HIGHTECH FORUM

Open Science and Innovation

A discussion paper from the High-Tech Forum*

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The leading members are responsible for the content: Prof. Dr. Dr. Andreas Barner, Prof. Dr. Katharina Hölzle, Prof. Dr. Hanna Krasnova and Prof. Johannes Vogel Ph.D.

HIGHTECH STRATEGIE 2025
Köpfe. Kompetenzen. Innovationen.

1 Change for an open culture of science and innovation

The number of researchers has never been greater than it is today. There have never been more scientific publications and the trend is rising.[1,2] Many scientific findings, however, are disregarded and remain unexploited for society.[3,4] There are many reasons for this: Databases and research results are not accessible or not prepared for socially relevant reuse; knowledge often remains hidden behind (pay)walls and fundamentally open management of knowledge is neither promoted nor rewarded in scientific practice.[5] In addition, collaborations, transfer and spin-off activities frequently fail due to different interests in protection, legal uncertainties or lack of a suitable environment.

At the same time, pressure on the international community to act is increasing. On the one hand, complex knowledge and innovations for coping with acute global crises must be available in the shortest time possible, such as for the COVID-19 pandemic.[6] On the other hand, a large number of innovations are necessary to meet the challenges facing society. Promoting the transfer of ideas, knowledge and technology is therefore an important goal of the High-Tech Strategy 2025[7] and a requirement for the future innovation capacity and competitiveness of Germany and Europe. Various approaches to open science and innovation already exist in our society and have shown their potential, for example in dealing with the COVID-19 pandemic, thus allowing them to be used as a blueprint for opening up processes in science and innovation:[8] International collaboration, early and accessible publication of research results (preprints, open access) and the sharing of research data (open data) help to understand the virus and its consequences as quickly as possible and to develop therapies and vaccines in the long term.[9] Intensive scientific communication helps to address people's questions and concerns and create understanding for the measures taken. The task now is to transfer the operating principles of a culture of openness into everyday practice so that we can address the grand societal challenges of our time. These include, for example, better linking global environmental data to combat climate change, the participation of citizens in the redesign of their living environment or the efficient exchange of machinery, soil and weather data in agriculture.

This paper is the High-Tech Forum's way of emphasizing the opportunities that strategically opening up will offer for the German innovation system. The data pools from science, business and public administration should be made much more usable for society than has been the case so far. And conversely, the data from business and society could be made accessible for research. Involving different sources of knowledge for this is just as important as a sustainable cultural change towards openness with new skills and tasks in science. A new way of conducting science must make use of the digital opportunities for good scientific practice, employing them to strengthen the quality, efficient use of results, innovation orientation, transparency and inclusive accessibility. The High-Tech Forum recommends leveraging this potential and setting appropriate incentives and framework conditions, particularly in funding policy and in the system of scientific careers and reputation. The requirements for this are a nationally coordinated approach to promoting open science and innovation as well as international networking and research partnerships.

Opening up is not an end in itself. It serves to leverage value creation potential, enable social benefit and strengthen confidence in science and innovation. The aim is expressly not to disclose all innovation processes, but to strengthen open collaboration between science, business and civil society. Boundaries and risks must be considered. The principles of intellectual property protection and individual self-determination must be respected, and the one-way knowledge drain in international competition must be prevented. This forms the basis of opening up strategically (see box below): as open as possible, as protected as necessary.

In the following sections, the High-Tech Forum addresses the relevant fields of action and makes (short and medium-term) recommendations on how change may succeed with the help of research and innovation funding (section 2), the science system (section 3) and politics (section 4).

