditure declined in real terms between 1989 and 1991; 1992, however, seems to have brought a turn around. It is hardly reassuring for Germany that its most important competitors have lost some of their dynamism in R&D expenditure. First, these competitors were able to keep their lead in some technology areas during this period and second, the industries of these countries are not at the same time burdened with an additional financial disbursement comparable with that for the reconstruction efforts in the new Länder (cf. Table II/22 and Figure II/14).

[1]) In these industries the share of R&D in turnover exeeds 3.5 %.

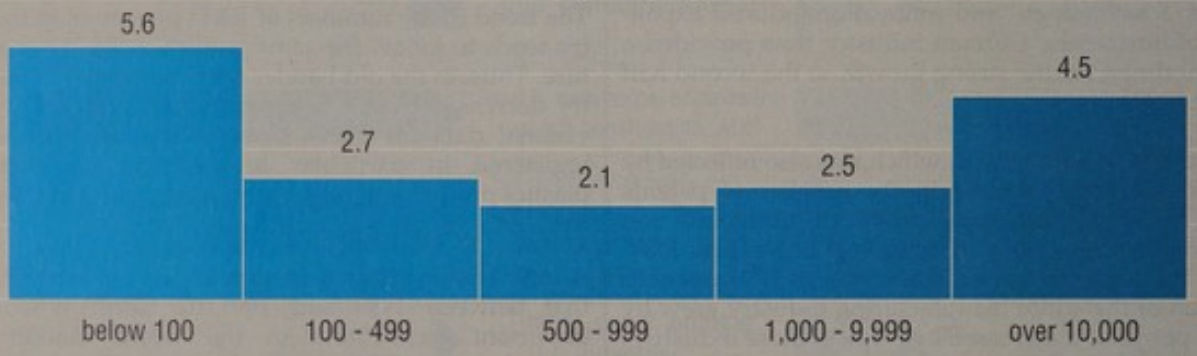
Figure II/11

Intramural R&D expenditure of industry in 1989

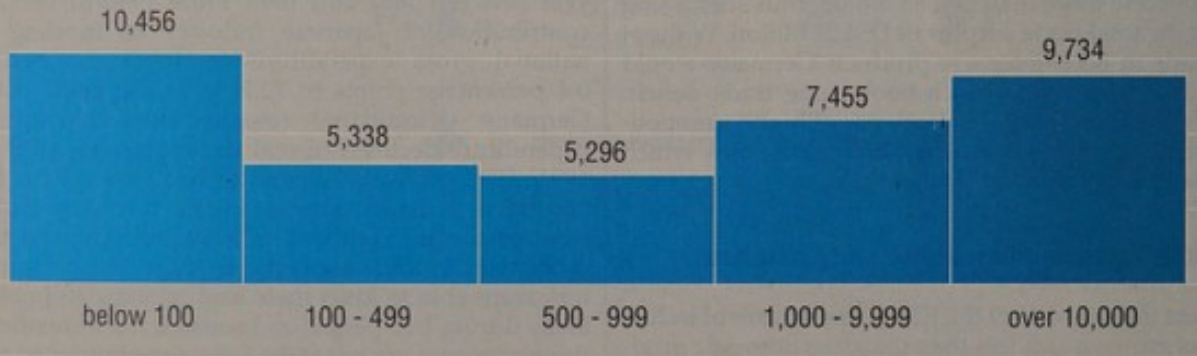
Intramural R&D expenditure of industry by company size
– DM million –



Percentage of turnover accounted for by intramural R&D expenditure of industry, broken down by company size[1)]



Intramural R&D expenditure of industry per employee by company size[1)]
– DM –



1) Number of employees and turnover of companies with R&D expenditure.

Sources: SV-WiStat GmbH and BMFT calculations

BMFT, BuFo '93

Although after unification Germany has to be seen in a new light in terms of foreign trade policy, the analysis of its foreign trade structure indicates that German industry is falling behind in the high-technology markets: From 1990 to 1991 the world trade volume of manufactured goods rose by almost 2.3 %, the growth of R&D-intensive goods even by just under 5 %. The share of R&D-intensive goods in total world exports thus went up to almost 45 %. The largest exporter of such goods in 1991 was Japan with a share of 19.6 %, followed by Germany and the USA with 18 % each. But in spite of its still strong position Germany – unlike its two main competitors – suffered a considerable decline of 0.9 percentage points, compared with 1990, in its share in the world trade with R&D-intensive goods. It is alarming that the negative trend of the market position of German industry seems to extend to international technology markets: In the late 1980s, Germany was still the world's largest exporter in the markets for R&D-intensive goods, leading ahead of Japan and the USA.

But when making such comparisons with the Japanese and US economies, one should bear in mind that the Japanese economy is about twice as large and the US economy approxomately four times as large as the German economy. In this light the performance of German businesses in the international markets is still evidence of considerable efficiency. In view of this difference in dimensions even the fact that Japanese industry is now holding a higher world market share than Germany does not in itself provide any cause for concern; but what is disquieting is the rate at which German industry lost ground to Japanese industry.

Acting in a changed world

As a result of many new developments in industry and science as well as national and international politics, research and technology policy today needs to be integrated into an international framework much more than has been the case in the past.

With the beginning of 1993, the Single European Market became a reality. The economies of the member states of the European Community now constitute a single homogeneous market where movements of goods, services and capital are hardly hindered by national barriers. This opens up completely new development dimensions for the enterprises within the Community; but at the same time competition is becoming stiffer which will entail many advantages, especially for the consumers.

Isolated protected markets have mostly disappeared in Europe. Tougher competition will spur both industry and European governments to achieve advantages by creating innovative products and production processes as well as attractive basic conditions and thus maintain and extend their position in the enlarged European market place. But the process of deepening and widening the European Community is anything but completed. The European Economic Area (EEA) will integrate into the structure of the Single Market some other trading partners that are important for Germany. Economies in Central and Eastern Europe are also highly interested in participating in the Single Market. These economies as well as those of the Commonwealth of Independent States are at present undergoing an enormous and radical restructuring process. In spite of the tremendous current problems associated with these events one should consider the possibility that, once the economic upswing in these countries has begun, Europe may become one of the most dynamic growth regions in the world. Farsighted businesses bear this in mind when making innovation, cooperation and sales decisions today.

Although the Single European Market constitutes the largest homogeneous trading area in the world, attention needs to be directed to all world markets. In a large number of – especially technology-intensive – market segments competition today is of a global nature: Mechanical engineering companies from Baden-Württemberg compete with manufacturers from Japan and Taiwan. Aircraft manufacturers from Europe are engaged in tough competition with their counterparts from the USA, and even standards for home electronics, e.g. HDTV, can no longer be established on a national or regional level, but have to be defined and enforced globally.

Stiff competition with companies from other trading areas is also a vital stimulus for innovation and growth. The unimpeded and free exchange of goods, which is the objective of the ongoing GATT negotiations, is an indispensable prerequisite for an accelerated expansion of the international economy. This is why the successful conclusion of these negotiations is of vital importance for businesses in the EC, and especially in Germany, which rely heavily on worldwide trade.

In the light of these developments basic conditions promising the companies based or potentially based at an industry location positive external effects, are becoming more and more important. In addition to the large domestic markets already realised in Europe, such conditions include a high level of training qualification and hence qualified manpower, an efficient infrastructure, a powerful and flexible R&D structure as well as adequate administrative structures, to mention only a few factors. The positive interaction of these components in an efficient and operative network is a vital prerequisite for the high quality of an industry location.

The high level of spatial flexibility confronts economic, educational, transport and infrastructural policies, and especially research and technology policy, with a large number of changing requirements. It is more important than ever before to plan an industry location as a network meeting ecological requirements and to design it with all its players and lines of communication in such a way that it attracts innovative economic and scientific activities aimed at sustained growth. These activities will in turn provide both the basis and the stimulus for the solution of the urgent issues that we have to address, for example, in the environmental area or in tackling the mobility problem.

Furthermore, businesses and society as a whole are facing new fundamental technological challenges. In borderline areas between physics, chemistry, informa-

tion technology, biology and engineering sciences, new 'technologies of the 21st century' will play an important role for the efficient development of new processes and products and hence have a lasting impact on the competitiveness of German industry. These technologies are primarily designed to preserve resources and the environment, and permit problem solutions without doing damage elsewhere. They are a vital prerequisite for sustained growth, because they meet the need for closed product cycles to a considerable extent, thus reducing the waste of natural resources.

In the spring of 1993, a broad-based study of technologies at the beginning of the 21st century, initiated by the Federal Government, presented a list of 87 technologies which promise to provide important thrusts for future innovative products and processes. On this basis priority tasks for technology policy are now being identified, e.g. in areas such as the development of new materials, tomorrow's production and technology management methods, biological and genetic engineering methods as well as microsystems and microelectronics processes down to nanometer dimensions. The advancing integration of information as a raw material into technological or biological systems, e.g. in photonics, molecular electronics and bioelectronics, is opening up important new possibilities for leaps in performance in information and communication technologies. Among the most important challenges for technology policy over the next few years in terms of strategic technologies of the future will be biotechnology, information technology, new materials and environmental engineering.

Objectives of the promotion of research and development in industry

The enterprises of trade and industry are the most important players in the German research scene. Not only do they finance the largest proportion of research expenditure in the entire economy, they also have the largest research capacities. This demonstrates that the technological potential and competitiveness of the entire German economy are primarily determined by industry and that its research capacities are essential for tackling complex technological problems that can only be solved on a long-term basis. This is why government promotion of research and development in industry is pursuing two basic objectives: In the area of basic and preventive research (e.g. environmental, health and climate research) as well as for long-term government programmes (e.g. in space and fusion research) industry with its research capacities is an indispensable partner when it comes to the speedy provision and further development of technological bases required for preventive government action in these areas. Furthermore, the development of specific key technologies whose importance goes far beyond individual companies or branches of industry is promoted also in businesses, if necessary, thus serving the interest of the entire economy; the development results then have to be accessible to third parties.

In promoting such key technologies in industry, the Federal Government is guided by the principle of subsidiarity. The criteria for government research promotion are met only in those cases where companies are not able to develop such technologies under their own steam or where they cannot do so to an adequate extent or fast enough. But even then the Federal Government will basically limit itself to providing help for self-help. In terms of objectives and character, this promotion is designed as "technology promotion" and is not intended to support certain companies. This approach is mainly reflected in the specialised technology programmes of the BMFT. If necessary, additional thrust for intensifying research and development efforts as well as for improving the innovation structures in the companies is provided by usually temporary indirect measures, without at the same time influencing the themes of the research and development projects.

A permanent priority of research and development policy is the promotion of R&D in small and medium-sized enterprises (SMEs). Their share in total R&D promotion in trade and industry has increased considerably since 1982. Small and medium-sized enterprises not only receive promotion funds through indirect measures, but also more and more from specialised technology programmes.

Research and technology policy is facing a special challenge in supporting the restructuring and development of efficient market-driven research and development capacities in the companies in the new Länder. To this end, a broad-based coordinated research concept was created at short notice. Special emphasis is on indirect measures which are designed to support the quick adjustment of research and development capacities and innovation structures (cf. Part II, section 9).

Measures to promote research and development in industry

Indirect measures

Indirect measures provide a non-technology-specific impetus for intensifying intramural research and development efforts. They are largely aimed at promoting research and development in small and medium-sized businesses. Table II/14 provides a summary of the Federal Government's most important indirect promotion measures.

A number of central promotion measures were phased out in the late 1980s. Among these are the schemes for financing research and development personnel (grants towards R&D payroll costs by the BMWi, funding for additional R&D staff by the BMFT) which contributed with great success to strengthening research and development potentials in SMEs. Two successful promotion schemes, "Contract research and development", which facilitated the companies' access to external R&D capacities, and "Research cooperation between industrie and science", which promoted the exchange of young scientists from companies to research institutions, were also phased out. These two schemes were part of a group of measures entitled "Support of co-

operation between industry and science" and aimed at companies in the old Länder. Scientific evaluation has shown that these schemes have successfully contributed towards the dynamic development of the market for external research and development services in Germany as well as of the cooperation between industry and science. The promotion of cooperative industrial research at the level of branches of industry has continued and even expanded. The pilot scheme "Outside capital for new technology-based firms" has also been extended which provides incentives for private venture capitalists to invest more in new technology-based firms. The pilot scheme for improving data retrieval from databases by small and medium-sized enterprises (MIKUM) which was launched on January 1, 1991 has turned out to be quite promising; it aims to introduce small and medium-sized firms to the benefits of using specialised information from external databases for research, development and innovation.

Based on numerous experiences gathered over the last few years the instruments of indirect promotion were used after German unification to create a close network of special schemes for restructuring and building up efficient market-driven research and development capacities in the new Länder. These measures included potential-oriented schemes for R&D personnel funding and instruments for intensifying cooperation between industry and science, e.g. for promoting contract research, as well as the support of new technology-based firms. Prior to being employed, they were revised, adjusted and harmonised. They were also complemented by new indirect approaches which were tailored specifically to the situation prevailing in the new Länder, such as pilot schemes for technology transfer or innovation promotion.

When indirect measures are developed further, a new overall concept will have to be prepared in the near future which takes account of the changed situation in

Table II/14

Indirect measures for the promotion of research and development in trade and industry

Schemes, responsible ministry in brackets	Funds/tax revenue shortfalls (DM million)						
	1982	1987	1989	1990	1991	1992	1993[1])
Potential-oriented scheme							
– R&D-personnel costs subsidy (BMWi) ..	390.0	193.1	29.3	5.2	1.9	48.8	107.0
– Research-personnel increase promotion (BMFT)	–	57.6	81.5	59.9	30.3	25.9	31.7
– R&D investment allowance (tax-related measure pursuant to sect. 4 of the Investment Grant Act) [2])	283.0	443.0	449.3	470.9	178.8	–	–
– Special R&D depreciation (tax-related measure pursuant to sect. 82d of the Ordinance Regulating the Income Tax Law) [2])[3])	–	750.0	600.0	600.0	600.0	480.0	–
Schemes to support cooperation between industry and science							
– Industrial cooperative research (BMWi)	83.5	101.8	106.9	112.2	199.8	198.1	170.0
– Contract research and development (BMFT)	13.5	52.0	28.0	22.0	31.7	44.3	59.5
– Technology transfer and research cooperation (BMFT)	8.9	23.2	21.9	17.9	15.7	17.8	18.8
– Technology transfer pilot projects (including patent inspection offices) (BMWi)	–	–	0.8	6.5	13.5	27.9	33.5
Innovation promotion (BMWi)	9.9	–	–	–	0.2	8.4	30.0
Promotion of new technology-based firms (BMFT)	6.0	54.4	53.5	40.2	45.9	77.0	93.8
R&D loans for small companies to promote the application of new technologies (BMFT)	–	–	–	–	–	–	4.3
Pilot scheme to support information retrieval from databases (BMFT)	–	–	–	–	2.8	8.1	8.2
Total	**794.8**	**1,675.1**	**1,371.2**	**1,334.8**	**1,120.6**	**936.3**	**556.8**

[1]) Budgeted; including special funds for "Aufbauhilfe Ost" (Development assistance for the new Länder).
[2]) Tax revenue shortfalls of Federal, Länder and local governments.
[3]) Estimated; in some cases adjusted estimates.

Source: BMFT

Rounding error

unified Germany. The new scheme "R&D loans" was launched in 1992 as the first element of this new concept; it is designed as a pilot scheme to test the promotion of extensive innovations in small firms (annual turnover up to DM 50 million) by means of a loan. Another important approach will be the support of R&D cooperations.

Measures for the rapid diffusion of key technologies

The rapid diffusion of key technologies is a central concern of all specialised technology programmes. The promotional steps taken are adapted to the nature and environment of these technologies. Special emphasis is on direct specific promotion developed by the BMFT which permits broadly effective promotion of research and development in certain areas over a relatively short period of time in order to speed up the implementation of key technologies for developing new products and processes.

By offering simplified application and implementation procedures these indirect specific measures which are usually implemented under specialised programmes aim primarily at disseminating technologies through small and medium-sized businesses. In recent years this instrument has mainly been used in the areas of production engineering, information technology, energy technology and biotechnology. The "Microsystems" scheme, for example, which was launched in early 1990 and focusses on combining various microtechnologies like microelectronics, micromechanics and microoptics met with positive response. After only half of the originally scheduled time had elapsed, the total funds earmarked for research projects could be granted. Experience with this promotion scheme has again confirmed the high efficacy of indirect specific promotion in those cases where within a short period of time the greatest possible thrust has to be provided for the diffusion of new technologies. In the period under review a new indirect specific measure was launched in the area of biotechnology-promoting projects for the development of biotechnologically relevant safety and waste management procedures, new biological environmental technologies and new biotechnological processes and methods for plant breeding and biological crop protection. Furthermore, the scheme for the promotion of manufacturing companies by supporting developing work for the preparation and introduction of computer-integrated manufacturing (CIM) was relaunched exclusively for the new Länder. Details of indirect specific measures are provided in Table II/15.

In the field of energy technology it is the "250 MW Wind" scheme which is to support the rapid diffusion of key technologies. To push the testing of cost-effective wind energy plants, this scheme – through the construction and operation of a large number of wind energy plants with a total output of 250 MW – provides incentives for demonstration users to construct and operate such plants as well. Similar objectives are pursued by the photovoltaics programme "1,000 Roofs" which is jointly financed by the Federal and Länder governments and supports the construction and operation of photovoltaic facilities with a peak output of 1 to 5 kW which are to be mounted on roofs and connected with the mains.

Project promotion by the Federal Ministry for Research and Technology

Project promotion by the BMFT comprises the following areas:

- Cross-programme basic research (1)
- Long-term government programmes (2)
- Preventive research (3)
- Promotion of technology and innovation (4).

Table II/15

Indirect specific promotion of R&D in trade and industry by the Federal Ministry for Research and Technology

Scheme	Funds (DM million)						
	1982	1987	1989	1990	1991	1992	1993[1])
Special microelectronics programme ..	87.5	–	–	–	–	–	–
Production engineering (CAD/CAM, robotics, CIM)	–	80.2	21.5	58.2	63.0	92.6	45.0
Information technology (microperipherals, microsystems)	–	21.6	8.4	4.4	22.1	32.6	42.0
Bioprocess engineering [2])	–	15.7	38.3	22.1	7.3	24.8	29.5
250 MW Wind	–	–	0.2	3.8	8.0	16.4	27.0
1,000 Roofs photovoltaics programme	–	–	–	0.3	3.0	20.7	22.0
Total	**87.5**	**117.5**	**68.4**	**88.8**	**103.4**	**187.1**	**165.5**

[1]) Budgeted; including special funds for "Aufbauhilfe Ost" (Development assistance for the new Länder).
[2]) Including research scholarships.

Source: BMFT

Rounding error

Table II/16

Direct project promotion by the Federal Ministry for Research and Technology in 1992, broken down by functions, promotion areas and promotion priorities [1])
– profile review –

Function Promotion area/promotion priority	Total DM '000	Share of industry DM '000	 %
1 Cross-programme basic research (MPG; large-scale equipment for basic research)	**137,048**	–	–
of which:			
A4 Basic funding of institutions and restructuring of research in the new Länder	2,500	–	–
B Large-scale equipment for basic research	134,548	–	–
2 Long-term government programmes	**610,362**	**191,769**	***31.42***
of which:			
C1 Marine research	77,830	11,611	*14.92*
C3 Polar research	6,804	366	*5.38*
D Space research and space technology	452,328	179,713	*39.73*
O1 Geosciences (especially deep drillings)	73,400	79	*0.11*
3 Preventive research	**1,033,383**	**167,384**	***16.20***
of which:			
F1 Ecological research	84,555	2,064	*2.44*
F2 Environmental technologies	197,013	97,119	*49.30*
F7 Climate and atmospheric research	89,619	18,370	*20.50*
G Research and development in the service of health	179,861	3,116	*1.73*
H Research and development to improve working conditions	88,939	38,091	*42.83*
P2 Building research and technology, research and technology for preserving the architectural heritage	41,399	4,799	*11.59*
V Humanities; economic and social sciences	46,400	–	–
W1 Generic activities (including technology impact assessment)	305,597	3,824	*1.25*
4 Promotion of technology and innovation	**2,083,730**	**1,064,576**	*51.09*
of which:			
C2 Marine technology	41,200	26,873	*65.23*
E1 Coal and other fossil fuels	81,656	47,303	*57.93*
E2 Renewable energies and energy conservation	253,801	119,843	*47.22*
E3 Nuclear energy research (excluding decommissioning of nuclear facilities)	134,084	88,104	*65.71*
E4 Decommissioning of nuclear facilities; risk sharing	212,657	127,587	*60.00*
I1 Computer science	87,569	20,010	*22.85*
I2 Basic information technologies	306,594	195,862	*63.88*
I3 Application of microsystems (including microelectronics and microperipherals)	65,907	30,781	*46.70*
I4 Production engineering	59,517	20,475	*34.40*
K Biotechnology	187,791	36,067	*19.21*
L1 Materials research	129,896	77,841	*59.93*
L2 Physical and chemical technologies	162,363	59,126	*36.42*
M Aeronautical research and hypersonic technology	130,511	48,131	*36.88*
N Research and technology for ground transport	169,001	152,750	*90.38*
O2 Raw material supplies	2,002	459	*22.93*
T1 Indirect funding of R&D personnel in industry	3,512	–	–
T2 Improving the transfer of technology and knowledge	879	–	–
T3 Sharing the innovation risk of technology-based firms	8,591	7,647	*89.01*
U Specialised information	46,200	5,747	*12.44*
Total	**3,864,523**	**1,423,729**	**36.84**

[1]) Provisional actual figures as of December 31, 1992; including the funds controlled and allocated by the BMFT to industry-related research in the new Länder and East Berlin under departmental budget 60 (DM 274 million).

Source: BMFT

Rounding error

Table II/17

Direct project promotion funds allocated by the Federal Ministry for Research and Technology to trade and industry from 1989 to 1992 [1], broken down by functions, promotion areas and promotion priorities
– profile review –

Function Promotion area/promotion priority	Funds, DM '000			
	1989	1990	1991	1992 [2]
1 Cross-programme basic research (MPG; large-scale equipment for basic research) ...	–	–	–	–
2 Long-term government programmes	**237,363**	**233,003**	**223,124**	**191,769**
of which:				
C1 Marine research	10,177	8,011	13,096	11,611
C3 Polar research	160	30	164	366
D Space research and space technology	226,882	224,802	209,796	179,713
O1 Geosciences (especially deep drillings)	144	161	68	79
3 Preventive research	**137,839**	**140,840**	**150,698**	**167,384**
of which:				
F1 Ecological research	4,866	1,766	1,714	2,064
F2 Environmental technologies	63,218	57,960	74,435	97,119
F7 Climate and atmospheric research	8,700	16,573	24,402	18,370
G Research and development in the service of health	8,337	6,995	4,919	3,116
H Research and development to improve working conditions	39,377	40,436	34,632	38,091
P2 Building research and technology, research and technology for preserving the architectural heritage	12,963	9,783	8,397	4,799
V Humanities; economic and social sciences	–	10	–	–
W1 Generic activities (including technology impact assessment)	378	7,315	2,198	3,824
4 Promotion of technology and innovation	**1,192,095**	**1,079,849**	**1,081,782**	**1,064,576**
of which:				
C2 Marine technology	22,254	16,100	19,562	26,873
E1 Coal and other fossil fuels	114,862	105,760	70,268	47,303
E2 Renewable energies and energy conservation	120,737	127,882	141,180	119,843
E3 Nuclear energy research (excluding decommissioning of nuclear facilities)	204,000	176,585	172,139	88,104
E4 Decommissioning of nuclear facilities; risk sharing	142,000	60,000	60,000	127,587
I1 Computer science	56,759	22,085	17,367	20,010
I2 Basic information technologies	109,415	118,616	136,276	195,832
I3 Application of microsystems (including microelectronics and microperipherals)	27,817	23,776	33,778	30,781
I4 Production engineering	14,734	18,914	19,358	20,475
K Biotechnology	24,991	31,875	42,515	36,067
L1 Materials research	80,628	74,357	73,850	77,841
L2 Physical and chemical technologies	49,377	62,363	54,180	59,126
M Aeronautical research and hypersonic technology	54,461	59,877	59,577	48,131
N Research and technology for ground transport ...	160,961	174,696	169,702	152,750
O2 Raw material supplies	2,622	1,479	999	459
T3 Sharing the innovation risk of technology-based firms	2,930	1,406	5,149	7,647
U Specialised information	3,547	4,076	5,881	5,747
Total	**1,567,297**	**1,453,692**	**1,455,604**	**1,423,729**

[1] Including the funds controlled and allocated by the BMFT to industry-related research in the new Länder and East Berlin under departmental budget 60 (DM 274 million).
[2] Provisional actual figures as of December 31, 1992.

