

RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION

EFI

REPORT

2008 2009 2010

2011 2012 2013

2014 2015 2016

2017 2018 2019

We wish to thank

Prof. Dr. Carsten Agert, Robert D. Atkinson, Ph.D., Alexander Augst, Ph.D., Prof. Dr. Andreas Barner, Clyde J. Behney, Dr. Frank W. Bobe, Prof. Dr. Steffen-Sebastian Bolz, Ann C. Bonham, Ph.D., Dr. Klaus Bosslet, Charles Cameron, Dr. Paul Chartrand, Dr. Chung-Wai Chow, Joanne Conroy, Prof. Dr. Dennis Daneman, Sarah De La Rue, Prof. Dr. Horst Domdey, Dr. Johannes Drepper, Dr. Karin Effertz, Prof. Dr. Ralph Eichler, Prof. Dr. Stefan Endres, Prof. Dr. Thomas Eschenhagen, Stephen Ezell, Ph.D., Frank Feist, Dr. Harvey Fineberg, Peter Fischer, Dr. Stephan Fischer, Lauren C. Foster, Johannes Fruehauf, Ph.D., Prof. Dr. Simone Fulda, Dr. John Gallin, Prof. Dr. Dr. Levi A. Garraway, Prof. Dr. Dr. Klaus W. Grätz, Jens Hanefeld, Stephen Heinig, Dr. Peter-Paul Henze, George Herrfurth, Dr. Catherine L. Ives, Prof. Dr. Rudolph Jaenisch, Pasi A. Jänne, Ph.D., Michael Julius, Ph.D., Dr. Shaf Keshavjee, Darrell G. Kirch, Dr. Daniela S. Krause, Dr. Shoo K. Lee, Prof. Dr. Reiner Leidl, Dr. Peter N. Lewis, Mary-Jo Makarchuk, Sebastian Mate, Michael McGinnis, Raymond Mataloui, Ph.D., Dr. Wolfgang Mehnert, Stephen A. Merrill, Ph.D., Prof. Dr. Holger Moch, Sharyl J. Nass, Ph.D., Derek Newton, Ph.D., Dr. Frederick P. Ognibene, Alexander K. Ommaya, Christopher J. Paige, Ph.D., Dr. Alvaro Pascual-Leone, Prof. Dr. Arnold Picot, Ben Poynton, Dr. Heinz Riederer, Janet Rossant, Ph.D., Michael Salter, Prof. Dr. Ulrich Schmoch, Ph.D., Dr. Edward Scolnick, Prof. Dr. Werner Seeger, Philip M. Sherman, Susan Sauer Sloan, Walter Stechel, Karl-Heinz Streibich, Dr. Lawrence Tabak, Dr. Andreas Tecklenburg, Prof. Dr. Joachim Thiery, Dr. Siegfried Throm, Dr. Christian Tidona, Dr. Frances Toneguzzo, Michael Vorländer, Annett Wache, Prof. Charles W. Wessner, Ph.D., Dr. Christoph Westphal, Dr. Frank Wissing, Prof. Karl Dane Wittrup, Ph.D. and Prof. Dr. Daniel Wyler, all of whom contributed their expertise to the report.

In addition, we wish to thank all those persons who helped prepare the studies on the German innovation system, as well as the German Aerospace Center (DLR), the Jülich Research Centre (FZJ), the Helmholtz Zentrum Dresden Rossendorf, the Max Planck Society and the Hungarian Academy of Sciences for providing visual material for the illustration of the EFI Report.

The Expert Commission wishes to emphasise that the positions expressed in the report do not necessarily represent the opinions of the aforementioned persons.

