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REPORT ON RESEARCH,
INNOVATION AND TECHNOLOGICAL
PERFORMANCE IN GERMANY

COMMISSION OF EXPERTS
FOR RESEARCH
AND INNOVATION



REPORT

2023 2024 2025

2026 2027 2028

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AND INNOVATION

EFI

REPORT
2023

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Foreword

The new Federal Government will have been in office for more than a year on the day this Annual Report is handed over to the Federal Chancellor. The governing parties have formulated highly ambitious goals in the coalition agreement with their announcements on research and innovation policy (R&I policy). The key projects include: embedding the New Mission Orientation as an innovative interdepartmental policy approach, implementing the comprehensive Future Strategy for Research and Innovation (Zukunftsstrategie Forschung und Innovation), establishing a German Agency for Transfer and Innovation (Deutsche Agentur für Transfer und Innovation, DATI), improving the legal framework conditions for SPRIND. The coalition agreement, even if it has not yet been fully formulated, contains important and appropriate proposals for reforming R&I policy and focusing it on the grand societal challenges and the associated transformations.

After the ambitious start, a certain disillusionment has descended now, more than a year later. For example, DATI still lacks a viable concept and SPRIND is still awaiting the necessary room to manoeuvre. Although the Future Strategy for Research and Innovation contains essential elements of the New Mission Orientation, it only hints at an interdepartmental governance structure, which is so important for the implementation of missions. It also remains superficial when it comes to defining the content of the missions. Further strategies with R&I policy relevance were conceptualized and adopted, from the detailed Startup Strategy to the Digital Strategy, which is more reminiscent of 'old wine in new bottles'. Enduring issues such as the development and use of digital technologies, overcoming skilled labour shortages and establishing suitable framework conditions for radical and transformative innovations round off the picture. There is no doubt that these problems are partly due to the failures of previous governments.

To finally make noteworthy progress on this front, the Federal Government must now usher in a new era of R&I policy characterized by a mission-oriented alignment of strategies with R&I policy relevance, which are implemented based on new, interdepartmental governance structures. The Future Strategy for Research and Innovation serves as an overarching and guiding strategy. Under this banner, the various strategies and measures are to be interlinked in terms of content and structure and filled with life.

The successful implementation of mission orientation in R&I policy requires pronounced strategic steering at the highest level as well as clear commitments and responsibilities for the transformations and missions. Major success can only be achieved by consistently turning away from silo thinking, acting in a coordinated manner across ministries along roadmaps and skilfully integrating all societal actors in the implementation. At present, these conditions are only met in a few cases.

In view of the grand societal challenges, a spirit of optimism across society is urgently needed. However, German R&I policy has not yet triggered this spirit of optimism. The Commission of Experts is fully aware that the Covid-19 crisis and the war in Ukraine have changed priorities and that financial margins are diminishing. Nevertheless, long-term perspectives must not be sacrificed to short-term crisis management, as necessary as the latter may be.

The Commission of Experts therefore urges the Federal Government to send a clear signal to citizens by means of an active mission-oriented R&I policy: for the transformations to succeed, the business sector and society must embark on fundamentally new paths and develop radically fresh solutions. And the Federal Government itself must also rise to the challenges, open itself up to new thinking and innovative solutions, new objectives and strategies as well as new forms of action and cooperation. It is also called upon to fundamentally reform its own actions, its structures and its processes. It will be impossible to solve these long-term tasks with a 'business as usual' approach.

The Commission of Experts' Annual Report 2023 contains several proposals for new governance structures. These proposals can support the Federal Government in initiating trend-setting developments in the upcoming transformations, in providing the necessary support for transformative processes and in coordinating the numerous interdependent measures and activities.

And this must not be delayed any longer!

Berlin, 15 February 2023



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EXECUTIVE SUMMARY

Executive Summary

A CURRENT DEVELOPMENTS AND CHALLENGES

A0 R&I Policy at a Turning Point in History

In its 2021 and 2022 reports, the Commission of Experts emphatically emphasized the crucial importance of research and innovation (R&I) for mastering the major transformations, such as the energy transition, the mobility transition and the digitalization of the economy and society. The complex R&I policy tasks associated with these transformations are further complicated by the Covid-19 crisis and the war in Ukraine. Germany's scope for action to support and orchestrate the forthcoming major transformations with R&I policy and to actively tackle them with the help of innovative solutions is being massively restricted as a result. Whether the Federal Government will succeed in mastering the current crises and transformation challenges also depends on whether agile policy action is enabled by means of adequate decision-making processes and governance structures. Equally, German R&I policy requires long-term orientation, strategic planning and clear priorities. A new era is also needed in R&I policy.

A1 Creating Agile Governance Structures

A new, agile policy style and a corresponding governance structure are needed to advance the major transformations swiftly and in a socially acceptable manner, while at the same time safeguarding the competitiveness of the German economy and its companies. Silo mentality within the Federal Government must be overcome and cooperation between the ministries improved. In this context, the Commission of Experts recommends establishing a government committee for innovation and transformation incorporated in the Federal Chancellery. In addition, interdepartmental mission teams should be formed quickly and the ministries involved should be integrated at state secretary level. Moreover, the project-executing agency system should be reformed by bundling R&I programmes mission-related with the respective project-executing agencies and by steering the use of funding in a more outcome-oriented manner.

A2 Tackling the Grand Societal Challenges

In the opinion of the Commission of Experts, the Federal Government should vigorously pursue the policy approach of New Mission Orientation. Within the six missions of the Future Strategy for Research and Innovation, which are very broadly conceived, several action-guiding missions should be agreed upon in each case and underpinned by measurable transformation goals. Roadmaps should be developed for each of these action-guiding missions, which coordinate and structure the activities of the various ministries in terms of content and timing. In light of the war in Ukraine, there is a risk that the goals of energy security and climate protection will be pitted against each other. The Commission of Experts maintains that the expansion of renewable energy and the increase in energy efficiency contribute to both energy security and climate protection in the long term.

A3 Catching Up and Avoiding Technological Gaps

The ongoing transformations will not be mastered without innovative technologies. Key enabling technologies are of particular importance in this context. Germany, and to some extent Europe, are not at the forefront of these technologies in an international comparison. More dynamic developments can be observed especially in Asia. To avoid losing touch in the key enabling technologies, Germany and its European partners must accelerate the development and advancement of the corresponding competencies as well as the regulatory framework and infrastructure. It is also important to reduce dependence on China and to initiate a fundamental reform of digitalization governance in Germany. In parallel, the strict separation of military and civilian research that exists in Germany should be overcome to facilitate synergies.

A4 Removing Barriers to Innovation

The current situation of overlapping crises is putting a strain on many companies and exposing them to high levels of uncertainty. This raises the risk of research-based companies cutting back on longer-term investments in R&I or even withdrawing from the market altogether. The main objective of R&I policy must therefore be to provide effective incentives for the continuation of R&I activities and for the establishment of new innovative companies. At the same time, existing regulations and lengthy administrative procedures prevent and slow down innovation processes. The Federal Government can therefore promote R&I activities not only by providing financial support, but also by improving the framework conditions to create new incentives for innovation, for example in the data economy and in public procurement, and to reduce barriers to innovation.

A5 Securing the Skilled Labour Base

In the years ahead, the pressure to secure the skilled labour base in Germany, already noticeable today, will continue to increase. Due to the demographic ageing of society, the working age population will shrink significantly, meaning that growth- and innovation-impeding shortages of skilled workers are likely to intensify and become more prevalent. It is therefore necessary to make better use of the existing skilled labour base and to attract foreign skilled workers. As a result of the structural change taking place alongside demographic change, increased efforts in education and training are also needed. In addition, the ability to plan the careers of researchers in the doctoral and postdoc phases should be improved.

A6 Key Recommendations for Action

- Establish a government committee for innovation and transformation
- Integrate state secretaries in mission teams
- Reform the project-executing agency system
- Create mission-related roadmaps
- Avoid unintended knowledge outflow to China
- Relaunch governance for administrative digitalization
- Create synergies between military and civilian research
- Make greater use of real-world laboratories and evaluate them systematically
- Set clear rules for data economy
- Improve scientific career planning

B Core Topics 2023

B 1 Innovation in an Ageing Society

Demographic ageing threatens the preservation of Germany's innovation capacity. In the future, it will therefore be of increasing importance that older people can contribute to innovation as employees and through business start-ups. To make the best possible use of the innovation potential of older people, the Commission of Experts recommends that:

- Older employees should be given attractive options for retiring later at their own request.
- The Commission of Experts does not see any particular need for protection when retirees enter a new employment relationship. For this reason, a fixed-term contract without an objective reason should always be an option, even multiple times.
- The initiation and start-up funding of regional and sector-related platforms should be considered to support SMEs in the recruitment of senior experts.
- Older entrepreneurs should be systematically included in existing formats of start-up promotion. Stereotypes of 'young' entrepreneurs should be eliminated when addressing those interested in establishing a business.

Demographic ageing also affects social cohesion in an increasingly digital society, where a minimum level of digital literacy is a prerequisite for social participation. Moreover, the social security systems are confronted with mounting financing problems because of demographic ageing. The Commission of Experts therefore makes the following recommendations:

- The conditions for older people's digital participation must be improved. In addition to expanding the broadband network, systematic measures for increasing the digital competence of older people are of vital importance.
- The digitalization of public services should be actively advanced. This should be combined with comprehensive support services for older users that focus on the attainment of digital skills.
- To optimally leverage digital innovations in the health and care system, professionals working in health and care need basic and job-specific digital competences. Therefore, developments in medical technology should be systematically integrated into the curricula of nursing training.
- The steps adopted in the coalition agreement on innovation-promoting reforms, such as those of the Federal Joint Committee (G-BA), should be implemented without delay.

B 2 Markets for Technology

Technological knowledge is traded on markets for technology in the form of intellectual property rights (IP rights, e.g. patents). Markets for technology enable better exploitation of IP rights and thereby create incentives to invest in research and development. However, the functioning of markets for technology is limited by several obstacles. Actors in markets for technology often find it difficult to find suitable trading partners or to reliably assess the value of an IP right. The Commission of Experts recommends the following measures to leverage the potential of innovation and value creation associated with greater participation in technology trade and improved functioning of markets for technology:

- To reduce search and transaction costs and enable better matches, R&I policy should drive the further development of the patent offices' (German Patent and Trade Mark Office and European Patent Office) public and freely accessible databases, for example with the help of AI-assisted methods.
- In addition, the deal database envisioned in the Federal Government's Startup Strategy should be established at the patent offices.
- The Federal Government should initiate and promote an information campaign to provide potential market participants with more information about these databases.
- To improve transparency about ownership of IP rights and thus reduce search costs for potential buyers, greater incentives should be provided for reporting transfers of ownership centrally and quickly to the German Patent and Trade Mark Office.
- Financial incentives in the form of a reduced renewal fee for patents should be provided for the non-binding declaration of willingness to license.
- Low-threshold information and advisory services are particularly important for small and medium-sized enterprises. Existing initiatives to promote the patenting and exploitation of inventions, such as the support programme WIPANO – Knowledge and Technology Transfer via Patents and Standards, should be continued and expanded.
- To facilitate rapid technology transfer, contractual standards should be established that take into account the interests of all actors involved in technology trade.
- To promote the transfer and economic utilization of research results, technology transfer and exploitation of patented inventions should be further professionalized and made more entrepreneurial and competitive.

