ORGANISATION OF SCIENTIFIC RESEARCH IN GERMANY

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This article considers the structure of research system in Germany. It describes the federal and state levels of research management. The Federal Ministry of Education and Research (BMBF) bears primary responsibility for science and technology policy at the federal level. At the state level, this responsible is shared by the Ministry of Education and Science and the Ministry of Economy. The author emphasizes the role of the National Academy of Sciences "Leopoldina", whose principal objective is to provide advisory services to German policymakers and present German science at the international level. Special attention is paid to the wide spectrum of German research agents: public and private research organizations, higher education institutions, R&D departments of industrial companies. The article stresses the research potential of universities that receive funding under the Excellence Initiative and describes the contribution of production in research and development activities, focusing on the top ten German companies in terms of R&D expenditure.

***Key words**:* Germany, research, universities, National Academy of Sciences "Leopoldina"

International cooperation in the field of science and education is a necessary condition of creating innovative economy and raising competitiveness of Russia on the world market. Active research and exchange of best practices in education between Russia and Germany, strengthening mutually beneficial cooperation, and the recognition of Germany a world leader in innovative development [1] stimulate interest in the study of the organization of research in Germany.

The general organization of research in Germany is presented in Figure 1. Re-

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search management in Germany, according to its political system, is carried out both at the federal level and the state level.

At the federal level, the primary responsibility for the implementation of the policy in science and technology belongs to the Federal Ministry of Education and Research (BMBF). The Federal Ministry of Economy and Technology (BMWi) is responsible for the innovation and technology policy, as well as for some areas of R&D policy. It indirectly provides measures to support small and medium-size businesses, special research programmes in the field of energy, transportation and aerospace research and deals with issues connected with innovation-friendly environment. Several sectoral ministries have their own research institutes (Ressortforschungseinrichtungen). The German Parliament has a permanent Committee on Education, Research and Technology Assessment and approves the research budget.

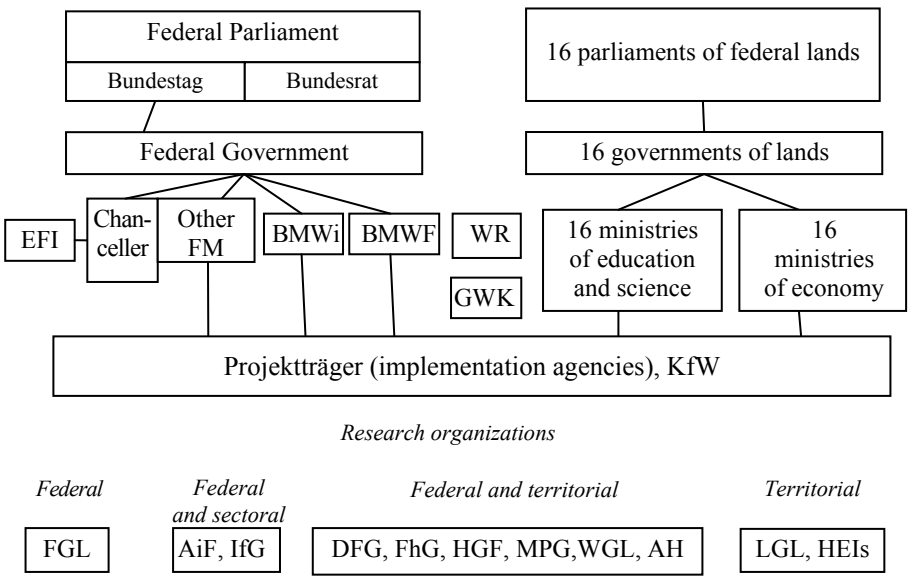

Fig. Structure of the research system in Germany:
BMWi: Federal Ministry of Economy and Technology; BMBF: Federal Ministry of Education and Research; FhG: Fraunhofer Society; MPG: Max Planck Society; WGL: Leibniz Association; HGF: Helmholtz Association; AoS: Academies of Sciences; FGL: Federal Government Research Organisations (Federal Agencies); DFG: German Research Foundation; AiF: Association of Industrial Research Institutes; IfG: Institutes of Co-operative Industrial Research; KfW: KfW Banking Group — State-owned bank (80% Federal Government, 20% States); SC: Science Council; GWK: Joint Science Conference of the Federal Government and the Federal States; LGL: Länder Government Research Organisations; EFI: Expert Commission on Research and Innovation; HEIs: Higher Education Institutions [11]