Opening up strategically: New potential at the interfaces between open science and innovation

The terms "open science" and "open innovation" have different origins.[10] Open science describes the effort to enable free access to scientific results, thus making them reusable (utilization aspect) and reproducible (quality aspect), for example by means of open data (free access to data), open access (free access to publications)[11] or the application of FAIR principles[12]. Digital change not only increases the amount of data available and the speed at which data is generated in science, business and society alike. Digital technologies also enable different stakeholders to participate more widely in knowledge production. Open innovation approaches describe the purposeful (partial) opening up of innovation processes and entrepreneurial R&D activities (innovation as an open research and development process).[13] External sources of innovation are incorporated in the process (e.g. via crowdsourcing, outside-in processes) and own ideas are offered on the market (e.g. via licenses; inside-out processes). The interfaces between both approaches can be found where research results are applied for social benefit and where a culture of collaboration is practiced. The High-Tech Forum's recommendations concentrate on these interfaces and are based on a strategic understanding of openness. Strategically opening up thus means consciously considering and purposefully planning the integration of outflow of knowledge for parts of the value creation process in order to leverage potential. It takes into account and explores both opportunities and potential as well as boundaries and protected areas.

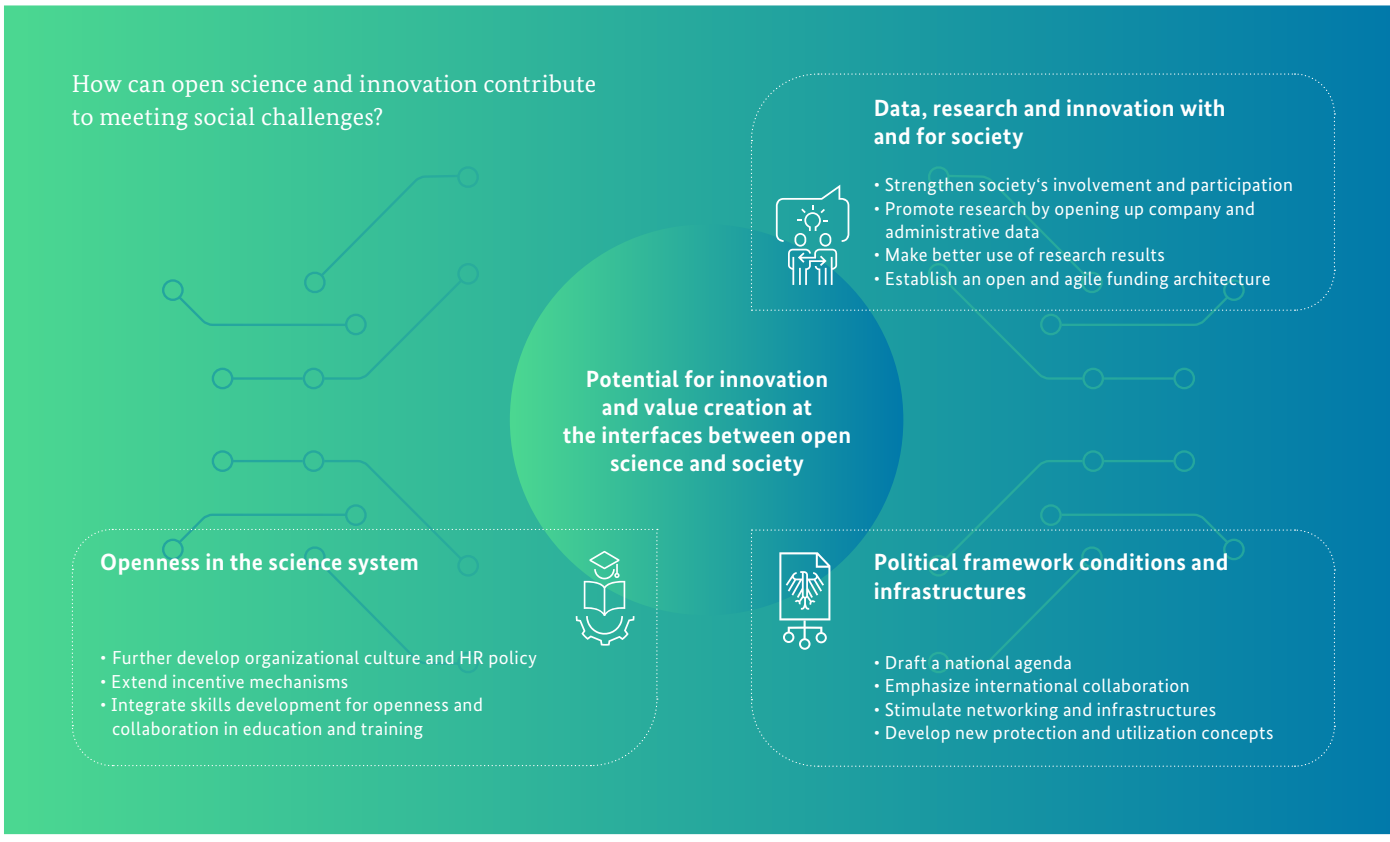

Fig.: Overview of this discussion paper's recommendations.