Source: BMFT

Rounding error

Direct project promotion by the BMFT in the industrial sector focusses on the promotion priorities of marine technology, energy, information technology, materials research as well as research and technology for ground transport. In these areas the share of industry in BMFT project promotion is 60 % and more. In 1992, direct promotion of technology and innovation in industry which in the long term will help increase the technological capabilites of the entire economy amounted to about DM 1.1 billion. This is equivalent to 27.5 % of total direct project promotion and 11.3 % of the BMFT budget.

Industrial companies also participate in long-term government programmes such as marine and space research and technology, as well as the promotion of preventive research, e.g. environmental and health research. In the case of these programmes, however, government interest is focussed on research results (a survey of total direct project promotion by the BMFT specifying the proportion of industrial promotion is given in Table II/16).

Since 1982, there has been a decline in the promotion of technology and innovation and also in the overall scope of project promotion in trade and industry. A drastic cut of the funds for energy research promotion (especially coal and other fossil energy sources as well as nuclear energy research) compares with increases in funds earmarked for modern key technologies such as information technology and physical and chemical technologies (cf. Table II/17). When promoting projects in industry the BMFT pursues a policy of funding not the highest possible number of widely scattered projects, but rather pushing major long-term projects at the pre-competitive stage where many companies cooperate in research networks.

Collaborative research ("Industrielle Verbundforschung")

The concept of collaborative research has turned out to be a great success of the project promotion policy of the BMFT. Through the joint participation of, if possible, several companies and research institutions in one project collaborative research is designed to ensure that better use is made of scarce research capacities by pooling resources, that the technology transfer between industry and science is accelerated, that synergy effects are created, and that promotion is not selective, but rather broad-based. At the same time, collaborative research reduces the potential distorting effect of government technology promotion on competition and provides critical thrusts for research cooperation in Germany. This approach also takes into account the recognition that inter-firm cooperation in research and development is becoming more and more important for the innovation process in industry. In the case of high technology in particular, such networks are often of critical importance, because technological and industrial progress is increasingly the result of the combination of hitherto separate technology areas. By introducing collaborative research in 1984 the Federal Government provided considerable impetus in this field.

Table II/18

Percentage of direct project promotion funds for industry devoted to collaborative projects – selected technology areas –

Technology area	1984	1987	1989	1990	1991
Production engineering	17.0	100.0	100.0	100.0	87.6
Information technology	21.3	74.2	100.0	85.8	95.8
Materials research	14.8	68.7	80.3	79.2	87.2
Biotechnology ...	48.7	47.8	45.6	71.2	61.9
Physical and chemical technologies	1.6	27.1	54.2	65.0	61.9

Source: BMFT

The figures in Table II/18 give an impression of the weight collaborative research has within the BMFT's project promotion. Since its inception in 1984 collaborative research has become the predominant approach to promotion in the selected technology areas listed in that table.

The results that are now available of scientific evaluations of the various specialised programmes show that the instrument of collaborative research has to a great extent met the expectations it raised when it was launched in 1984. The exchange between industry and science has been improved and the involvement of small and medium-sized firms with their partly excellent know-how in critical areas could be increased also in the high-technology fields. The research networks resulting from collaborative research make an important contribution towards the rapid diffusion of new findings and results. Against the background of this experience the greater work load for all those concerned which is naturally involved in setting up such networks seems to be more than justified.

Collaborative research also plays an important role in bringing together research in the united Germany. The participation of companies and research institutes from the old and the new Länder makes it easier for researchers from the East to catch up quickly with the global level of technological performance; it enables researchers and companies from all over Germany to establish numerous lasting contacts for the future. Since scientists have the opportunity to meet and learn from each other in collaborative projects, research in Germany is growing together. This is a gain for the whole of Germany and its technological capabilities.

Table II/19

Promotion of civil research and development in trade and industry [1]) by the Federal Government, broken down by ministries and number of companies/agencies receiving promotion

Ministry/scheme	1990		1991	
	Industrial companies/ agencies receiving funds	Funds/ tax revenue shortfalls [2])	Industrial companies/ agencies receiving funds	Funds/ tax revenue shortfalls [2])
	Number	DM million	Number	DM million
Federal Ministry for Research and Technology				
– Direct project promotion	1,143	1,453.7	1,268	1,455.6
– Microperipherals (indirect specific measure)	191	4.3	367	22.1
– Production engineering (indirect specific measure)	1,150	58.2	927	63.0
– Biotechnology (indirect specific measure)	147	13.9	32	2.4
– 250 MW Wind	116	3.8	291	8.0
– 1,000 Roofs photovoltaics progamme	10 [3])	0.3	489 [3])	3.0
– Research-personnel increase promotion	2,581	58.0	914	28.6
– Contract research and development	391	20.2	327	30.6
– New technology-based firms (NTBFs)	226	29.9	219	35.6
– Research cooperation between industry and science	756	17.7	660	15.1
– Technology transfer and specialised information	20 [4])	4.0 [4])	416	8.1
– Federal Ministry for Research and Technology – subtotal	6,731	1,664.0	5,910	1,672.1
Federal Ministry of Economics				
– Industrial cooperative research	516	112.2	768	199.8
– R&D-personnel costs subsidy	155	5.2	44	1.9
– Innovation promotion	–	–	1	0.2
– Promotion of R&D in SMEs in Berlin [5])	19	5.4	29	4.9
– Technology transfer and specialised information	81	17.5	58	32.8
– Grants towards the development of civil aircraft	3	676.6	3	641.5
– Promotion of projects at industry-related research institutions	–	–	115	59.3
Federal Ministry of Economics – subtotal	774	816.9	1,018	940.4
Other ministries	.	139.4	.	146.0
Tax-related measures				
– R&D investment allowance (sect. 4 of the Investment Grant Act)	–	470.9	–	178.8
– Special R&D depreciation (sect. 82d of the Ordinance Regulating the Income Tax Law)	–	600.0	–	600.0
Tax-related measures - subtotal	–	1,070.9	–	778.8
Total	**7,505**	**3,691.2**	**6,928**	**3,537.3**

[1]) Definition of trade and industry differs from that of Table II/20.
[2]) Tax revenue shortfalls of Federal, Länder and local governments.
[3]) Appropriations.
[4]) Estimated.
[5]) Scheme expired in 1992.

Source: BMF, BMWi, BMFT

Rounding error

EUREKA

The EUREKA initiative, too, is based on the idea of collaborative research – in this case, however, at the European level. The objective of EUREKA is to motivate European industry and research institutions to intensify their cooperation in technological research and development. In this way EUREKA is to contribute to strengthening European competitiveness in the world market.

EUREKA is not a programme with clear-cut research themes (this is why it is referred to as an initiative), but it provides an open framework for European cooperative projects. EUREKA takes a "bottom up" approach. This means that participants do not respond to invitations to participate in a specific programme, but define theme, partners, scope and type of cooperation on their own initiative. This approach has enabled EUREKA to establish itself as a successful and complementary alternative to EC research programmes.

Twenty states and the Commission of the European Communities are at present participating in EUREKA. In addition to the twelve EC member states there are Finland, Iceland, Norway, Austria, Sweden, Switzerland, Turkey and – since May 1992 – Hungary as the first Central/East European country. In principle, participation in individual EUREKA projects is also open for non-member states.

EUREKA projects cover a wide range of technological research and often fill "white spots" between other programmes. Nevertheless, the following priorities can be identified: materials research, production engineering, medical technology and biotechnology, information technologies, communication technologies, energy, laser development and application, transport as well as environmental technologies. Information technology is playing the leading role in terms of funding volume, while environmental technology as well as medical technology and biotechnology are topping the list in terms of the number of projects. In recent years, these three areas also had the highest growth rates.

Launched with only very few projects in 1985, EUREKA now includes 647 ongoing individual projects with about 3,500 participants. Another 81 projects have been completed successfully in the meantime. About 530 German companies and research institutes are involved in 208 projects, 42 of them are based in the new Länder. The financial volume of all EUREKA projects totals about DM 25.1 billion, the German contribution is DM 3.75 billion.

The projects are funded separately at the national level, i.e. in each participating country. In Germany, EUREKA status does not inevitably entail government funding, but basically all appropriate EUREKA programmes are eligible for promotion in Germany. The BMFT is funding 95 of the 208 EUREKA projects with a total of DM 1.25 billion, while the other project contributions are primarily financed by the participants themselves. This demonstrates that the primary objective of EUREKA is not government promotion, but motivation for cooperation at the European level.

Promotion by federal ministeries

The overview of the individual measures of R&D promotion provided in Table II/19 shows that the Federal Government responds to widely differing promotion requirements by using a coordinated system of different instruments, thus reaching a large number of companies. As part of the tax reform, the tax-related measures for promoting R&D which are still listed in this table have in the meantime been phased out without substitution.

As shown in Table II/20 which was extended to include the expenditure of the Federal Ministry of Defence (BMVg) on R&D contracts in the defence sector, the promotion of research and development in trade and industry was kept stable in the years prior to German unification. However, this was the result of a structural shift between the individual ministries in the course of which the BMFT has continuously reduced its expenditure on R&D promotion in industry since 1992. It is not intended, however, to fall below the current level.

9. Special priorities of industry-related research and technology policy: Research and development in small and medium-sized enterprises and in the businesses in the new Länder

Promotion of research and development in small and medium-sized enterprises

The role of small and medium-sized enterprises in the innovation process in Germany

The innovative potential of a national economy is the result of a complex process in which various players interact. In industry there is a division of labour between large businesses and small and medium-sized enterprises (SMEs). Costly basic innovations are mostly implemented by large companies which because of their resources are better equipped to develop innovations further for subsequent serial production and launching. In industry, costly and high-risk basic research can usually only be performed by large companies as well. In contrast, small and medium-sized companies – since they are closer to the customer and have greater flexibility – are more involved in selecting and trying out new technologies for different applications and special markets. The particular strength of small and medium-sized businesses is in application-oriented research and development. They fulfil an invaluable function in the rapid diffusion of new high technologies through industry as a whole.

In spite of this system of division of labour, SMEs have also successfully competed with large companies in many high-technology areas in recent years. Many

Table II/20

R&D promotion in trade and industry by the Federal Government including research-related tax revenue shortfalls of Länder and local governments from 1974 to 1991

Year	total expenditure[1])	of which						Tax revenue shortfalls[2])	Total funding
		BMFT		BMWi		BMVg			
	DM million	DM million	%	DM million	%	DM million	%	DM million	
1974	2,916	1,284	44	300	10	1,283	44	353	3,269
1975	3,162	1,501	47	285	9	1,319	42	149	3,311
1976	3,053	1,273	42	240	8	1,462	48	106	3,159
1977	3,110	1,444	46	139	4	1,449	47	153	3,263
1978	3,493	1,668	48	173	5	1,559	45	138	3,631
1979	4,544	2,162	48	610	13	1,657	36	169	4,713
1980	4,618	2,191	47	798	17	1,496	32	191	4,809
1981	4,631	2,324	50	852	18	1,355	29	289	4,920
1982	5,630	3,245	58	816	14	1,458	26	283	5,913
1983	5,070	2,646	52	716	14	1,595	31	364	5,434
1984	5,157	2,610	51	703	14	1,729	34	530	5,687
1985	5,772	2,533	44	897	16	2,235	39	615	6,387
1986	5,404	2,226	41	843	16	2,237	41	633	6,037
1987	5,058	1,985	39	638	13	2,331	46	1,179	6,237
1988	5,038	1,981	39	621	12	2,321	46	1,249	6,287
1989	5,177	1,788	35	650	13	2,626	51	1,049	6,226
1990	5,380	1,656	31	803	15	2,782	52	1,071	6,451
1991	5,470	1,652	30	924	17	2,747	50	779	6,249

[1]) Including funds received by business enterprises abroad.
[2]) R&D investment allowance (sect. 4 of the Investment Grant Act) and special R&D depreciation (sect. 82d of the Ordinance Regulating the Income Tax Law), tax revenue shortfalls of Federal, Länder and local governments.

Source: BMFT

Rounding error

successful new technology-based firms demonstrate that small and medium-sized companies can also hold their own in the high-tech sector by being close to the customer and showing flexibility and a wealth of imagination.

The highly developed sector of innovative SMEs gives Germany a major advantage as an industry location. Small and medium-sized businesses play a key role in providing the basis for the technological potential of the entire national economy. Depending on technology area, product and function, small and medium-sized companies also stimulate competition and through their supply relations with large companies contribute to the international competitiveness of German industry.

A special feature of the R&D activities of SMEs is that, in terms of staff and organisation, they are much more linked with other operations. In many cases these activities are carried out in the context of specific orders or they accompany the introduction of new products or process technologies. This is why often accounting for the R&D expenditure of SMEs is much more difficult than in the case of large companies. As can be seen from the top part of Figure II/11 small and medium-sized businesses have made sizeable contributions to the total R&D spending of industry. In 1989, their contribution amounted to more than 16 %.

The middle part of Figure II/11 gives the percentage of turnover spent on intramural R&D, broken down by company size. It shows that, with 5.6 %, especially smaller companies with up to 100 employees devoted a disproportionally large percentage to R&D; this level is not even reached by large companies with more than 10,000 employees. A similar result is obtained when R&D expenditure is related to the number of employees. Again small firms spending DM 10,000 per employee on R&D come first ahead of all other company size categories. This U-shaped profile of R&D expenditure broken down by company size results from the fact that research and development in small firms are associated with a relatively high level of costs.Successful research and development require a minimum level of expenditure and even small companies cannot remain below this level. This demonstrates that, due to the necessary R&D activities, these firms have to carry a heavier financial burden in relative terms.

In spite of some disadvantages caused by their size small and medium-sized companies have an extraordinary ability to adjust to fundamental structural changes. It has been observed not only in areas of structural

change in Germany, but also in other OECD countries that in those cases where traditional large-scale industrial structures decline, small and medium-sized companies are often the first to emerge and offer new employment. This pioneering role of SMEs in mastering structural crises will be of special importance for developing efficient and high-growth industrial structures in the new Länder. This is another argument in favour of putting special emphasis – within research and technology policy – on the promotion of SMEs in the new Länder. In the current phase of establishing and restructuring, SMEs in the new Länder are given a structure which will possibly be crucial for quite some time. This is why it is vital to set up innovation-friendly SME structures right from the beginning.

Small and medium-sized businesses are of great significance for growth and innovation in German industry. This highlights the fact that – from the perspective of the economy as a whole – the special promotion of R&D in SMEs is not an act of charitable generosity. It is rather a critical contribution to improving the efficiency and competitiveness of the entire economy. The promotion of R&D in SMEs does directly strengthen Germany as an industry location.

Approaches to the promotion of research and development in small and medium-sized enterprises

Various scientific studies as well as the promotion experience of the Federal Government suggest that in the old Länder alone there are about 25,000 small and medium-sized businesses which perform R&D at least on a temporary basis. This figure and the well-known variety of German SMEs reflect numerous widely differing technological interests and priorities. In terms of promotion instruments, these in part completely different problems call for a harmonised package of individual measures in order to address the various needs in a flexible manner.

In view of this diversity the use of non-technology-specific instruments such as the indirect measures of the BMFT and the BMWi are of special importance in the promotion of R&D in SMEs. Without defining the technological contents of the project, they offer promotion opportunities to an extraordinarily large number of SMEs. These indirect measures are designed to provide different approaches to strengthening the firms' innovation potential. Another area of R&D promotion in SMEs is technology-specific promotion under the BMFT's specialised programmes. Here, SMEs play an important role also in the development of high technologies, especially in collaborative projects ("Verbundprojekte") with larger companies and research institutes.

Depending on the promotion objective concerned, the Federal Government has highly sophisticated promotion tools

- to strengthen intramural R&D potentials

  Promotion measures: e.g. technology-specific collaborative research under specialised programmes, broadly effective SME-oriented measures for technology diffusion (e.g. indirect specific measures), R&D-personnel costs subsidy and research-personnel increase promotion in the new Länder;

- to strengthen cooperation and technology transfer

  Promotion measures: e.g. furthering contract research, industrial cooperative research, exchange of staff between industry and research institutes, infrastructural measures (centres for information and consultancy, innovation consultants at the Chambers of Industry and Commerce, agencies for technology transfer and innovation promotion);

- to strengthen R&D funding

  Promotion measures: R&D loans for small companies to promote the application of new technologies;

- to support new technology-based firms

  Promotion measures: Outside capital for young technology-based firms and, in the new Länder, the promotion of new technology-based firms (NTBFs) as well as of technology parks providing the infrastructure for these NTBFs.

When looking at these research and technology policy measures it should be borne in mind that approaches to SME promotion are not only reflected in specific programmes and schemes, but that promotion programmes which, in principle, are open to companies of all sizes often contain specific SME provisions which favour these firms. For example, in order to facilitate even more the access of small and medium-sized companies to project promotion by the BMFT under specialised programmes, administrative procedures were considerably simplified by the introduction of the "NKFT 88" (Nebenbestimmungen für Zuwendungen auf Kostenbasis des BMFT an Unternehmen der gewerblichen Wirtschaft für Forschungs- und Entwicklungsvorhaben; Additional provisions for grants by the Federal Ministry for Reasearch and Technology to research and development projects by trade and industry). Under these provisions small and medium-sized firms can settle the accounts for their research and development projects under this project support scheme by applying a simplified procedure, using a lump sum. Under this procedure, categories of costs that are easy to determine (such as material cost, payroll cost and travel expenses) can be allocated as individual costs, while categories of costs that are more difficult to determine (such as intra-plant service output costs and administrative costs) can be considered in the form of a lump sum of 120 % of the total of wages and salaries. In this way access to project promotion under specialised programmes of the BMFT is facilitated for small and medium-sized businesses which often do not have sophisticated accounting systems. In addition to the introduction of highly simplified promotion under indirect specific promotion schemes, this simplified administrative procedure represents a major step towards a promotion scheme for SMEs which, on the whole, can be regarded as very simple and makes the best possible use of the scope of manoeuvre limited by legal regulations and the necessary prevention of misuse.

Table II/21a

Schemes of the Federal Government to promote research and development in small and medium-sized enterprises [1])
– DM million –

Ministry/Scheme	1982	1987	1989	1990	1991	1992	1993[2])
Federal Ministry for Research and Technology							
1 Project promotion under specialised programmes	237.9	229.4	219.3	247.7	276.0	259.2	271.0
(of which: Project promotion in industrial cooperative research under specialised programmes)	(48.2)	(32.9)	(26.0)	(39.6)	(30.8)	(25.9)	(25.0)
2 Indirect specific measures							
Special microelectronics programme	75.3	–	–	–	–	–	–
Production engineering (CAD/CAM, robotics, CIM)	–	72.6	19.1	49.8	55.3	83.2	41.0
Information technology (microperipherals, microsystems)	–	17.7	6.4	3.9	19.1	25.8	34.0
Bioprocess engineering	–	6.8	21.8	8.9	1.3	14.5	18.0
250 MW Wind	–	–	0.2	2.7	5.7	10.6	2.0
1,000 Roofs photovoltaics programme	–	–	–	–	0.5	2.9	2.0
3 New technology-based firms	6.0	42.8	40.9	29.9	35.6	69.7	89.9
4 R&D credit scheme for small companies to promote the application of new technologies	–	–	–	–	–	–	4.3
5 Research-personnel increase promotion	–	56.8	80.2	58.0	28.6	22.4	29.7
6 Contract research and development	13.0	49.1	27.0	20.2	30.6	43.6	53.4
7 Research cooperation between industry and science	–	13.4	13.0	13.0	11.5	12.5	13.0
8 Information and consultancy centres	–	36.4	33.4	38.0	42.2	26.3	20.0
9 Technology transfer and specialised information	8.9	4.6	4.1	4.0	3.0	8.1	10.0
Federal Ministry for Research and Technology – subtotal	341.1	529.6	465.4	476.1	509.4	578.8	588.3
Federal Ministry of Economics							
1 Industrial cooperative research	83.5	101.8	106.9	112.2	199.8	198.1	170.0
2 R&D-personnel costs subsidy	390.0	192.4	29.3	5.2	1.9	48.8	107.0
3 Innovation promotion	9.9	–	–	–	0.2	8.4	30.0
4 Promotion of research and development in small and medium-sized enterprises in Berlin	6.3	6.0	6.8	5.4	4.9	3.5	–
5 Technology transfer pilot projects (including patent inspection offices)	–	–	0.8	6.5	13.5	27.9	33.5
Federal Ministry of Economics – subtotal	489.7	300.2	143.8	129.3	220.3	286.7	340.5
Total	**830.8**	**829.8**	**609.2**	**605.4**	**729.7**	**865.6**	**928.8**

[1]) Includes only appropriations to small and medium-sized enterprises.
[2]) Budgeted or estimated; including special funds for "Development assistance for the new Länder".
Source: BMFT

Rounding error

As Table II/21a shows, R&D promotion in SMEs by the BMFT has reached a very high level since 1982. In the period under review the share of SMEs in total industrial R&D promotion of about 10 % has gone up to about one third. This underlines again the importance which small and medium-sized companies have today in the Federal Government's R&D promotion.

Industrial R&D in the new Länder

Initial situation and development

The structural change in the new Länder initiated by the unification process has also hit industrial R&D and led to a sizeable reduction of industry-related R&D capacities. The R&D sector is a key sector in the national economy. Maintaining and building up efficient R&D capacities in East German industry is a critical prerequisite for competitive companies and safe jobs. Only if East German companies manage to enter growth-driven markets with innovative and competitive products will it be possible to start a self-sustaining economic upswing in that part of Germany as well.

Building up and maintaining efficient industrial R&D capacities in the new Länder has been difficult and inconsistent since German unification. On the one hand, redressing economic imbalances and overcoming the lack of competitive and innovative potential of the former collective combines call for a radical restructuring of industry, to be accompanied by a reorientation of intramural R&D. On the other hand, there is the risk that due to short-term financing gaps and temporarily empty order books R&D capacities which are worth maintaining and vital for future competitiveness will be discarded in this restructuring and adjustment process.

The so-called Research GmbHs (limited liability companies) which in late 1990/early 1991 were hived off from the former collective combines into independent operations and were originally owned by the Treuhandanstalt represent a special problem of industry-related R&D in the new Länder. After becoming independent, they lost the necessary links with the producing sectors, but at that time accounted for a considerable percentage of industry-related R&D capacities in the new Länder. In a joint effort the Federal Government (BMWi, BMFT), the Treuhandanstalt and the new Länder succeeded in privatising a major part of the R&D capacities of the Research GmbHs or in finding new investors and operators, thus keeping important capacities.

The decline of industrial R&D capacities in the new Länder has not yet come to a halt, although the reduction of manpower has slowed down recently. A survey conducted by SV-Wissenschaftsstatistik GmbH on behalf of the Federal Government showed that in late 1992 just under 24,000 persons (calculated on a full-time equivalent basis) were still working in the R&D sector. It is important for the future that industry, the Treuhandanstalt, the new Länder as well as the Federal Government, further the development of efficient industrial R&D capacities that has been initiated in the new Länder. An even greater commitment of industry is of critical importance, because in the medium and long term only industry itself can maintain and employ efficient R&D capacities. It is not obviously limited government funds that are required here; but it is necessary that all companies set priorities for their R&D activities according to the regulatory principles underlying a social market economy and based on their market experience and market knowledge. Also companies in the old Länder are called upon to show greater commitment.

The Treuhandanstalt which is still in possession of sizeable R&D capacities has a special responsibility in reorienting industry-related R&D in the new Länder. When the remaining businesses are privatised and reorganised, special attention needs to be given to maintaining qualified R&D potentials. The evaluation of the efficiency of the R&D personnel working in Treuhand companies, which has been initiated by the Treuhandanstalt, is an important step in this direction.

Measures by the Federal Government to promote industrial R&D in the new Länder

During a transitional period the Federal Government is supporting the development of efficient industrial R&D capacities in the new Länder by means of specific government schemes. As early as mid-1990 the BMWi and the BMFT devised a package of coordinated and complementary promotion measures (cf. Figure II/12). These schemes aim

- to create and increase the *technological competitiveness* of East German companies,
- to promote *new technology-based firms*,
- to build up and strengthen *innovative small and medium-sized enterprises*,
- to develop an *R&D-supporting infrastructure*.