At the state level, the responsibility for science policy is usually shared between the Ministry of Science and Education and the Ministry of Economy. The Joint Science Conference (GWK) is the main body that coordinates research policies between the federal government and state governments.

In contrast to other countries, Germany has no strategy council to coordinate research and/or innovation policies. The German Council of Science

and the Humanities (Wissenschaftsrat — WR) is one of the main advisory bodies in the field of research and education. Its main function is to consult the federal government and the state government on the development of science, research and higher education. The Committee prepares recommendations and reports which primarily concern their structure and performance, the development and funding of research institutions, as well as general questions related to the system of higher education, selected structural aspects of research and teaching as well as the strategic planning and assessment of specific fields and disciplines. The German Research Foundation (Deutsche Forschungsgemeinschaft, DFG) plays a central role in financing fundamental research in Germany, complementing institutional funding of fundamental research with project-type funding. Most publicly funded R&D programmes are administered and managed by a range of implementation agencies ("Projektträger"), which are mostly located in large research centres. In addition, the German Federation of Industrial Research Associations "Otto von Guericke" (AiF) deals with the promotion of applied R&D for small and medium-size enterprises.

Research in Germany is conducted by a wide range of organizations and institutions. Private R&D companies constituted 67.3 % of the German R&D expenditures in 2010 (68.2 % in 2009). The share of 409 higher education institutions in Germany is 18.0 % of total R&D expenditures. In addition, there is a wide range of public research organisations, whose share is 14.7 % of total R&D expenses (14.5 % in 2009), i. e. their quantitative significance in the German research system is comparable to that of universities [10; 11]. The business sector is leading in the number of researchers (62 % of total staff engaged in research), then follow HEIs (22 %) [17].

The non-university public research system is based on four main research organisations — Max Planck Society (MPG), Fraunhofer Society (FhG), Helmholtz Association (HGF), and Leibniz Association (WGL).

Currently the Max Planck Society maintains 80 institutes, research units, and working groups doing research into the most promising science areas; their research theme focuses on biomedical and physical chemistry, as well as on social sciences and the humanities.

Fraunhofer Society (FhG) supports more than 80 research units mainly in the field of applied research and provides scientific and technical expertise to businesses, particularly small and medium enterprises.

Helmholtz Association (HGF) is a community of 16 research centres and is the largest research association in Germany. Centres of the Association provide equipment and the related infrastructure for national and international research groups. In cooperation with universities and other research organizations, primarily the Leibniz Association, the Helmholtz Association performs top-rate research participating in strategic programmes in the fields of energy, earth and environment, health, key technologies, structure of matter, transport and space.

Leibniz Association (WGL) includes 86 research institutions and service centres. It works in the field of problem-oriented fundamental and applied research.

The above mentioned organizations differ with regard to the degree of their organisational integration. While MPG and FhG are integrated organi-

sations with strong headquarters, HGF and WGL are comparatively loose umbrella organisations of legally independent institutes [13].