B3 German Aerospace Between Old and New Space

Space flight has changed rapidly worldwide in recent decades. Having been mainly state-managed until the 2000s, a strongly private sector driven space economy is currently developing. Still, the state plays an important role – not least because of the high strategic relevance of space flight for the economy and society as well as the preservation of technological sovereignty. However, the space industry in Germany and Europe operates in an environment determined by pronounced national and supranational interests, a complex funding landscape and, in Germany, uncertainty about the future regulatory framework. Given the increasing importance of space flight, the Commission of Experts recommends the following measures:

- The Federal Government must swiftly adopt and implement its new space strategy.
- The Federal Government must create suitable structures for interdepartmental cooperation in the implementation and further development of the space strategy.
- Germany should adopt a national space law that regulates the approval and monitoring of space activities, the registration of space objects, and liability in the event of damage.
- The infrastructure required to implement this space law should be integrated into the German Space Agency. The Space Agency, in turn, should be disaffiliated from the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) and set up as an independent actor.
- Cooperation between civilian and military actors in the provision and operation of space infrastructure should be intensified and synergies created through joint use.
- The Federal Government should consider entering into anchor tenancy contracts for clearly specified but technologically open contracts with companies in the space industry and in coordination with the space agencies.
- Technological sovereignty in the field of space must be thought of in European terms to keep efficiency losses to a minimum.
- The Federal Government should lobby the EU to ensure that the critical space infrastructure used in the European network is effectively protected.
- The possibility of relaxing the principle of geographical return of ESA funds in favour of efficiency criteria should be examined.

A

CURRENT DEVELOPMENTS AND CHALLENGES



A0 R&I Policy at a Turning Point in History

In its 2021 and 2022 reports, the Commission of Experts emphatically emphasized the crucial importance of research and innovation (R&I) for mastering the major transformations. Be it the energy transition, the mobility transition, the digitalization of the economy and society, the transition to organic farming or others, they are all intended to help achieve the major objectives of climate neutrality and sustainability. The fact that Germany as an R&I location, with its internationally top-ranking performance, is well positioned for these tasks was highlighted in the reports, as were the obvious difficulties in aligning R&I activities with the new transformation-oriented challenges. Therefore, it was urged that the style and structure of R&I policy be tailored to the requirements of wide-ranging transformations and radical technological as well as social innovations. To this end, the Commission of Experts considers a new R&I policy approach necessary - a market-oriented version of the New Mission Orientation.¹

As if this R&I policy task were not complex and challenging enough, it is currently further complicated by two major crises: the Covid-19 crisis since 2020 and the war in Ukraine since 2022. Disrupted supply chains and lockdowns, energy crisis, high energy prices and inflation are weighing on the economy and society. Acute economic distress in private households as well as in many companies, especially in energy-intensive industries, were and are to be compensated for in the short term. The immediate support of the economy, the avoidance of a recession, the fight against inflation and measures to alleviate the energy crisis dominate the day-to-day business of economic policy. Long-term issues such as climate change in particular are in danger of slipping to the back of the agenda. Government-funded compensation and support measures for companies and private households are putting further pressure on public budgets, progressively limiting their

financial leeway – today and, because of the accumulated high debts, also in the future. Accordingly, the scope for action to support and orchestrate the upcoming major transformations in R&I policy and to actively tackle them with the help of innovative solutions is becoming increasingly limited.

Strengthening Technological Sovereignty in Times of De-Globalization

For Germany to successfully pursue its transformation objectives, it needs to be in a position of economic strength. However, Germany's successful model of an open, export-oriented economy is coming under increasing pressure. The trend towards de-globalization is being driven by geopolitical polarization, especially between China and the Western industrialized countries. Increasing demarcation and nationalization tendencies are not limited to China, however, but are also present in the USA and within the European Union (EU). This puts existing supply chains, access to raw materials as well as free trade and the open exchange of knowledge and technology at risk.² Dependencies regarding important raw materials and key enabling technologies such as semiconductors are having an increasingly noticeable impact. This threatens Germany with a loss of technological sovereignty.³ To prevent this and to safeguard the technological competitiveness of companies for the future, considerable private-sector efforts are required, supported by strategically smart public investment, especially in R&I activities in key enabling technologies.⁴

Ensuring Economic and Structural Capacity for Transformations

Strong economic performance is a prerequisite for the success of the major transformations. The fun-

damental reform of existing structures also requires a high degree of commitment to renewal and agility on the part of society, the economy and politics. The key objectives of climate neutrality and sustainability are just as important as improving the ability of social and economic systems to adapt to changing conditions and to show resilience in the face of adverse developments. The current crises not only reduce the amount of available financial resources, that are urgently needed for this transformation. They also threaten the social acceptance of the transformation objectives, especially if these objectives are perceived as less urgent than the current emergencies due to their long-term character. As a result, necessary transformation measures are threatened with further and further postponement, which, however, cannot be justified in view of impending tipping points and irreversibility, especially regarding climate and the environment.

Balancing Conflicting Goals Between Crisis Interventions and Transformations

Managing the overlapping crises, facing the demands of the new geopolitical situation and meeting the transformation requirements poses immense challenges for policy making. This is because the complexity of this situation leads to numerous conflicting objectives. Measures to support production and employment in the short term often focus on established technologies and business models to directly maintain economic power. As a result, the transformations required in the medium and long term, including the necessary innovations, are in danger of falling behind in these fields. Compensatory measures such as an energy price cap also trigger similar conflicts of objectives. While certainly desirable from a social point of view, caps of this kind can stand in the way of incentives to innovate and develop alternative energy sources.

To balance such conflicting objectives, a clever combination of short-term support measures and transformation-oriented investments in the future is needed. The Federal Government must resist the temptation to fully compensate for the consequences of the current crises and the expected negative impacts of the transformations. The Commission of Experts calls attention to the fact that a lasting solution to the crisis cannot be achieved through consumption, but only through investment. Therefore, compensation payments must be limited to

particularly needy persons and hardship cases in companies.

As a rule, it is important to ensure that investment measures to overcome the crisis not only solve acute problems, but also promote future viability. For instance, the Bundeswehr's special assets of €100 billion offer the opportunity to increase not only the alliance and defence capabilities in the long term, but also Germany's technological competitiveness by promoting R&D activities in the field of digital technologies or in aerospace.

Acting More Strategically Due to Limited Resources

The coordinated and efficient use of public budgets requires a strategically acting state. Whether the Federal Government will succeed in mastering the current crises and transformation challenges also depends on whether agile policy action is enabled by means of adequate decision-making processes and governance structures.⁵ Without agility, the tightening financial margins cannot be used effectively. Agility, however, requires the willingness of politics and society to actively reform deficient or outdated structures and not to sit it out by creating parallel structures or compensation payments. In addition to the ability to react agilely to current events and changing requirements, German R&I policy needs a long-term orientation as well as strategic planning and the formulation of clear priorities. A turning point is also needed in R&I policy.

A 1 Creating Agile Governance Structures

A new, agile policy style and a governance structure to match are needed to advance the major transformations (e.g. towards climate neutrality and the digital transformation) swiftly and in a socially acceptable manner, while at the same time safeguarding the competitiveness of the German economy and its companies. These transformations affect large parts of the economy and society and require numerous technological and social innovations. To initiate these, diverse and coordinated interventions from different policy fields are required. Accordingly, transformations do not fall within the remit of a single ministry, but of several. At the heart of the new policy approach, which can be described as a market-based mission and transformation policy, is the fact that the ministries concerned coordinate their strategies and measures in line with the transformation objectives and cooperate in an agile manner. The Commission of Experts is of the opinion that several structural and procedural adjustments are needed to successfully implement this policy approach.

Agile policy action is not only characterized by a quick and flexible reaction to changes.⁶ It is also proactive, involves relevant actors, continuously reviews the measures introduced and adapts them to changing conditions if necessary. The main requirement here is to continuously coordinate long-term planning and short-term adjustments. The silo mentality within the Federal Government still constitutes a major obstacle to agile policy action. The Commission of Experts emphatically points out that cooperation between and within the ministries urgently requires improvement in view of the tasks ahead. Germany cannot afford a 'business as usual' approach to policy coordination, neither in terms of time nor financially.

Establish a Government Committee for Innovation and Transformation

In order to more closely dovetail the content of the innovation- and transformation-related policies

of the various ministries at the strategic level, the Commission of Experts recommends establishing a permanent government committee for innovation and transformation. This committee is intended to provide, at the highest level, alignment and coordination of content, as well as the regular review of strategies related to R&I policy. This will create the greatest possible commitment and joint strategic responsibility for missions and transformations.

Although the Federal Government has already adopted or will soon adopt several strategies related to R&I policy (cf. box A 1-1) in the current legislative period, the Commission of Experts considers these strategies to be still insufficiently interlinked. In view of the transformations, better coordination of content would be important to ensure greater effectiveness and efficiency of policy action. Funding instruments that overlap or work in different directions must be avoided, complementary policy measures must be coordinated and complex processes must be managed jointly and in a smartly timed manner.

The Commission of Experts is of the opinion that the currently established mechanisms of inter-ministerial coordination are not suitable for formulating an overarching set of objectives for the Federal Government regarding innovation and transformation-related topics and for clarifying which strategies should be (further) developed to pursue which objectives. These government tasks can neither be adequately performed within the context of cabinet meetings nor in the course of interministerial coordination of individual strategies.⁷ Instead, these tasks should be assumed by the government committee for innovation and transformation recommended by the Commission of Experts in order to prepare and be responsible for a planned and coordinated approach of the Federal Government at the strategic level.

The government committee for innovation and transformation should be established within the Federal Chancellery.⁸ In other countries, commit-

tees with a similarly comprehensive range of tasks are also established at the highest political level.⁹ In addition to the head of the Federal Chancellery, the government committee for innovation and transformation should include as permanent members those ministers whose departments are most closely involved with innovation- and transformation-related issues. Other ministers should be consulted on an ad hoc basis.

To ensure that the strategic level and the implementation level are interlinked and to increase commitment, the government committee for innovation and transformation should regularly report to the Federal Cabinet and the German Bundestag. In turn, the government committee for innovation and transformation should receive reports from the individual ministries represented there.

Assign Clear Responsibilities to Interdepartmental Mission Teams

The claim formulated in the Federal Government's Future Strategy for Research and Innovation to actively shape transformation processes also gives rise to the need for comprehensive inter-ministerial coordination at the implementation level. The draft version of the Future Strategy published by the BMBF in autumn 2022 proposed 'six mission teams as agile, interdepartmental and topic-specific steering units'¹⁰ that would specify objectives, derive milestones as well as review and, if necessary, readjust progress.¹¹ The Commission of Experts considers the establishment of such units to be urgently necessary and crucial to the success of the missions. As the tasks of the mission teams are demanding and require sufficient scope for agile policy action (cf. chapter A 2), the Commission of Experts sees the need to provide the mission teams with clear areas of responsibility and sufficient decision-making powers. To create the greatest possible commitment in the coordination and implementation of mission-oriented policy, the Commission of Experts recommends that the ministries involved be integrated into the mission teams at state secretary level. It is equally important that the mission teams report regularly to the proposed government committee for innovation and transformation.

Finally Expanding SPRIND's Scope for Action

With its focus on leap innovations,¹² SPRIND GmbH,¹³ founded in 2019, promotes a segment of the German R&I system that was previously covered neither by government support programmes and research institutions nor by the involvement of private actors.¹⁴ To cope with its specific task, SPRIND GmbH was given an institutional structure that differs significantly from the structures of ministries and project executing agencies. It has become apparent, however, that the agency's scope for decision-making is not yet sufficient to enable it to act agilely enough. The governing parties have announced in the coalition agreement that they will substantially improve the legal framework of SPRIND GmbH without delay.¹⁵ The Commission of Experts urges that this plan finally be implemented.

Dovetail DATI Funding with Mission Orientation

Knowledge and technology transfer in Germany must be made more effective, efficient and rapid.¹⁶ To this end, suitable instruments must be developed and transfer must be holistically and systematically embedded in the science and innovation system. The Federal Government is therefore planning to establish the German Agency for Transfer and Innovation (Deutsche Agentur für Transfer und Innovation, DATI). In a policy brief, the Commission of Experts critically examined the key issues paper on the configuration of DATI published in April last year.¹⁷ The Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung, BMBF) is currently developing the DATI concept further, taking into account the results of stakeholder consultations.¹⁸

Functioning transfer processes are crucial for the success of the Future Strategy. The Commission of Experts therefore considers it sensible for DATI to be used to develop and implement a nationwide concept for the promotion of transfer processes. To achieve this, all transfer-relevant actors should be integrated into this concept through interfaces and a central service point for transfer should be established. In terms of content, the DATI concept should be dovetailed with the missions (cf. chapter A 2) of the Future Strategy. The DATI should be open with regard to the supported actors and

technologies and not restrict the support of actor groups in regional terms.