To create and increase the *technological competitiveness* of East German businesses and to support the reorientation of industry-related R&D capacities is of paramount importance. The BMFT supports companies and industry-related research institutions in the new Länder by promoting R&D projects under its specialised programmes, especially in the areas of environmental technology, production engineering, renewable energies and energy conservation, basic information technologies, space technology, materials research as well as ground transport. The funding rate for recipients in the new Länder is 10 % higher than in the West, and there are numerous provisions to accelerate, simplify and facilitate applying for, and appropriating, grants. With its scheme for promoting industrial cooperative research at the level of branches of industry the BMWi supports pre-competitive, application-oriented basic research driven by industrial demand. Funds have also been allocated to various research projects which were identified as tasks of mutual interest by companies that have formed research associations. Since 1992 a certain percentage of these funds has been reserved

Figure II/12

Federal Government schemes to promote industrial R&D in the new Länder

Objective	Scheme	1992 Budget DM million
To create and increase technological competitiveness	Project promotion under specialised BMFT programmes	151.4
	Special funds "Aufschwung Ost", BMWi/BMFT	195.1
	Cooperative industrial research	68.1
To promote new technology-based firms	New technology-based firms, BMFT (NTBFs)	43.2
	Establishment and expansion of technology parks and research incubators, BMFT	9.7
To build up and strengthen SMEs	R&D-personnel costs subsidy in the East, BMWi	47.9
	Research-personnel increase promotion in the East, BMFT	19.3
	Contract research and development, BMFT (East; West/East)	33.5
	Innovation promotion scheme, BMWi	8.4
To develop an R&D-supporting infrastructure	Agencies for Technology Transfer and Innovation Promotion, BMWi	16.5
	Innovation consultants at Chambers of Industry and Commerce, BMFT	0.4
	Centres for Information and Consultancy, BMFT	7.4
	Industry-related specialised information, BMWi	6.5
	Total	**607.4**

Source: BMFT

BMFT, BuFo '93

for including companies and research institutions from the new Länder in industrial cooperative research. In 1992, the Federal Government – in its joint scheme "Aufschwung Ost" ("Upswing East") – appropriated an extra DM 200 million to industrial research in the new Länder. These funds went to about 880 R&D projects conducted by Research GmbHs, by units hived off from institutes of the former Academy of Sciences as well as by companies performing their own R&D. To continue this scheme in 1993, the BMWi has earmarked DM 100 million for "Developing pre-competitive industrial research and structural change"; the BMWi and the BMFT together have appropriated another DM 100 million for "Aufbauhilfe Ost" ("Development assistance for the new Länder").

By supporting *new technology-based firms* the Federal Government contributes to building up innovative small and medium-sized enterprises. A BMFT pilot scheme promotes NTBFs in the new Länder. The basic purpose of the new firms has to be the technical development of new products and processes. In addition to financial support, promotion also includes counselling by the BMFT project management organisation in charge of this scheme. Funds are provided during the conceptual phase, the actual R&D phase as well as the commercialisation phase. The pilot scheme "Development and expansion of technology parks and research incubators" supports the NTBF scheme. It helps develop adequate support and financing structures for NTBFs. During the difficult early years the technology parks offer the NTBFs not only commercial premises at favourable terms and conditions, but also joint office and administrative facilities as well as management, consultancy and support services. In the new Länder the BMFT supports the construction and expansion of 15 technology parks and research incubators as well as the planning activities for another 10 technology parks.

Table II/21b

Schemes of the Federal Government to promote research and development in trade and industry in the new Länder
– DM million–

Ministry/Scheme	1991	1992	1993[1])
Federal Ministry for Research and Technology			
1 Project promotion under specialised programmes	121.6	133.4	180.0[3])
2 Promotion of projects at industry-related R&D institutions[2])	–	92.4	–
3 New technology-based firms	13.6	43.2	64.5
4 Establishment and expansion of technology parks	6.3	9.7	7.0
5 Contract research and development	13.0	33.5	56.0
6 Research-personnel increase promotion	10.6	19.3	29.5
7 Production engineering (indirect specific CIM promotion)	–	18.0	35.0
8 Innovation and consultancy centres	14.8	7.4	5.0
9 Pilot scheme on innovation consultants at Chambers of Industry and Commerce	0.4	0.4	0.5
Federal Ministry for Research and Technology – subtotal	180.3	357.3	377.5
Federal Ministry of Economics			
1 Industrial cooperative research	67.2	68.1	45.0
2 R&D-personnel costs subsidy in East Germany	–	47.9	107.0
3 Innovation promotion	0.2	8.4	30.0
4 Technology transfer	4.8	16.5	26.0
5 Industry-related specialised information	3.7	6.5	4.0
6 Design promotion	–	–	4.0
7 Promotion of projects at industry-related research institutions[2])	59.3	102.7	100.0
Federal Ministry of Economics – subtotal	135.2	250.1	316.0
Total	**315.5**	**607.4**	**693.5**

[1]) Budgeted; including special funds for "Development assistance for the new Länder" (rounded off).
[2]) Appropriations under departmental budget 60.
[3]) Estimated total of a large number of individual budgetary items.

Source: BMFT

Rounding error

The BMFT and the BMWi support the strengthening of *innovative small and medium-sized enterprises* by means of specific measures. The BMWi scheme "R&D-personnel costs subsidy in the East" aims to restructure and strengthen the innovative potential of small and medium-sized firms. At the same time, it is intended to support the creation of qualified jobs and the market-led employment of R&D personnel. About 1,400 manufacturing companies receive grants towards R&D payroll cost twice a year. The BMFT's funding for additional R&D staff supports the development and expansion of R&D capacities in SMEs in the new Länder. Increasing the R&D personnel capacities contributes to restructuring industrial research and strengthening the innovative potential of the companies in the new Länder. This scheme also supports the reintegration of unemployed researchers and developers or of scientists working under job creation schemes.

The BMFT has two versions of its scheme for the promotion of contract research and development, contract research East and contract research West/East; they are designed to support farming out and winning R&D contracts. On the one hand, these schemes contribute to increasing the innovative strength of East German businesses by acquiring external know-how (contract research East). On the other hand, it is made easier for R&D capacities to adjust to the markets, and the market opportunities of East German R&D contractors are increased due to potential price reductions (contract research West/East).

With its scheme for the promotion of innovation the BMWi supports the development of new innovative products and processes in small and medium-sized enterprises in the new Länder. The technical and economic risk associated with such development is reduced by subsidies (of up to 35 %).

By developing an *R&D-supporting infrastructure* the BMWi and the BMFT create important basic conditions for the innovation process. Agencies for Technology Transfer and Innovation Promotion support building up and expanding SMEs in technical and administrative terms and provide assistance in the preparation and implementation of product and process innovations. By the end of 1992, 21 agencies and 10 branch offices had been set up in the new Länder. The agencies contribute considerably to developing competitive SMEs. The agencies' activities are complemented by industry- or technology-oriented transfer centres which act as clearing houses for specialised technical know-how. With this pilot scheme the BMFT promotes the development and enlargement of innovation consultancy centres at selected Chambers of Industry and Commerce in the new Länder. In this way contacts are provided for companies in the area of research, development and innovation, and the companies' R&D commitment is supported by consultancy and the transfer of knowledge and technology. The scheme consists of two components. On the one hand, payroll and equipment costs of the innovation consultants employed by the selected Chambers of Industry and Commerce are subsidised. On the other hand, support is given to the exchange of experience with partner Chambers in the old Länder and also to the training of consultants in the new Länder. An important approach to promoting the transfer of technology, especially to small and medium-sized companies in the new Länder, is the support of so-called Centres for Information and Consultancy in new technology areas by the BMFT. At these centres, small and medium-sized enterprises are given the opportunity to gather hands-on experience with key technologies in order to make up for information deficits and reduce the risk of embarking upon these new technologies. Under this scheme, the BMFT is currently funding nine demonstration centres in the new Länder, six in the CIM area, two in the field of new materials research and one in the area of laser technology. The know-how and the experience of companies leading in the world market in research and the application of new technologies is also of great benefit to other companies, especially smaller, highly innovative firms. This is why in early 1992 the BMWi launched the scheme "Technology-oriented visiting and information programmes" which is to enhance the continuous transfer of technical know-how between businesses. From the moment the scheme was launched, leading technology companies have shown great willingness to demonstrate the use of modern technology and technological strategies on their own premises.

All in all, the Federal Government's promotion schemes for industrial R&D in the new Länder are successful. About 80 % to 90 % of R&D-performing firms in East Germany take advantage of this promotion. The Federal Government is thus making a substantial contribution to renewing the structure of industry in East Germany. In 1992 alone about DM 610 million were earmarked for this purpose. In 1993, too, the BMFT and the BMWi will continue to support the development of efficient industrial research in East Germany. In 1993, they will together appropriate about DM 700 million (including "Aufbauhilfe Ost" ("Development assistance for the new Länder")) for this purpose (cf. Table II/21b). The success of these efforts, however, will very much depend on whether industry will increase its own R&D commitment as well. These specific federal schemes for promoting R&D are complemented by tax-related and regional measures conducive to investment, such as investment grants, special write-offs and investment subsidies under the joint scheme "Improvement of regional economic structures". With these general investment aids the Federal Government also supports investment in the R&D sector, thus rounding off its range of promotion schemes.

10. International comparison of resources for research and development

Information on the trend of science, research and development at the European and international levels is gaining increasing importance. It should be noted, however, that the assessment of the research performance of a country on the basis of statistical data calls for a careful selection and interpretation of the statistics and indicators used. This applies in particular to international comparisons. They can only yield viable

results, if the data used are derived from coordinated data-collection programmes and have the highest possible level of comparability.

The Organisation for Economic Cooperation and Development (OECD) plays a leading role in developing a methodology in the area of science and technology indicators. For about thirty years, the OECD has conducted surveys on research and development in its member states and provided a forum for the international discussion on new approaches to measuring research performance.

As early as 1963, a "Proposed Standard Practice for Surveys of Research and Experimental Development" was agreed on in the area of input statistics. Meanwhile, the fifth edition of the "Frascati Manual" (called after its place of origin) has been published by the OECD, after revision had been completed in 1992. In recent years OECD acitivities have increasingly focussed on the methodological development of impact or output statistics.

International agreements were concluded concerning the methodology relating to important indicators. They can be found in the "family of Frascati Manuals". But in addition to developing new indicators, the further development and improvement of traditional (input) statistics is still an important element of international cooperation.

The European Communities, too, conduct regular R&D surveys. Whereas the OECD collects data on the resources actually spent on R&D in a specific country (gross domestic expenditure), the EC data relate to the budget appropriations for R&D. The OECD also publishes data on the public financing of research and development on the basis of budget appropriations: Complementary to the data made available by the EC, it collects the necessary data – in a breakdown by socio-economic research objectives – in the other OECD countries. This makes it possible to compare these budget appropriations in all OECD member states. In recent years, the Statistical Office of the European Communities (EUROSTAT) has increasingly developed initiatives in the area of research and innovation statistics. It has started close cooperation with the OECD in many areas.

The following considerations are focussing on traditional, established input statistics and especially statistics related to financial and human R&D resources.

The tables shown here mostly contain data from completed surveys up to and including 1990 and – as far as they were available – provisional data for 1991. They cover the G7 countries, i.e. apart from the Federal Republic of Germany they include France, the United Kingdom, Italy, Japan, the USA and Canada.

The statistical indicators used for international comparisons of financial R&D resources are usually based on gross domestic expenditure on research and development in the various countries. This includes all funds used in a country to perform R&D, irrespective of their source of finance; it also includes funds from abroad and from international organisations earmarked for research in the respective country, but does not cover the payments made by this country to other states or to international organisations for performing research and development activities there.

The USA has the highest gross domestic expenditure on R&D: It accounts for about half of the funds allocated for R&D every year by all G7 states (1981: 49.9 %; 1990: 48.0 %). Second and third place are held by Japan and Germany, with this order having remained unchanged since the mid-1970s. In all countries under consideration this nominal expenditure, converted into US $ purchasing power parities, has increased substantially in the 1980s. In the period from 1987 to 1990, Japan (12.4 %), Italy (10.1 %), and France (9.5 %) had the highest mean annual growth rates. For the other countries the figure is about 6 %.

These variables, however, do not suffice to describe the research performance of the various countries. First, the absolute figures (also) reflect considerable differences in size of the national economies under consideration and second, the rates of change relate to different price developments.

One of the indicators most common in comparisons of national research efforts is gross domestic expenditure on R&D expressed as a percentage of a country's GDP. In terms of this ratio, Germany, Japan and the USA have held the top positions among the major industrialised countries since the mid-1970s. While the share of gross domestic expenditure on R&D in the gross domestic product in all countries considered here – with the exception of the United Kingdom – had increased considerably until the mid-1980s, the picture of the years after 1987 is rather heterogeneous: In Japan, France and Italy, the positive trend – slightly slowed down in part – continued up to 1990, while the figure for Canada stagnated until 1990 and did not begin to increase again before 1991. The shares of the other countries showed a slightly downward tendency.

In the Federal Republic of Germany, the R&D share in GDP rose from 2.43 % in 1981 to 2.88 % in 1987 and 1989. In 1987, Germany was still leading ahead of Japan and the USA. In 1990 and 1991, the percentages were considerably lower at 2.77 % and 2.66 %, respectively. It should be noted that the 1990 data relate to the former West Germany, while the 1991 data cover the whole of Germany. In the USA, a slightly downward tendency set in earlier. The country's figures peaked in 1985 at 2.93 % so that the USA ranked first ahead of Japan and the Federal Republic of Germany. In the meantime, Japan has taken over first place, being the only country in the top group that was able to achieve increases also for the period up to 1990 (1987: 2.82 %; 1990: 3.07 %). The Japanese figure for 1991 is 3.04 % (cf. Figure II/13). It should be pointed out, though, that in comparison with other countries the Japanese data are overestimated due to the inclusion of excessive personnel expenditure, because the figures for R&D personnel were not calculated on a full-time equivalent basis.

Table II/22

Gross domestic expenditure on R&D (GERD) in selected countries

Country	1981	1987	1988	1989	1990	1991 [1]
	– US $ million [2] –					
Federal Republic of Germany [3]	16,614	26,446	28,199	30,378	31,904	35,476
France	11,439	18,091	19,478	21,475	23,760	24,957
United Kingdom [4]	12,253	17,089	18,111	19,466	20,150	19,300
Italy	4,725	8,957	9,853	10,752	11,964	13,370
Japan [5]	25,351	47,094	52,371	59,344	66,965	71,994
USA [6]	73,692	127,855	136,358	143,603	149,225	154,348
Canada [7]	3,558	5,962	6,353	6,702	7,199	7,496
	– *% of GDP* [8] –					
Federal Republic of Germany [3]	*2.43*	*2.88*	*2.86*	*2.88*	*2.77*	*2.66*
France	*1.97*	*2.27*	*2.28*	*2.34*	*2.42*	*2.42*
United Kingdom [4]	*2.41*	*2.25*	*2.21*	*2.24*	*2.21*	*2.1*
Italy	*0.87*	*1.19*	*1.22*	*1.24*	*1.30*	*1.38*
Japan [5]	*2.32*	*2.82*	*2.86*	*2.98*	*3.07*	*3.04*
USA [6]	*2.45*	*2.87*	*2.84*	*2.80*	*2.77*	*2.78*
Canada [7]	*1.23*	*1.40*	*1.38*	*1.37*	*1.41*	*1.44*

[1]) Provisional OECD data, based partly on national estimates, partly on OECD estimates.
[2]) Nominal expenditure, converted into US $ purchasing power parities.
[3]) Data for even years estimated; 1990 and 1991 revised estimates; 1987 break in series; up to and including 1990 former West Germany, 1991 Germany as a whole.
[4]) 1991 data provided by Central Statistical Office, London (March 31, 1993).
[5]) R&D expenditure overestimated.
[6]) Excludes most or all capital expenditure.
[7]) Provisional data for 1990.
[8]) GDP: Gross domestic product.

Source: OECD (1992/2) and BMFT calculations

Rounding error

As mentioned above, not only Japan, but also France and Italy attained increases in the years following 1987: France raised its percentage from 2.27 % in 1987 to 2.42 % in 1991, thus reducing the lead of the top group. Italy's ratio rose from 1.19 % in 1987 to 1.38 %, thus reducing the margin between itself and Canada whose trend stagnated (cf. Table II/22).

Another statistical indicator used for comparing national research efforts is the per capita gross domestic expenditure on R&D in the various countries.

In the period under review the USA has invariably had the highest per capita expenditure on R&D. Up to 1989, the Federal Republic of Germany ranked second, but in 1990 Japan succeeded in taking this place due to its disproportionately high increase in expenditure. France and the UK followed, holding fourth and fifth place, respectively.

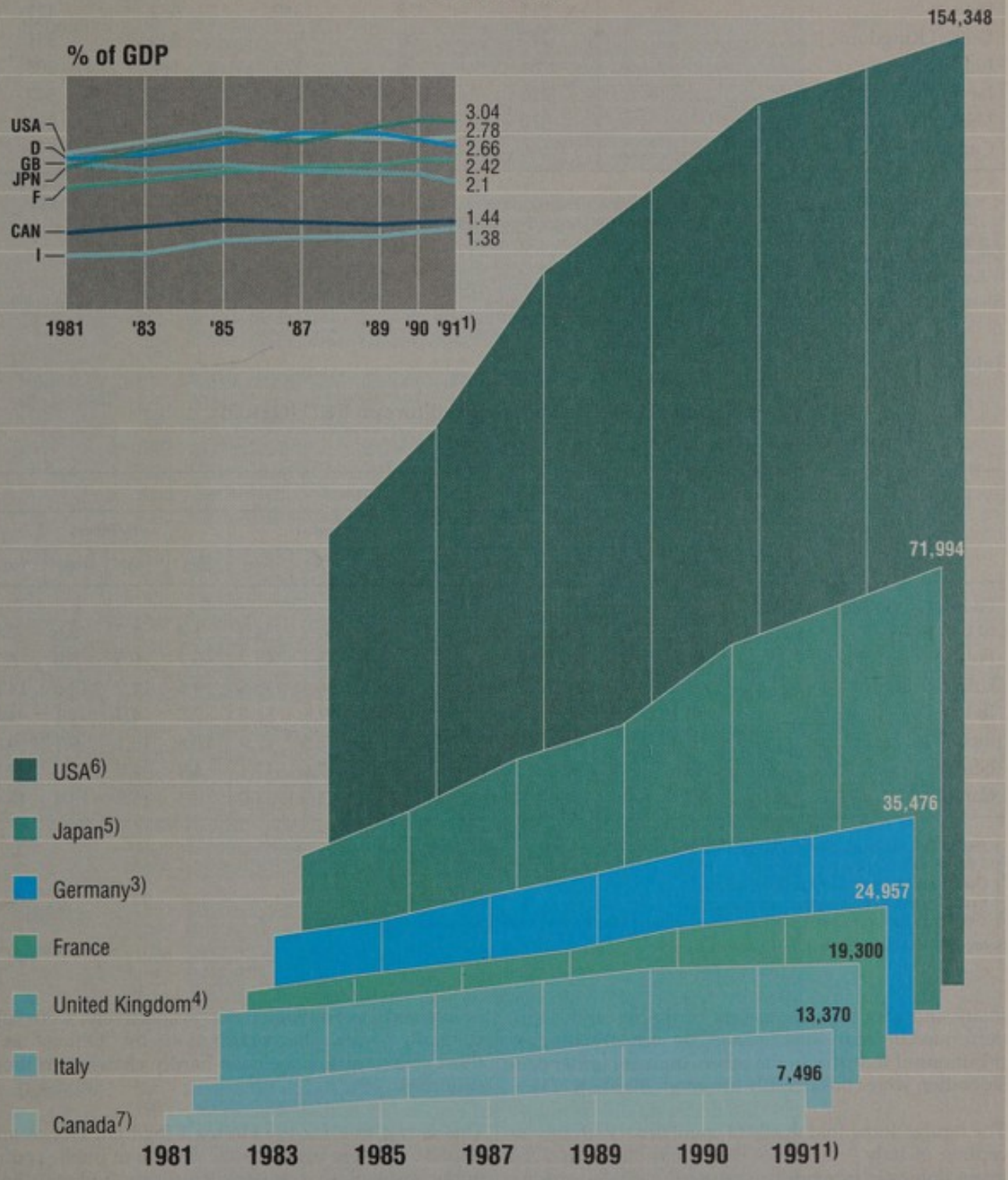
While the per capita expenditure averaged over the countries under consideration has almost doubled compared with 1981 (+ 97.5 %), the increases in Japan and Italy, at 150 %, are clearly above average; growth in Canada, the USA and the Federal Republic of Germany, at about 85 %, is slightly below average. With 61 %, the United Kingdom has the lowest growth rate; on closer examination it turns out, however, that this is primarily the result of a restrained development in the first half of the 1980s. With an increase rate of 17 % in 1987, the United Kingdom holds a midfield position ahead of the USA (+ 13 %) as well as the Federal Republic of Germany and Canada with 15 % each. The growth rates of Japan and Italy are 40 % and 33 %, respectively (cf. Table II/23).

One of the most important characteristics of the research scene is the funding structure of research expenditure. A comparison of the percentage of national gross domestic expenditure on R&D financed by industry is of major importance in this context. In both Japan and Germany, industry made the highest contributions. In Germany, the percentage rose from 57.9 % in 1981 to 63.6 % in 1987 and 63.3 % in 1989. In 1990, however, it dropped considerably. In Japan, the contribution of industry went up from 62.3 % in 1981 to 68.5 % in 1987 and 73.1 % in 1990. Consequently, just under two thirds of the research activities carried out in Ger-

Figure II/13 (cf. Table II/22)

Gross domestic expenditure on R&D (GERD) in selected countries

– US $ million[2] –



1) Provisional data.
2) Nominal expenditure, converted into US $ purchasing power parities.
3) Data for even years estimated; 1987 break in series; 1990 and 1991 revised estimates; up to and including 1990 former West Germany, 1991 German as a whole.
4) 1991 data provided by Central Statistical Office, London (March 31, 1993).
5) R&D expenditure overestimated.
6) Excludes most or all capital expenditure.
7) Provisional data for 1990.

Source: OECD (1992/2) and BMFT calculations.

BMFT, BuFo '93

Table II/23

Gross domestic expenditure on R&D (GERD) per capita population in selected countries
– US $ [1]) –

Country	1981	1987	1988	1989	1990
Federal Republic of Germany [2])	269	433	459	490	505
France	211	325	349	382	421
United Kingdom	217	300	317	340	351
Italy	84	156	172	187	208
Japan [3])	216	386	427	482	542
USA [4])	320	524	554	577	593
Canada [5])	146	233	245	255	270

[1]) Nominal expenditure, converted into US $ purchasing power parities.
[2]) 1987 break in series; 1988 and 1990 data estimated (1990 revised estimate).
[3]) R&D expenditure overestimated.
[4]) Excludes most or all capital expenditure.
[5]) Provisional data for 1990.

Source: OECD (1992/2), Federal Statistical Office and BMFT calculations

Rounding error

Table II/24

Financing of gross domestic expenditure on R&D (GERD)
– in % –

Country	financed											
	by industry				by government				by others			
	1981	1987	1989	1990	1981	1987	1989	1990	1981	1987	1989	1990
Federal Republic of Germany [1])	57.9	63.6	63.3	62.4	40.7	34.7	34.1	34.7	1.4	1.7	2.6	2.8
France	40.9	41.8	43.9	43.5	53.4	51.7	48.1	48.2	5.7	6.5	8.0	8.2
United Kingdom [2])	41.3	49.2	50.7	49.4	49.0	39.1	36.4	35.8	9.6	11.7	12.8	14.8
Italy	50.1	41.7	46.4	43.7	47.2	54.0	49.5	51.5	2.7	4.3	4.1	4.8
Japan [3])	62.3	68.5	72.3	73.1	26.9	21.5	18.6	17.9	10.8	10.1	9.1	9.0
USA [4])	48.8	49.0	50.2	50.6	49.3	49.1	47.6	47.1	1.9	1.9	2.2	2.3
Canada [5])	41.7	41.1	41.0	40.8	50.1	45.2	44.3	44.0	8.3	13.8	13.4	13.4

[1]) 1987 break in series, 1990 revised estimate.
[2]) 1986 break in series.
[3]) Contribution of industry underestimated.
[4]) Excludes most or all capital expenditure.
[5]) 1989 and 1990 unrevised breakdown not adding to the revised total. Provisional data for 1990.

Source: OECD (1992/2) and BMFT calculations

Rounding error

many and about three quarters of the research work performed in Japan were financed by industry; the contributions of industry in the other countries under consideration were considerably lower (cf. Figure II/14).