2 Data, research and innovation with and for society

Open science and innovation improve the availability of knowledge, but at the same time they also enable social participation.[14] Broad participation of society in the innovation process and a mutual exchange of knowledge should increasingly be promoted politically to co-develop new solutions and to increase confidence in a democratic knowledge society.

Strengthen society's involvement and participation:
For some years, citizens' interest and participation in research and innovation has been growing.[15] A wide range of different approaches make it possible to include citizens' knowledge and perspectives:[16] citizens' dialogues, co-creation (e.g. hackathons), crowd science[17], participatory or transdisciplinary research and citizen science. Among other things, the aims are a better user-centered approach and scientific literacy as well as strengthening of the citizens' political commitment.[18] So far, approaches to participation can be found in various forms, for example in participatory urban design (e.g. "Open LabNet"[19] in Halle), in nature conservation projects (e.g. "BerlinAir NO2-Atlas"[20]), in health studies (e.g. "Migraine radar"[21]) and in pandemic research (e.g. "Corona Archive"[22]).

The participation of society in science and innovation is already being promoted politically in Germany and the EU.[23] The High-Tech Forum recommends that participation in the German research system should be further promoted, evaluated and sufficiently funded.

The understanding of participation must go well beyond scientific communication. Rather, it must be promoted at all levels of knowledge production in order to open up the potential for value creation: by identifying research questions, designing the research process, analysis, and developing innovation and business models (citizen innovation, e.g. the "Civic Innovation Challenge" of the National Science Foundation[24]). This could be implemented by integrating the various groups in calls for proposals, e.g. in the case of interdisciplinary research on artificial intelligence (AI).

Participation can work via stronger collaboration between science and schools (e.g. "plastic pirates[25]" or "ring-a-scientist[26]"), via events with a high public profile or via the creation of dialogue-oriented spaces in which participatory innovation formats can be tested, e.g. in collaboration with civil society platforms, science shops, libraries and museums but also with doctors' surgeries, associations or the media. Digital communication and platforms are promising for opening up more widely and easier networking between citizens and researchers. However, they have to be implemented with a view to non-discriminatory access and clear rules on the handling of personal data (e.g. in the medical and health sector or when working with students).

The participation formats and research approaches must be further developed and continuously improved. To this end, accompanying research and evaluation must be promoted in order to understand to what extent more active participation can contribute to innovative and needs-based solutions, and strengthen confidence in science and empowerment. In this sense, it is also important to involve citizens or other civil-society stakeholders more frequently in evaluations and monitoring bodies (e.g. advisory boards) and accordingly to reopen the debate on assessment standards. Research publications should identify the contribution of social stakeholders (diversity criterion) to increase the visibility and appreciation of the (transfer) performance of participatory formats. This then also enables database queries, e.g. with regard to evaluations.

Strategically opening up research and innovation also requires that questions of data quality and ethics be discussed in a context-specific manner and that new standards be defined if necessary. In addition, practice-oriented advisory services (e.g. at universities or chambers of industry and commerce) and new communication channels should be established to meet the need for advice on implementing participatory research and innovation projects and to share best practices (e.g. SciStarter[27]).

Promote research by opening up company and administrative data: Companies and public authorities possess large quantities of data that are extremely valuable for research, e.g. mobility data, environmental data or data from agriculture and forestry for climate change research. Particularly with regard to the analysis and collection of big data and related innovations, individual companies have strong research approaches and even advantages over public science. We should not complain about this but make productive use of it. To make these data treasures accessible for research purposes, however, we need to overcome a number of hurdles. For example, there is a lack of incentives, infrastructures and knowledge in the scientific community, business and public institutions for the utilization of these data.