Reform Structure of Project Executing Agencies

The Commission of Experts feels that the development, adaptation and administration of traditional R&I support programmes should be more agile than has been the case to date. In as far as possible, R&I funding procedures should be designed uniformly and in a consistent digital format for the recipients across the various support programmes. In addition, funding should be made available as a lump-sum budget and linked to results-oriented monitoring. Barriers to the participation of small and medium-sized enterprises (SMEs) and start-ups in funding procedures should be reduced as far as possible and approval procedures kept short.

In Germany, the individual R&I support programmes are usually administered by so-called project executing agencies (German: Projektträger). These support the funding departments in the ministries, also in terms of content, in the design and adaptation of measures as well as in monitoring. The structure of project executing agencies has developed in such a way that thematically related R&I support programmes are managed by different project executing agencies.¹⁹ To achieve more coherence here and to leverage synergies, a mission-related bundling of R&I programmes at individual project executing agencies would make sense. The commissioning of missions, as well as the commissioning of project executing agencies outside of missions, should be carried out on a competitive basis.

The project executing agencies are often very actively supported by the responsible departments in the ministries and have few opportunities to

Box A 1-1 Select Federal Government Strategies with R&I Policy Relevance

Future Strategy

The Future Strategy for Research and Innovation (short: Future Strategy),²⁰ which replaces the previous government's High-Tech Strategy 2025, identifies two top priorities of R&I policy, namely 'Science, Research and Transfer' and 'Actively Shaping Transformation Processes'.

The priority 'Science, Research and Transfer' comprises six R&I policy goals aimed at boosting the level of R&I activities to meet the 3.5 percent target and achieving a more purposeful use of funds. These goals are to prepare the ground for tomorrow's progress, to turn new knowledge into innovations, to reinforce European and international cooperation, to increase participation in research and innovation, to promote talent across the board and at the top, and to establish an agile research and innovation policy.

In the priority 'Actively Shaping Transformation Processes', the aim is to steer R&I activities in socially desired directions. Six so-called missions are specified for this purpose. These include enabling resource-efficient industry and sustainable mobility, protecting the climate and biodi-

versity, improving health for all, safeguarding Germany's and Europe's technological sovereignty and harnessing the potential of digitalization, exploring and sustainably using space and the oceans, and strengthening societal resilience, diversity and cohesion. For each of these missions, the Federal Government formulates objectives against which the missions are to be fulfilled.

In its Future Strategy, the Federal Government also sets out how it intends to promote communication, exchange and participation in the R&I sector.

Start-up Strategy

The Federal Government's Start-up Strategy was developed under the leadership of the Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz, BMWK) and adopted by the Cabinet in July 2022.²¹ With its strategy, the Federal Government highlights the importance of start-ups for the transformation of the economy and society as well as for safeguarding technological sovereignty. The aim is to improve the conditions for start-ups and the growth phase of start-ups. The strategy is structured into ten fields of action:

1. Strengthen funding for start-ups,
2. Make it easier for start-ups to attract talent – make employee ownership schemes more attractive,
3. Ignite the startup spirit – make startups easier and more digital,
4. Strengthen female start-up founders and diversity in start-ups,
5. Make it easier to create startup spin-offs from science,
6. Improve the general environment for non-profit start-ups,
7. Mobilise start-up skills for public contracts,
8. Make it easier for start-ups to access data,
9. Strengthen regulatory sandboxes – make access easier for start-ups,
10. Put the focus on start-ups.²²

Numerous measures, e.g. regarding the participation of institutional investors, employee participation and the recruitment of foreign experts, demonstrate a discrepancy between the key issues paper published by the BMWK in advance and the final strategy. Some of the start-up-friendly regulations proposed by the BMWK are now only included in the Start-up Strategy as review requests.

Digital Strategy

The 'Digitalstrategie – Gemeinsam digitale Werte schöpfen' (Digital Strategy – Creating Digital Value Together) presented in August 2022 is intended to achieve a breakthrough in digitalization projects²³ that have been planned for a long time and had already been identified as important projects in the precursor strategies.²⁴ Examples include the electronic patient record, digital identity and stable internet connections throughout Germany. With the voluntary commitment to expand infrastructures such as fibre-optic and mobile networks on a large scale, the Digital Strategy also adopts the key objectives of the Gigabit Strategy published in July 2022.²⁵ The Digital Strategy is structured into three fields of action: 'Connected and Digitally Sovereign Society', 'Innovative Economy, Work, Science and Research' and 'Learning, Digital Government'. The fields of action in turn comprise numerous projects, 18 of which have been designated as lighthouse projects. Each ministry is represented with at least one lighthouse project, which it implements under its own responsibility.²⁶ One

example of this is the establishment of a National Education Platform by the BMBF.

The three projects 'High-capacity and sustainable networks and availability of data and data tools', 'International uniform technical norms and standards' and 'Secure and user-friendly digital identities and modern registers'²⁷ are highlighted in the Digital Strategy as projects with a leverage effect. They are given absolute priority as they set the stage for all other projects.

Skilled Labour Strategy

The Federal Government's Skilled Labour Strategy was published in October.²⁸ In it, the Federal Government analyses the opportunities and challenges facing Germany as a business location and presents the skilled labour requirements up to 2026. In the objective of securing the supply of skilled workers, the following five priority fields of action are identified: 'Up-to-date Training', 'Targeted Continuing Education and Training', 'Exploiting the Labour Force Potential, Increasing Labour Market Participation', 'Improving the Quality of Work and Changing the Culture of Work' and 'Modern Immigration Policy and Reducing Emigration'. These five priority fields of action are backed up with measures in the Skilled Labour Strategy. The Federal Government sees the Skilled Labour Strategy as an overarching strategy for the various activities of the Federal Government and as a basis for exchange with all actors in the education and labour market.

Continuing Education Strategy

To continue and further develop the National Continuing Education Strategy (Nationale Weiterbildungsstrategie)²⁹ adopted in 2019, the 'National Continuing Education Strategy. Continuation and Further Development. Together for a Decade of Continuing Education – Moving Towards a Continuing Education Republic' (Nationale Weiterbildung. Fortführung und Weiterentwicklung. Gemeinsam für ein Jahrzehnt der Weiterbildung – Aufbruch in die Weiterbildungsrepublik) was agreed in September 2022.³⁰ The following cross-cutting issues form the core of the strategy: 'Facilitating Access to Counselling, Support and Continuing Education', 'Intensifying Cooperation in Regions and Sectors', 'Further Developing Concepts' and 'Strengthening Digital Continuing Education'.

shape processes themselves. As a result, it is not possible to respond adequately to potential adaptation needs in R&I projects and policy learning is made more difficult. The project executing agencies should therefore be granted more leeway, includ-

ing experimental leeway, in the implementation of support measures. This should be combined with a more results-oriented management of the use of funding by the project executing agencies and regular, state-of-the-art evaluations of the measures.

A 2 Tackling the Grand Societal Challenges

R&I policy is called upon to make a significant contribution to solving the grand societal challenges. These include first and foremost human-made climate change, digitalization and the demographic ageing of society. The New Mission Orientation in R&I policy is designed to address these grand societal challenges.³¹ The Commission of Experts is of the opinion that the Federal Government should pursue it resolutely.

Refining the Mission-oriented Approach of the Future Strategy

The Commission of Experts welcomes the Federal Government's commitment to a mission-oriented R&I policy in its Future Strategy,³² but sees the need to refine the transformation goals set out in the missions and to specify them in an operable manner.³³ The Commission of Experts considers the six objectives named as missions in the Future Strategy (cf. box A 1-1)³⁴ to be too wide-ranging to be manageable in strategic and operational terms. For this reason, it recommends naming several action-guiding missions within each of these overarching objectives and formulating measurable and ambitious, but realistic, transformation goals with a precise time frame. To increase commitment on the part of policy-makers, it should also be specified which transformation goals are to be achieved by the end of the already advanced legislative period.

An action-guiding mission could be, for example, 'Climate-neutral Motorized Private Transport'. As part of such a mission, it would be necessary to specify which savings targets are to be realized and by when. By involving potentially affected groups of actors and federal levels from the outset in the conception of action-guiding missions, the acceptance of mission-oriented policies can be increased and the mobilization of agents of innovation can be facilitated. The Commission of Experts expects that the naming of the action-guiding missions and the specification of the transformation goals will in themselves contribute to the success of the missions, as they provide orientation for the development of a policy mix and the adjustment of measures.³⁵

For the six overarching missions or objectives defined in the Future Strategy, a large number of individual goals are listed, some of which have the character of measures but are not put in relation to each other.³⁶ The Commission of Experts calls on the Federal Government to draw up roadmaps for specific transformation goals that coordinate and structure the measures of the various ministries in terms of content and timing. Coordination processes with the Länder and municipalities as well as the EU³⁷ may also be required. In addition, actors in business and society who can contribute to achieving the mission goals should be involved in the preparation of the roadmaps. There must be no simple juxtaposition of relevant measures.

Rather, an effective and efficient interaction of R&I projects, support measures and legal frameworks is needed for mission success. For example, in an action-guiding mission of ‘Climate-neutral Motorized Private Transport’, R&I policy instruments must be linked with measures concerning CO₂ pricing, a complementary reform of taxes and levies, the development of charging infrastructure and the expansion of renewable sources of electricity, as well as regulations on the data exchange of autonomously driving cars.³⁹

The implementation of missions takes place in a dynamic environment and not all processes can be perfectly controlled. This results in the requirement to conduct continuous monitoring as well as to evaluate the measures taken and adjust them if necessary. The Commission of Experts recommends that monitoring and evaluation processes be taken into account from the outset when designing missions.³⁹ In this way, measures and packages of measures can be continuously improved and aligned with the transformation goals to be achieved. In this respect, the final report of the supporting scientific research on the High-Tech Strategy 2025 already provides a large number of practical tips on how mission-oriented R&I policy can be designed to be more effective and efficient than before.⁴⁰

Not Pitting Energy Security and Climate Protection Against Each Other

In light of the energy crisis brought about by the war in Ukraine, there is a risk that the goals of energy security and climate protection will be pitted against each other. The Commission of Experts maintains that the expansion of renewable energy and the increase in energy efficiency contribute to both energy security and climate protection in the long term. Price signals, which provide important incentives for the transformation of the economy and consumption behaviour, should therefore not be undermined by ever new ‘price brakes’. Although socio-political compensation is necessary, especially for low income groups, the Commission of Experts considers the current design of the energy price brakes⁴¹ with a price cap for a basic quota of consumption (usually 80 percent) and a market price compensation for consumption above the discounted quota to be socially unbalanced. Moreover, the energy price brakes only create savings incentives for consumption above the discounted quota and

tempt consumers to make full use of this quota. Should compensation for energy price increases still be necessary in the future, simple flat-rate payments for lower income groups should be used instead of quota solutions for all. Compensation for the industry, which should be limited in time, should be based on benchmarks rather than historical consumption and should be made more dependent on how exposed the respective industry is to international competition.

Implement CO₂ Boundary Adjustment As Soon as Possible

The Commission of Experts welcomes that the European Parliament and the European Council reached a preliminary agreement in December 2022 on the establishment of a CO₂ border adjustment mechanism.⁴² Such a mechanism helps to limit carbon leakage to non-EU countries. It incentivizes industry to accelerate decarbonization through the deployment of innovative technologies, while protecting it from companies from countries with less ambitious climate targets. This will also create incentives for other countries to operate more sustainably and emit fewer emissions. It will now be important to clarify the technical details to implement the border adjustment mechanism as quickly as possible and to coordinate it with the measures of the Climate Club⁴³ established by the G7 in December 2022.