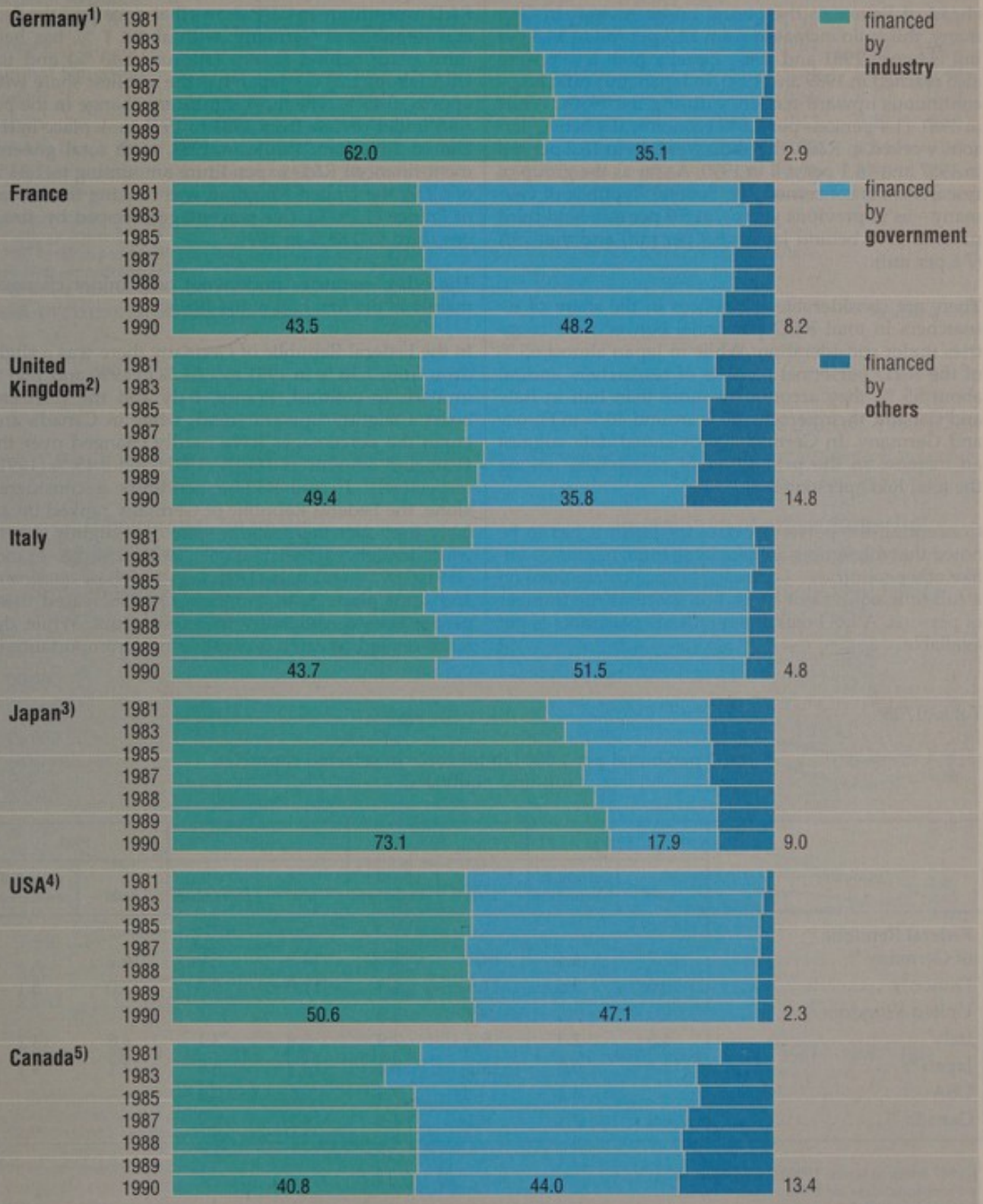
The figures show that in all G7 countries – with the exception of Italy – the percentage of publicly financed gross domestic expenditure on R&D declined during the 1980s, while contributions by industry rose. One of the most marked changes in the financing structure can be detected in Japan where the public contribution dropped by about 10 percentage points and industry's contribution rose at the same rate. The corresponding figures for Germany and the USA, at 5 percentage points and 2 percentage points respectively, were substantially lower. The contributions by "Others" as a third source of finance haye hardly changed in those countries.

This is not true for the United Kingdom, France and Canada. In these countries the decline in public contributions was partly compensated for by "Others". Italy is the only country among the G7 states where – with great variations over the years under review – an opposite trend can be identified: The contribution of industry fell from 50.1 % in 1981 to 43.7 % in 1990, while the proportion of publicly financed expenditure rose from 47.2 % to 51.5 % over the same period (cf. Table II/24).

Figure II/14 (cf. Table II/24)

Financing of gross domestic expenditure on R&D (GERD) in selected countries

– in % –



1) 1987 break in series. 1988 and 1990 revised estimates.
2) 1986 break in series.
3) Share of industry underestimated.
4) Underestimated: excludes most or all capital expenditure.
5) Provisional.

Source: OECD (1992/2) and BMFT calculations.

BMFT, BuFo '93

Information on financial R&D resources of a country is supplemented by data on personnel working in research and development. One of the most common ratios used in international comparisons is that of research personnel to total labour force (cf. Table II/25).

In terms of total R&D personnel which comprises researchers, technical staff and other supporting staff, the Federal Republic of Germany and Japan lead the list ahead of France in the period under review. In Germany, this ratio increased from 12.7 per mil to 14.3 per mil between 1981 and 1987. Equally high levels were also reached in 1989 and 1990. In Japan, this ratio had a continuous upward tendency during the 1980s. While in 1981 11.4 persons per 1,000 economically active persons worked in R&D, this ratio went up to 13.2 per mil in 1987 and 14.1 per mil in 1990. As far as the group of researchers is concerned, the Federal Republic of Germany – as in previous years -, at 5.9 per mil, held third place in 1989 behind Japan (8.9 per mil) and the USA (7.6 per mil).

There are considerable differences in the share of researchers in total R&D personnel between the countries under consideration: While in Japan almost 65 % of the R&D personnel consists of researchers and, at about 55 %, they account for more than half in Italy and Canada, their percentage is around 40 % in France and Germany. In Germany, provisional data suggest an increase in the proportion of researchers among the total R&D personnel.

Concerning the personnel data for Japan it has to be noted that the figures are much too high, because – unlike other countries – Japan does not calculate them on a full-time equivalent basis, but specifies the number of persons. A US breakdown of R&D personnel is not available.

OECD reports also include data on government-financed R&D expenditure; these data relate to budget appropriations. It should be noted that these figures also include the public funds earmarked for research and development abroad and hence are not included in gross domestic expenditure on research and development. In this way it is possible to separate the expenditure on defence research from that on civil research. A comparison of the shares of government-financed R&D expenditure in GDP shows that since 1987 the Federal Republic of Germany, with about 1 %, has held third place behind France (approx. 1.40 %) and the USA (about 1.20 %). Japan has the smallest share with approx. 0.45 %. The most significant change in the period under review from 1981 to 1991 took place in the United Kingdom: While in 1981, with total government-financed R&D expenditure amounting to 1.34 % of GDP, the United Kingdom was ranking first ahead of France (1.29 %), this percentage dropped by about one third to 0.88 % in 1991.

The other countries underwent only minor changes, mainly in the first half of the 1980s.

In the Federal Republic of Germany there was a slight drop from 1.16 % in 1981 to 1.04 % in 1990 and 1.05 % in 1991. In contrast, France, Italy and the USA can boast a slightly upward trend, while in Canada and Japan the percentages have hardly changed over the years and amount to 0.60 % (1991) and 0.45 % (1991), respectively. If civil R&D expenditure is considered alone, the Federal Republic of Germany ranked invariably first over the years in spite of a slightly downward tendency (1981: 1.05 %; 1991: 0.94 %). France (1991: 0.89 %) and Italy (1991: 0.70 %) follow on second and third place. Both countries have increased these percentages considerably in recent years. While defence-related research is of rather minor importance in

Table II/25

R&D personnel per 1,000 labour force in selected countries
– full-time equivalent –

Country	1981		1987		1989		1990	
	total	of which researchers	total	of which researchers	total	of which researchers	total	of which researchers
Federal Republic of Germany [1]	12.7	4.4	14.3	5.6	14.3	5.9	14.2	.
France [2]	10.6	3.6	11.5	4.5	11.9	5.0	12.0	5.1
United Kingdom [3]	.	.	9.9	4.6	.	.	.	.
Italy	4.5	2.3	5.3	2.9	5.8	3.1	6.0	3.2
Japan [4]	11.4	6.9	13.2	8.4	13.8	8.9	14.1	9.1
USA	.	6.2	.	7.5	.	7.6	.	.
Canada [5]	6.9	3.4	8.2	4.5	8.2	4.6	.	.

[1] 1987 break in series, 1990 revised estimate.
[2] Provisional data for 1990.
[3] Underestimated.
[4] Data overestimated.
[5] Provisional data for 1989.

Source: OECD (1992/2)

Rounding error

Table II/26

Total government R&D expenditure in % of gross domestic product *)

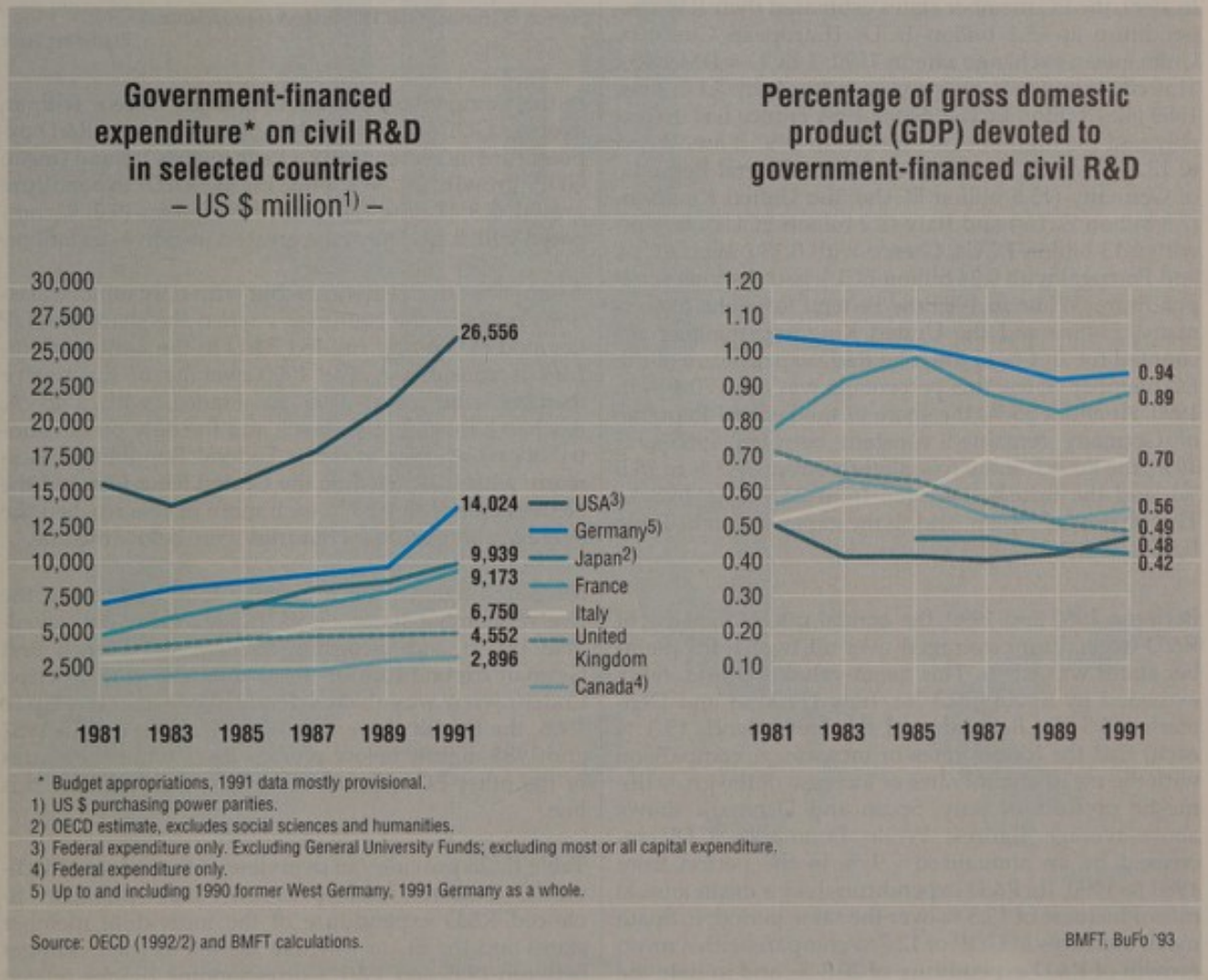
Country	Total %					% of civil R&D expenditure				
	1981	1987	1989	1990	1991 [1])	1981	1987	1989	1990	1991 [1])
Federal Republic of Germany [2])	1.16	1.11	1.06	1.04	1.05	1.05	0.97	0.93	0.90	0.94
France	1.29	1.39	1.34	1.42	1.42	0.79	0.89	0.84	0.85	0.89
United Kingdom	1.34	1.05	0.94	0.90	0.88	0.72	0.57	0.51	0.51	0.49
Italy	0.56	0.75	0.73	0.74	0.76	0.52	0.70	0.66	0.70	0.70
Japan	.	0.48	0.46	0.45	0.45	.	0.46	0.43	0.43	0.42
USA [3]) [4])	1.12	1.28	1.21	1.18	1.19	0.51	0.40	0.42	0.44	0.48
Canada [3])	0.60	0.57	0.57	0.59	0.60	0.56	0.53	0.52	0.55	0.56

*) Budget appropriations.
1) Partly provisional data.
2) 1987 break in series with previous years. Up to and including 1990 former West Germany, 1991 Germany as a whole.
3) Federal expenditure only.
4) Excluding General University Funds and most or all capital expenditure.

Source: OECD (1992/2) and BMFT calculations

Rounding error

Figure II/15 (cf. Table II/26)



* Budget appropriations, 1991 data mostly provisional.
1) US $ purchasing power parities.
2) OECD estimate, excludes social sciences and humanities.
3) Federal expenditure only. Excluding General University Funds; excluding most or all capital expenditure.
4) Federal expenditure only.
5) Up to and including 1990 former West Germany, 1991 Germany as a whole.

Source: OECD (1992/2) and BMFT calculations.

BMFT, BuFo '93

Japan, Italy and Canada with shares of 7 % each in total government-financed R&D expenditure and in Germany with about 10 % in the period under review, it is of much more significance in the other countries. In 1991 the corresponding percentages were 60 % in the USA, 44 % in the United Kingdom and 37 % in France (cf. Table II/26).

The trend of publicly financed expenditure on research and development in terms of final budget appropriations of all member states up to and including 1990 can be derived from the surveys conducted by the EC (cf. Table II/27). Figure II/16 provides an overview of the expenditure levels in total and per capita of population in the individual member states in 1990. The EC data have the advantage that they are also available broken down by research objectives. This breakdown is based on the Nomenclature for the Analysis and Comparison of Science Programmes and Budgets (NABS 1983). The surveys cover the final budgets as well as provisional budget data of the following year so that at present data for 1990 (final) and 1991 (provisional) are available. The 1990 data for the Federal Republic of Germany relate to the former West Germany, the 1991 data cover the whole of Germany, but do not yet include the funds of the five new Länder (Berlin is completely covered).

In 1990, the EC member states estimated their R&D expenditure at 45.1 billion ECUs (European Currency Units, mean exchange rate in 1990: 1 ECU = DM 2.05). This corresponds to an increase in funds by 7.1 % over 1989 (42.1 billion ECUs). Since 1984 France has invariably had the highest expenditure. In 1991 it amounted to 13.8 billion ECUs, followed by the Federal Republic of Germany (13.5 billion ECUs), the United Kingdom (7.3 billion ECUs) and Italy (7.2 billion ECUs). Ireland with 0.13 billion ECUs, Greece with 0.15 billion ECUs and Portugal with 0.24 billion ECUs had the lowest expenditure. While in 1985 the Federal Republic of Germany, France and the United Kingdom together accounted for 76.1 % of the total R&D expenditure of the EC member states, this percentage was only 70.4 % in 1990. At about 25 %, the share of the Federal Republic of Germany remained constant between 1985 and 1990, the French share rose slightly (from 27.3 % to 28.5 %), and the British share fell from 23.8 % to 16.8 %. The shares of Spain and Italy expanded (cf. Table II/27).

Between 1980 and 1990, the annual rate of increase of R&D expenditure averaged over all twelve EC member states was 8.5 %. This mean value is considerably exceeded by Spain (20.3 %), Italy (17.2 %) and Denmark (13.5 %). Belgium and the Netherlands (5.3 % each) had the lowest rates of increase. A comparison with the mean annual rates of increase of the gross domestic product of Italy, Spain and Denmark shows above-average figures: While Denmark's GDP increased by an annualised 7.9 % in the period from 1980 to 1990, its R&D expenditure had a mean annual rate of increase of 13.5 % over the same period; in Spain mean increases in GDP of 12.7 % compare with a mean growth of R&D expenditure of 20.3 %, and in Italy the corresponding percentages are 14.4 % and 17.2 %.

Table II/27

Shares of individual member states in government R&D expenditure of the countries of the European Communities [1])
– in % –

	1985	1990
Federal Republic of Germany	25.0	25.1
France	27.3	28.5
United Kingdom	23.8	16.8
Total	**76.1**	**70.4**
Belgium	1.9	1.8
Denmark	1.0	1.3
Greece	0.4	0.5
Spain	3.2	5.3
Ireland	0.3	0.3
Italy	12.0	15.1
Netherlands	4.6	4.5
Portugal	0.4	0.8
Total	**100.0**	**100.0**

[1]) At 1985 purchasing power parities and prices.
Source: EC (provisional 1990 budget appropriations)
Rounding error

In this comparison of rates of change, Greece with an average GDP increase of 19.8 % and a mean R&D expenditure increment of 12.1 % as well as Ireland (mean GDP growth 10.7 % and mean R&D expenditure growth 7.9 %) and the United Kingdom (9.2 % compared with 5.7 %) have the greatest negative deviations.

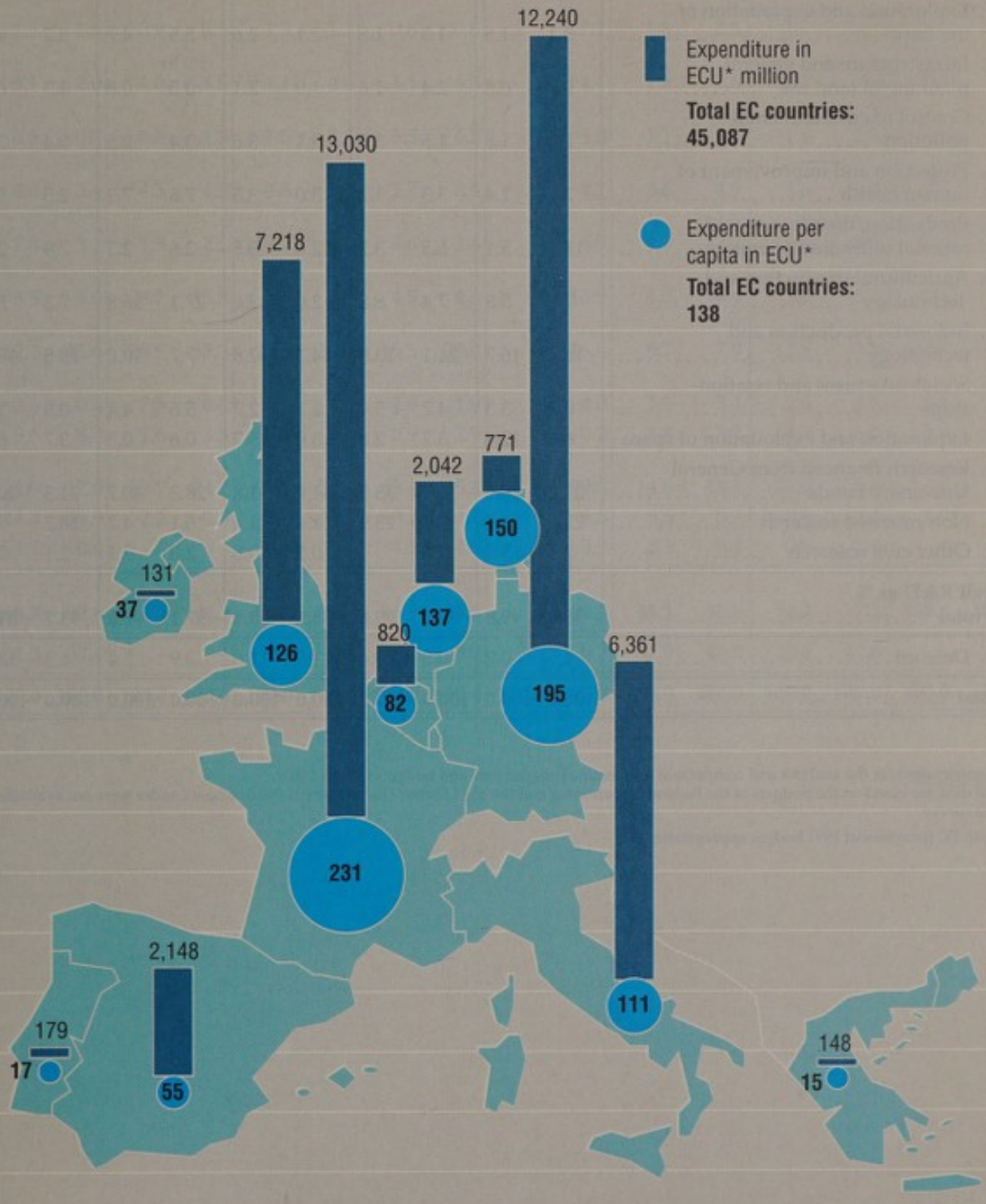
A similar pattern emerges – but with only minor variations between the countries – when the share of GDP devoted to publicly funded R&D in the various countries is considered: The 1990 average of the twelve member states was 0.95 %. France, with 1.40 %, reached a much higher level, and the only other country above average was the Federal Republic of Germany with 1.04 %, while the United Kingdom and the Netherlands with 0.93 % each more or less reached the average and the other countries were below the line.

Measured against the respective total budgets of the twelve member states – data, however, are only available up to and including 1988 –, the French and German expenditure on R&D over the entire period under review was always clearly above average. Up to 1986, the British share was slightly above and in 1987 and 1988 slightly below average level, while the shares of the other EC member states are clearly below this line.

Table II/28 provides an overview of the shares of individual research objectives in total publicly financed R&D expenditure of the individual member states and the EC as a whole as well as their changes between 1985 and 1991. Corresponding figures related to groups of research objectives are given in Table II/29.

Figure II/16

Government financed expenditure on research and development in the member states of the European Communities in 1990



* ECU = European Currency Unit; mean rate of exchange 1990: 1 ECU = DM 2.04503

Source: European Communities (EC)

BMFT, BuFo '93

Table II/28

Shares of research objectives in government R&D expenditure of EC member states in 1985 and 1991 (budget appropriations)
– in % –

Research objectives according to NABS chapters (NABS 1983) [1]	B		DK		D		GR		E	
	1985	1991	1985	1991	1985	1991 [2]	1985	1991	1985	1991
1. Exploration and exploitation of the Earth	3.1	1.8	1.3	1.8	2.1	2.6	5.5	4.7	6.7	4.6
2. Infrastructure and general planning of land use	0.7	0.8	2.4	1.6	1.9	2.1	0.5	0.8	4.3	0.6
3. Control of environmental pollution	2.5	1.8	1.5	3.5	3.1	3.6	3.4	2.5	0.4	3.6
4. Protection and improvement of human health	2.7	1.4	3.3	1.7	3.0	3.5	7.6	7.3	2.5	5.4
5. Production, distribution and rational utilisation of energy	11.5	5.1	6.5	3.2	12.6	5.8	2.6	2.3	7.9	2.2
6. Agricultural production and technology	7.0	5.8	7.4	8.8	2.0	2.6	27.1	16.8	7.3	5.2
7. Industrial production and technology	16.4	16.7	21.1	13.5	14.1	12.8	7.7	10.0	18.5	19.0
8. Social structures and relationships	0.7	3.3	4.2	5.4	2.3	2.7	5.6	4.4	0.8	1.5
9. Exploration and exploitation of space	6.6	12.4	3.2	2.8	3.9	5.7	0.6	0.3	3.7	6.7
10. Research financed from General University Funds	22.2	23.9	31.0	33.5	31.4	31.8	28.3	40.7	21.3	20.6
11. Non-oriented research	22.4	21.5	17.7	23.9	11.4	14.4	6.1	4.7	18.2	9.6
12. Other civil research	2.7	5.3	–	–	0.1	0.8	2.0	3.1	2.1	2.8
Civil R&D as % of total	**98.5**	**99.8**	**99.5**	**99.6**	**88.1**	**88.4**	**97.1**	**97.6**	**93.7**	**81.6**
13. Defence	1.5	0.2	0.5	0.4	11.9	11.6	2.9	2.4	6.3	18.4
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

[1]) Nomenclature for the analysis and comparison of scientific programmes and budgets (NABS 1983).
[2]) The data are based on the budgets of the Federal Government and the old Länder. The budgets of the five new Länder were not available for this survey.