In these digitalized times, data is a key competitive factor for companies and is increasingly seen as an intangible asset.[28] As a result, economic and also legal reasons often oppose the opening up and transfer of such data. The recommendations of the Data Ethics Commission regarding controlled opening up of personal and non-personal data for research purposes, weighing up the different interests, are highly relevant here (e.g. development of anonymization standards[29]).

In Germany, the potential of open data is still used and communicated too little. In addition to knowledge gains in science, companies also have great opportunities which are the result of private-public cooperation projects. One example of this is the Structural Genomics Consortium[30] in which international companies and research establishments share information and cooperate in new areas of human biology and drug research. There are a number of cooperation projects which are supported by science and companies – yet it is striking that they are frequently initiated in the Anglo-Saxon region and then partners from Germany join in. One goal ought to be that of also launching such initiatives from Germany. The High-Tech Forum addressed the structure and framework conditions of new, data-based business models in the discussion paper "The Future of Value Creation".[31]

Research and innovation funding should support the establishment of new partnerships and protected (digital and physical) spaces where private and public sector stakeholders can open up their databases while at the same time respecting applicable data protection law, including in international research contexts. The use of intermediaries[29,32], e.g. public data trusts or data cooperatives, should be examined and, if necessary, tested. These activities should be supported (e.g. via funding programs or licensing models) to incentivize the processing and controlled opening up of appropriate databases in companies. The state should lead the way here as a model for a culture and practice of controlled opening up. Relevant data should be published across all federal states and in compliance with data protection regulations via the "govdata.de"[33] portal. The High-Tech Forum also recommends establishing government data donations as part of research promotion (instead of exclusively financial funding).

Make better use of research results: Compared to leading innovation locations, Germany often fails to translate the excellent basic research into an economic use. The "Valley of Death"[34] – the gap between publicly funded basic research and economic use – is one of the central structural obstacles to successful technology transfer. The low availability of venture capital for science-based start-ups, but also a rigid legal framework and an inadequate start-up culture, are obstacles to knowledge and technology transfer.[35]

The division of labor between university and non-university research establishments (including basic and applied research) is considered a strength of the German innovation system. In the context of a transfer value creation chain, an independent body may identify where more openness and transfer would be needed. To this end, it is necessary to identify concrete transfer points and cooperation models in order to improve technology transfer and the spin-off rate in the German innovation system.

With a view to a more efficient alliance and a stronger exchange between business and academia, we should develop new incentives for cooperation between universities and companies which leverage state-funded programs with a clear application orientation. The percentage of third-party funding for research projects from the commercial sector is in fact falling continuously at universities (26.2 percent, 2006; 18.6 percent, 2018).[36]

In addition, employees in universities and research establishments should be enabled – at least temporarily – to use part of their working time for start-up activities and thus further develop or commercialize their research results (cf. USA[37]). To implement higher spin-off rates, these would have to be weighted more heavily as success indicators and stronger financial incentives would have to be provided.

Finally, instruments for knowledge and technology transfer that already exist should be applied on a broad basis accor-

ding to needs. This includes the implementation of living or open innovation labs as experimental spaces for business and research partners, where prototypes and standardized methods can be co-developed and tested (e.g. smart city applications). Transfer centers and transfer scouts should be evaluated according to whether they, as intermediaries and regional experts, network the relevant competences, infrastructures and sources of capital with each other (e.g. "Innovation Hub 13"[38]).

Establish an open and agile funding architecture: Public innovation funding and its formats frequently target specific social challenges already. This is to be welcomed in terms of research relevance and benefit to society. The path to problem solving, however, must be more dynamic, i.e. more agile, as already recommended by the High-Tech Forum.[39]

To encourage more openness and social participation in research and innovation, appropriate requirements and criteria in the funding programs and the award process need to take these aspects into account (e.g. consideration of the increased effort required to coordinate different stakeholders or by integrating open innovation in science modules[40]). The utilization of non-academic data from business and public administration should be explicitly addressed in funding programs and supported with resources.