Compensating Negative Emissions in Pilot Projects

At the United Nations Climate Change Conference COP 27 in Sharm-el-Sheikh,⁴⁴ the international community was once again unable to agree on any concrete steps to reduce greenhouse gases. It is therefore becoming increasingly unlikely that CO₂ emissions worldwide can be reduced fast enough to reach the two degree target, let alone the 1.5 degree target. Therefore, it will also be important to develop technologies that remove CO₂ from the Earth’s atmosphere. The ongoing discussion about the conditions and requirements for the final storage or further use of stored CO₂ from direct air capture and carbon capture and storage technologies inhibits R&D activities of companies in this field. In addition to further R&D funding, the Commission of Experts proposes that a limited quota of reliably

stored CO₂ withdrawn from the Earth's atmosphere be remunerated within a pilot project in order to create incentives for the development of these technologies. This should be considered especially if a European consensus on key issues concerning the use of these technologies is not achievable in the short term.

Make Network Charges Structure Compatible with Incentives

Germany has committed itself to ambitious climate targets. To achieve these, a significant expansion of capacities for CO₂-neutral electricity generation is needed, as well as an interregional and intertemporal balancing of supply and demand. In Germany, electricity transmission through the grids is

still priced based on a uniform tariff that does not adequately reflect local, regional and temporary grid shortages. Relatively high network charges make the use of surplus green electricity unattractive, e.g. for the production of hydrogen.⁴⁵ Proposals to create different prices for different regional zones do not address the root of the problem. Rather, what is needed is flexible network pricing, so-called nodal pricing, which reflects the scarcity of the respective transmission capacities. This can create considerable incentives to use green power more efficiently and to store it. In particular, innovative concepts for long-term storage are required to compensate for the scarce supply of green electricity in the winter months (dark period) on the way to climate neutrality. Existing technologies such as smart meters must be increasingly used in a transformation of the electricity market design.⁴⁶

A 3 Catching Up and Avoiding Technological Gaps

The ongoing transformations will not be mastered without innovative technologies. Key enabling technologies such as digital technologies, materials technologies, production technologies, bioeconomy and life sciences are of particular importance. Germany, and to some extent Europe, are not at the forefront of these technologies in an international comparison. More dynamic developments can be observed in Asia in particular.⁴⁷ To avoid losing touch in the key enabling technologies, Germany and its European partners must accelerate the development and advancement of knowledge and skills as well as the regulatory framework and infrastructure to be able to independently develop and apply technologies of this kind. This is all the more important as access to technologies via the global market is no longer assured due to increasing de-globalization and intensified geopolitical antagonisms.

Intensify the Establishment of Production Facilities for Key Enabling Technologies

In recent years, foreign companies in Germany have invested in the establishment of infrastructure facilities and production sites for the manufacture and further development of key enabling technologies. In doing so, they are contributing to maintaining Germany's technological sovereignty. In some cases, these investments are linked to substantial government funding commitments.⁴⁸ The Commission of Experts is generally in favour of funding research and production facilities if they serve to maintain Germany's technological sovereignty. It advises the Federal Government and the Länder governments to ensure in their funding commitments that self-sustaining structures are created which can continue to operate even if the investor withdraws from Germany. To this end, public funding should be invested primarily in infrastructures and in the

development of competencies on site, for example in the establishment of R&D capacities, start-up centres and networking activities.

Regardless of whether it is a domestic or foreign investor, the Commission of Experts urges that the promotion of key enabling technologies should have a catalytic character and must not amount to permanent subsidization.

The Commission of Experts points out that the locations for the research, development and production of key enabling technologies do not necessarily have to be in Germany but can also be located in other EU Member States. Since Germany's technological sovereignty can only be secured in cooperation with its European partners, the establishment of key enabling technologies in a European partner country is also in Germany's interest. A business location policy coordinated at the European level is also a key prerequisite for avoiding an intra-European subsidy race. Moreover, the Federal Government must lobby at EU level for a much faster pace in the promotion of key enabling technologies. Considering the massive state support measures, such as those seen for the chip industry in China, Japan, South Korea, Taiwan and the USA, the European countries are in danger of falling further behind.⁴⁹

Reduce Dependence on China

Germany is highly dependent on Chinese sales markets as well as on technology and commodity imports from China. The increasing tendency of the Chinese government to distance itself from the Western community of states and to politically control international economic relations makes these dependencies a growing risk for Germany. Ultimately, in the event of a crisis, Germany could come under increasing pressure by being excluded from Chinese sales markets and from technology and commodity imports from China. The risk of such a crisis occurring has risen sharply in recent years. With this in mind, the Federal Government has begun to formulate a new China strategy. Even though no official preliminary version is yet available, the media have already reported extensively and quoted from the strategy document.⁵⁰

The Commission of Experts advocates that the Federal Government, with its new China strategy, develop an interdepartmental concept that can help

to systematically reduce Germany's pronounced economic dependence on China.⁵¹ This should in no way involve severing the extensive economic and cooperation ties with China. Instead of unilaterally distancing Germany from existing international cooperation partners, the diversification of trade relations, especially with Asia, Latin America and Africa, must be promoted.

To ensure that German companies diversify more regionally, the Commission of Experts recommends that economic activities in China no longer be supported to the same extent as before. Companies are free to decide whether and with what intensity they want to be active in China. However, the associated entrepreneurial risks should not be borne by the state and consequently by the public. Accordingly, a cap and a tightening of the conditions for granting investment and export credit guarantees are a logical step.⁵²

Another important aspect of Germany's China policy must be its integration into joint European action.⁵³ It is equally important to develop and expand technological competencies, e.g. in key enabling technologies, together with European partner countries. In this way, the necessary critical mass can be achieved to keep up with China as well as other dynamic economic and innovation locations in Asia and North America.⁵⁴

To this end, standardization activities must also be pursued more strategically together with the EU partner countries. Political support for the standardization efforts of German actors is necessary to counter China's increased involvement in the international standardization organizations.⁵⁵

Establish a China Competence Centre

In the field of scientific cooperation with China, care must continue to be taken to avoid an unintended outflow of knowledge – while maintaining freedom of research. The Commission of Experts considers it sensible not to fund R&I projects in which Chinese actors are involved and a knowledge drain is likely, or to fund such projects only under strict conditions.

Moreover, cooperation must have limits where it can lead to results that run counter to our liberal democratic values. These limits are tightening more

and more, because as a result of the Chinese objective of geopolitical dominance, the risks of disclosing research results have increased in many areas of research.⁵⁶ The Federal Government and the EU have already reacted to this problem with educational measures and adjustments to dual-use regulations.⁵⁷ The actors in the science system are also called upon to act responsibly in this sense.

In view of the increasingly difficult environment, the Commission of Experts welcomes the BMBF's initiatives to expand China competence in Germany.⁵⁸ However, in contrast to a devolved and regional network approach as pursued by the BMBF, the Commission of Experts refers to its recommendation in the 2020 Report to establish a central competence centre to advise German scientists. This competence centre should provide expertise on legal issues relevant to cooperation and research, for example regarding the protection of intellectual property and data protection. In addition, the competence centre should systematically collect and evaluate information on experiences and problems in German-Chinese cooperation and provide it to scientists and research institutions.⁵⁹

Restructure Governance for Digitalization of Public Administration

The implementation of the Online Access Act (Onlinezugangsgesetz, OZG) has failed. Of the 575 administrative services defined in the Act, only a fraction were available nationwide after the implementation deadline of 31 December 2022.⁶⁰ There is broad consensus on the reasons for the continued failure of the digitalization of the German administration: Responsibilities are fragmented, there is no clear distribution of competences and no unequivocal responsibilities, in other words, there is a lack of suitable digitalization governance.⁶¹ This makes it difficult to define and implement uniform technical standards and interfaces down to the municipal level.

By delaying the digitalization of the administration, Germany not only risks falling further and further behind as a location for business and innovation in international comparison. The state's ability to act and its ability to withstand crises are also increasingly in doubt.⁶² Repeated administrative problems, whether in the registration of refugees, the recording of Covid-19 infections or the payment of flat-rate energy allowances, clearly show that political

crisis management by the public administration can only be implemented inadequately and with considerable delay. In its Digital Strategy (cf. box A 1-1), the Federal Government has once again announced that it will eliminate the long-standing main deficits in e-government. This is to be achieved by the end of 2025.

Foremost importance is attached to the so-called OZG 2.0. A draft bill on the subject aims to achieve greater harmonization of important digital services. For citizens and businesses, there is to be a single federal account in connection with a federal ID instead of various user accounts of the Länder. Also, so-called electronic application assistants are to be introduced for the simplified online processing of one or more administrative services of the Federal Government and the Länder. The Commission of Experts supports these harmonizations. However, it considers it critical that the draft bill, unlike the previous version, refrains from making the one-for-all principle⁶³ and end-to-end digitalization mandatory.⁶⁴ The Commission of Experts therefore remains sceptical that a breakthrough in the digitalization of public administration will succeed without a fundamental reform of digitalization governance, including Federal-Länder cooperation.⁶⁵

Create Synergies Between Military and Civilian Research

The Russian attack on Ukraine has brought the issue of military security and military research back into focus in Germany. This is also reflected in the special assets for modernizing and upgrading the Bundeswehr, a small part of which is to be invested in research, development and artificial intelligence (AI),⁶⁶ as well as in the additional measures planned for military cyber security.⁶⁷

The Commission of Experts draws attention to the fact that there are synergies between military and civilian research in the field of AI and cyber security. Studies show that research activities in the military sector provide important impulses for innovations in the civilian sector and vice versa.⁶⁸ The strict separation of military and civilian research in Germany leads to parallel structures and prevents synergies between the two sectors. As a result, R&I resources are currently not being used efficiently to solve socially important problems, such as safeguarding data networks and critical infrastructure.

In light of the changing times, the Commission of Experts recommends that the Federal Government consider potential synergies between military and civilian research in its own R&I funding. In addition, the actors in the R&I system should review their voluntary commitments and regulations, which aim at a strict separation between military and civilian research.

Empower the Cyber Agency With More Freedom

The Cyber Agency (Agentur für Innovation in der Cybersicherheit – Agency for Innovation in Cybersecurity) is an organization that overcomes the separation of military and civilian research. With the projects it invites to tender, it initiates innovation

activities in the civilian sector that are intended to contribute to improving Germany's internal and external security against cyberattacks. However, the Cyber Agency is struggling with structural problems that limit the effectiveness of its work. For instance, IP rights to research results that arise in the tendered projects usually fall to the Cyber Agency. Exceptions to this rule can only be applied for with significant effort. This renders cooperation unattractive for researchers and companies and makes it difficult for the agency to find suitable cooperation partners for its projects. In addition, restrictive framework conditions of public procurement law hamper the tendering of research projects with high uncertainty of results. The Cyber Agency needs more freedom to fulfil its core task of advancing research and pioneering innovations in the field of cyber security.

A 4 Removing Barriers to Innovation

The current situation of overlapping crises is putting considerable financial strain on many companies and exposing them to elevated levels of uncertainty. This raises the risk of research-based companies cutting back on longer-term investments in R&I or even withdrawing from the market altogether. The main objective of R&I policy must therefore be to provide effective incentives for the continuation of R&I activities and for the establishment of new innovative companies. It is equally important to identify and remove barriers to the development and dissemination of innovations. In the current times of crisis, the financial resources for an expansion of support structures are increasingly limited. R&I policy is therefore particularly challenged to initiate structural reforms and use regulatory levers to raise innovation potentials and eliminate existing inefficiencies in the R&I system.

Develop Innovation-friendly Framework Conditions With Real-world Laboratories

Existing laws and regulations as well as lengthy administrative procedures are increasingly preventing or slowing down innovation processes.⁶⁹ The Federal Government should therefore not only promote R&I activities through financial support, but also create new incentives for innovation and remove barriers to innovation by adapting legal framework conditions. Moreover, it should work to ensure that this also happens in the EU.

Real-world laboratories as regulatory sandboxes are an effective means of developing innovation-friendly framework conditions. The Commission of Experts advocates the increased use of this means as well as the plan to create a real-world laboratory law.⁷⁰ Evaluations will be necessary to gain insights into the effectiveness of the real-world laboratories. This is quite methodologically demanding in

real-world laboratories. Therefore, when setting up a real-world laboratory, impact-oriented evaluation should be included in the concept right from the start.