Source: EC (provisional 1991 budget appropriations)

Table II/28

F		IRL		I		NL		P		GB		EUR 12		EC	
1985	1991	1985	1991	1985	1991	1985	1991	1985	1991	1985	1991	1985	1991	1985	1991
1.5	1.6	0.9	0.3	1.3	1.2	0.6	0.6	.	7.1	1.8	2.5	1.7	2.1	1.5	2.4
3.1	1.0	4.0	4.6	1.1	0.4	4.1	4.3	.	4.1	1.2	1.6	2.1	1.4	0.6	5.5
0.5	0.7	0.8	1.3	1.0	2.8	3.3	4.2	.	3.0	1.1	1.5	1.6	2.3	5.4	5.3
4.0	3.4	4.3	4.5	4.6	5.9	2.7	2.6	.	4.1	3.6	4.9	3.6	4.0	4.2	3.6
7.8	3.1	1.3	2.1	19.7	5.0	4.6	3.4	.	4.5	4.5	2.4	9.6	4.0	55.8	24.0
3.5	4.0	28.7	15.8	3.8	2.8	4.5	4.4	.	13.9	4.6	4.4	3.7	3.8	2.8	5.9
12.1	12.6	28.9	35.3	20.6	15.5	15.5	20.0	.	16.4	6.7	7.9	12.8	13.2	26.7	46.1
2.6	0.4	7.5	6.4	1.1	7.9	2.6	1.9	.	4.0	1.2	3.4	2.0	2.9	0.5	1.8
5.6	8.4	1.6	3.3	7.1	6.8	0.9	2.9	.	0.2	1.8	3.2	4.2	6.2	1.0	0.8
11.9	12.0	19.7	24.2	21.7	30.6	43.4	35.4	.	29.6	14.6	18.1	21.0	23.4	–	–
14.4	14.9	2.2	2.3	7.5	10.3	10.2	12.7	.	8.5	6.5	5.3	10.9	12.4	1.3	2.0
1.7	0.4	–	–	0.6	3.1	4.5	4.3	.	3.9	0.3	0.4	0.9	1.3	–	2.7
68.7	**62.6**	**100.0**	**100.0**	**90.1**	**92.3**	**96.9**	**96.7**	**.**	**99.3**	**48.1**	**55.8**	**74.2**	**77.2**	**100.0**	**100.0**
31.3	37.4	–	–	9.9	7.7	3.1	3.3	.	0.7	51.9	44.2	25.8	22.8	–	–
100.0	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Rounding error

Compared with 1985, the shares of government financed R&D expenditure devoted to "Technological objectives" and "Defence" dropped from 28.9 % to 25.6 % and from 25.8 % to 22.8 %, respectively. The shares of the other groups of research objectives grew slightly. It is striking that, as a result of increases in the shares of "Human and social objectives" and "Agriculture" – like the decline of "Technological objectives" – over those years, changes that had taken place in the first half of the 1980s were offset so that the 1990 figures of these groups differ only slightly from the 1980 data.

Table II/29

Government R&D expenditure of EC member states by groups of research objectives
– in % –

Groups of research objectives (according to NABS 1983) [1]	1980 [2]	1985	1991
Human and social objectives (NABS chapters 2, 3, 4, 8) ..	11.6	9.5	10.7
Technological objectives (NABS chapters 1, 5, 7, 9) ..	26.7	28.9	25.6
Agriculture (NABS chapter 6)	3.7	2.8	3.8
Research financed from General University Funds (NABS chapter 10)	32.4	21.2	23.4
Non-oriented research ..... (NABS chapter 11)		10.9	12.4
Other civil research (NABS chapter 12)	0.2	0.9	1.3
Defence (NABS chapter 13)	25.4	25.8	22.8
Total	**100.0**	**100.0**	**100.0**

[1] Nomenclature for the analysis and comparison of scientific programmes and budgets (NABS 1983); cf. Table II/28.
[2] Not including Greece, Spain and Portugal.
Source: EC (provisional 1991 budget appropriations)

Rounding error

11. Patent and licence transactions with foreign countries

Among the common international science and technology indicators a national economy's receipts from and expenditure on patent and licence transactions with foreign countries need to be handled and interpreted with special care and expertise.

At regular intervals, the Deutsche Bundesbank comments in its Monthly Reports on the development of patent and licence transactions with foreign countries, as well as on the exchange of technical know-how through service transactions (cf. e.g. Monthly Reports of the Deutsche Bundesbank, April 1992). The results are based on statistical reports submitted pursuant to the Foreign Trade and Payments Ordinance.

At the international level, data pertaining to these indicators, the so-called Technological Balance of Payments, are compiled by the Organisation for Economic Cooperation and Development (OECD).

In view of the varied use of these data, on the one hand, and the problems involved in their expert interpretation, on the other hand, a manual containing recommendations on guidelines for the compilation and interpretation of statistics on the Technological Balance of Payments was prepared and published a few years ago under the umbrella of the OECD. This manual leans heavily on the Frascati Manual which contains general guidelines for statistical surveys of research and experimental development.

The Technological Balance of Payments doubtless contains interesting information on economic and technological structures and relationships, but by no means does it provide a complete picture of international technology transfer and hence does not suffice as a basis for the assessment of the level of technological performance of a country.

Factors not covered by the Technological Balance of Payments, although they are of great importance for the transfrontier exchange of technical knowledge, are foreign trade in high-tech industrial products, sales of industrial plants and the establishment of production and distribution facilities outside the territory of the country in which a company is based (direct investment).

Even though these transactions are not the immediate object of the Technological Balance of Payments, they influence the level of receipts from and expenditure on patent and licence trade or technological research and development to a certain extent, as the Deutsche Bundesbank explains in its reports (Monthly Reports, April 1992).

The long-term trend of receipts from and expenditure on patents, inventions and processes (cf. Table II/30) shows that the "traditional deficit" of the Federal Republic of Germany, which since the mid-1970s had been slightly above DM 1 billion and had increased to almost DM 2 billion by 1989, reached almost DM 3 billion in 1990 and 1991. From July 1990 onwards, the results have also included transactions on the territory of the former GDR.

Starting with a negative balance of DM – 1,976 million in 1989, the deficit rose by 16.8 % to DM – 2,308 million in 1990 and by 25.9 % to DM – 2.905 million in 1991.

The sizeable increase in the deficit from 1990 to 1991 is the result of two trends: The receipts which had continuously grown over the last 15 years, declined for the first time – even though only slightly (- 0.6 %) -, while expenditure – as in most previous years – continued to increase (+ 12.3 %).

The reports of the Deutsche Bundesbank suggest that the cause of the decline in receipts is a cyclical downturn in Germany's partner countries, as a result of

Table II/30

German receipts from and expenditure *) on patents, inventions and processes, by enterprises holding participating interests abroad, enterprises in which foreigners hold participating interests and other enterprises
– DM million –

Year	Receipts				Expenditure				Balance			
	Total	Enterprises			Total	Enterprises			Total	Enterprises		
		holding participating interests abroad [1]	with foreign participating interests [2]	Other enterprises		holding participating interests abroad [1]	with foreign participating interests [2]	Other enterprises		holding participating interests abroad [1]	with foreign participating interests [2]	Other enterprises
1974	679	635	44	.	1,509	353	1,156	.	– 830	+ 282	– 1,112	.
1975	757	716	41	.	1,793	410	1,383	.	– 1,036	+ 306	– 1,342	.
1976	728	654	74	.	1,746	420	1,326	.	– 1,018	+ 234	– 1,252	.
1977	778	724	54	.	1,895	462	1,433	.	– 1,117	+ 262	– 1,379	.
1978	864	774	90	.	1,937	428	1,509	.	– 1,073	+ 346	– 1,419	.
1979	901	820	81	.	1,952	436	1,516	.	– 1,051	+ 384	– 1,435	.
1980	1,011	922	89	.	2,079	459	1,620	.	– 1,068	+ 463	– 1,531	.
1981	1,095	993	102	.	2,143	536	1,607	.	– 1,048	+ 457	– 1,505	.
1982	1,194	1,033	161	.	2,201	524	1,677	.	– 1,007	+ 509	– 1,516	.
1983	1,313	1,013	300	.	2,481	436	2,045	.	– 1,168	+ 577	– 1,745	.
1984	1,473	1,188	285	.	2,592	527	2,065	.	– 1,119	+ 661	– 1,780	.
1985 r)	1,608	1,365	243	.	2,940	589	2,351	.	– 1,332	+ 776	– 2,108	.
1986 r)	1,693	1,296	264	134	3,378	539	2,660	180	– 1,685	+ 757	– 2,396	– 46
1987 r)	1,792	1,366	262	165	3,398	493	2,729	176	– 1,606	+ 873	– 2,467	– 11
1988 r)	1,898	1,552	217	129	3,239	548	3,093	198	– 1,941	+ 1,004	– 2,876	– 69
1989 r)	2,104	1,718	197	189	4,080	670	3,164	247	– 1,976	+ 1,048	– 2,967	– 58
1990	2,434	1,947	324	163	4,742	785	3,678	279	– 2,308	+ 1,162	– 3,354	– 116
1991	2,419	1,734	547	138	5,324	771	3,984	569	– 2,905	+ 963	– 3,437	– 431

*) From July 1990 including the external transactions of the former GDR.
[1]) Enterprises in which there is no major foreign capital interest, whereas they hold major capital interests abroad. Participating interests of more than 20% (at least 25% until 1989) are considered to be major interests. Up to 1985, including enterprises without capital ties.
[2]) Enterprises in which there is a major foreign capital interest, i.e. an interest of more than 20% (at least 25% until 1989).
r) Revised data.

Source: Deutsche Bundesbank

Rounding error

which sales figures for German products made under licence abroad dropped, licence agreements were not renewed on expiry and payments due were deferred. The expenditure on patents and licences rose mainly because domestic sales of products made under foreign licence went up; this was caused by cyclical factors, but was probably also a result of the increased demand for technical know-how in the wake of German unification. In some cases, large one-off payments were made to acquire foreign patents (cf. Monthly Reports of the Deutsche Bundesbank, April 1992).

By no means, however, can a "technological gap" between the Federal Republic of Germany and other countries be inferred from these data. German patent and licence transactions with foreign countries are characterised by the fact that transfrontier payments mostly take place between associated enterprises (cf. Table II/30). In 1990, 80 % of the receipts was accounted for by companies with subsidiaries abroad, and just under 78 % of the expenditure was accounted for by firms in Germany in which foreigners hold participations; the corresponding percentages for 1991 are 72 % and 75 %, respectively.

In reporting on the development of the patent and licence trade the Bundesbank draws attention to the special structural and institutional characteristics of this indicator. The fact that most of the transactions take place between associated companies suggests that the companies are anxious to keep technological know-how within the group, thus avoiding competition with their own products and losses of their market shares.

As in previous years, companies with participations abroad – considered separately – generated net receipts of DM + 963 million in 1991, which however are lower than in 1990 (DM + 1,162 million). Over the same period the negative balance of companies with

foreign participation increased slightly (by 2.5 % to DM -3,437 million).

The negative balance of patent and licence transactions of the companies in which foreigners hold participations may be attributable to very different factors. In addition to technological factors, tax-related and economic factors are of special importance.

In most cases, the right to use a patent or a technical process is granted in the form of a manufacturing or marketing licence. The ensuing payments are usually made by subsidiaries to their parent companies. This is why German companies with foreign capital participation have a large net expenditure, while German companies with subsidiaries abroad always record high net receipts.

Regarding the increase of German direct investment abroad – it is now exceeding foreign direct investment in Germany -, it may be surprising at first that also in recent years the receipts of German groups arising from patent and licence transactions with foreign subsidiaries were lower than the corresponding payments made by German subsidiaries to their foreign parent companies. The Deutsche Bundesbank attributes this to the relatively short time that German enterprises have held assets abroad and the higher level of technology-intensive foreign direct investment in Germany. It draws attention to the fact that due to the different levels of taxation and other fiscal charges in the various countries there may be shifts – especially when associated companies are involved – between patent and licence payments on the one hand and distributions of profits on the other (cf. Monthly Reports of the Deutsche Bundesbank, April 1992).

Since the balance of payments only covers financial transactions, cases where licences granted are paid for in kind are not included in the licence account. Like payments in patent and licence trade, payments of cash contributions towards financing research and development projects are also subject to different influencing factors.

For many years, the Federal Republic of Germany has had net receipts – which, however, had been subject to major variations – arising from payments for research and development projects which are primarily intended to develop new products and processes and provide scientific consultancy. The 1989 balance was DM + 37 million. Whereas receipts rose considerably in 1990 (+ 34.6 %), expenditure hardly changed (+ 1.7 %). The Deutsche Bundesbank explains that domestic subsidiaries of foreign groups of enterprises accounted for most of the growth in receipts. For the most part, this was probably a reflection of changes in the division of labour within the groups. The trend was reversed in 1991. Receipts grew only slightly (+ 3 %), while expenditure rose substantially (+ 20 %). Expenditure increased mainly in those sectors where non-residents enjoy a particularly high level of technological know-how and development, such as microelectronics, genetic engineering and biotechnology. Although the traditional net receipts arising from payment for research and development in 1991 were virtually half of what they had been in 1990, the average of these two years was the same as in 1988 and 1989 (cf. Monthly Reports of the Deutsche Bundesbank, April 1992).

The breakdown of German patent and licence transactions by branches of economic activity shows that the electrical industry (including data processing), the chemical industry and the metal-producing and metal-working industries are still the most important licensors and licensees. In 1991, these three sectors of industry accounted for 85 % of receipts and 75 % of expenditure. Individual trends in these industries, however, were rather divergent.

The chemical industry accounted for the highest proportion of receipts (50.9 %) which – apparently due to the cyclical slowdown – is slightly below the 1990 level (51.6 %), but still higher than in 1989. The trend in expenditure was similar: In 1990, its proportion rose to 22.2 %, while it was only 18.6 % in 1991. All in all, receipts in the chemical industry in 1991 of DM 1,232 million compare with expenditure of DM 991 million.

Patent and licence transactions in the electrical industry followed an opposite trend. In 1990, the electrical industry's share in receipts was 18.1 %, in 1991 it amounted to 21.0 %. During the same period, its share in expenditure dropped from 49.5 % to 48.1 %. The negative balance of this sector of industry continued to increase as a result of the higher growth in expenditure. In 1991, it amounted to DM – 2,052 million.

At DM – 147 million, the balance of the metal-producing and metal-working industries was negative for the first time in 1991 (1990: DM + 155 million).

The Deutsche Bundesbank notes that this reversal of the traditional net receipts of these industries was caused by a large one-off payment for foreign licences in the mechanical engineering sector. Another contributing factor was the reverse development of the economy in Germany and abroad (Deutsche Bundesbank, April 1992).

Germany's partner countries in patent and licence transactions are almost exclusively industrialised countries. In 1991, these countries accounted for 87.8 % of receipts and 99.3 % of expenditure. While these figures hardly changed in the period under review, the share of EC countries in receipts and expenditure accounted for by industrialised countries rose to 33.0 % and 25.4 %, respectively (1990: 30.2 % and 23.3 %, respectively).

In 1991, too, expenditure was concentrated on the USA (57.9 %), Switzerland (11.2 %) and the Netherlands (9.9 %), followed at some distance by France (4.1 %) and Japan (2.9 %). In terms of the book value of their corporate assets, the USA, Switzerland and the Netherlands are also most important direct investors in Germany (Monthly Reports of the Deutsche Bundesbank, April 1992).

Receipts are much more widely distributed among the various regions than expenditure (comparable with German direct investment abroad). In 1991, just under

one half of total receipts (48.6 %) came from the USA (29.4 %), Japan (11.1 %) and France (8.1 %), with Italy now ranking fourth (6.0 %). While the shares of the EC countries as a whole and of Japan rose, the US share declined. The shares of the developing and OPEC countries as well as of the Central and East European countries undergoing economic reform and the centrally planned economies have hardly changed over the last few years.

All in all, the USA is Germany's most important partner country in patent and licence transactions; the traditional German deficit in favour of the USA has continued to grow. The net expenditure with respect to the Netherlands and Switzerland has declined slightly between 1990 and 1991. In its transactions with most other industrialised countries, especially Japan, as well as with other groups of countries, Germany still has net receipts.

Commenting on an international comparison of patent and licence transactions which are also mainly conducted between associated enterprises, the Deutsche Bundesbank explains that 1989 and 1990 results were determined by increasing corporate investments of Japan and the USA. The latter's direct investments were mainly in the newly industrialised countries of Latin America and Asia and in the European Community, while Japan stepped up its foreign capital interests mainly in the USA and in the EC countries. Investment in Europe seems to have been encouraged both by existing and possible future trade restrictions and by expected growth opportunities in the future Single European Market (Monthly Reports, April 1992).

In an international comparison of results, it should be taken into account that the national data on receipts from and expenditure on patent and licence transactions are not always directly comparable, for statistical and methodological reasons. For instance, copyrights are also included here which is not the case with purely national compilations.

While in 1989 – as in previous years – only the USA and the United Kingdom had net receipts from patent and licence transactions, in 1990 the UK is also among the countries with net expenditure (US $ – 56 million; 1989: US $ + 74 million). Germany's deficit is much higher: in 1990, it rose to US $ – 1,900 million. Among the industrialised countries, the Federal Republic of Germany is one of the most important licensees; in this balance, only Japan had greater expenditure. Among the licensors, Germany ranks fifth behind the USA, Italy, the United Kingdom and Japan. While in most countries, including Germany, net expenditure increased, France, Italy and the Netherlands could record declining deficits.

In its report on patent and licence transactions, the Deutsche Bundesbank repeatedly emphasises the connection between direct investments and payments in patent and licence trade. Referring to the substantial increase in UK expenditure, it draws attention to the UK's lower wage costs and tax burdens compared with other EC countries, and fewer language barriers as well as the international orientation of British industry. These factors made the United Kingdom the favourite European investment country, especially for Japanese investors, whose direct investments in the United Kingdom have increased more than tenfold since the mid-1980s.

Japan's trend is similar to that of the United Kingdom. Although internationally Japan still has the highest expenditure, its receipts from patent and licence transactions have increased much more than its expenditure. Japan's fairly high net expenditure relative to the stock of its direct investments indicates that, owing to the particular institutional characteristics of Japanese industry, non-resident enterprises are still issuing licences to Japanese firms with which they have no capital ties in most cases, but at best cooperation agreements. On the other hand, it seems that so far foreign licensors have only made limited use of the possibility of transferring technological know-how by setting up marketing offices and production plants (Monthly Reports of the Deutsche Bundesbank, April 1992).

All this demonstrates again how limited the value of the Technological Balance of Payments is as an indicator of the transfer of knowledge and how important it is to interpret the data available in an objective and expert manner.

Part V

European and international cooperation in research and technology policy – International organisations and research institutions with German participation

Contents

Introduction

Today, national research and technology policy does not make any sense unless it is integrated into transfrontier cooperation. Due to the enormous sums required and the investment risks involved, fewer and fewer large-scale research projects and costly technology programmes, e.g. space flight, high-energy physics and microelectronics, can be realised without such cooperation. Within the European Community this cooperation has gained particular significance in the light of the Single European Act and the Treaty on European Union (Maastricht Treaty).

There are many different forms of cooperation. They include bilateral agreements and projects, bilateral or multilateral coordination of national research activities, cooperation in individual projects or in specific research areas under the umbrella of European or global organisations as well as the coordination of national research and technology policies within the European Community.

The Federal Government and the research institutions and project managing agencies it finances have concluded agreements or accords on scientific and technical cooperation with partners in more than 50 countries. German agencies are members of numerous international research organisations and institutions. The most important objectives of cooperation are

(1) to pool and coordinate national research, technology and financial resources in order to use them specifically – and on a cost-sharing basis – for individual large-scale projects or in particular research areas;

(2) to exchange and compare scientific and technological findings, especially with the major industrialised countries;

(3) to strengthen Europe's technological competitiveness at the international level – also in the context of enhancing Germany's position as an industry location;

(4) to support the political and economic restructuring process in the countries of Central and Eastern Europe including the independent states of the former Soviet Union, especially to introduce them to European and worldwide cooperation in research;

(5) to increase the economic and technical potential of the countries of the Third World, especially of the newly industrialising countries, through the transfer of technology.

The Federal Government hopes that – in addition to the obvious benefit for science and technology – this cooperation will provide important thrusts for

- the further economic and political integration of Europe;
- the stabilisation of the countries in Central and Eastern Europe including the independent states of the former Soviet Union under democratic and market economy systems;
- transatlantic cooperation;
- intensified cooperation with the technology countries of the East Asian region;
- the worldwide exchange of ideas, knowledge and experience;
- curbing protectionist tendencies in the global economy;
- solving the existential problems of the Third World;
- increasing responsibility for the conservation of resources and the ecological balance of the Earth; and
- developing internationally uniting objectives in a joint effort to provide for the future of the world.

The description of German involvement in international research cooperation in this part of the Report of the Federal Government on Research is structured as follows:

- European cooperation
  - cooperation in Western Europe
  - cooperation with the countries of Central and Eastern Europe including the independent states of the former Soviet Union
- Worldwide cooperation under the umbrella of international organisations and research institutions
- Bilateral cooperation outside Europe.

Cooperation in research and technology in Western Europe is based on a wide range of instruments, consisting of different forms of organisation and resources, whose core consists of the research and technology programmes of the European Community. Collaboration is extended beyond Community borders by cooperation schemes like COST (Cooperation with third countries in applied research), JET and ITER (European and worldwide cooperation in fusion research), EC participation in EUREKA and ESA projects as well as – more recently – the cooperation of the EC and EFTA, based on the Treaty on the European Economic Area (EEA). This is complemented, in particular in the technological area, by the cooperation of industrial companies and research institutions within the EUREKA framework and the cooperation of European states in space research and technology within ESA as well as in numerous specific multilateral and bilateral research projects.

The joint objectives of this cooperation are to coordinate national research activities, pool resources, contribute national results to joint projects and use them there, as well as strengthen European ties and thus increase European competitiveness at the international level. Concerning Community research policy, the Federal Government has explained its ideas in its "Memorandum on European Research Policy". It calls primarily for concentration on certain research priorities, increased cooperation between EC and EUREKA, an increase in the share of the EC budget devoted to research, improved access of small and medium-sized enterprises to Community R&D programmes, more emphasis on the principle of subsidiarity and on decentralisation in programme implementation as well as more transparent and efficient procedures for deciding on grant applications ("debureaucratisation"). These demands feature prominently in the discussion on the Fourth Framework Programme, in which countries, science and industry are involved. German EC presidency in the second half of 1994 will provide a very good opportunity to contribute German ideas.

Cooperation with the countries in Central and Eastern Europe including the independent states of the former Soviet Union has developed into a new priority as a result of the fundamental political changes of the last few years. In this process basic conditions have changed radically. The change of the political and economic systems has created leeway for individual scientists and research institutions which opens up new possibilities of cooperation. But this change of systems also entails the symptoms of an economic and social crisis which affect scientific and technical cooperation. In order to contribute to stabilising the economic and social development as well as to maintaining the cooperation potential, traditional cooperation in joint research and development projects needs to be supplemented by additional assistance; these states have to be supported in restructuring their research systems and in maintaining efficient research potentials. Since these measures are meant to provide help for self-help, they are of a temporary nature. Apart from specific bilateral cooperation, the Federal Government is mainly endeavouring to open up Western forms of multilateral cooperation and organisation for collaboration with these countries and to integrate their potential (e.g. space technology, fusion research) into this collaboration.

Whereas in Western Europe bilateral cooperation in research and technology at many different levels usually works smoothly without any intergovernmental agreements and is increasingly governed by supranational and multilateral forms of cooperation, collaboration with Central and Eastern Europe is based on intergovernmental agreements. These were first concluded with Romania and Yugoslavia in the 1970s and after 1986 with almost all other states in that region which existed at the time. Most of these agreements continue to be valid; in some cases they have been taken over by states succeeding the former parties to the agreements. Cooperation focusses, among other things, on environmental research, energy research and basic physical research. In addition, Germany is increasingly providing assistance in applying evaluation methods and in restructuring the research infrastructure. This has become necessary as a result of the introduction of democratic and market economy systems. This assistance includes stimulating the transfer of knowledge from research to industrial application as well as encouraging innovations and setting up new companies, e.g. by providing technology parks and research incubators.

Outside Europe the Federal Government's cooperation in research and technology is based both on bilateral agreements and on worldwide international organisations and institutions such as UNO, IAEA, OECD, UNESCO and – more recently – CSD, which has been entrusted with implementing the Rio resolutions of UNCED. *Multilateral cooperation* mainly focusses on space research and technology projects (ESA/NASA cooperation) including satellite communication (INTELSAT), reactor safety and nuclear materials control (IAEA, OECD-NEA), fusion research (ITER), molecular biology and neurobiology (HFSPO) in Strasbourg and systems analysis (IIASA) in Laxenburg near Vienna.

Bilateral cooperation agreements which differ widely in type were concluded with numerous countries. They have two objectives: Cooperation with industrialised countries focusses on pooling resources, on a division of labour and on exchanging knowledge. Cooperation with Third World countries involves mostly newly industrialising countries and centres primarily on technology transfer in order to help develop infrastructures and increase those countries' performance.