In addition, the possibility of dynamic redirection in the event of new findings or even in the event of failure and a culture of error in research funding should be more widely accepted and acknowledged. This requires freedom, also with collaborations, and trial phases for unconventional and open-ended research ideas (e.g. the Volkswagen Foundation's funding program "Experiment! – In search of bold research ideas"[41] or the Federal Government's "WirVsVirus" hackathon[42]). Experience with these practical examples or with failed projects should be processed and possibly transferred to other public funding programs.

A funding logic which relies on iteration, testing and readjustment further requires appropriate legal and financial framework conditions. The funding and budgetary law of the research funders should be examined and further developed to this effect. This could be done, for example, along a selected funding guideline using a regulatory sandbox [43].

3 Openness in the science system

Existing structures of the German science system often stand in the way of an open approach to data, research results and partners, e.g. disciplinary boundaries, scientific success criteria and rigid career paths. In future, organizational structures and human resources policy must enable and promote greater openness and interdisciplinary collaboration. Activities in research and teaching that contribute to greater participation and opening up to the outside world should be perceived positively and encouraged. This also means that these activities and skills are considered in the system of scientific careers and reputations. Ultimately, we need to lay the foundations for a more open culture of knowledge, innovation and data in education and training.

Further develop organizational culture and HR policy in science: At universities and science organizations, the employment structures, scientific success models and career paths are not conducive to open data handling or cross-departmental collaboration. Internal competitive pressure, fixed-term employment contracts and thus high staff turnover, and uncertainties regarding quality assurance of the data as well as data protection concerns were identified as obstacles to transparency, openness and reuse of data.[44,45,46]

For an open culture of science and innovation, there must be a change in appreciation within science and its organizations with regard to opening up and transfer. Up to now, basic research has counted for more than applied research in the scientific reputation system, publications for more than a proof of concept of results or startup experience. What is essential for a cultural change in the relevant scientific establishments is the commitment and dedication of the management levels (project leads, tenured professors, executive committees) to promote these activities and to set an example.

In principle, scientific careers should be made more flexible and open, both between scientific disciplines and in exchange with business, politics, public administration and media. This can be encouraged, for example, by establishing networks, mentoring programs or specific agreements between individual organizations. Appointment criteria, the German law on fixed-term employment contracts in academia and funding project structures should consider and appreciate such interdisciplinary experience so that ideas can be pursued beyond traditional paths. The Mercator Science-Policy Fellowship Program[47] or the Journalist in Residence Fellowship of the Berlin Social Science Center[48] are examples of exchange programs.

The High-Tech Forum also recommends the creation of new job profiles in science between research and administration which promote the curation (as a requirement for re-use) and sharing of data and open collaboration formats. It would be conceivable here to set up intermediaries or catalysts, e.g. open data coordinators, data infrastructure managers or process supervisors for co-creation, who would provide expert services and assistance for researchers. For example, by calling for and funding the setting up of such positions, they could be institutionally anchored in the universities. It would be possible to form "data tandems" for faster transfer by creating complimentary positions on the company side.

The new profiles have to be professionalized and strengthened by appropriate remuneration, human resources development, training opportunities and anchoring in the organizational structure (e.g. in libraries).

Extend incentive structures in science: Many scientists are already engaged in exchange and dialogue with stakeholders from (civil) society and business. Current incentive systems in the scientific community, however, do not adequately identify, promote and reward such commitment.

The High-Tech Forum therefore recommends introducing alternative indicators and considering appropriate activities (such as publications in freely accessible formats, publication of data sets, replication studies) in framework agreements, such as the Pact for Research and Innovation and the state laws on higher education, to acknowledge this commitment and make it measurable.[49,50] The established indicators should be further developed to take account of openness in all phases of research. In particular, there should be recognition for achievements in science communication, active involvement of society in research and teaching, technology and knowledge transfer. Such indicators are important, particularly in performance appraisals of scientists and performance-related pay but also in university appointment procedures and for assessing the scientific excellence of universities. This would have to be linked to offerings for further education, mentoring, networking and financial support (such as in the Wikimedia Fellows Program promoting Free Knowledge[51] or in the Lab for Open Innovation in Science of the Ludwig Boltzmann Society[52]).