Boost Innovation-oriented Procurement

Public procurement can provide important impulses for innovation activities. However, the formal requirements of public procurement with a detailed description of the goods and services to be procured stand in the way of innovation-oriented procurement. With the establishment of the intermediary platform KOINNOvationsplatz at the Competence Centre for Innovative Procurement (Kompetenzzentrum Innovative Beschaffung, KOINNO), the Federal Government enables exploration of the range of potential innovative solutions before awarding contracts. On the one hand, this renders the procurement-relevant challenges of public administration visible, and on the other hand, companies are given the opportunity to present innovative solutions. The platform offers support in market research and matchmaking. Public contracting authorities can invite the companies active on the platform to submit a bid for current or planned tenders.⁷¹

The Commission of Experts welcomes the establishment of the KOINNOvationsplatz. It considers this to be an important step towards giving greater consideration to start-ups and SMEs in the awarding of public contracts. This is in line with the goal formulated in the Federal Government's Start-up Strategy to make greater use of the innovative offerings of start-ups for public contracts and at the same time to promote them by awarding contracts.⁷²

Set Clear Rules for Data Economy

Clear rules on data use are a prerequisite for the development of a data economy that includes a digitalized public administration, networked companies and research institutions, platforms and private users. The Federal Government had announced a national data strategy for this purpose, but its development has been delayed.⁷³

The existing data protection regulations are not conducive to the development of a data economy, as they create a high degree of uncertainty due to

varying scope for reading and interpretation. The conditions for using data need urgent clarification. The Federal Government should use its planned national data strategy to end the state of uncertainty through clear and simple regulations. According to the Commission of Experts, this also includes a harmonized interpretation of data protection regulations across all Länder. The Commission of Experts moreover recommends not losing sight of the implementation of the old Data Strategy, which was not adopted until 2021, over efforts to formulate a new national data strategy. The funding of research projects on the anonymization of personal data announced by the BMBF can additionally help to better reconcile data use and data protection.⁷⁴ Waiting for these results should not, however, lead to a further delay in the urgently needed improvement of data access, especially for research purposes.

The Commission of Experts sees the data institute planned by the Federal Ministry of the Interior and Community (Bundesministerium des Innern und für Heimat, BMI) and the Federal Ministry for Economic Affairs and Climate Action (BMWK) as a key step that can help to make rapid progress on the issue of data use. It is intended to promote data sharing and data evaluation, especially across different sectors, and to develop the necessary governance models. Pilot projects are to be launched as early as the start-up phase,⁷⁵ to quickly gather practical experience that will be useful for the further institutional design. It should also be noted that the data institute plans to establish data trustee models⁷⁶ and to use the already existing competences, for example in research data centres.⁷⁷

Promote Manufacturing-X

The large-scale project Manufacturing-X, initiated by companies and trade associations, is intended to create a decentralized network for the manufacturing sector, including the automotive industry, which will enable the actors involved to securely share data with each other.⁷⁸ This will enable the digitalization of value-added networks in a way that allows them to react quickly to disruptions and make them more resilient. In addition, it can facilitate new business models and digital innovations.⁷⁹ The model is Catena-X, the association of the automotive industry for the networking of value chains. More intensively than Catena-X, which is geared towards large companies, Manufacturing-X aims to involve SMEs.

The Commission of Experts sees Manufacturing-X as an important initiative to advance the digitalization of SMEs and to force their integration into the data economy. Seed funding from the Federal Government can make an important contribution to quickly establishing a reliable and trustworthy data space that is used by many companies for data exchange and data analysis. However, the Commission of Experts points out that the goal must be to further develop Manufacturing-X as a private-sector initiative that is supported by the member companies in the medium term. Existing solutions should be used and expanded as needed.

Regardless of the financial support, the initiators must quickly agree on a data trustee model. The teething problems of the Gaia-X project associated with Manufacturing-X reveal that the design of the data trusteeship is critical to success. Here, the planned data institute could take on a supporting role in the future.⁸⁰

Make Employee Equity Participation More Attractive

In July 2022 and thus at the beginning of the legislative period, the Federal Government presented a Start-up Strategy (cf. box A 1-1), in which it emphasizes the importance of start-ups for the transformation of the economy and society.⁸¹ The strategy contains a comprehensive package of measures, including improving financing opportunities, recruiting employees, spin-offs from academia and giving greater consideration to start-ups in public contracts.⁸² All measures are to be implemented during this legislative period.⁸³

To further support the development of start-ups, the modular Future Fund established by the previous Federal Government in 2021 is to raise up to €30 billion in venture capital for critical areas of innovation and transformation by 2030 in cooperation with private investors. Specifically mentioned are AI, quantum technology, hydrogen, medicine, sustainable mobility, bioeconomy and circular economy as well as climate, energy and environmental technology. Climate technologies are also to be supported by the DeepTech & Climate Fund, financed from resources of the Future Fund and the ERP Special Fund, to help deep-tech companies with a validated business model achieve sustainable growth while maintaining their independence.⁸⁴

The Commission of Experts welcomes the Start-up Strategy as a sign that the Federal Government is aware of the importance of start-ups as drivers of innovation and structural change. However, the Commission of Experts criticizes the failure to open up venture capital financing to institutional investor groups from the field of statutory and private pension provision. The Start-up Strategy does not contain any specific measures in this regard, but only a review request.⁸⁵

So far, the Federal Government has not been able to decide to revise the comparatively unattractive conditions for employee equity participation in Germany. It has, however, announced that it will adjust income tax law with the planned Future Financing Act.⁸⁶ Until now, non-cash benefits from shares have to be taxed in the event of a change of employer or after twelve years at the latest, even if no real inflow of liquidity has taken place (so-called dry income taxation). A liquidity inflow usually only occurs when the company is sold or goes public. The Federal Ministry of Finance (Bundesfinanzministerium, BMF) is now considering extending the twelve-year period to 20 years. As with capital gains tax, a flat tax rate of 25 percent is to be applied for the taxation of these assets.⁸⁷ The Commission of Experts regards these considerations as a step in the right direction.

A 5 Securing the Skilled Labour Base

The pressure to maintain Germany’s skilled labour base, which is already noticeable today, will continue to increase in the coming years.⁸⁸ The demographic ageing of society will cause the working-age population to shrink significantly, so that growth and innovation inhibiting shortages of skilled labour are likely to intensify and become more entrenched. It is therefore necessary to make better use of the domestic skilled labour base and at the same time to attract more foreign skilled labour. As a result of the structural change taking place parallel to demographic change, increased efforts in education and training are also required.⁸⁹

Improve Utilisation of Existing Skilled Labour Base

The skilled labour base available in Germany is currently not being sufficiently leveraged. The Commission of Experts therefore welcomes the fact that the Federal Government’s Skilled Labour Strategy contains a range of measures to increase women’s participation in gainful employment and to achieve more full-time employment for women. This urgently requires a further improvement in the compatibility of family and work. Among other things, this would involve sufficient care infrastructure for children and others in need of care, which, however, is itself challenged by the lack of skilled workers in these fields.

In the Skilled Workers Strategy, the Federal Government also announced that it will enter into a social dialogue with management and union representatives on how to make it easier for older workers to remain in the labour force for longer.⁹⁰ However, the Skilled Workers Strategy does not mention any definite policy measures that could contribute to an extension of working life. More specific measures should consider the interests of employees and employers. For example, there is little evidence of a need to protect retirees against repeated fixed-term employment by the same previous employer (cf. chapter B 1). The Commission of Experts is there-

fore of the opinion that employing retirees on fixed-term contracts should always be permitted without having to specify an objective reason.

Reduce Bureaucracy in the Immigration of Skilled Workers

In light of the demographic ageing of society, Germany must position itself better in the international competition for skilled labour. In particular, it needs to become more attractive for skilled workers from third countries, i.e. from countries outside the EU. In November 2022, the Federal Government presented its ‘Key Issues Regarding the Immigration of Skilled Workers from Third Countries’ (Eckpunkte zur Fachkräfteeinwanderung aus Drittstaaten) and addressed major obstacles.⁹¹ The key issues paper provides for employers with collective bargaining agreements to be given more responsibility in deciding on the immigration of skilled workers from third countries. The Commission of Experts thinks that this approach is very well suited to achieving higher quality, better matching and quicker recruitment of skilled workers from third countries.

Modernising the Dual System of Vocational Training

In Germany, the dual system of vocational education and training makes a significant contribution to implementing innovations and managing transformative changes.⁹² However, the dual system is coming under increasing pressure, both from the supply and the demand side. The Federal Government has recognized this and identified ‘Modern Training’ as one of five priority fields of action in its Skilled Labour Strategy.⁹³ The Commission of Experts considers the planned expansion of collaborative training⁹⁴ to be sensible, as it enables smaller companies without technical-infrastructure capabilities to train junior staff. It also supports the ‘Excellence Initiative for Vocational Education and Training’ (Exzellenzinitiative Berufliche Bildung),⁹⁵

by means of which the Federal Government aims, among other things, to provide more vocational orientation for young people at grammar schools and to develop and test innovative vocational education and training programmes.⁹⁶ However, the Commission of Experts points to the additional need of making a larger share of young people fit for vocational training than has been the case so far.

Strengthening Professional Adaptability Through Continued Training

Transformative change increases the demands on professional adaptability.⁹⁷ Members of the labour force need to develop digital as well as personal and social-communicative core skills in order to maintain professional competence. It is therefore necessary to intensify job-related continuing education and training. Against this background, the Commission of Experts welcomes the fact that ‘Targeted Continuing Education and Training’ is also one of the priority fields of action of the Federal Government’s Skilled Labour Strategy and that the National Continuing Education Strategy will be continued and further developed (cf. box A 1-1). However, the focus of the support instruments should not be solely on continued employment with the previous employer, because this will not always be possible. The Commission of Experts therefore reiterates its call for the development and regional testing of instruments for anticipatory adaptation training that make it easier for employees to switch to a new employer. These instruments should involve both the transferring and the receiving employer appropriately in the financing and ensure a balance of interests.

Increase Transparency of Academic Career Paths

The shortage of skilled workers affects almost all segments of the labour market. According to the Skilled Labour Monitoring of the Federal Ministry of Labour and Social Affairs (Bundesministerium für Arbeit und Soziales, BMAS), only six out of 140 occupational groups are expected to have an excess supply of potential applicants in the future compared to the vacant positions. These six occupational groups include the occupational group ‘Teaching and Research at Tertiary Education Institutions’, which is highly relevant for the German innovation

system. In its Skilled Labour Strategy, the Federal Government refers to the high professional mobility of members of this occupational group, for whom good labour market opportunities are anticipated due to expected bottlenecks, for example in research (‘Technical Research and Development’) and continuing education (‘Teaching at Extracurricular Educational Institutions’).

However, the current discussion on career opportunities for young researchers shows that working outside the academic system is often not perceived as an attractive option by those concerned. The Commission of Experts therefore recommends that researchers in the doctoral and postdoctoral phase be better prepared for careers outside the academic system than has been the case to date. Public research funding, which finances a significant part of the qualification positions at universities, should pay more attention to alternative career paths for young researchers in its support programmes.

The Federal Government is currently preparing a reform of the Act on Temporary Contracts in Science Research (Wissenschaftszeitvertragsgesetz, WissZeitVG),⁹⁸ last amended in 2016, based on the evaluation commissioned by the BMBF and published in May 2022.^{99 100} The Commission of Experts is of the opinion that contract periods, especially for PhD candidates, should be adapted even more closely to the duration of the qualification phase. The Commission of Experts moreover advocates that the decision for or against an academic career should be made earlier than before and also institutionalized, for example, in the context of a career interview after two to three years of postdoctoral experience.¹⁰¹ This would ensure transparent career paths and prevents a surprise end to an academic career after the potential junior staff member has already worked in the academic sector for many years. The Commission of Experts rejects considerations to further reduce the permissible fixed-term employment period of twelve years set out in the WissZeitVG.