- Scientific relations with the USA are characterised by broad-based, future-oriented cooperation. About 50 cooperation agreements address the following areas: Space research and technology, energy technologies including reactor safety research, medical, bioscientific and transport research as well as aeronautical engineering. In spite of the great distance and the stiff competition, a comparable level of technological development and joint basic political and social ideas facilitate cooperation. The two countries are not only connected by numerous bilateral programmes and projects, but also share ideas concerning the substance and objectives of government research policy. These include loyalty to the principle of freedom of research as well as the awareness of the responsibility of research and its promotion for solving the global problems facing humanity at the end of the 20th century. The decentralised structure of research in both countries provides a basis for numerous contacts between scientists on both sides of the Atlantic. To develop this rich potential for the future and to make use of it is an integral part of the Federal Government's research policy vis-à-vis the USA.

- In East Asia, the focus is on scientific and technological cooperation with Japan. In a performance-driven competition Japan has conquered important key industries in the world markets. Its dynamic development of up-to-date technologies is a growing challenge also for Germany. In view of the geographical distance, cooperation mainly centres on the exchange of specific information, especially in

the areas of biosciences, environmental research and information technologies. In the area of space research, negotiations are underway on possibilities for intensified cooperation. An important factor – in addition to free and fair competition with equal opportunities – is the German willingness to address the "Japanese phenomenon" and to learn from it. Today, we have to adapt increasingly to Japanese innovation strategies. In this context it is very important that more and more young scientists take advantage of the possibility to spend some time in Japan for scientific purposes and that this is adequately honoured by science and industry.

- Relations with Third World countries have been redefined by the United Nations Conference on the Environment and Development (UNCED) in 1992. Bearing this in mind, the Federal Government contributes towards the necessary scientific and technical development by helping to accomplish the urgent environmental and development tasks identified by the Conference.

1. European cooperation

1.1 Cooperation in Western Europe

Cooperation in research and technology in Western Europe focusses on collaboration within the European Community. In recent years the role of the EC in the field of research and technology development has become more and more important. The EC's promotion measures have increased so much in intensity and scope that they are also of considerable importance for Germany with its multi-facetted research promotion by the Federal and Länder governments as well as industry. In some areas promotion by the European Community is of special significance. In fusion research, for example, member states coordinate all their activities which are financed to a considerable extent by the EC; in the case of information technologies, a major part of public funding in the industry-related area comes from the EC.

The Treaty on European Union (Maastricht Treaty) gives Community research and technology promotion a new dimension: In addition to the previous objective of strengthening the scientific and technological bases of Community industry, it will in the future cover all areas for which the Community – on the basis of the Treaty on European Union – has general jurisdiction. The growing importance of the EC is also reflected in the budget funds which have continuously increased for more than a decade. In 1992, they amounted to about DM 5 billion, thus reaching a level that is comparable with national promotion. In March 1993, the Council of Research Ministers in Brussels decided to step up the ongoing Third Framework Programme by 900 million ECUs = DM 1.8 billion.

Involvement in the various bodies of the European Community is very important. This applies to cooperation as such as well as to harmonising national research policy with Community programmes. In the current discussion on the Fourth Framework Programme (1994 to 1998) the Federal Government is striving to limit Community R&D promotion to the pre-competitive phase, to focus it on specific programmes with European "value added" as well as to use the funds available for specific priorities, based on the principle of subsidiarity.

The Treaty on the European Economic Area (EEA), which was concluded in 1992 between the member states of the EC and EFTA, will considerably extend the geographical borders of international cooperation also in the research area.

The second pillar of research and technology cooperation in Europe is EUREKA. With the EUREKA technology initiative, the member states intend to promote, coordinate and intensify transfrontier project cooperation between industrial companies and research institutions with a view to helping create a European Technology Community, thus increasing Europe's competitiveness in the high-tech world market. Because of its deliberately flexible and variable forms of cooperation, EUREKA has developed into a novel and unique instrument of European cooperation:

- The number of projects of transfrontier cooperation between companies – including small and medium-sized enterprises – and research institutions of the current 20 EUREKA member states as well as the EC Commission was increased substantially.

- The financial volume of all projects amounts to almost DM 25 billion.

- Even before the EEA agreement entered into force, EUREKA had been an important link between the research sectors of the two economic areas in Western Europe. Today, EUREKA is assuming more and more the function of a bridge between the West and the countries of Central and Eastern Europe.

Since 1971, COST (European Cooperation in the Field of Scientific and Technical Research) has provided another organisational framework for coordinating national research activities beyond EC borders. COST cooperation is based on the principles of voluntariness, of funding at the national level and of implementation in joint programmes. The programme themes are open, telecommunications and transport are priorities. After having opened up towards Central and East European countries, COST has gained special importance.

In the area of space research and space technology multilateral cooperation focusses on the European Space Agency, ESA. The Federal Government's policy aims to realise national space research interests to the greatest possible extent under the ESA umbrella. At the same time, it endeavours to intensify cooperation between ESA and the EC. In addition, there are bilateral projects, mainly with the USA, and – gradually developing – with the successor states of the Soviet Union and with Japan. The purpose of these cooperation efforts is mainly to coordinate national activities

and pool the resources available in this costly research area which exceeds the financial strength of individual states.

The basis of current European space activities is the long-term plan which was adopted by the ESA Council at ministerial level in The Hague in 1987. It comprises a coherent space programme based on European autonomy, which is to be interpreted as efficiency, competitiveness and eligibility for partnerships in the international environment. At the Council meeting in Munich in 1991, ESA decided to continue this policy and at the same time extend international cooperation. In this way it takes account of the changed international environment, which opens up greater possibilities of cooperation with the independent states of the former Soviet Union. Another meeting of the ESA Council at ministerial level took place in Granada in 1992. Three resolutions were adopted, (1) on a new long-term European space plan from 1992 to 2005 and its stepwise implementation, (2) on intensifying international cooperation, and (3) on cooperation with the Russian Federation. This reorientation, which makes allowance for the changed political, technical and financial circumstances, created a satisfactory perspective for European space research: The European science programme HORIZON 2000 will be continued; the earth observation strategy which had already been launched in Munich could be upgraded considerably by including the ENVISAT and METOP projects. The ESA member states decided to implement neither the free-flying MTFF laboratory module as part of the COLUMBUS programme nor the HERMES spaceplane, which was replaced by a technology programme to provide a reorientiation phase. A new situation has arisen for the European APM laboratory module since the US government decided to review the plans for the FREEDOM Space Station with a view to cutting costs. This has been greatly welcomed by the German side; the cost-benefit ratio of the European contribution should also be improved and the costs of the future operation of the Space Station should be reduced.

Furthermore, Germany is a member of numerous international organisations and institutions which have the task of coordinating cooperation in research and technology at the European level or engage in research and technological development in specific areas themselves. The membership and functions of these institutions are as varied as their organisational structures.

In the area of scientific basic research using large-scale equipment, cooperation mainly serves to provide a division of labour and pool resources. At the same time, such international research institutions, with their attraction for outstanding scientists from all over the world, represent fora for the exchange of experience and scientific cooperation beyond the joint utilisation of such equipment. International research institutions offer great benefits for the scientific culture of Europe and of the world as a whole. They include bilateral and trilateral research projects, such as the German-Netherlands wind tunnel (DNW) and the German-British-French very-high-flux reactor (ILL) in Grenoble, as well as institutions with coordinating functions, such as the European Centre for Medium-Range Weather Forecast in the United Kingdom, and multilateral large-scale research institutions, such as CERN in Geneva (high-energy physics), EMBL in Heidelberg (biological basic research), ESO in Munich (building and operation of optical telescopes for astronomical research) and ESRF in Grenoble (synchrotron radiation facility). Their organisational structures range from simple cooperations within the framework of international conferences (COST, EMBC) – some of them supported by small secretariats and national coordinating agencies (EUREKA) - to institutions set up under national private law (ILL, ESRF and the European Transonic Wind Tunnel (ETW) in Cologne) to international organisations which are legal entities in their own right (ESA, ESO, CERN, EMBL).

New priorities, above all increasing the technological competitiveness of German industry in the old and new Länder, which is very important for the future of Germany as a site for research, development and business, imply that, in view of scarce and hardly increasing budget funds, posteriorities, i.e. matters of minor importance, also need to be defined. The phase of setting up and expanding international research institutions as well as of commissioning new large-scale equipment for basic research will now have to be succeeded by a phase of consolidation and intensive revision of the efficiency of the use of funds at international research institutions.

1.3 Cooperation with the countries in Central and Eastern Europe, including the successor states of the Soviet Union

The end of communist rule in Central and Eastern Europe has set off a differentiated development in the countries of that region, which also entails fundamental changes in scientific and technological cooperation. In this context, the Federal Republic of Germany is pursuing different, albeit related objectives. The challenge now is to take advantage of available know-how and resources in cooperation and to open up and facilitate access to European and worldwide research cooperation for the partner states in Central and Eastern Europe. In particular in the areas of ecology, environment and safety of technological facilities which have transfrontier effects, joint responsibility in Europe necessitates intensified scientific and technical cooperation; finally, the introduction of democracy and market economy triggers reform processes also in the research system, which are taken up and implemented by the various countries with differing intensity and swiftness.

CENTRAL AND EASTERN EUROPEAN STATES (without former Soviet Union)

This is most clearly visible in the advanced reform states which are Germany's direct or indirect neighbours, viz. Poland, the Czech Republic and Hungary. When they launched political and economic reforms, these countries also started an early and consistent process of restructuring the system of science and research to meet the needs of modern industrialised states; at the

same time, they sought to be integrated into European research cooperation.

This is why – in addition to traditional project cooperation between individual scientists or research groups – bilateral cooperation in research and technology is focussing more and more on restructuring the research system. The challenge is to overcome a dual split which had impaired the transfer of knowledge and technology or even made it impossible: First, the split between research and teaching, caused by the imposed model of quasi-autonomous and privileged Academies of Science and second, the split between research and industry, brought about by research in specific branches of industry which was integrated into the economy and separated from academic research.

One example of successful cooperation is the foundation in Hungary in 1992 of a group of institutes for applied, industry-related research, modelled on the Fraunhofer Society; this project was supported by Germany.

In the other countries in Central and Eastern Europe, some of which – such as the former Socialist Federal Republic of Yugoslavia – need to be rebuilt in completely new configurations, the focus is first of all on taking stock of and evaluating the research potential.

Consultancy to, and cooperation with, Central and East European states are based on the following principles:

- To provide help for self-help;
- to transfer experience gathered in Germany, especially in the new Länder;
- to launch cooperative projects between new institutions in the partner countries and German institutes;
- to facilitate the partner countries' access to European research cooperation (e.g. EC programmes, EUREKA, CERN, EMBL, etc.);
- to take advantage of promotion opportunities offered by EC programmes (Third and Fourth Framework Programme for project cooperation and the exchange of scientists; PHARE programme for technical assistance in restructuring the research infrastructure);
- to establish new, or build on earlier, regional cooperations based on division of labour (especially with neighbouring countries and the new Länder).

SUCCESSOR STATES OF THE SOVIET UNION

Cooperation with Russia, the largest partner country in the region, centres upon nuclear energy, including reactor safety research, space research, space flight, agricultural and health research. It is one of the objectives of space research cooperation to introduce the Russian side to European space research cooperation within the ESA framework and to make it possible to take advantage of the efficient Russian space flight capacities under major European cooperation programmes. This applies in particular to cooperation in manned space flight (MIR 92) and in planetary research (MARS 94). Cooperation will gradually be extended to include other areas such as biotechnology, chemical and physical technologies as well as materials research, with new opportunities arising as hitherto strictly shielded military research institutions are being opened up.

Cooperation with other successor states of the Soviet Union, which had previously been limited to individual areas, is also being extended step by step. For the time being, priority is given to relations with Ukraine and the Baltic Republics.

During a transitional period, project cooperation proper is complemented by "help for self-help" schemes to support the states of the region in stabilising and restructuring their research potential. These schemes are mainly designed to improve the conditions of scientific work, e.g. by establishing links with international scientific data networks and by providing temporary assistance in acquiring literature and equipment. The Federal Government also assists its partners in the region in utilising Western know-how, e.g. in the area of environmental protection, as well as in their efforts to participate in pan-European and global research and development networks.

Of special importance for intensifying cooperation with the successor states of the Soviet Union are multilateral initiatives to set up the "International Science and Technology Centre" in Moscow as well as the "International Association for the Promotion of Cooperation with Scientists from the Independent States of the Former Soviet Union", which the Federal Government supports actively.

On the basis of a bilateral agreement Germany contributes to the work of the Dubna United Institute for Nuclear Research (in the Moscow region), at the same time supporting the efforts of this international institute to change its structure and become part of the pan-European research scene. Cooperation is based on the protection of confidence with regard to international treaties and agreements concluded by the former GDR, as agreed in the Treaty on German Unity.

The further development of cooperation with Central and Eastern European countries and the successor states of the Soviet Union will depend on the progress of the general economic and social restructuring process in the various partner countries. It can be expected for the future that cooperation approaches will be differentiated further and that in cases where this seems appropriate cooperative projects will be grouped on a regional basis. Such grouping has already been started successfully in the area of reactor safety research.

3. Bilateral cooperation outside Europe

While scientific and technological cooperation with West European neighbouring countries is today largely handled by multilateral forms of cooperation,

such as the EC, EUREKA and ESA, cooperation between the Federal Government and non-European partner countries is mainly based on bilateral agreements. These are concluded by the governments themselves or by subordinate research institutions. The main advantages of this cooperative approach are the simplified voting procedure, the possibility of taking account of specific interests and of the level of technological development of the two partners as well as the selection of partners. Its functions are first and foremost to select specific partners from a technological and political point of view, to provide for an appropriate division of labour and pooling of resources as well as to fill free space that is not, or cannot be, filled by multilateral cooperation. Quite often bilateral cooperation is the nucleus of a multilateral form of organisation.

3.1 Cooperation with the USA

Among the industrialised countries, the USA ranks first with about 50 cooperation agreements. Joint programmes and projects focus on the following areas:

- Space research and space engineering: Cooperation in this area takes a double-track approach. On the one hand, Germany makes a sizeable contribution – under the ESA COLUMBUS programme – to the FREEDOM International Space Station and to the successfully launched GIOTTO comet probe; on the other hand, there is a traditionally close bilateral cooperation which in spring 1993 reached another highlight with the manned D2 mission. This mission ranks among a large number of joint projects, such as the X-ray satellite ROSAT, the Jupiter probe GALILEO and the Gamma-Radiation Observatory GRO.

- Energy technology, in particular safety aspects of nuclear energy;

- medical research, especially cardiovascular diseases, cancer and public health research;

- geoscientific research (mutual deep-drilling programmes);

- ground transport research (public transport and high-speed transport technologies);

- aeronautical engineering, including projects concerning air navigation safety systems and cryo-wind tunnel technology;

- environmental research, in particular cleaning up contaminated sites.

Further departmental agreements can be concluded as soon as a number of open questions concerning intellectual property rights have been settled.

The foundation of the German Historical Institute in Washington in 1987 provided an important impetus for historical research to study the USA.

In all research areas, 2,600 publicly sponsored visits by scientists to the partner country every year and a traditionally extensive exchange of information ensure that there is an enormously wide range of joint or complementary scientific work.

Acting as an additional intellectual bridge, the "German-American Academic Council", which intends to activate the existing scientific and human potential in a vigorous and mutually beneficial fashion, will start work in 1993. This institution, which is funded by important science organisations of both countries and to which personalities from science, industry, politics and culture will contribute, has been set up to produce and promote new ideas for interdisciplinary programmes and projects in the sciences and the humanities. In March 1993, Chancellor Kohl and President Clinton declared that they fully supported this project.

3.2 Cooperation with Canada

Since the cooperation agreement with *Canada* was concluded in 1971, cooperation has developed continuously. Today, it extends beyond the traditional areas of agriculture and forestry to include subjects like high-energy physics, space research as well as marine and environmental research.

It is planned to intensify cooperation in the industrially important sectors of biotechnology, materials science and information technology.

3.3 Cooperation with Asian countries

Cooperation with *Israel* in basic and applied research, which began more than 30 years ago, is a major highlight of the bilateral relations with that country. The joint Foundation for Scientific Research and Development (GIF), whose funds will be doubled from DM 150 million in 1993 to DM 300 million in 1995, the support of German-Israeli cooperation centres through the Minerva-Stiftung Gesellschaft für die Forschung as well as the research projects directly promoted by the two national research ministries are the pillars of cooperation. The integration of scientists who immigrated to Israel from the former Soviet Union and the participation of research institutions in the new Länder were made a special concern of joint exercises. To intensify the scientific and technological relations of the two countries a cooperation council for high technology and environmental technology will be set up, which will strive in particular to strengthen cooperation at the industrial level.

The East Asian region is characterised by *Japan's* dominating position in the high-tech sector. Dynamic developments have also emerged in Korea, which has entered into competition with Japan.

In October 1974, the governments of Japan and Germany concluded an agreement on cooperation in science and technology. This cooperation focusses on

information technologies and biosciences, environmental research and, more recently, increasingly on space research. Numerous fora and panels provide opportunities for the exchange of specific information between the scientists from universities and industry.

Another important element is the German Institute for Japanese Studies (DIJ).

For quite some time there has been intensive cooperation between scientists from both countries in the field of high-energy physics. Japan has become a very interesting partner in space research, too. In June 1992 the two space agencies (DARA and NASDA) held their first meeting. They studied the possibility of expanding bilateral cooperation in the space sector, in particular in the areas of earth observation, space research, product assurance and future joint programmes. The fifth joint expert meeting on microgravity research also took place in 1992. Industrial consortia of both countries have signed a cooperation agreement relating to the German D2 mission, which concerns in particular the industrial utilisation of microgravity. Experience gathered in Russia with retrievable and reusable capsules is intended to be used in a trilateral project (EXPRESS).

To intensify bilateral relations, a cooperation council for high technology and environmental technology will be set up, which is to introduce new lines especially in industry-oriented cooperation.

The Eighth German-Japanese Forum on Information Technology held in Weimar in May 1993 provided further impetus for cooperation in various areas of information technology. In the field of biotechnology and other life sciences, Japan has come forward with proposals for worldwide cooperation under the Human Frontier Science Programme.

On the whole, Japan and Germany are willing to continue to intensify scientific and technological cooperation. Although Japan is still oriented towards the USA in scientific and technological cooperation, it is endeavouring to expand its international cooperation, especially with other advanced industrialised countries and also with developing countries in Asia.

Cooperation with *Korea* focusses on basic research as well as on the exchange of scientists and experience in energy research. A joint working group on the high-speed rail link Seoul-Pousan has studied the German Transrapid and ICE technology offers. The highlight was the Technogerma Seoul 1991 from February 27 to March 9, 1991 which – with the Day of German Technology – made an important contribution to presenting German high technology right in the centre of the intensely competitive and very promising Korean market.

3.4 Cooperation with developing countries

In a world characterised by increasing interdependence and the globalisation of technological development, on the one hand, and by a wide gap between developing and industrialised countries, on the other hand, science, research and technology are faced with the challenges of making contributions – beyond national borders – towards the solution of problems in the Third World. This is not only in keeping with the principle of solidarity, but is also spawned by the joint responsibility for the peaceful coexistence of nations.

In this spirit, the Federal Government has set itself the task to promote the capacities and thus the faster development and prosperity of Third World countries through intensified scientific and technical cooperation. The total funds earmarked by the Federal Ministry for Research and Technology for ongoing projects relevant to developing countries amount to about DM 260 million. These projects complement the development work of the Federal Ministry for Economic Cooperation, which supports, among other things, the development and improvement of a scientific and technological infrastructure (higher education institutions, technology centres, research institutes) in the developing countries.

New priorities are being defined for the activities of the BMFT. They focus mainly on

- the development and testing of new technologies for use in developing countries; these involve, for instance, low-pollution and raw material-saving production processes;

- the adaptation of processes and technologies commonly used in industrialised countries to the conditions prevailing in the respective partner country; for instance, solar-electric pumping as well as photovoltaic and wind energy plants are adapted to operating and maintenance conditions in the Third World;

- the transfer of scientific and technological knowledge to strengthen the R&D capacities and economic efficiency and competitiveness of the developing countries.

Partner countries in this sense are mainly newly industrialising countries which – at least in some areas – have attained an almost identical scientific and technological level. The main partner countries in Latin America are Brazil and Argentina, in Asia there are China, India and Indonesia, and in the Arab region it is Egypt.

The promotion of scientific and technical cooperation with developing countries focusses on energy research and technology, ecological research, environmental technologies, biotechnology as well as marine research.

- Traditionally, energy research and technology rank first among the areas of cooperation. Most important are the utilisation of renewable energies – which is in fact the most extensive area of cooperation with developing countries – as well as coal technology. In contrast, cooperation in nuclear technology only plays a minor role today and centres on issues of safety engineering.

In the field of renewable energies, special promotion is given to projects relating to the utilisation of solar and wind energy. These projects mainly focus on the development, testing and adaptation of photovoltaic plants and wind power generators for drying, cooling, air-conditioning, for pumping water and also for decentralised electricity generation in rural areas.

- In environmental research, the exploration of tropical ecosystems is gaining increasing importance. The objectives of the projects carried out in this area are to increase the knowledge of the mechanisms of action within ecologically important biosystems, to develop concepts for their environmentally compatible utilisation and to improve environmental management strategies and environmental protection in the partner countries.

  Cooperation in the field of environmental technologies focusses on the development and adaptation of low-emission technologies to be used in developing countries. Important activities are the development of environmentally compatible production processes, sewage and waste treatment as well as studies of soil and air pollution.

- Biotechnological cooperation with developing countries is also gaining rapidly in significance. The main areas of cooperation include the investigation and control of tropical diseases, microbial treatment of sewage and waste, plant breeding, biochemical production processes for food and luxury goods as well as the production of active plant ingredients for medicines.

- Cooperation with coastal countries in the Third World in the field of marine research is primarily intended to take stock of the conditions required for the utilisation of marine resources and the problems of the marine environment.

- In addition, Germany supports the preparations for setting up UN training centres for instructors in the area of satellite-based earth observation in developing countries.