The positive perception and acknowledgement of open science can also be promoted by awarding distinctions and prizes for exemplary research institutions and projects (e.g. prize for co-creative research).

Integrate skills development for openness and collaboration in education and training: A culture of open science and innovation needs open people and mindsets. At present, however, the practices of open science and participatory research are insufficiently communicated in degree courses and in scientific qualification programs. They should be offered as educational modules in master's degrees and form part of continuing education and training courses in science. They should also be subject to continuous further development.

The priority areas of data literacy, communication skills and entrepreneurship must be integrated into education to a much greater extent than it is currently the case.[53]

Universities should develop more curriculum-based modules in which students, particularly those from research-oriented courses, can acquire and try out the skills of interdisciplinary exchange and communication with stakeholders from business and society (e.g. innovation competitions).

4 Political framework conditions and infrastructures for openness, networking and utilization

A culture of open science and innovation needs two things: a coordinated national program to promote open science and innovation, and trustworthy international (research) collaboration. To develop global solutions, Germany should assume its responsibility and provide the necessary political framework, legal certainty and technical infrastructures. They are the basis of innovation ecosystem with which data and research processes (and not just publications or patents as end products) can be made available and brought together. A broader understanding of transfer also requires innovative utilization strategies and new ways of making ideas available while protecting intellectual property.

Draft a national agenda for promoting open science and innovation: The High-Tech Forum recommends that innovation policymakers develop a national, interministerial agenda to promote and disseminate open science and innovation. Some countries, such as France[54], the Netherlands[55] or Finland[56], have already established national strategies or national coordinators for open science or are in the process of doing so (e.g. Austria[57]). To achieve the goals of the High-Tech Strategy 2025, this agenda should combine open science and open innovation. Scientific institutions, companies, public administration, politics and society should be jointly involved in their role as producers of data, knowledge and innovation. The key points could be measures for further developing an agile funding architecture, strengthening culture and competencies for open science and innovation, networking and developing innovation ecosystems, and removing obstacles to cooperation, e.g. by revising the legal framework conditions and developing quality standards.

In the interests of policy coherence, care must be taken to interlink the Federal Government's new data strategy[58], the Federal Ministry of Education and Research's open access strategy[59] and the digitalization plan for the Federal Administration of the Federal Ministry of the Interior[60], to disclose conflicting aims and avoid contradictions. Only a coordinated strategic and interministerial approach with a coherent set of targets, measures and responsibilities will increase the impact of the various initiatives and visibility - also in the European area.

A clear program also requires central monitoring to ensure target achievement and coordinated networking of the stakeholders involved. It should be examined how these tasks can be organized in a meaningful way.

Emphasize international collaboration: Open science and innovation should be understood as elements of foreign policy on innovation. Basic research, as the basis for subsequent applications and innovations, is well positioned and financed in Germany and Europe. The published results are usually available to users as a public good regardless of nationality and location. These standards should be strengthened in a global consensus, e.g. within the framework of the current UNESCO process[61], so that there are no distortions of competition due to different degrees of openness in international flows of knowledge. Here, Europe could become a driving force for international standards of open science and innovation without giving up its own strengths in international competition. Against the background of geopolitical and technological competition, consideration should be given to how European interests can be better protected and represented internationally.

The High-Tech Forum basically emphasizes the importance of cross-border, international cooperation for joint research data management (including the confidential storage and secure retrieval of data) and innovation development.

Joint research successes (e.g. on the Sustainable Development Goals[62]), fairness and orientation towards the common good can only be achieved on the basis of a culture of openness and with international partnerships – including with countries with less well-equipped resources and infrastructures.[63] Knowledge and technology partnerships with the global South in particular should be strengthened.