Equally, the Commission of Experts takes a critical view of the regular extension of employment contracts for an indefinite period of time after completion of a doctorate or in the early postdoctoral phase, and thus the automatic creation of permanent positions. This would shift the moment of decision for or against an academic career too far forward. Instead, the widely established tenure track prin-

principle should be further consolidated, as it makes the path to a professorship more predictable than was previously the case. The tenure track principle could also be introduced for the path to permanent non-professorial faculty positions.

The number and proliferation of permanent positions must be handled prudently. An increase in permanent positions must not be allowed to reduce

the necessary flexibility in academia and the universities' continuous ability to renew themselves in terms of personnel and intellect, and thus the quality of research and teaching.¹⁰² For this reason, too, a balance must be found between fixed-term and permanent positions in the non-professorial faculty. It is therefore necessary to define permanent tasks in a comparatively narrow manner.¹⁰³

A 6 Key Recommendations for Action

In its 2021 and 2022 reports, the Commission of Experts emphatically emphasized the crucial importance of R&I for mastering the major transformations, such as the energy transition, the mobility transition and the digitalization of the economy and society. As if the related R&I policy task were not complex and challenging enough, it is further complicated by the Covid-19 crisis and the war in Ukraine. Publicly funded compensation and support measures for companies and private households are increasing the pressure on public budgets. Germany's scope for action to support and orchestrate the forthcoming major transformations with R&I policy and to actively tackle them with the help of innovative solutions is being massively restricted as a result.

The coordinated and efficient use of public budgets requires a strategically acting state. Whether the Federal Government will succeed in mastering the current crises and transformation challenges also depends on enabling agile policy action by means of adequate decision-making processes and governance structures. Equally, German R&I policy requires long-term orientation, strategic planning and clear priorities. A new era is also needed in R&I policy.

The Commission of Experts' key recommendations for action are as follows:

Establish a Government Committee for Innovation and Transformation

To intensify inter-ministerial coordination at the strategic level of innovation and transformation policy, it is necessary to establish a government committee for innovation and transformation based in the Federal Chancellery (cf. chapter A 1). The task of such a committee should be to formulate an overarching set of objectives for the Federal Government on innovation and transformation-related topics and to coordinate the political strategies derived from these. The government committee should regularly report to the Federal Cabinet and the German Bundestag. In turn, the individual ministries represented there should report to the government committee.

Integrate State Secretaries in Mission Teams

The interdepartmental mission teams planned in the draft version of the Future Strategy published by the BMBF in autumn 2022 must be established quickly and coordinate the mission-oriented policy at the implementation level (cf. chapter A 1). To ensure the greatest possible commitment to coordination and implementation, the Commission of Experts recommends that the ministries involved

be integrated into the mission teams via the level of state secretaries.

Reform the Project Executing Agency System

The project executing agency system should be reformed (cf. chapter A 1). For example, a mission-related bundling of R&I programmes at the project executing agencies and a more results-oriented monitoring of the use of funding is advisable. The project executing agencies should moreover be granted more leeway in the implementation of measures.

Create Mission-related Roadmaps

Within each of the six missions of the Future Strategy for Research and Innovation, which are very broadly conceived, several action-guiding missions should be agreed upon and underpinned by measurable transformation goals (cf. chapter A 2). With a view to the specific transformation goals, roadmaps should be developed for each of these action-guiding missions that coordinate and structure the measures of the various ministries in terms of content and timing.

Avoid Unintended Knowledge Outflow to China

R&I projects involving Chinese actors and where an unintended outflow of knowledge is likely should not be funded, or only under strict conditions (cf. chapter A 3).

Restructure Governance for the Digitalization of Public Administration

To finally achieve a breakthrough in the digitalization of public administration after the failed implementation of the Online Access Act (OZG), the Commission of Experts calls for a fundamental reform of digitalization governance, including Federal-Länder cooperation (cf. chapter A 3).

Create Synergies Between Military and Civilian Research

In light of the changing times, the Commission of Experts recommends that the Federal Government consider potential synergies between military and civilian research in its own R&I funding (cf. chapter A 3). In addition, the actors in the R&I system should review their voluntary commitments and regulations, which aim at a strict separation between military and civilian research.

Make Greater Use of Real-world Laboratories and Evaluate Them Systematically

Real-world laboratories as regulatory sandboxes are an effective means of developing innovation-friendly framework conditions and therefore should be used to a greater extent. Impact-oriented evaluation should be included in the concept right from the start when setting up a real-world laboratory (cf. chapter A 4).

Set Clear Rules for Data Economy

The Federal Government should use its planned national data strategy to end the state of uncertainty through clear and simple regulations (cf. chapter A 4). According to the Commission of Experts, this also includes a harmonized interpretation of data protection regulations across all Länder.

Improve Planning of Academic Careers

Researchers in the doctoral and postdoctoral phase should be better prepared for careers outside the academic system than has been the case to date. Contract periods for PhDs should be adapted even more closely to the duration of the qualification (cf. chapter A 5). Suitable formal regulations should contribute to deciding for or against an academic career earlier than in the past. The maximum permissible fixed-term employment period under the *WissZeitVG* of twelve years should be retained.

B

CORE TOPICS 2023



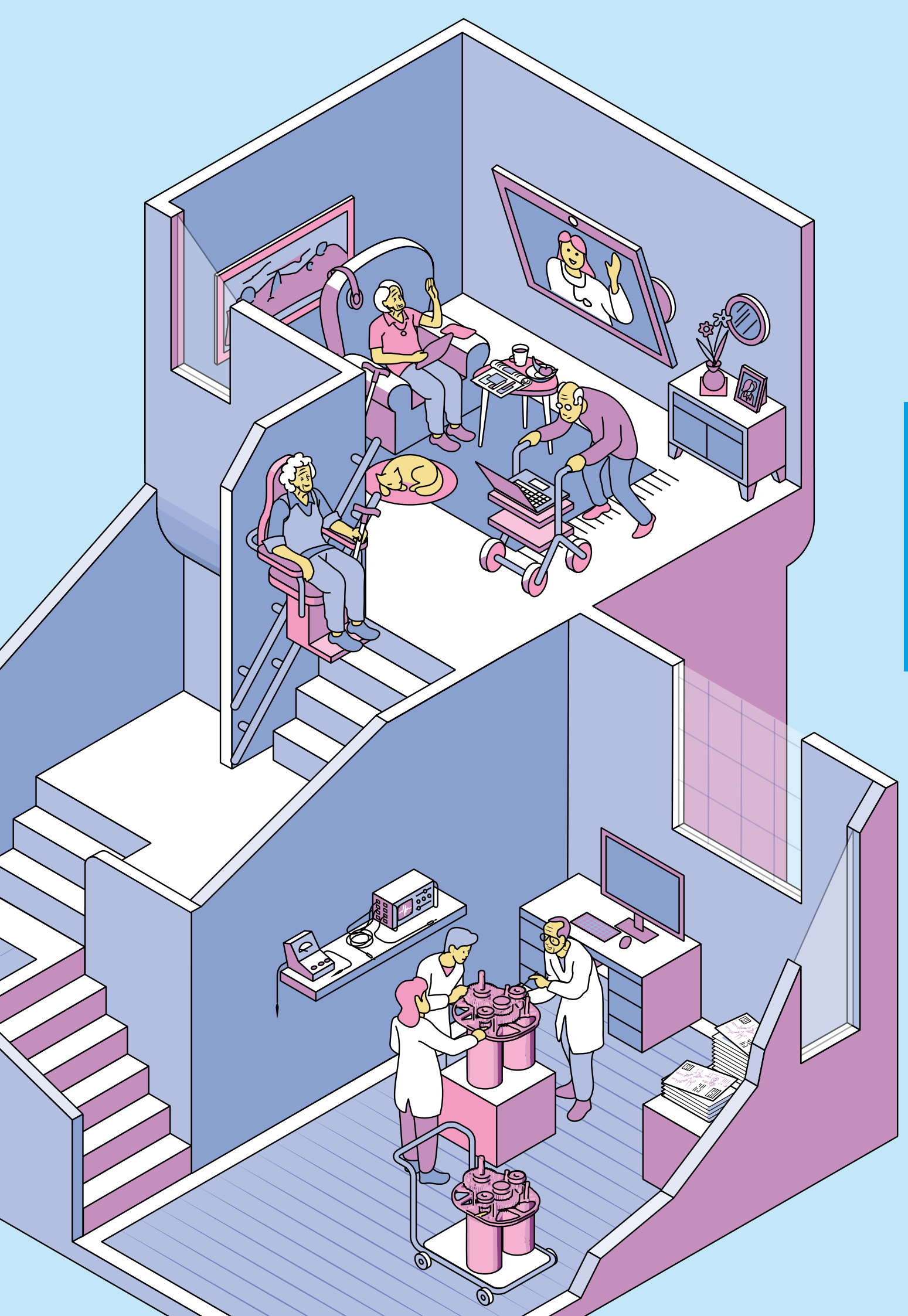
B 1 Innovation in an Ageing Society



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Demographic ageing creates economic and societal challenges for Germany. The skilled labour shortage will continue to worsen, with negative effects on the innovative power, productivity and growth of the economy. Besides, in an increasingly digitalized society, the participation of older people must be ensured. The financing of social security systems will also become more difficult with an ageing population. To meet these challenges, it will be increasingly important in the future to use the innovation potential of older people. Older people should be offered attractive and flexible options to remain in the labour force beyond retirement, be it as employees or entrepreneurs. To promote the social participation of older people, their digital skills must be improved, and innovations in the health and care system must be promoted to relieve the burden on social security systems.





B 1 Innovation in an Ageing Society

Demographic ageing in Germany, as in other industrialized economies, presents a challenge to innovative power, productivity and growth. However, it also holds opportunities for new developments.

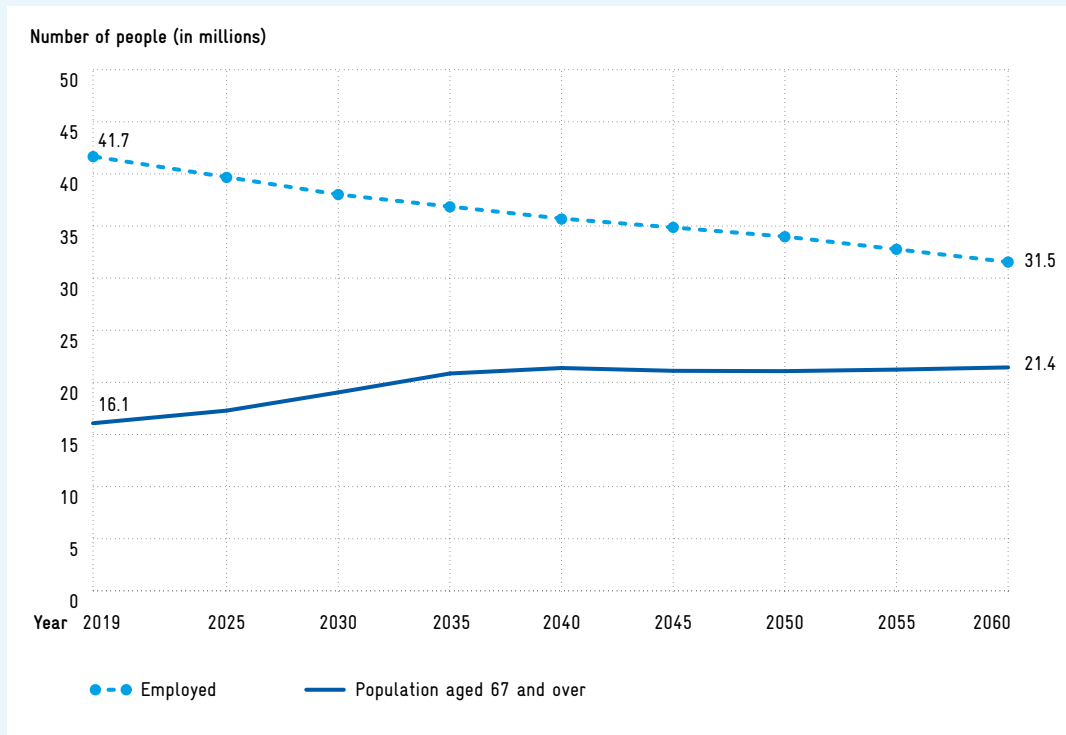
of people in employment in Germany by 2060.¹⁰⁴ According to this forecast, the number of older people will rise significantly in the coming years due to increased life expectancy. The growing number of older people will result in new potential for innovation, particularly in goods and services that are specifically tailored to this age group.