RESEARCH, INNOVATION
AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION

EFI

MEMBERS OF THE COMMISSION OF EXPERTS FOR RESEARCH AND INNOVATION (EFI)

Professor Dr. Uschi Backes-Gellner

University of Zurich, Department of Business Administration, Chair for Empirical Research
in Business, Industrial Relations and Human Resource Management

Professor Dr. Christoph Böhringer

Carl von Ossietzky University of Oldenburg, Department of Business Administration,
Economics and Law, Chair for Economic Policy

Professor Dr. Dominique Foray

École Polytechnique Fédérale de Lausanne, Chaire en Economie et Management de l'Innovation

Professor Dr. Alexander Gerybadze

University of Hohenheim, Center for Research on Innovation and Services (FZID),
Center for International Management and Innovation

Professor Dietmar Harhoff, Ph.D. (Chair)

Max Planck Institute for Innovation and Competition, Munich Center for Innovation and
Entrepreneurship Research (MCIER)

Professor Dr. Monika Schnitzer (Deputy Chair)

Ludwig Maximilians University of Munich, Seminar for Comparative Economics

This report is also the result of the highly competent and dedicated work of the staff of the Expert Commission's coordination office and the staff of the Commission members.

STAFF OF THE EFI COORDINATION OFFICE

Christine Beyer
Dr. Alexander Cuntz
Dr. Nina Czernich
Dr. Helge Dauchert
Dr. Petra Meurer
Elena Mostovova, student assistant
Annika Philipps
Magdalena Skurnog, student assistant

STAFF OF THE COMMISSION MEMBERS

Professor Dr. Karin Hoisl, Max Planck Institute for Innovation and Competition,
Munich Center for Innovation and Entrepreneurship Research (MCIER)

Peter Höschler, University of Zurich, Department of Business Administration,
Chair for Empirical Research in Business, Industrial Relations and Human Resource Management

Malte Klein, University of Hohenheim, Center for Research on Innovation and Services (FZID),
Center for International Management and Innovation

Markus Nagler, Ludwig Maximilians University of Munich, Seminar for Comparative Economics

Emmanuel Asane Otoo, Carl von Ossietzky University of Oldenburg, Department of Business
Administration, Economics and Law, Chair for Economic Policy

Hendrik Schaffland, University of Hohenheim, Center for Research on Innovation and Services
(FZID), Center for International Management and Innovation

Jan Schneider, Carl von Ossietzky University of Oldenburg, Department of Business Administration,
Economics and Law, Chair for Economic Policy

Alexander Suyer, Max Planck Institute for Innovation and Competition, Munich Center for
Innovation and Entrepreneurship Research (MCIER)

Translation

Michael O'Sullivan, Ingrun Wenge, Berlin

SUMMARY

CURRENT DEVELOPMENTS AND CHALLENGES

A 1 FURTHER DEVELOPING THE REFORM INITIATIVES

Following the expiry of the Higher Education Pact, the Excellence Initiative and the Pact for Research and Innovation, a package of measures will have to be developed over the next few months to further support tertiary education institutions and non-university research organisations.

Basic funding of tertiary education institutions should be strengthened. In this regard, it is imperative to amend Article 91b of the German constitution so as to re-enable the Federal Government to support tertiary education institutions at an institutional level. In the medium term, any projects funded by the public sector should also be granted full-cost funding. The expected decline in student numbers should be taken advantage of to improve the quality of teaching and research: the student/teacher ratio and teaching commitments of professors in tertiary education institutions have to be adapted to meet international standards. The Expert Commission recommends providing special support to the best performing tertiary education institutions in particular, in order to strengthen top-level research and thus the international competitiveness of the German research system.

The Federal and *Länder* governments should fund non-university research institutions based on a uniform financing key of approximately 70:30. The Expert Commission would like to emphasise that the performance of non-university research organisations can only be enhanced provided that increases in financing are granted not only in nominal, but also in real terms.

A 2 PROMOTING INNOVATION MORE EFFICIENTLY THROUGH THE EVALUATION OF SUPPORT MEASURES

Scientifically valid evaluations of innovation policy measures are an important basis for well-founded economic policy decisions. Evaluations facilitate the tailoring of individual measures for achieving the desired results based on an efficient use of resources. Evaluations thus contribute to promoting research and innovation in Germany more efficiently. Several other countries are more advanced than Germany when it comes to applying and institutionalising such evaluations. The Federal Republic should align itself to these best practice examples and promote the use of scientifically well-founded evaluations.

To institutionalise well-founded evaluations, the Expert Commission recommends systematically expanding centralised centres of competence, an approach that has been initiated in some of the ministries, while also creating relevant data centres. It is

crucial to design the evaluation of policy measures transparently. The data required for a well-founded analysis should be collected parallel to the implementation of a project. Based on the principle of transparency, data should also be made available to scientists to enable them to replicate and review evaluation results. To facilitate the commissioning of evaluations, 0.5 percent of the relevant ministry's project budget should be allocated to the centralised evaluation bodies.