Stimulate networking and infrastructures: German innovation policy should advocate stronger networking of data infrastructures and data strategies at national and international level. A common European research and data space[64,65] is a requirement for the emergence of new knowledge and the resulting value creation benefits for Europe. The synergies and interfaces of the National Research Data Infrastructure (NFDI)[66] and the European Open Science Cloud (EOSC) with the GAIA-X data infrastructure project should be appropriately examined and used so that it is possible to develop and scale innovations from Europe.

Germany should be involved in these projects and agreements which are important for research policy on an equal footing. In addition to the discussion on technical standards, the High-Tech Forum recommends that legal issues and ethical standards for the responsible use of research data should also be discussed. This includes data protection issues in line with the requirements of the European Data Protection Basic Regulation, IT security, different utilization interests and equal access to research data and processes. Among other things, we should examine the understanding of open research data and a mutual exchange between different regions of the world (e.g. between Germany and China).

In future at universities and research establishments, we must place even greater value on building up and maintaining data infrastructures. At present, it is particularly difficult to finance the storage and curation of big data, which is created during research projects. Infrastructure projects must be set up on a long-term basis or, if evaluated well, be continued, independently of fixed-term project funds. This can be done, for example, via designated cost centers or fixed research costs.

Finally, it is also essential to promote the necessary technology development for implementation of the FAIR principles[11], in particular the findability, accessibility, interoperability and re-usability of data.

Develop new protection and utilization concepts: Existing ways of protecting intellectual property and utilizing innovations do not consider participatory and open research and development. Questions arise, such as "Where does knowledge worthy of protection emerge in participatory processes and who is responsible for it?" or "How can we design proprietary business models based on open research?"

Antitrust and regulatory questions often arise in cross-sectoral research and innovation consortia when involving business partners. Furthermore, in business practice, concerns about industrial property rights and possible data misuse or violations of regulations prevent the sharing of data and opening up of innovation projects. Here, there is a need to better address uncertainties regarding legal responsibility and proprietary rights. One possibility would be to set up advice centers to pool legal expertise and develop case studies for typical problems. Greater freedom should also be granted in community and collaborative projects when sharing industrial property rights among partners. Until now, the rights to utilize results have been shared equally between all partners, making it difficult to set up a company or commercialize the research results.

At university and non-university research establishments, implementing the non-profit and state aid law also sets strict limits when assigning infrastructures and protected knowledge. To a certain extent, this conflicts with opening up and transfer. For spin-offs and start-ups, the demand for customary market prices for the assignment constitutes a barrier, particularly in the initial phase when work on prototypes is often still in progress. Success-based and longer-term remuneration opens up better development opportunities for spin-offs. Public institutions would participate in business success in the long term but without restricting start-ups with short-term costs.

The patent rights system should be reviewed with regard to the following aspects: Data protection problems should be prevented and the introduction of a "pre-patent" (preliminary stage to the actual patent) should be examined. The process of patent application procedures should be simplified, for example by providing different ways of applying for a patent, a more user-friendly application procedure, and accelerated procedures.

5 Annex

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About this discussion paper

The content of the present discussion paper was deliberated and commented on at the meeting of the High-Tech Forum on 30 September 2020. It does not constitute a unanimous decision of the committee.

The positions presented in this discussion paper do not necessarily reflect the views of the Federal Government.

This discussion paper was produced by the High-Tech Forum team appointed to work on the topic "Open Science and Innovation". Its purpose is to advise the Federal Government on the implementation of the High-Tech Strategy 2025. The team comprises the following members: Prof. Dr. Dr. Andreas Barner, Prof. Dr. Katharina Hölzle, Prof. Dr. Hanna Krasnova and Prof. Johannes Vogel Ph.D.

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Fraunhofer-Forum Berlin
Anna-Louisa-Karsch-Strasse 2, 10178 Berlin
www.hightech-forum.de

Dr. Franziska Engels
Project Manager
Secretariat of the High-Tech Forum
engels@hightech-forum.de
T. +49 30 688 3759 1617

Contact | Press

Valerie Ponell
PR and Communications Manager
ponell@hightech-forum.de
T. +49 30 688 3759 1621

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