Figure B 1-1 illustrates the projected development of the population aged 67 and over and the number

Fig. B 1-1 Population and employment forecast, 2019–2060 in millions



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Legend: According to the forecast, in 2060 there will be 31.5 million people in employment and 21.4 million older people aged 67 and over in Germany.
Source: Labour Force Projection (Variant 2 W2-EQ1) Destatis (2020); 14th Coordinated Population Projection.
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The number of people in employment is expected to decline significantly in the coming decades, especially as the baby boomers enter retirement. Provided immigration remains at a similar level as before, the already pronounced skilled labour shortage will become even more acute – with negative consequences for the development and application of innovations. To nonetheless maintain the innovative power and, based on this, the productivity and growth of the German economy, it will be of crucial importance to harness the innovation potential of older people.¹⁰⁵ Older people can make a significant contribution to Germany's innovative power through their willingness to remain in employment for longer, be it as employees or entrepreneurs. It is important to create favourable conditions for them to do so.

Demographic ageing entails challenges for social cohesion. The advancing digitalization requires a minimum level of digital competence for participation in social life. If we succeed in improving and continuously developing the digital skills of older people, they will also demand innovative digital products and services, e.g. in the health and care system, and will be able to maintain their social integration for longer. This creates additional opportunities for innovation and new business models for the providers of these products and services.

Demographic ageing also affects the social security systems. In the pension insurance system, fewer and fewer contributors must support a growing number of pensioners. At the same time, an increasing number of people who are ill due to old age and in need of care is putting a strain on the health and care system. Digital innovations provide opportunities to reduce costs and thus relieve the burden on the health and care system. The prerequisite for this, however, is a sufficiently high level of digital competence on the part of the service providers and the service users.

B 1-1 Older People as Innovators

Older people have considerable potential to develop innovative ideas and to help market them. As employees, they engage in the innovation activities of their employers; as entrepreneurs, they market innovative ideas themselves.¹⁰⁶ To demonstrate these correlations empirically, the following section uses data recording older people in age groups based on age, although there are certainly other ways of defining age (cf. box B 1-2).

Box B 1-2 Dimensions of Age-related Development Processes

There is no generally valid definition of the age at which someone is considered an older person. A distinction is commonly made between three different dimensions of age-related development processes:¹⁰⁷

- The physiological-biological dimension, characterized by a reduction in physical performance.
- The psychological dimension, which includes cognitive performance. Based on experience and knowledge, increased performance can occur in this dimension with increasing age.

At the same time, performance can also decline due to reduced ability to adapt and adjust.

- The social dimension, which is determined by integration into the social environment. Here, retirement in particular can lead to a loss of activities and contacts. However, it also creates the opportunity for reorientation and the establishment of a new social environment.¹⁰⁸

Changes in these three dimensions affect the contribution of older people to the innovation process as well as their willingness and ability to use innovations. When and to what extent such changes occur varies from person to person.

Older Workers Quite Active in Research, Development and Design

To develop new ideas and to launch them on the market as innovations, companies and research institutions use employees who conduct research, development or design activities and thereby contribute their creativity, knowledge and skills to the employer's innovation activities. Figure B 1-3 shows for different age groups the percentage of employees who say they 'frequently' perform research, development or design activities. Across all age groups, 12.6 percent of employees are frequently engaged in these activities. At 13.6 percent, the rate is above average in the age group under 50. Among the over 50s, it initially declines with increasing age and then rises again: For example, the rate in the age group 55 to 59 is 10.3 percent; for those aged 65 or over it is 12.4 percent.¹⁰⁹ The statistics show that older workers are involved in innovation activities to quite a considerable extent and that the share of older workers in research, development or design activities is only slightly below that of the average for all age groups. One explanation for this finding is that occupational groups that frequently conduct research, development or design activities remain in the labour force longer than occupational groups that sometimes or never carry out these tasks.¹¹⁰

Start-Ups by Older People Relatively Often in the Mid- and High-Tech Sector

Older people also contribute to innovation as founders of technology-based companies. Figure B 1-4 provides an international comparison of the share of mid- and high-tech start-ups in the total number of start-ups by younger people up to and including the age of 59 and older people aged 60 and over.¹¹¹ Across all the countries considered, the share of mid- and high-tech start-ups¹¹² among those aged 60 and over is 9.0 percent, slightly higher than the share among those aged up to 59 at 8.5 percent. In Germany, this difference is pronounced at 9.9 percent for those aged 60 and over and 8.4 percent for those aged up to 59.¹¹³ However, the comparatively high percentages for mid- and high-tech start-ups by older people coincide with few start-ups overall in this age group. For example, the start-up rate¹¹⁴ in the mid- and high-tech sector for those aged 60 and over was only 0.3 percent over the period from 2012 to 2018 in Germany, but for those aged 59 and under it was 0.5 percent.¹¹⁵

The innovation contribution of young companies founded by older people alone or in teams can be determined for Germany using data from the IAB/ZEW Start-up Panel.¹¹⁶ The analysis includes all businesses that were less than four years old at the time of observation and are referred to as recent start-ups hereinafter. For these, the age of the founding entrepreneur, the assignment to the high-tech sector¹¹⁷ and the introduction of product or process innovations are known. The innovation contribution can be determined using the percentage of recent start-ups with product or process innovations and presented separately for the individual age groups and for assignment to the high-tech sector. The percentages in figure B 1-5 show that the innovation contribution of recent start-ups is largely independent of the age of the entrepreneurs. Around half of all recent start-ups in the high-tech sector feature innovations. At 53.7 percent, the share of recent start-ups among the over 65s is higher than that in the other age groups. In the non-high-tech sector,¹¹⁸ between 31.9 and 36.9 percent of recent start-ups have introduced product or process innovations across all age groups.

Start-ups by Older People More Likely Involving Market Novelties

If the aspect of quality in innovations is taken into account and only market novelties are considered,¹¹⁹ then the high innovation contribution of recent start-ups by older people becomes clear.¹²⁰ Figure B 1-6 shows the percentage of recent start-ups with market novelties differentiated by age groups of the entrepreneurs¹²¹ for the periods from 2006 to 2012 and from 2013 to 2020. In both periods, the percentages in the age groups of 50 years and older are higher than the percentages of those under 50 years of age. In the age group 65 and over, the shares of recent start-ups with market novelties are far above average at 14.1 percent in the period from 2006 to 2012 and 13.4 percent in the period from 2013 to 2020.

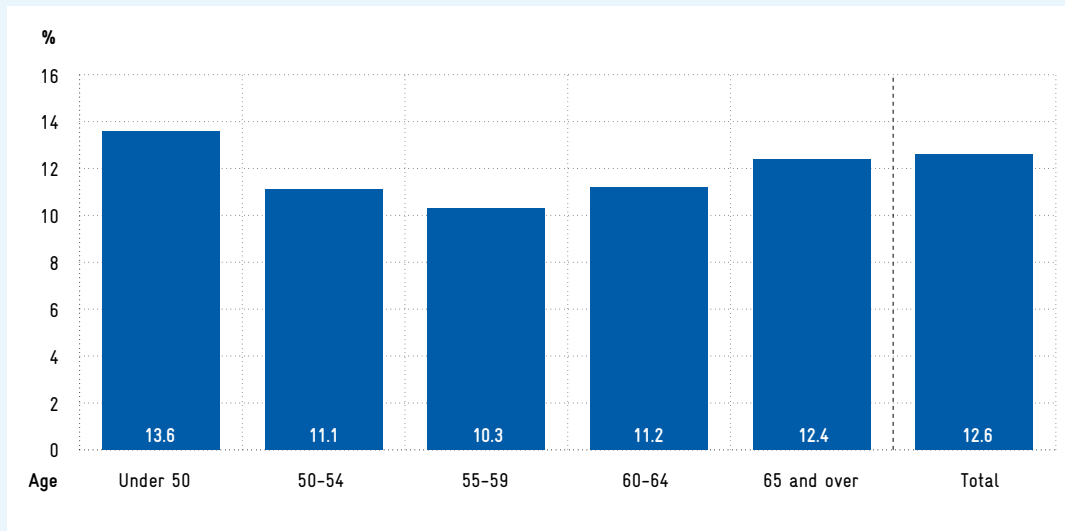
More Pronounced R&D Activities in Recent Start-ups by Older People

The higher innovation contribution of recent start-ups by older people is associated with more regular and more pronounced research and development (R&D) activities. Figure B 1-7 shows for recent start-ups not only the amount of annual R&D expenditure but also the share of enterprises

Fig. B1-3 Percentage of dependent employees who frequently perform the task 'Research, Development, Design Activities', by age group



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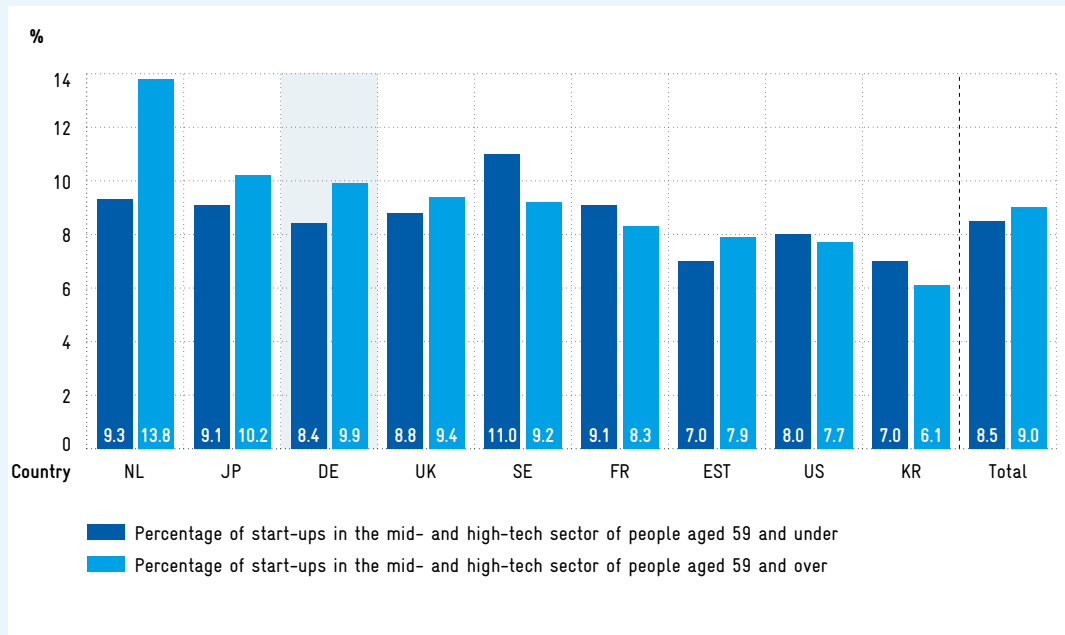


Answer to the question: I would now like to list a few selected activities. Please tell me how often these activities occur in your work, whether frequently, sometimes or never. Task Research, Development, Design Activities.
 Legend: For the years 2006, 2012 and 2018, an average of 12.4 percent of dependent employees in the age group 65 years and over were frequently engaged in research, development or design activities.
 Source: BIBB/BAuA Employment Survey 2006, 2012 and 2018. Own calculations. Own representation. N=53.132.
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Fig. B1-4 Percentage of start-ups in the mid- and high-tech sector among all start-ups by country and age group of entrepreneurs