THE RELEVANCE OF TERTIARY EDUCATION AND VOCATIONAL EDUCATION AND TRAINING FOR INNOVATION

A 3

The German production and innovation model, particularly in the industrial sector, is based on a specific combination of highly qualified university graduates – mostly from natural sciences and engineering – and highly skilled workers from the dual vocational education system.

To avoid jeopardising this inherent strength, investments in retaining and developing the attractiveness of vocational training have to be continued. Talented, ambitious graduates from vocational training should be provided with clear-cut career options based on individual development opportunities and an increased permeability between different educational tracks. Future goals for the German educational system should focus on an optimal mix of different types of education and flexible individual educational paths, rather than the ratio of university graduates. To achieve these goals, new education indicators will have to be developed.

Based on the foreseeable decline in the numbers of graduates from compulsory schooling, the financing formulas for upper secondary and tertiary education should in the future focus on schooling quality and learning achievements, rather than focussing on student enrollment numbers. Regular external achievement tests should be conducted at all levels of the general school system. These should aim to document the individual learning progress in particular. The results of these assessments should be made publicly available at school level. Such assessment tests should be combined with an increase in autonomy for schools in terms of allocating their resources.

STRUCTURE AND DEVELOPMENT OF THE KNOWLEDGE ECONOMY

A 4

A structural change towards the expansion of the knowledge economy can be observed on a global scale. The knowledge economy includes research-intensive industries and knowledge-intensive services. Germany tends to show strength in the area of research-intensive industries, but continues to show deficits in knowledge-intensive services. Germany's strengths in the field of high-value technologies should be supplemented by complementary developments in the field of cutting-edge technologies and knowledge-intensive services.

Germany's research and innovation policy needs to significantly improve conditions for cutting-edge technologies. To achieve this, it will be essential to enhance efforts in the fields of entrepreneurship, innovation and growth financing, as well as R&D tax credits.

Even more than in the past, businesses in Germany should focus on increasing productivity by utilising the latest information and communication technologies (ICT).

Furthermore, the expansion of the knowledge economy should not be conducted in isolation from the upstream and downstream sectors of the economy, but should also be utilised to promote spillover effects and productivity gains in the non-knowledge-intensive industries of the German economy and the public sector.

A 5 INTERNATIONALISATION OF RESEARCH AND DEVELOPMENT

In recent years, the internationalisation of research and development (R&D) of German companies has increased significantly. Yet, when it comes to cutting-edge technology, it is of concern that German companies are increasingly performing their R&D activities abroad. In the field of cutting-edge technology, Germany is losing a considerable number of scientists and inventors to other countries (cf. Chapter B 2). German companies, especially those in ICT, in turn are relocating their research and development facilities in search of such cutting-edge expertise in precisely those countries. These developments thus mutually reinforce each other, thereby weakening Germany as an innovation location in the long term.

It is therefore of central importance for Germany's R&I policy to retain talented innovation professionals, whether it is scientists or inventors, in Germany, or to recover them from abroad, respectively. Measures relating to such efforts (cf. Chapters B 2 and B 3) must be coupled with incentives in order for international companies to become active in the field of cutting-edge technologies in Germany.

A 6 ELECTROMOBILITY: SOME ACHIEVEMENTS, AND A LOT MORE TO DO

The development of the transport sector towards more environmentally friendly electromobility is regarded as crucial for the sustainability of future energy systems. Since 2009, stakeholders from politics and industry have significantly increased their efforts to promote electromobility. The aim is to develop Germany as the lead market and lead supplier for electromobility. However, at this point in time, it is not possible to conclusively evaluate the effectiveness of research funding programmes.

In recent years, efforts to introduce electromobility have been focussed on battery-powered vehicles. In addition to high-performance batteries, fuel cells could also be established as a propulsion technology for electric motors. Research funding policies should not discriminate between research in the fields of high-performance batteries and fuel cells. Existing programmes should be reviewed for effectiveness and future potential in order to decide how built-up expertise can be retained in Germany and how a market launch may be successfully supported. Electromobility also represents an important field of application for ICT. A close integration of research programs on electromobility and ICT should be conducted as part of the Federal Government's Digital Agenda.