The German Academy of Sciences Leopoldina is the oldest academy in natural sciences in Germany. Founded in 1652, it operates under the name the National Academy of Sciences Leopoldina since 2008. The main tasks of the Academy include offering consultancy to German policymakers and representing German science at the international level. Leopoldina maintains contacts in the field of science with other countries through joint activities, as well as through cooperation with various associations, including the national academies of the G8. The Academy provides assistance to researchers by organizing a large number of meetings and workshops, annual conferences, as well as monthly lectures and research seminars. It supports the development of young professionals in the field of science through the Leopoldina Fellowship Programme and provides project funding to young scientists in the framework of the Young Academy Programme. In addition, Leopoldina has its own archive and library, and awards prizes and awards. All research activities are open to the interested public and are published in collated editions of "Nova Acta Leopoldina", "Acta Historica Leopoldina" and "Jahrbuch" [4].

The Leopoldina Academy has approximately 1,400 members working primarily in the field of natural sciences and medicine, as well as related industries of social sciences and psychology. Three quarters of the members are from German-speaking countries (Germany, Austria, and Switzerland) [5]. Since 2010, Jörg Hacker has been president of the Academy. At present, the Academy consists of 28 sections, which are grouped into four departments: mathematics, science and technology; life sciences; medical sciences; humanities, social and behavioural sciences. [5].

Higher education institutions (HEIs) play an increasingly big role in scientific research. The expenditures of HEIs on R&D increased from €8.1b in 2000 to €11.8b in 2009 [15]. The widest range of research, including fundamental research, is done in German universities. In 2005, through a competitive selection procedure within the "Excellence Initiative" (Exzellenzinitiative) an independent panel selected nine elite universities in Germany, which in the period 2006—2011 received additional funding for the development of research, including fundamental research. In 2009, it was decided to extend the Excellence Initiative for the period 2012—2017 [15]. The list of elite universities includes: Free University Berlin (Freie Universität zu Berlin), Technical University Aachen (Technische Hochschule Aachen), University Freiburg (Universität Freiburg), University Goettingen (Univrersität Göttingen), University Heidelberg (Universität Heidelberg), University Konstanz (Universität Konstanz), Ludwig Maximilian University Munich (Ludwig-Maximilian Universität München), Technical University Munich (Technische Universität München), Technical Institute Karlsruhe (Karlsruher Institut für Technologie (KIT)) [15]. The Excellence Initiative involves three different types of institutions and activities to be funded: postgraduate schools, creating superclusters and development concepts (Table 1).

Table 1

The profile of universities within the framework of the Excellence Initiative [6; 12; 14; 16; 18]

University	Development concept	Superclusters	Graduate schools
Free University of Berlin (Freie Universität zu Berlin)	The International Network University	The Formation and Transformation of Space and Knowledge in Ancient Civilizations (together with the Berlin University. Humboldt), the language of emotions, the treatment of neurological disorders — on the way to better results (together with the Berlin University. Humboldt), unified concept in catalysis	Graduate schools under the auspices of Dahlem Research School
Technical University of Aachen (Technische Hochschule Aachen)	RWTH 2020 — to meet global challenges	Production of Fuels from Biomass; Integrative Production Technology for High-wage countries; Ultra-High-Speed Mobile Information and Communication	Computer Engineering
Freiburg University (Universität Freiburg)	Windows for Research	The Centre for Biological Signalling Studies	Spemann Graduate School of Biology and Medicine
Goettingen University (Univrersität Göttingen)	Goettingen: Tradition — Innovation — Autonomy	Microscopy at the nanometre range	Goettingen Graduate School for Neurosciences, Biophysics, and Molecular Biosciences (GGNB)
Heidelberg University (Universität Heidelberg)	Realising the Potential of a Comprehensive University	Asia and Europe in the global context, cellular networks	Graduate School of fundamental Physics, International Graduate School of Molecular and Cellular Biology, School of Mathematical and Computational Methods for the Sciences