Part VI

Promotion organisations and research institutions in the Federal Republic of Germany

Contents

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Promotion organisations and research institutions in the Federal Republic of Germany

– Extract from research addresses –

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Tel.: 089/92461, Telefax: 089/9246247

Max-Planck-Institut für ausländisches
und internationales Privatrecht
20148 Hamburg, Mittelweg 187
Tel.: 040/41271, Telefax: 040/4127288

Max-Planck-Institut für psychologische Forschung
80802 München, Leopoldstraße 24
Tel.: 089/386021, Telefax: 089/342473

Max-Planck-Institut für europäische Rechtsgeschichte
60489 Frankfurt/M., Hausener Weg 120
Tel.: 069/78978-0, Telefax: 069/78978-169

Max-Planck-Institut für ausländisches
und internationales Sozialrecht
80802 München, Leopoldstraße 24
Tel.: 089/386021, Telefax: 089/342473

Max-Planck-Institut für ausländisches
und internationales Strafrecht
79100 Freiburg i. Br., Günterstalstraße 73
Tel.: 0761/7081-1, Telefax: 0761/7081294

Max-Planck-Institut für ausländisches öffentliches Recht und Völkerrecht
69120 Heidelberg, Berliner Straße 48
Tel.: 06221/482-1, Telefax: 06221/482288

MPG working groups at universities in the new German Länder

Arbeitsgruppe "Strukturelle Grammatik" an der Humboldt-Universität Berlin
10117 Berlin, Jägerstr. 10/11
Tel.: 030/20360-451, Telefax: 030/20360-452

Arbeitsgruppe "Algebraische Geometrie und Zahlentheorie" der MPG
an der Humboldt-Universität zu Berlin
10117 Berlin, Mohrenstraße 39
Tel.: 030/20377-303/304, Telefax: 030/20377-303

Arbeitsgruppe "Röntgenbeugung an Schichtsystemen" an der Humboldt-Universität zu Berlin
10117 Berlin, Hausvogteiplatz 5–7
Tel.: 030/20377441, Telefax: 030/2004536

Arbeitsgruppe "Nichtklassische Strahlung"
an der Humboldt-Universität zu Berlin
12489 Berlin, Rudower Chaussee 5
Tel.: 030/6392-3980, Telefax: 030/6392-3990

Arbeitsgruppe "Quantenchemie"
an der Humboldt-Universität zu Berlin
12489 Berlin, Rudower Chaussee 5, Gebäude 2.1
Tel.: 030/6392-3960, Telefax: 030/6392-3968

Arbeitsgruppe "Zellteilungsregulation und Gensubstitution" an der Humboldt-Universität zu Berlin
13125 Berlin-Buch, Max-Delbrück-Haus,
Robert-Rößle-Straße 10
Tel.: 030/946-2310, Telefax: 030/946-3306

Arbeitsgruppe "Transformationsprozesse in den neuen Bundesländern" an der Humboldt-Universität zu Berlin
10117 Berlin, Jägerstraße 10/11
Tel.: 030/20360-550, Telefax: 030/2291200

Arbeitsgruppe "Theorie dimensionsreduzierter Halbleiter" an der Humboldt-Universität zu Berlin
10117 Berlin, Hausvogteiplatz 5–7
Tel.: 030/20377509, Telefax: 030/20377514

Arbeitsgruppe "Fehlertolerantes Rechnen"
an der Universität Potsdam
Fachbereich Informatik
14415 Potsdam, Postfach 60 15 53
Tel.: 0331/9710-0

Arbeitsgruppe "Nichtlineare Dynamik (in der Astrophysik)" an der Universität Potsdam
14469 Potsdam, Am Neuen Palais Geb. 19
Tel.: 0331/9710-611, Telefax: 0331/9710-288

Arbeitsgruppe "Ostelbische Gutsherrschaft als sozialgeschichtliches Phänomen"
an der Universität Potsdam
14469 Potsdam, Geb. "K", 2. OG, Am Neuen Palais 10
Tel.: 0331/9710-303, Telefax: 0331/9710-763

Arbeitsgruppe "Partielle Differentialgleichungen und komplexe Analysis" an der Universität Potsdam
14469 Potsdam, Am Neuen Palais 10
Tel.: 0331/9710-269, Telefax: 0331/971799

Arbeitsgruppe "Theoretische Vielteilchensysteme"
an der Universität Rostock
18055 Rostock, Universitätsplatz 3
Tel.: 0381/369353, Telefax: 0381/369-363

Arbeitsgruppe "Komplexkatalyse" der MPG
an der Universität Rostock
18055 Rostock, Buchbinderstraße 5–6
Tel.: 0381/46693-69, Telefax: 0381/46693-24

Arbeitsgruppe "Asymmetrische Katalyse"
an der Universität Rostock
18055 Rostock, Buchbinderstraße 5–6
Tel.: 0381/46693-35, Telefax: 0381/46693-24

Arbeitsgruppe "Theorie komplexer und korrelierter Elektronensysteme" der MPG
an der Technischen Universität Dresden
Abt.: Physik
01069 Dresden, Mommsenstr. 13
Tel.: 0351/463-3853, Telefax: 0351/463-7029

Arbeitsgruppe "Mechanik heterogener Festkörper"
an der Technischen Universität Dresden
01069 Dresden, Hallwachsstraße 3
Tel.: 0351/4659-340 oder -349, Telefax: 0351/4659-544

Arbeitsgruppe "Zeitaufgelöste Spektroskopie"
an der Universität Leipzig
04318 Leipzig, Permoserstraße 15
Tel.: 0341/235-2713, Telefax: 0341/235-2317

Arbeitsgruppe "Enzymologie der Peptidbindung" an der Martin-Luther-Universität Halle-Wittenberg
06120 Halle/Saale, Weinbergweg 16a
Tel.: 0345/617255, Telefax: 0345-647126

Arbeitsgruppe "Umweltrecht"
an der Martin-Luther-Universität Halle-Wittenberg
06110 Halle/Saale, Franckeplatz 1, Haus 42
Tel.: 0345/29852, Telefax: 0345/29853

Arbeitsgruppe "Synthese, Struktur und Eigenschaften von flüssigkristallinen Systemen"
an der Martin-Luther-Universität Halle-Wittenberg
06108 Halle/Saale, Mühlpforte 1
Tel.: 0345/503912, Telefax: 0345/503912

Arbeitsgruppe "CO_2-Chemie"
an der Friedrich-Schiller-Universität Jena
07743 Jena, Lessingstraße 12
Tel.: 03641/8225562, Telefax: 03641/82-25062

Arbeitsgruppe "Röntgenoptik"
an der Friedrich-Schiller-Universität Jena
07743 Jena, Max-Wien-Platz 1
Tel.: 03641/82-25366, Telefax: 03641/8223843

Arbeitsgruppe "Physik und Chemie des interstellaren Staubes in Sternentstehungsgebieten"
an der Friedrich-Schiller-Universität Jena
07745 Jena, Schillergäßchen 2
Tel.: 03641/555-93, Telefax: 03641/555-94

Arbeitsgruppe "Gravitationstheorie"
an der Friedrich-Schiller-Universität Jena
07743 Jena, Friedrich-Schiller-Universität Jena,
Max-Wien-Platz 1
Tel.: 03641/25528, Telefax: 03641/22262

Arbeitsgruppe "Molekulare und zelluläre Physiologie" an der Friedrich-Schiller-Universität Jena
c/o Max-Planck-Institut für biophysikalische Chemie
37018 Göttingen, Am Faßberg
Tel.: 0551/201-675, Telefax: 0551/201-688

Arbeitsgruppe "Pharmakologische Hämostaseologie"
an der Friedrich-Schiller-Universität Jena
07745 Jena, Winzerlaer Str. 10
Tel.: 03641/85-2439, Telefax: 03641/85-2439

Arbeitsgruppe "Modulation der Signalübertragung von Wachstumsfaktoren"
an der Friedrich-Schiller-Universität Jena
07743 Jena, Löbderstraße 3
Tel.: 03641/82-24654, Telefax: 03641/8224295

Branch offices of Max Planck institutes in the new German Länder

Außenstelle Berlin-Adlershof des Max-Planck-Instituts für extraterrestrische Physik
12489 Berlin, Rudower Chaussee 5
Tel.: 030/6392-3922, Telefax: 030/6392-3939

Außenstelle Berlin des Max-Planck-Instituts für Plasmaphysik (IPP)
10117 Berlin, Mohrenstraße 40/41
Tel.: 030/20366-102, Telefax: 030/20366-111

2.2 Fraunhofer-Gesellschaft zur Förderung der angewandten Forschung e. V. (Fraunhofer Society for the Promotion of Applied Research, FhG), 80636 München, Leonrodstraße 54 Tel.: 089/1205-01, Telefax: 089/1205-317

Institutes and research laboratories of the Fraunhofer Gesellschaft by Länder

Baden-Württemberg

Fraunhofer-Institut für Produktionstechnik und Automatisierung (IPA)
70569 Stuttgart, Nobelstraße 12, Postfach 80 04 69
Tel.: 0711/970-00, Telefax: 0711/970-1399

Fraunhofer-Institut für Grenzflächen- und Bioverfahrenstechnik (IGB)
70569 Stuttgart, Nobelstraße 12, Postfach 80 04 69
Tel.: 0711/970-00, Telefax: 0711/970-4200

Fraunhofer-Institut für Arbeitswirtschaft und Organisation (IAO)
70569 Stuttgart, Nobelstraße 12, Postfach 80 04 69
Tel.: 0711/970-01, Telefax: 0711/970-2299

Fraunhofer-Institut für Bauphysik (IBP)
70569 Stuttgart, Nobelstraße 12, Postfach 80 04 69
Tel.: 0711/970-00, Telefax: 0711/970-3395

Informationszentrum für Raum und Bau (IRB)
70569 Stuttgart, Nobelstraße 12, Postfach 80 04 69
Tel.: 0711/970-2500, Telefax: 0711/970-2507

Technologie-Entwicklungsgruppe Stuttgart (TEG-S)
70569 Stuttgart, Nobelstraße 12, Postfach 80 04 69
Tel.: 0711/970-3500, Telefax: 0711/970-3999

Fraunhofer-Institut für Physikalische Meßtechnik (IPM)
79110 Freiburg, Heidenhofstraße 8
Tel.: 0761/8857-0, Telefax: 0761/8857-224

Fraunhofer-Institut für Werkstoffmechanik (IWM)
79108 Freiburg, Wöhlerstraße 11
Tel.: 0761/5142-0, Telefax: 0761/5142-147

Fraunhofer-Institut für Solare Energiesysteme (ISE)
79100 Freiburg, Oltmannsstraße 22
Tel.: 0761/4014-0, Telefax: 0761/4014-100

Fraunhofer-Institut für Angewandte Festkörperphysik (IAF)
79108 Freiburg, Tullastraße 72
Tel.: 0761/5159-0, Telefax: 0761/5159-400

Fraunhofer-Institut für Kurzzeitdynamik (EMI) – Ernst-Mach-Institut –
79104 Freiburg, Eckerstraße 4, Postfach 12 40
Tel.: 0761/2714-0, Telefax: 0761/2714-316

Fraunhofer-Institut für Systemtechnik und Innovationsforschung (ISI)
76139 Karlsruhe, Breslauer Straße 48
Tel.: 0721/6809-0, Telefax: 0721/6891-52

Fraunhofer-Institut für Informations- und Datenverarbeitung (IITB)
76131 Karlsruhe, Fraunhoferstraße 1
Tel.: 0721/6091-0, Telefax: 0721/6091-413

Fraunhofer-Institut für chemische Technologie (ICT)
76327 Pfinztal, Joseph-von-Fraunhofer-Straße 7
Tel.: 0721/4640-0, Telefax: 0721/4640-111

Bayern/Bavaria

Fraunhofer-Institut für Lebensmitteltechnologie und Verpackung (ILV)
80992 München, Schragenhofstraße 35
Tel.: 089/149009-0, Telefax: 089/149009-80

Fraunhofer-Institut für Festkörpertechnologie (IFT)
80686 München, Hansa-Straße 27d
Tel.: 089/54759-000, Telefax: 089/54759-100

Patentstelle für die Deutsche Forschung (PST)
80636 München, Leonrodstraße 68
Tel.: 089/1205-02, Telefax: 088/1205-467

Fraunhofer-Institut für Atmosphärische Umweltforschung (IFU)
82467 Garmisch-Partenkirchen,
Kreuzeckbahnstraße 19, Postfach 13 43
Tel.: 08821/183-0, Telefax: 08821/73573

Fraunhofer-Institut für Integrierte Schaltungen (IIS)
91058 Erlangen/Tennenlohe, Wetterkreuz 13
Tel.: 09131/776-0, Telefax: 09131/776-999

Fraunhofer-Arbeitsgruppe für Integrierte Schaltungen (AIS) – Abt. für Bauelementetechnologie –
91052 Erlangen, Artilleriestraße 12
Tel.: 09131/8104-02, Telefax: 09131/8104-50

Fraunhofer-Institut für Silicatforschung (ISC)
97082 Würzburg, Neunerplatz 2
Tel.: 0931/41909-0, Telefax: 0931/41909-80

Berlin

Fraunhofer-Institut für Produktionsanlagen und Konstruktionstechnik (IPK)
10587 Berlin, Pascalstraße 8–9
Tel.: 030/39006-0, Telefax: 030/3911037

Fraunhofer-Institut für Siliziumtechnologie (ISIT) mit vorläufigem Sitz in Berlin (vgl. auch Nr. 59), bisher Fraunhofer-Institut für Mikrostrukturtechnik (IMT)
14199 Berlin, Dillenburger Straße 53
Tel.: 030/82998-0, Telefax: 030/82998-199

Fraunhofer-Einrichtung für Software- und Systemtechnik (ISST)
10117 Berlin, Kurstraße 33
Tel.: 030/20372-0, Telefax: 030/20372-207

Fraunhofer-Institut für Informations- und Datenverarbeitung (IITB)
Außenstelle für Prozeßoptimierung (EPO)
10117 Berlin, Kurstraße 33
Tel.: 030/20372-0, Telefax: 030/20372-207

Fraunhofer-Institut für Produktionsanlagen und Konstruktionstechnik (IPK)
Außenstelle für Robotersystemtechnik (ERS)
10117 Berlin, Kurstraße 33
Tel.: 030/20372-0, Telefax: 030/20372-207

Fraunhofer-Institut für Produktionsanlagen und Konstruktionstechnik (IPK)
Außenstelle für Bildverarbeitung (EBV)
10117 Berlin, Kurstraße 33
Tel.: 030/20372-0, Telefax: 030/20372-207

Fraunhofer-Institut für Atmosphärische Umweltforschung (IFU)
Außenstelle für Luftchemie (ELC)
12489 Berlin-Adlershof, Gebäude 10.1,
Rudower-Chaussee 5
Tel.: 030/6704-0, Telefax: 030/677-4239

Fraunhofer-Einrichtung für Zuverlässigkeit und Mikrointegration
13355 Berlin, Gustav-Meyer-Allee 65

Brandenburg

Fraunhofer-Einrichtung für Angewandte Polymerforschung (IAP)
14513 Teltow-Seehof, Kantstraße 55
Tel.: 03328/46-0, Telefax: 03328/46-344

Fraunhofer-Institut für Angewandte Materialforschung (IFAM)
Außenstelle für Polymerverbunde (EPV)
14513 Teltow-Seehof, Kantstraße 55
Tel.: 03328/46-0, Telefax: 03328/46-582

Fraunhofer-Institut für Umweltchemie und Ökotoxikologie (IUCT)
Außenstelle für Biochemische Ökotoxikologie (EBÖ)
14558 Bergholz-Rehbrücke,
Arthur-Scheunert-Allee 114–116
Tel.: 033200/8-0, Telefax: 033200/8-206

Bremen

Fraunhofer-Institut für Angewandte Materialforschung (IFAM)
28717 Bremen, Lesumer Heerstraße 36
Tel.: 0421/6383-0, Telefax: 0421/6383-190

Hessen/Hesse

Fraunhofer-Institut für Betriebsfestigkeit (LBF)
64289 Darmstadt-Kranichstein, Bartningstraße 47
Tel.: 06151/705-1, Telefax: 06151/705-214

Fraunhofer-Institut für Graphische Datenverarbeitung (IGD)
64283 Darmstadt, Wilhelminenstraße 7
Tel.: 06151/155-0, Telefax: 06151/155-199

Mecklenburg-Vorpommern/West Pomerania

Fraunhofer-Institut für Graphische Datenverarbeitung (IGD)
Außenstelle Rostock (EGD)
18059 Rostock, Joachim-Jungius-Straße 9
Tel.: 0381/44-2185, Telefax: 0381/44-1065

Niedersachsen/Lower Saxony

Fraunhofer-Institut für Toxikologie und Aerosolforschung (ITA)
30625 Hannover, Nikolai-Fuchs-Straße 1
Tel.: 0511/5350-0, Telefax: 0511/5350-155

Fraunhofer-Arbeitsgruppe für Holzforschung (WKI)
– Wilhelm-Klauditz-Institut –
38108 Braunschweig, Bienroder Weg 54E
Tel.: 0531/3909-0, Telefax: 0531/351587

Fraunhofer-Institut für Schicht- und Oberflächentechnik (IST)
38106 Braunschweig, Bienroder Weg 54E
Tel.: 0531/3909-0, Telefax: 0531/353718

Nordrhein-Wesfalen/North Rhine-Westphalia

Fraunhofer-Institut für Mikroelektronische Schaltungen und Systeme (IMS)
47057 Duisburg, Finkenstraße 61
Tel.: 0203/3783-0, Telefax: 0203/3783-266

Fraunhofer-Institut für Materialfluß und Logistik (IML)
44227 Dortmund, Joseph-von-Fraunhofer-Straße 2–4
Tel.: 0231/9743-0, Telefax: 0231/9743-211

Fraunhofer-Institut für Produktionstechnologie (IPT)
52074 Aachen, Steinbachstraße 17
Tel.: 0241/8904-0, Telefax: 0241/8904-198

Fraunhofer-Institut für Lasertechnik (ILT)
52074 Aachen, Steinbachstraße 15
Tel.: 0241/8906-0, Telefax: 0241/8906-121

Fraunhofer-Institut für Umweltchemie und Ökotoxikologie (IUCT)
57392 Schmallenberg/Grafschaft, Postfach 12 60
Tel.: 02972/302-0, Telefax: 02972/302-319

Fraunhofer-Institut für Naturwissenschaftlich-Technische Trendanalysen (INT)
53881 Euskirchen, Appelsgarten 2
Tel.: 02251/181, Telefax: 02251/18277

Saarland

Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (IzfP)
66123 Saarbrücken, Universität, Gebäude 37
Tel.: 0681/30238-01, Telefax: 0681/39580

Fraunhofer-Institut für Biomedizinische Technik (IBMT)
66386 St. Ingbert, Ensheimer Straße 48
Tel.: 06894/897-0, Telefax: 06894/897-50

Sachsen/Saxony

Fraunhofer-Einrichtung für Elektronenstrahl- und Plasmatechnik (FEP)
01324 Dresden, Zeppelinstraße 1
Tel.: 0351/378-251, Telefax: 0351/361-39

Fraunhofer-Einrichtung für Werkstoffphysik und Schichttechnologie (IWS)
01069 Dresden, Helmholtzstraße 20
Tel.: 0351/4659-0, Telefax: 0351/4659-546

Fraunhofer-Einrichtung für Keramische Technologien und Sinterwerkstoffe (IKTS)
01277 Dresden, Winterbergstraße 28
Tel.: 0351/2322-0, Telefax: 0351/2322-599

Fraunhofer-Einrichtung für Umformtechnik und Werkzeugmaschinen (IUW)
09126 Chemnitz, Reichenhainer Straße 88,
Postfach 7 45
Tel.: 0371/561-0, Telefax: 0371/555-89

Fraunhofer-Institut für Mikroelektronische Schaltungen und Systeme (IMS)
– Institutsteil Dresden –
01109 Dresden, Grenzstraße 28, Postfach 34
Tel.: 0351/5632-0, Telefax: 0351/5632-930

Fraunhofer-Institut für Integrierte Schaltungen (IIS)
Außenstelle für Automatisierung des Schaltkreis- und Systementwurfs (EAS)
01069 Dresden, Haeckelstraße 20
Tel.: 0351/463-0, Telefax: 0351/471-7558

Fraunhofer-Institut für Informations- und Datenverarbeitung (IITB-DV)
Außenstelle für Prozeßsteuerung (EPS)
01069 Dresden, Haeckelstraße 20
Tel.: 0351/463-0, Telefax: 0351/471-7558

Fraunhofer-Institut für Angewandte Materialforschung (IFAM)
Außenstelle für Pulvermetallurgie und Verbundwerkstoffe (EPW)
01069 Dresden, Helmholtzstraße 20
Tel.: 0351/4659-0, Telefax: 0351/4695-549

Fraunhofer-Institut für Zerstörungsfreie Prüfverfahren (IzfP)
Außenstelle für Akustische Diagnostik und Qualitätssicherung (EADQ)
01326 Dresden, Krügerstraße 22
Tel.: 0351/36-666, Telefax: 0351/36-301

Sachsen-Anhalt/Saxony-Anhalt

Fraunhofer-Einrichtung für Fabrikbetrieb und Automatisierung (IFF)
39104 Magdeburg, Elbstr. 3–5
Tel.: 0391/420-74, Telefax: 0391/480-84

Fraunhofer-Institut für Werkstoffmechanik (IWM)
Außenstelle für Mikrostruktur von Werkstoffen und Systemen (EMWS)
06120 Halle, Heideallee 19
Tel.: 0345/601513, Telefax: 0345/22155

Schleswig-Holstein

Fraunhofer-Institut für Siliziumtechnologie (ISIT)
Itzhoe (im Bau)
z. Z. 14199 Berlin, Dillenburger Straße 53
Tel.: 030/82998-0, Telefax: 030/82998-199

Thüringen/Thuringia

Fraunhofer-Einrichtung für Angewandte Optik und Feinmechanik (IOF)
07745 Jena, Schillerstraße 1
Tel.: 03641/582-0, Telefax: 03641/52963

3. National research centres

Alfred-Wegener-Institut für Polar- und Meeresforschung (AWI)
27568 Bremerhaven, Columbusstraße
Tel.: 0471/4831-0, Telex: 238 695 polar d,
Telefax: 0471/4831-149

Deutsches Elektronen-Synchrotron (DESY)
22607 Hamburg, Notkestraße 85
Tel.: 040/8998-0, Telex: 2 15 124 (desy),
Telefax: 040/8998-3282

Deutsches Krebsforschungszentrum (DKFZ)
69120 Heidelberg, Im Neuenheimer Feld 280
Tel.: 06221/42-0, Telefax: 06221/401271

Deutsche Forschungsanstalt für Luft- und Raumfahrt e. V. (DLR)
51147 Köln, Linder Höhe
Tel.: 02203/601-0, Telex: 8810-0 dlr d,
Telefax: 02203/67310

Gesellschaft für Biotechnologische Forschung mbH (GBF)
38124 Braunschweig, Mascheroder Weg 1
Tel.: 0531/6181-0, Telex: 9 52 667 (gibio d),
Telefax: 0531/6181515

GeoForschungsZentrum Potsdam (GFZ)
14473 Potsdam, Telegrafenberg
Tel.: 0331/310-0, Telefax: 0331/22824

GKSS-Forschungszentrum Geesthacht GmbH (GKSS)
21502 Geesthacht, Max-Planck-Straße
Tel.: 04152/87-0, Telex: 0218712 gkssg

Gesellschaft für Mathematik und Datenverarbeitung mbH (GMD)
53731 Sankt Augustin, Postfach 13 16,
Schloß Birlinghoven
Tel.: 02241/14-0, Telex: 889 469 (gmd d),
Telefax: 02241/14-2889

GSF-Forschungszentrum
85764 Oberschleißheim, Ingolstädter Landstraße 1
Tel.: 089/3187-0, Telex: 523125 stral d

Gesellschaft für Schwerionenforschung mbH (GSI)
64220 Darmstadt, Planckstraße 1, Postfach 11 05 52
Tel.: 06151/359-1, Telex: 04 19593,
Telefax: 06151/359 785

Hahn-Meitner-Institut Berlin GmbH (HMI)
14109 Berlin, Glienicker Straße 100
Tel.: 030/8009-1, Telex: 185763 (hmi d),
Telefax: 030/8009 2181

Max-Planck-Institut für Plasmaphysik (IPP)
85748 Garching bei München, Boltzmannstraße 2
Tel.: 089/3299-01, Telex: 5215 808 (ipp d),
Telefax: 089/3299 2200

Forschungszentrum Jülich GmbH (KFA)
52425 Jülich, Postfach 19 13
Tel.: 02461/61-0, Telex: 833 556 (kfa d),
Telefax: 02461/615327

Kernforschungszentrum Karlsruhe GmbH (KfK)
76021 Karlsruhe, Postfach 36 40
Tel.: 07247/82-0, Telefax: 07247/82-5070

Max-Delbrück-Centrum für Molekulare Medizin (MDC)
13125 Berlin-Buch, Robert-Rössle-Straße 10
Tel.: 030/9463278, Telefax: 030/9497008

UFZ-Umweltforschungszentrum Leipzig-Halle GmbH
04318 Leipzig, Permoserstraße 15
Tel.: 0341/2352242, Telefax: 0341/2352791

4. Institutions on the "Blue List" promoted jointly by the Federal and Länder governments by Länder

Baden-Württemberg

Deutsches Institut für Fernstudien an der Universität Tübingen (DIFF)
72072 Tübingen, Konrad-Adenauer-Straße 40,
Postfach 15 69
Tel.: 07071/979-0, Telefax: 07071/979-100

Fachinformationszentrum Karlsruhe GmbH (FIZ Ka)
76344 Eggenstein-Leopoldshafen 2
Tel.: 07247/808-606, Telefax: 07247/808-666

Gesellschaft Sozialwissenschaftlicher Infrastruktureinrichtungen e. V. (GESIS)
c/o Zentrum für Umfragen, Methoden und Analysen e. V. (ZUMA) (Vereinssitz)
68072 Mannheim, Postfach 12 21 55
Tel.: 0621/18004-0, Telefax: 0621/18004-49

Institut für deutsche Sprache (IDS)
68016 Mannheim, R 5, 6-13, Postfach 10 16 21
Tel.: 0621/1581-0, Telefax: 0621/1581-200

Kiepenheuer-Institut für Sonnenphysik (KIS)
79104 Freiburg, Schöneckstraße 6
Tel.: 0761/31980, Telefax: 0761/3198-11

Bayern/Bavaria

Deutsche Forschungsanstalt für Lebensmittelchemie München (DFA)
85748 Garching, Lichtenbergstraße 4
Tel.: 089/3209-4170, Telefax: 089/3209-4183

Deutsches Museum in München (DM)
80538 München, Museumsinsel 1
Tel.: 089/21791, Telefax: 089/2179324

Germanisches Nationalmuseum (GNM)
90402 Nürnberg, Kartäusergasse 12
Tel.: 0911/13310, Telefax: 0911/1331200

ifo Institut für Wirtschaftsforschung e. V. München (ifo)
81678 München, Poschingerstraße 5
Tel.: 089/9224-0, Telefax: 089/985369

Institut für Zeitgeschichte (IfZ)
86636 München, Leonrodstraße 46b
Tel.: 089/126880, Telefax: 089/1231727

Berlin

Deutsches Bibliotheksinstitut (DBI)
10717 Berlin, Bundesallee 184, Haus 1
Tel.: 030/8505-0, Telefax: 030/8585-100

Deutsches Institut für Wirtschaftsforschung (DIW)
14195 Berlin, Königin-Luise-Straße 5
Tel.: 030/82991-0, Telefax: 030/82991200