The Renewable Energy Sources Act (EEG) is one of the key instruments of German climate and energy policy. Yet, with the European emissions trading system (EU ETS) in place, which defines a fixed ceiling for CO₂ emissions across European energy-intensive industries, the EEG does not lead to more climate protection, but merely induces additional cost. Since the argument of climate protection does not qualify, the question arises whether the EEG does at least stimulate innovation. However, empirical studies do not find a measurable impact of the EEG on innovation.

In the view of the Expert Commission, a continuation of the EEG can therefore not be justified by appealing to climate protection or positive innovation effects.

CORE TOPICS

RESEARCH AND INNOVATION IN UNIVERSITY MEDICINE

The importance of medical research as a source of innovation continues to grow. What is more, the development of healthcare services in Germany largely depends on medical research. Therefore, research and innovation policies need to place special emphasis on this area. Against this background, the Expert Commission recommends the following:

- Decisions on the establishment and institutional design of additional German Centres for Health Research (DZG) should only be made after the existing centres have been evaluated.
- The bearing of the university hospitals' systemic additional expenses should be balanced out. As these expenses can be partially allocated to patient care and partially to research and training, it is disproportionate to burden solely the health insurance companies.
- The interconnection of basic research and clinical research needs to be advanced further. Geographic concentration of basic research, clinical research and healthcare services should be promoted. Other stakeholders from the health sector should also be included, such as non-university research institutions and private enterprises.
- Research funding allocated to university medicine should be concentrated even further on those locations in Germany that are particularly strong in performance.
- The Coordinating Centres for Clinical Trials (KKS) and the Clinical Study Centres should be developed according to needs. These facilities should not enter into price competition with international institutions, but rather secure a high quality of clinical studies.
- The locations for university medicine should jointly phrase a code of conduct in order to avoid a conflict of interest when cooperating with businesses. Cooperation projects should be communicated as transparently as possible.
- The Federal and *Länder* governments should develop an action plan for the utilisation of large, complex amounts of data in medical research. Such an action plan should be integrated into the Digital Agenda scheduled by the Federal Government.
- Tertiary education students with an interest in research must be given the chance to specialise in research topics at an early stage. MD/PhD degree programmes should be expanded further.

- Physicians engaged in research should be provided with additional rotation positions and fixed time frames for research. Research capacities should no longer be employed for compensating bottlenecks in healthcare services.
- Young physicians with an interest in research should be provided with leeway for independent research. This can be achieved by expanding support and grant programmes.
- Remuneration of physicians engaged in research should be brought more into line with the level of remuneration received by physicians engaged in healthcare activities. The current pay gap reduces the attractiveness of careers in medical research at universities.

B 2 INTERNATIONAL MOBILITY OF SCIENTISTS AND INVENTORS AND ITS IMPACT ON INNOVATION

Overall, Germany has a rather poor balance as regards the international mobility of scientists and inventors. Too few of the best researchers stay in Germany or return to Germany, respectively. With regard to inventors – as measured by patent holders – Germany has a moderate emigration rate and a somewhat larger immigration rate. A particular problem is that the international mobility of inventors reinforces the existing R&D specialisation profile of Germany, i.e. it strengthens the strong fields and weakens the weak fields, such as ICT. The Expert Commission thus recommends the following:

- For attracting top scientists, the excellence of the national research system is decisive. Thus, to increase the competitiveness of the top segment of the German research system, a very good basic funding and excellent opportunities for project financing must be guaranteed. At the same time, research institutions in the top segment need more autonomy to be able to experiment with new staffing or budgetary structures.
- Germany should increase its efforts to attract international talent to Germany and to keep the best researchers in the country. In particular, this applies to the best international young researchers in the doctoral or post-doctoral phase.
- To facilitate the employment of foreign graduate students within the framework of the existing tariff structure, the minimum income threshold that has to be met to be eligible for a residence permit in accordance with §20 of the Residence Act (*AufenthG*) should be reduced.
- R&I policymakers and research institutions should aim at attracting top German researchers and inventors working abroad to return to Germany. Additional opportunities should be created to use “pooled appointments”, particularly in strategically important research areas and future core fields.
- Existing returnee programmes for German researchers abroad should be evaluated and should be focussed more on attracting the best researchers to return.
- In addition to fostering excellent research conditions, individual conditions for international mobility of foreign researchers should be improved. In this context, “dual career” issues are increasingly important and should be addressed in the context of visa regulations and when recruiting top foreign talent. Last but not least, the compatibility of European social security systems for researchers and inventors should be improved.