End of table 1

University	Development concept	Superclusters	Graduate schools
University of Konstanz (Universität Konstanz)	Towards a culture of creativity	Cultural Foundations of Social Integration	Graduate School of Biochemistry
Ludwig Maximilian University of Munich (Ludwig-Maximilian Universität München)	Quality: Working brains — Networking minds — Living knowledge	Munich Nanosystems Initiative study (together with the Technical University of Munich, the University of Augsburg), the Munich Centre for Integrated Protein Research, Munich Center for Advanced Photonics (together with the Technical University of Munich)	Graduate School in Systemic Neuroscience
Technical University of Munich (Technische Universität München)	Technical University of Munich — the entrepreneurial university	Cognition for Technical Systems, the Origin and Structure of the Universe (with the Ludwig Maximilian University of Munich), Munich Nanosystems Initiative Study (with the Ludwig Maximilian University of Munich, the University of Augsburg), the Munich Centre for Integrated Protein Research, Munich Centre for Advanced photonics (Ludwig Maximilian University of Munich)	International School of Science and Technology
Karlsruhe Institute of Technology (Karlsruher Institut für Technologie (KIT))	Research — Teaching — Innovation. The founding strategy of the Technical University of Karlsruhe by merging the University of Karlsruhe and the Forschungszentrum Karlsruhe	Functional Nanostructures	Graduate School in the Optics and Photonics

Postgraduate schools are mainly focused on young scientists and should provide adequate conditions especially for doctoral students. University clusters should represent scientific and educational centres of international scale, which will create a network with non-university institutions, specialized higher education institutions and industrial enterprises. As for the third activity, the academic profile of some universities is strengthening; such universities receive additional funding for the elaboration of their research development strategy [3].

Industry is an important player in research. More than two thirds of annual funding invested in research in Germany comes from the private sector. These funds will be spent both on the companies' own research as well as on joint projects with partners from science. The research conducted in this sector is applied by nature and is aimed directly at concrete results. Fundamental research plays a minor role in this sector [7].The largest amount of R&D (90%) is performed by large companies. Within the business sector, the largest amount of R&D in 2009 was done in the automotive sector, which spent 14 billion euros (31%). Electronics and electrical industry R&D expenditures accounted for 7.1 billion euro (16%), the same sum was spent by the chemical and pharmaceutical industries. Another relevant industry is mechanical engineering (Table 2).

Table 2

R&D expenditure within the business enterprise sector [8; 9]

Industrial sector	Total expenditure			
	2008		2009	
	EUR billion	% of total expenditure	EUR billion	% of total Expenditure
Automotive sector	15	33	14	31
Electronics and electrical industry	8,7	19	7,1	16
Chemical and pharmaceutical industries	6,6	14	7,1	16
Mechanical engineering sector	5,0	11	4,5	10
Other industries	10,8	23	12,6	27
Total	46,1	100	45,3	100

The top ten R&D spenders in Germany are: Volkswagen, Siemens, Daimler, Robert Bosch, Bayer, BMW, Boehringer Ingelheim, SAP, Continental, BASF [9].

In Germany, there are non-public RTOs in every industrial sector. Most of the private sectoral research and technology organisations are organised in the AiF, the German Federation of Industrial Research Associations "Otto von Guericke" (Arbeitsgemeinschaft industrieller Forschungsvereinigungen

"Otto von Guericke" e. V.). The AiF comprises an industry-based innovations network covering over 100 industrial research associations, with approximately 50,000 SMEs and about 700 associated research institutions. Outside the AiF, there is a wide range of (primarily non-sectoral) private research institutes. In general, they are fairly small and thus limited to restricted fields of activity. Their thematic scope ranges from surveying electors to medicine and covers more or less every scientific discipline. Trade unions as well as employers' associations have their own research institutes dealing with matters of economics, labour and politics [8].

Thus, Germany has developed a network of research institutions of various types, which carry out research in almost all fields of science. On the political and administrative level, research management in Germany is characterized by division of responsibility between the Federal and State authorities. Industry plays an important role in scientific research and most of R&D research is conducted by large companies. Universities play an increasingly important role especially in fundamental research. Within the Excellence Initiative, additional financial support is being provided to university-generated clusters in the fields of biology, medicine, nanosystems, and social sciences. The development of integration processes between research organizations should be emphasized.

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