Deutsches Institut für Internationale Pädagogische Forschung (DIPF-SERVICE)
10178 Berlin, Haus des Lehrers, Alexanderplatz
Tel.: 030/2441-351, Telefax: 030/

Fachinformationszentrum Chemie GmbH (FIZ CH)
10587 Berlin, Franklinstraße 9
Tel.: 030/39076-0, Telefax: 030/39076-333

Heinrich-Hertz-Institut für Nachrichtentechnik Berlin GmbH (HHI)
10587 Berlin, Einsteinufer 37
Tel.: 030/31002-0, Telefax: 030/31002-213

Wissenschaftszentrum Berlin für Sozialforschung gGmbH (WZB)
10785 Berlin, Reichpietschufer 50
Tel.: 030/25491-0, Telefax: 030/25491684

Forschungsverbund Berlin e. V. (FVB)
10177 Berlin, Jägerstraße 22/23
Tel.: 030/20370-0, Telefax: 030/2004571

Ferdinand-Braun-Institut für Höchstfrequenztechnik (FBH)
im Forschungsverbund Berlin e. V.
12489 Berlin-Adlershof, Rudower Chaussee 5
Tel.: 030/6704-5717, Telefax: 030/6704-4542

Forschungsinstitut für Molekulare Pharmakologie (FMP)
im Forschungsverbund Berlin e. V.
10315 Berlin-Friedrichsfelde, Alfred-Kowalke-Straße 4
Tel.: 030/51630, Telefax: 030/5128014

Institut für Angewandte Analysis und Stochastik (IAAS)
im Forschungsverband Berlin e. V.
10117 Berlin, Mohrenstraße 39
Tel.: 030/20377-0, Telefax: 030/2004975

Institut für Gewässerökologie und Binnenfischerei (IGB)
im Forschungsverbund Berlin e. V.
12587 Berlin, Müggelseedamm 310
Tel.: 030/6452803, Telefax: 030/6452891

Institut für Kristallzüchtung (IKZ)
im Forschungsverbund Berlin e. V.
12489 Berlin, Rudower Chaussee 6
Tel.: 030/6704-2893, Telefax: 030/6704-5921

Max-Born-Institut für Nichtlineare Optik und Kurzzeitspektroskopie (MBI)
im Forschungsverbund Berlin e. V.
12489 Berlin-Adlershof, Rudower Chaussee 6
Tel.: 030/6704-3951, Telefax: 030/6704-2386

Institut für Zoo- und Wildtierforschung (IZW)
im Forschungsverbund Berlin e. V.
10315 Berlin, Alfred-Kowalke-Straße 17
Tel.: 030/5168101, Telefax: 030/5126104

Paul-Drude-Institut für Festkörperelektronik (PDI)
im Forschungsverbund Berlin e. V.
10117 Berlin, Hausvogteiplatz 5–7
Tel.: 030/20377-352, Telefax: 030/20377515

Astrophysikalisches Institut Potsdam (AIP)
14482 Potsdam, An der Sternwarte 16
Tel.: 0331/762228, Telefax: 0331/762200

Deutsches Institut für Ernährungsforschung (DIfE)
14558 Bergholz-Rehbrücke,
Arthur-Scheunert-Allee 114/116
Tel.: 033200/8216, Telefax: 033200/8380

Zentrum für Agrarlandschafts- und Landnutzungsforschung (ZALF)
15374 Müncheberg, Wilhelm-Piek-Straße 72
Tel.: 033432/820, Telefax: 033432/82212

Institut für Agrartechnik Bornim (ATB)
14469 Potsdam-Bornim, Max-Eyth-Allee 1
Tel.: 03733/3310, Telefax: 03733/331599

Institut für Gemüse- und Zierpflanzenbau Großbeeren/Erfurt (IGZ)
14979 Großbeeren, Theodor-Echtermeyer-Weg 1
Tel.: 033701/80, Telefax: 033701/391

Institut für Halbleiterphysik (IHP) Frankfurt/Oder GmbH
15230 Frankfurt/Oder, Walter-Korsing-Straße 2, Postfach 4 09
Tel.: 0335/373-0, Telefax: 0335/326195

Institut für Regionalentwicklung und Strukturplanung e. V. (IRS)
10179 Berlin, Wallstraße 27 (vorläufig)
Tel.: 030/27803-565, Telefax: 030/27803-567

Brandenburg

Potsdam-Institut für Klimafolgenforschung e. V. (PIK)
14473 Potsdam, Telegrafenberg
Tel.: 0331/310-0, Telefax: 0331/22824

Bremen

Deutsches Schiffahrtsmuseum (DSM)
27568 Bremerhaven, Van-Ronzelen-Straße
Tel.: 0471/482070, Telefax: 0471/4820755

Hamburg

Bernhard-Nocht-Institut für Tropenmedizin (BNI)
20359 Hamburg, Bernhard-Nocht-Straße 74
Tel.: 040/31182-0, Telefax: 040/31182-400

Deutsches Übersee-Institut (DÜI)
20354 Hamburg, Neuer Jungfernstieg 21
Tel.: 040/3562593, Telefax: 040/3562547

Heinrich-Pette-Institut für Experimentelle Virologie und Immunologie (HPI)
an der Universität Hamburg
20251 Hamburg, Martinistraße 52
Tel.: 040/477001, Telefax: 040/464709

HWWA-Institut für Wirtschaftsforschung-Hamburg (HWWA)
20354 Hamburg, Neuer Jungfernstieg 21
Tel.: 040/35620, Telefax: 040/351900 und 3562262

Hessen/Hesse

Deutsches Institut für Internationale Pädagogische Forschung (DIPF)
60486 Frankfurt/M., Schloßstraße 29
Tel.: 069/770245, Telefax: 069/708228

Forschungsinstitut und Naturmuseum Senckenberg (FIS)
60325 Frankfurt, Senckenberganlage 25
Tel.: 069/7542-0, Telefax: 069/746238

Johann-Gottfried-Herder-Forschungsrat e. V. (JGHF)
35037 Marburg, Gisonenweg 5–7
Tel.: 06421/184-0, Telefax: 06421/184-139

Pädagogische Arbeitsstelle des Deutschen Volkshochschul-Verbandes e. V. (PAS)
60322 Frankfurt/M., Holzhausenstraße 21
Tel.: 069/154005-0, Telefax: 069/154005-74

Mecklenburg-Vorpommern/West Pomerania

Institut für Atmosphärenphysik an der Universität Rostock (IAP)
18225 Kühlungsborn, Schloßstraße 4–6
Tel.: 038293/680, Telefax: 038293/212

Institut für die Biologie landwirtschaftlicher Nutztiere, Dummerstorf (IBN)
18196 Dummerstorf
Tel.: 08198/70, Telefax: 08198/7531

Institut für Niedertemperaturplasmaphysik e. V. an der Ernst-Moritz-Arndt-Universität Greifswald (INP)
17489 Greifswald, Robert-Blum-Straße 8–10
Tel.: 03834/5991, Telefax: 03834/5944

Institut für Ostseeforschung
an der Universität Rostock (IOW)
18119 Warnemünde, Seestraße 15
Tel.: 0381/580, Telefax: 0381/58336

Niedersachsen/Lower Saxony

Akademie für Raumforschung und Landesplanung (ARL)
30161 Hannover, Hohenzollernstraße 11
Tel.: 0511/34842-0, Telefax: 0511/34842-41

Deutsches Primatenzentrum GmbH (DPZ)
37077 Göttingen, Kellnerweg 4
Tel.: 0551/3851-0, Telefax: 0551/3851-228

Institut für den Wissenschaftlichen Film gGmbH (IWF)
37075 Göttingen, Nonnenstieg 72
Tel.: 0551/202-0, Telefax: 0551/202200

Institut für Erdölforschung (IfE)
38678 Clausthal-Zellerfeld, Walther-Nernst-Straße 7
Tel.: 05323/711-0, Telefax: 05323/711-200

Niedersächsisches Landesamt für Bodenforschung – Geowissenschaftliche Gemeinschaftsaufgaben – (NLfB-GGA)
30655 Hannover, Stilleweg 2
Tel.: 0511/643-3496, Telefax: 0511/643-2304

Technische Informationsbibliothek (TIB)
30167 Hannover, Welfengarten 1B
Tel.: 0511/762-2268, Telefax: 0511/715936

Nordrhein-Westfalen/North Rhine-Westphalia

Deutsches Bergbau-Museum Bochum (DBM)
44791 Bochum, Am Bergbaumuseum 28
Tel.: 0234/58770, Telefax: 0234/5877111

Diabetes-Forschungsinstitut an der Heinrich-Heine-Universität Düsseldorf (DFI)
40225 Düsseldorf, Auf'm Hennekamp 65
Tel.: 0211/3382-1, Telefax: 0211/603

Forschungsinstitut für Kinderernährung (FKE)
44225 Dortmund (Brünninghausen), Heinstück 11
Tel.: 0231/714021, Telefax: 0231/711581

Institut für Arbeitsphysiologie an der Universität Dortmund (IFA)
44139 Dortmund, Ardeystraße 67
Tel.: 0231/1084-205, Telefax: 0231/1084-308

Institut für Spektrochemie und angewandte Spektroskopie (ISAS)
44139 Dortmund, Postfach 10 13 52,
Bunsen-Kirchhoff-Straße 11
Tel.: 0231/1392-0, Telefax: 0231/1392-120

Medizinisches Institut für Umwelthygiene (MIUH) an der Heinrich-Heine-Universität Düsseldorf
40225 Düsseldorf, Auf'm Hennekamp 50
Tel.: 0211/33890, Telefax: 0211/3190910

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI)
45128 Essen, Hohenzollernstraße 1–3
Tel.: 0201/8149-0, Telefax: 0201/8149-200

Zentralbibliothek der Landbauwissenschaft (ZBL)
53115 Bonn, Nußallee 15a
Tel.: 0228/733400, Telefax: 0228/733281

Zentralbibliothek der Medizin (ZBM)
50931 Köln, Joseph-Stelzmann-Straße 9
Tel.: 0221/4785600, Telefax: 0221/4785697

Zoologisches Forschungsinstitut und Museum Alexander Koenig (ZFMK)
53113 Bonn, Adenauerallee 162
Tel.: 0228/9122200, Telefax: 0228/216979

Rheinland-Pfalz/Rhineland-Palatinate

Forschungsinstitut für öffentliche Verwaltung (FÖV) bei der Hochschule für Verwaltungswissenschaften Speyer
67324 Speyer, Freiherr-vom-Stein-Straße 2
Tel.: 06232/910-386, Telefax: 06232/910-208

Römisch-Germanisches Zentralmuseum (RGZM) – Forschungsinstitut für Vor- und Frühgeschichte
55116 Mainz, Ernst-Ludwig-Platz 2
Tel.: 06131/232231, Telefax: 06131/232235

Zentralstelle für Psychologische Information und Dokumentation (ZPID) an der Universität Trier
54286 Trier, Postfach 38 25
Tel.: 0651/201-2877, Telefax: 0651/201-2071

Sachsen/Saxony

Forschungszentrum Rossendorf e. V. (FZR)
01314 Dresden, Postfach 51 01 19
Tel.: 0351/591-0, Telefax: 0351/36069

Institut für Festkörper- und Werkstofforschung Dresden e. V. (IFW)
01069 Dresden, Helmholtzstraße 20
Tel.: 0351/4659380, Telefax: 0351/4659500

Institut für Länderkunde (IfL)
04107 Leipzig, Beethovenstraße 4
Tel.: 0341/28003, Telefax: 0341/294872

Institut für Oberflächenmodifizierung e. V. (IOM)
04318 Leipzig, Permoserstraße 15
Tel.: 0341/2392-0, Telefax: 0341/2392-2313

Institut für ökologische Raumentwicklung e. V. (IÖR)
01217 Dresden, Weberplatz 1
Tel.: 0351/46790, Telefax: 0351/4679212

Institut für Polymerforschung Dresden e. V. (IPF)
01069 Dresden, Hohe Straße 6
Tel.: 0351/4658-0, Telefax: 0351/4658-214 oder 284

Institut für Troposphärenforschung e. V. (IfT)
04318 Leipzig, Permoserstraße 15
Tel.: 0341/23922321, Telefax: 0341/23922361

Sachsen-Anhalt/Saxony-Anhalt

Institut für Neurobiologie (IfN)
39118 Magdeburg, Brenneckestraße 6
Tel.: 0391/674100, Telefax: 0391/616160

Institut für Pflanzenbiochemie (IPB)
06120 Halle/Saale, Weinberg 3
Tel.: 0345/601312, Telefax: 0345/651649

Institut für Pflanzengenetik
und Kulturpflanzenforschung (IPK)
06466 Gatersleben, Corrensstraße 3
Tel.: 039482/5327, Telefax: 039482/5286

Institut für Wirtschaftsforschung Halle (IWH)
06108 Halle, Riebeckplatz 21
Tel.: 0345/834201/202, Telefax: 0345/834201

Institut für Agrarentwicklung
in Mittel- und Osteuropa
Halle

Schleswig-Holstein

Forschungsinstitut Borstel (FIB)
Institut für Experimentelle Biologie und Medizin
23845 Borstel, Parkallee 1
Tel.: 04537/10-0, Telefax: 04537/10-244

Institut für die Pädagogik der Naturwissenschaften
(IPN)
an der Universität Kiel
24118 Kiel, Olshausenstraße 62
Tel.: 0431/88000, Telefax: 0431/8801521

Institut für Meereskunde an der Universität Kiel (IfM)
24105 Kiel, Düsternbrooker Weg 20
Tel.: 0431/597-0, Telefax: 0431/565876

Institut für Weltwirtschaft (IfW)
an der Universität Kiel
24105 Kiel, Düsternbrooker Weg 120
Tel.: 0431/8814-1, Telefax: 0431/858553

Zentralbibliothek der Wirtschaftswissenschaften
(ZBW)
24105 Kiel, Düsternbrooker Weg 120
Tel.: 0431/884-1, Telefax: 0431/85853 oder 884500

Thüringen/Thuringia

Institut für Molekulare Biotechnologie e. V. Jena (IMB)
07745 Jena, Beutenbergstraße 11
Tel.: 03641/852200, Telefax: 03641/852203

5. Federal Government institutions performing research

Area of responsibility of the Federal Chancellery

Stiftung Wissenschaft und Politik (SWP)
82067 Ebenhausen, Zellerweg 27
Tel.: 08178/700, Telefax: 08178/70312

Area of responsibility of the Federal Foreign Office

Deutsches Archäologisches Institut (DAI)
14195 Berlin, Podbielskiallee 69–71
Tel.: 030/83008-0, Telefax: 030/83008108

Area of responsibility of the Federal Ministry of the Interior

Institut für Angewandte Geodäsie (IfAG)
60598 Frankfurt/M., Richard-Strauss-Allee 11
Tel.: 069/63331, Telefax: 069/6333425

Bundesinstitut für ostwissenschaftliche und internationale Studien (BIOst)
50823 Köln, Lindenbornstraße 22
Tel.: 0221/57470, Telefax: 0221/5747110

Bundesinstitut für Bevölkerungsforschung (BIB)
65189 Wiesbaden, Gustav-Stresemann-Ring 6
Tel.: 0611/762235, Telefax: 0611/39544

Bundesinstitut für Sportwissenschaften (BISp)
50933 Köln, Carl-Diem-Weg 4
Tel.: 0221/4979-0, Telefax: 0221/495164

Area of responsibility of the Federal Ministry of Economics

Physikalisch-Technische Bundesanstalt (PTB)
38116 Braunschweig, Bundesallee 100
Tel.: 0531/592-0, Telefax: 0531/592-4006

Bundesanstalt für Materialforschung und -prüfung (BAM)
12203 Berlin, Unter den Eichen 87
Tel.: 030/8104-1, Telefax: 030/8112029

Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
30655 Hannover, Stilleweg 2, Postfach 51 01 53
Tel.: 0511/643-0, Telefax: 0511/643-2304

Area of responsibility of the Federal Ministry of Food, Agriculture and Forestry

Bundesforschungsanstalt für Landwirtschaft Braunschweig-Völkenrode (FAL)
38116 Braunschweig, Bundesallee 50
Tel.: 0531/5961, Telefax: 0531/596814

Biologische Bundesanstalt für Land- und Forstwirtschaft Berlin/Braunschweig (BBA)
38104 Braunschweig, Messeweg 11/12
Tel.: 0531/2990, Telefax: 0531/2993001

Bundesanstalt für Milchforschung (BAM)
24103 Kiel, Hermann-Weigmann-Straße 1
Tel.: 0431/6091, Telefax: 0431/609222

Bundesforschungsanstalt für Fischerei (BFAFi)
22767 Hamburg, Palmaille 9
Tel.: 040/389050, Telefax: 040/38905129

Bundesforschungsanstalt für Forst- und Holzwirtschaft (BFH)
21031 Hamburg, Leuschnerstraße 91
Tel.: 040/739621, Telefax: 040/73962480

Bundesanstalt für Getreide-, Kartoffel- und Fettforschung (BAGKF)
32756 Detmold, Schützenberg 12
Tel.: 05231/7410, Telefax: 05231/741100

Bundesforschungsanstalt für Viruskrankheiten der Tiere (BFAV)
72076 Tübingen, Paul-Ehrlich-Straße 28
Tel.: 07071/6031, Telefax: 07071/603201

Bundesanstalt für Züchtungsforschung im Wein- und Gartenbau
76833 Siebeldingen
Tel.: 06345/410, Telefax: 06345/41177

Bundesanstalt für Fleischforschung (BAFF)
95326 Kulmbach, E.-C.-Baumannstraße 20
Tel.: 09221/8031, Telefax: 09221/803244

Bundesforschungsanstalt für Ernährung (BFE)
76131 Karlsruhe, Engesserstraße 20
Tel.: 0721/66250, Telefax: 0721/6625111

Bundesanstalt für Züchtungsforschung an Kulturpflanzen (BAZ)
06484 Quedlinburg, Neuer Weg 22/23
Tel.: 03946/470, Telefax: 03946/47255

Area of responsibility of the Federal Ministry of Labour and Social Affairs

Bundesanstalt für Arbeitsschutz (BAU)
44149 Dortmund, Vogelpothsweg 50/52
Tel.: 0231/17630, Telefax: 0231/1763454

Bundesanstalt für Arbeitsmedizin (BAfAM)
10317 Berlin, Nöldnerstraße 40–42
Tel.: 030/5509901, 030/2315458,
Telefax: 030/2315431

Institut für Arbeitsmarkt- und Berufsforschung (IAB) der Bundesanstalt für Arbeit (BA)
90478 Nürnberg, Regensburgerstraße 104
(Dienstgebäude: Platenstraße 46)
Tel.: 0911/179-0, Telefax: 0911/1793258

Area of responsibility of the Federal Ministry of Defence

Forschungsgesellschaft für Angewandte Naturwissenschaften e. V. (FGAN)
53343 Wachtberg-Werthhoven, Neuenahrer Straße 20
Tel.: 0228/8521, Telefax: 0228/340951

Forschungsanstalt der Bundeswehr für Wasserschall- und Geophysik (FWG)
24148 Kiel, Klausdorfer Weg 2–24
Tel.: 0431/7204-0, Telefax: 0431/7204-150

Wehrwissenschaftliche Dienststelle der Bundeswehr für ABC-Schutz (WWDBw ABC-Schutz)
48159 Münster, Humboldtstraße
Tel.: 05192/12-1, Telefax: 05192/126155

Wehrwissenschaftliches Institut für Materialuntersuchungen (WIM)
85435 Erding, Landshuter Straße 70
Tel.: 08122/57-1, Telefax: 08122/57-312

Bundesinstitut für chemisch-technische Untersuchungen (BICT) beim Bundesamt für Wehrtechnik und Beschaffung (BWB)
53913 Swisttal-Heimerzheim, Großes Cent
Tel.: 02222/60081, Telefax: 02222/1852

Area of responsibility of the Federal Ministry for Women and Youth

Deutsches Jugendinstitut e. V. (DJI)
81543 München, Freibadstraße 30
Tel.: 089/62306-0, Telefax: 089/62306-162

Area of responsibility of the Federal Ministry for Health

Bundesgesundheitsamt (BGA)
14195 Berlin, Thielallee 88–92
Tel.: 030/83080, Telefax: 030/2741

Paul-Ehrlich-Institut –
Bundesamt für Sera und Impfstoffe
63225 Langen, Paul-Ehrlich-Straße 51–59
Tel.: 06103/77-0, Telefax: 06103/77-123

Deutsches Institut für medizinische Dokumentation und Information (DIMDI), Köln
50899 Köln, Postfach 42 05 80
Tel.: 0221/47241, Telefax: 0221/411429

Area of responsibility of the Federal Ministry of Transport

Bundesanstalt für Straßenwesen (BASt)
51427 Bergisch Gladbach, Brüderstraße 53
Tel.: 02204/43-0, Telefax: 02204/43833

Bundesanstalt für Gewässerkunde (BfG)
56068 Koblenz, Kaiserin-Augusta-Anlagen 15–17
Tel.: 0261/1306-0, Telefax: 0261/1306-302

Bundesanstalt für Wasserbau (BAW)
76187 Karlsruhe, Kußmaulstraße 17
Tel.: 0721/9726-0, Telefax: 0721/9726454

Deutscher Wetterdienst (DWD) – Zentralamt –,
63067 Offenbach/M., Frankfurter Straße 135
Tel.: 069/8062-0, Telefax: 069/8062-339

Bundesamt für Seeschiffahrt und Hydrographie (BSH)
20359 Hamburg, Bernhard-Nocht-Straße 78
Tel.: 040/3190-0, Telefax: 040/31905000

Area of responsibility of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Umweltbundesamt (UBA)
14193 Berlin, Bismarckplatz 1
Tel.: 030/8903-0, Telefax: 030/8903-2285

Bundesamt für Strahlenschutz (BfS)
38226 Salzgitter, Albert-Schweitzer-Straße 18
Tel.: 05341/188-0, Telefax: 05341-188188

Bundesforschungsanstalt für Naturschutz und Landschaftsökologie (BfANL)
53179 Bonn, Konstantinstraße 110
Tel.: 0228/8491-0, Telefax: 0228/8491200

Area of responsibility of the Federal Ministry of Posts and Telecommunications

Wissenschaftliches Institut für Kommunikationsdienste GmbH (WIK)
53604 Bad Honnef, Postfach 20 00, Rathausplatz 2–4
Tel.: 02224/7700-0, Telefax: 02224/7700-66

Area of responsibility of the Federal Ministry for Regional Planning, Building and Urban Development

Bundesforschungsanstalt für Landeskunde und Raumordnung (BfLR)
53177 Bonn, Am Michaelshof 8
Tel.: 0228/826214, Telefax: 0228/826266

Institut für Erhaltung und Modernisierung von Bauwerken e. V. (IEMB)
13053 Berlin, Plauener Straße 163–165
Tel.: 030/9783-0, Telefax: 030/9751247

Area of responsibility of the Federal Ministry for Research and Technology

Biologische Anstalt Helgoland (BAH)
22607 Hamburg, Notkestraße 31 (BAH, Hamburg)
Tel.: 040/89693-0, Telefax: 040/89693115

Kunsthistorisches Institut Florenz (KHI)
I-50121 Firenze, Via G. Giusti 44
Tel.: 003955/2479161, Telefax: 003955/244394

Deutsches Historisches Institut in Paris (DHI Paris)
F-75116 Paris, 9, rue Maspéro
Tel.: 00331/45202555, Telefax: 00331/45246480

Deutsches Historisches Institut in Rom (DHI Rom)
I-00165 Rom, Via Aurelia Antica, 391
Tel.: 00396/6633011, Telefax: 00396/6623838

Deutsches Historisches Institut in London (DHI London)
GB-London WC 1A2 LP, 17 Bloomsbury Square
Tel.: 004471/4045486, Telefax: 004471/4045573

Deutsches Historisches Institut in Washington D.C. (DHI Washington)
Washington, D.C. 20009/USA, 1607 New Hampshire Avenue
Tel.: 001202/3873355, Telefax: 001202/4833430

Deutsches Institut für Japanstudien in Tokyo (DIJ Tokyo)
102 Tokyo/Japan, Nissei Kojimachi Bldg. 1 F, Chiyoda-ku
Tel.: 00813/32225077, Telefax: 00813/32225420

Orient-Institut Beirut (OI Beirut)
Beirut/Libanon, Rue Hussein Beyhum
z. Z. Ausweichstelle in Istanbul
c/o Generalkonsulat Istanbul, Postfach 15 00, W 5300 Bonn 1
Tel. (Istanbul): 00901/2446067, Telefax (Istanbul): 00901/2493659

Area of responsibility of the Federal Ministry of Education and Science

Bundesinstitut für Berufsbildung (BIBB)
10707 Berlin, Fehrbelliner Platz 3
Tel.: 030/8643-0, Telefax: 030/8643-2455

Area of responsibility of the Federal Ministry for Economic Cooperation

Deutsches Institut für Entwicklungspolitik gGmbH (DIE)
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