Information and communication technology (ICT) plays a pivotal role in the innovation system. As well as its pronounced research intensity, this sector is also characterised by a strong innovation dynamic. Due to its close links with other key areas of industry, ICT is particularly important for Germany's national economy. Therefore, the highest priority must be given to the future development of ICT and its economic and societal benefits. Against this background, the Expert Commission recommends the following:

- In the context of developing the Digital Agenda, the public sector should focus on specific fields of ICT application that are closely related to both the Federal Government's requirement areas as specified in the High-Tech Strategy, and the EU Framework Programme Horizon 2020. These fields of application include intelligent grids in the areas of mobility, healthcare services, energy and e-government, but also the digitalisation of production systems and value chains.
- Innovations in the field of ICT are primarily advanced through business start-ups and international growth strategies of young businesses. New enterprises and international growth should be promoted by means of suitable instruments for innovation and growth financing. This will ensure that, in future, strong German companies will be represented on the international ICT growth markets.
- To an increasing extent, business success in ICT is dependent on system standards and standard-essential patents. German companies and research institutions should exert influence on important international standards. In order to achieve this, the strategic monitoring of standards and active, coordinated participation in important international standardisation procedures are prerequisites.
- The Federal Government should commit to the creation of a unified single European regulatory framework for cloud computing without restricting the flexibility of European companies.
- A systematic evaluation should be conducted to assess whether EU and Federal Government funding resources in the field of ICT actually improve the competitive position of the ICT sector on a sustainable basis.
- Research-intensive SMEs in particular would benefit from R&D tax credits. As these businesses play a key role in ICT, the introduction of tax credits is considered essential.

THE ROLE OF WOMEN IN THE INNOVATION PROCESS

Women are underrepresented in the German innovation system. Compared with men, women are less often enrolled in STEM (Science, Technology, Engineering, and Mathematics) degree courses and are less active in the field of research and development. This imbalance is particularly pronounced at executive levels of industry and research. Considerable innovation potential is thus squandered; innovation potential that Germany in particular depends on as an innovation-based country. Especially in light of the shortages of skilled labour, Germany can no longer afford to underexploit the potential of well-educated women. What is more, greater participation of women in the innovation system would lead to greater diversity in research and management teams, thereby increasing the innovative capacity of Germany as a location.

Against this background, the Expert Commission calls for action in the following areas:

- Women’s and girls’ interest in and enthusiasm for natural sciences should be fostered to a greater extent than has been the case in the past. In this regard, it is mandatory for the public sector to provide sufficient resources for high-quality teaching in STEM subjects.
- To facilitate the combination of working and family life, the expansion of childcare facilities, and day schools in particular, should be advanced swiftly. Tax regulations (e.g. *Ehegattensplitting*) or childcare benefit regulations that provide incentives for well-trained women to exit their working life must be eliminated.
- As part of its coalition agreement, the Federal Government agreed on introducing a gender quota of 30 percent for non-executive boards of fully co-determined, listed business enterprises. The Expert Commission welcomes this initiative. However, to ensure that the quota and target agreements are met, it is crucial to establish clearly defined sanctions in the case of failure to achieve these goals.
- The proportion of women in executive roles should also be increased in the public administration sector.
- In addition to increasing the representation of women on non-executive boards, the representation of women on executive boards must also be addressed. The Corporate Governance Code should be employed to effectively increase the proportion of women on executive boards, as means of legal implementation are lacking in this area.

Contact and further information

Coordination office of the Commission of Experts
for Research and Innovation (EFI)

Pariser Platz 6

D-10117 Berlin

Phone: +49 (0) 30 32 29 82 564

Fax: +49 (0) 30 32 29 82 569

E-Mail: kontakt@e-fi.de

www.e-fi.de