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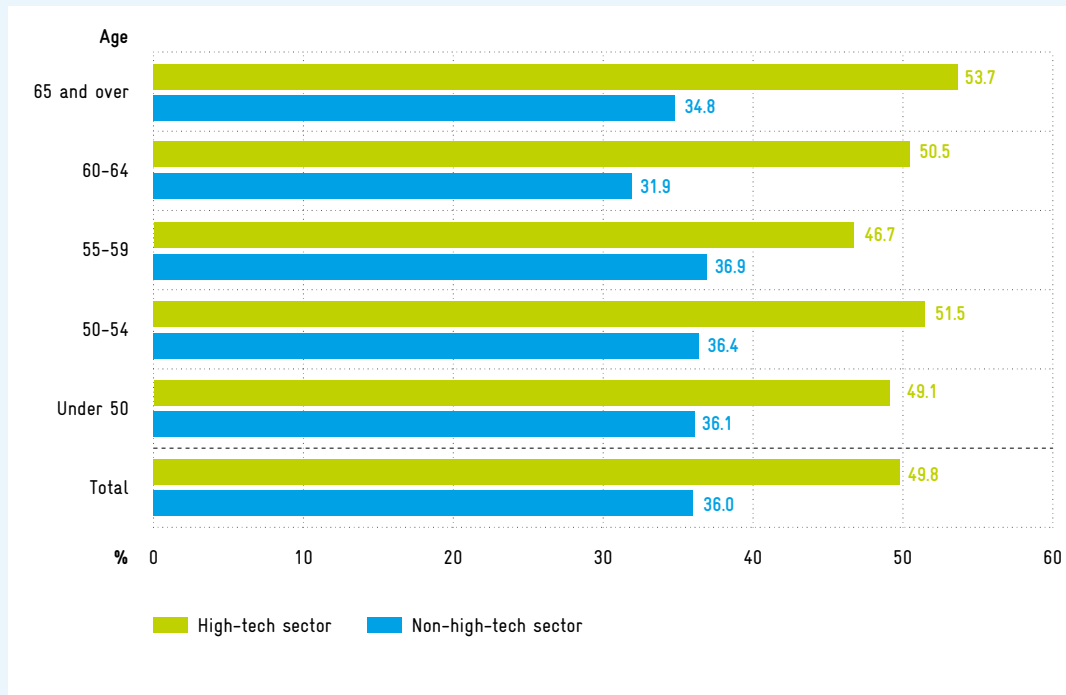


All other start-ups are in the no- and low-tech sector. TEATEC (Total Early Stage Entrepreneurial Activity in a Technology Sector) is recorded. This takes into account entrepreneurs who, at the time of the survey, are in the process of establishing a company or are the owner of a company that is no more than 42 months old in the mid- or high-tech sector.
 Legend: Among entrepreneurs aged at least 60 in Germany, the share of start-ups in the mid- and high-tech sector is 9.9 percent, among those aged up to 59 it is 8.4 percent.
 Source: Global Entrepreneurship Monitor 2012 to 2018. Own calculations. Own representation.
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Fig. B1-5 Percentage of recent start-ups with product or process innovations by age group of entrepreneurs



[Download Data](#)



Product or process innovations (yes/no) of recent start-ups (average values for the years 2007 to 2020, projection). Recent start-ups are those that were less than four years old at the time of observation. The high-tech sector is defined by the following industries: cutting-edge technology in manufacturing, high-value technology in manufacturing, technology-intensive service providers and software. The non-high-tech sector is defined by the following industries: Non-technology-intensive industries in manufacturing, knowledge-intensive service providers, creative consumer-related service providers, construction and finishing trades. Age classes are based on the age of the entrepreneur or, in the case of team start-ups, on the age of the oldest member of the start-up.
Legend: 53.7 percent of the entrepreneurs aged at least 65 in the high-tech sector have product or process innovations.
Source: Special evaluation by the IAB/ZEW Start-up Panel. Own representation.
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that conduct R&D activities continuously, in each case for different age groups of the entrepreneurs at the time of founding. Continuous R&D is above average if older people founded the business. In the age groups of people aged 60 to 64 and over 64, 7.4 percent and 6.3 percent, respectively, of the businesses have conducted continuous R&D activities since their establishment. The average across all age groups is 4.4 percent. At the same time, the average R&D expenditure of recent start-ups increases for entrepreneurs up to the age of 60 to 64, who have the highest R&D expenditure at an average of €114,800. The R&D expenditure declines again in recent start-ups by those aged 65 and over..

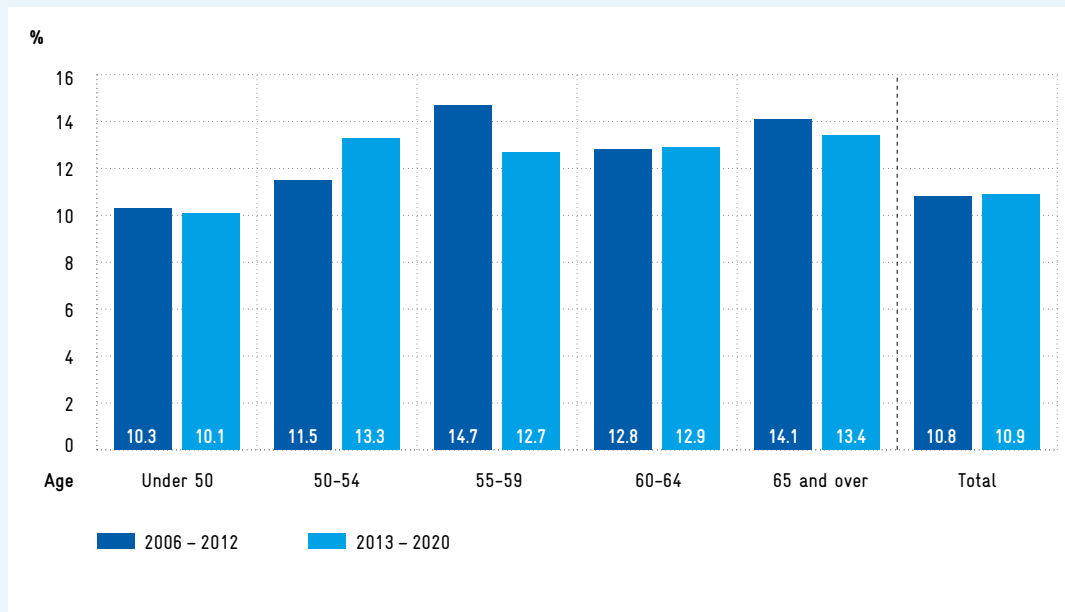
Patents by Older Inventors Less Disruptive

Patent data can be used to assess the genuine contribution of older people to the development of new technological ideas that can be the starting point for innovations. Comprehensive patent data with age classification are available for the USA.¹²² Around 1.2 million inventors are recorded for the period from 1976 to 2017. The patenting rate can be determined in relation to the respective age of these inventors. The highest patenting rate is achieved by men in their early 40s with one patent in four years and women in their late 30s with one patent in six years. With increasing age, patenting activities decrease: at the age of 65, the rate is about one patent in eight years for men and one patent in 14 years for women. In addition, patents by older people

Fig. B1-6 Percentage of recent start-ups with market novelties by age group of entrepreneurs



[Download Data](#)



Market novelties (yes/no) of recent start-ups for the periods from 2006 to 2012 and from 2013 to 2020, projection. Recent start-ups are those that were less than four years old at the time of observation. Age classes are based on the age of the entrepreneur or, in the case of team start-ups, on the age of the oldest member of the start-up.

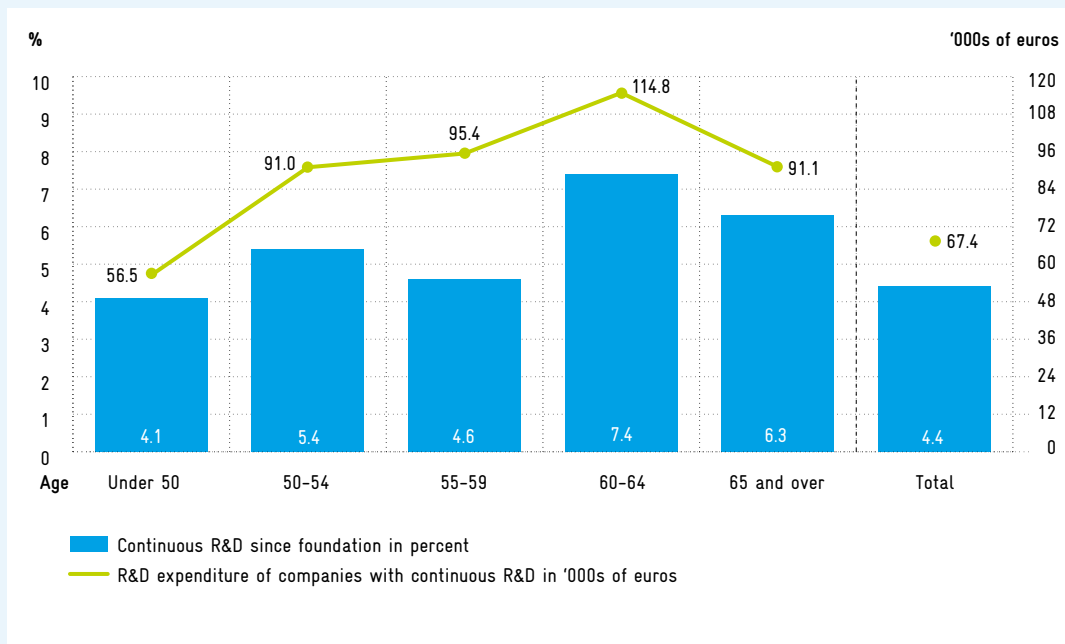
Legend: 13.4 percent of recent start-ups with at least 65-year-old entrepreneurs introduced market novelties in the period from 2013 to 2020.

Source: Special evaluation by the IAB/ZEW Start-up Panel. Own representation.
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Fig. B1-7 Percentage of recent start-ups with continuous R&D by age group of entrepreneurs and their R&D expenditures in thousands of euros



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Continuous research and development (R&D) in percent and average R&D expenditure in thousands of euros of recent start-ups since foundation, projection. Recent start-ups are those that were less than four years old at the time of observation. Age classes are based on the age of the entrepreneur or, in the case of team start-ups, on the age of the oldest member of the start-up.

Legend: In the age group of entrepreneurs aged at least 65, 6.3 percent of the recent start-ups report that continuous R&D activities have been carried out since foundation. The R&D expenditure of recent start-ups with continuous R&D amounts to an average of €95,700 for entrepreneurs who are at least 65 years old.

Source: Special evaluation of IAB/ZEW Start-up Panel. Own representation.
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tend to be less disruptive,¹²³ i.e. the degree of novelty of the ideas they protect is less pronounced. Accordingly, with increasing age, the contribution to technological development not only declines, but is also increasingly limited to incremental further development of already existing technologies. The probability of older people contributing to radically innovative ideas is comparatively low.

Older data for inventors employed in Germany subject to social security contributions also show a declining contribution to technological development with advancing age, measured in terms of patent applications. In 2011, the age group of inventors aged 50 to 59 accounted for 23.5 percent of patent applications, while the age group of those aged 60 or older contributed 4.4 percent. Compared to 2006, however, these percentages have increased, which indicates a growing contribution of older people to the patent volume. At that time, only 16.3 percent of patent applications were filed by inventors aged 50 to 59 and 3.2 percent by inventors aged 60 or older.¹²⁴

When combining data on start-ups with information on patents, it becomes apparent that recent start-ups by older people are more often patent-based than recent start-ups by younger people. While 2.8 percent of recent start-ups in the age group of under 50 have a patent at the time of foundation, the percentage increases with increasing age of the entrepreneurs. Among those aged 55 to 59, it accounts for 5.1 percent of all start-ups, and among those aged at least 65, it is as high as 7.6 percent of all recent start-ups.¹²⁵

Higher Likelihood of Innovation in Mixed-Age Teams

Older employees or older entrepreneurs often contribute to innovations in inventor teams or in the form of team start-ups. Based on data for dependent employees, it can be seen for Germany that in-house inventor teams with a higher average age have a lower probability of innovation.¹²⁶ This correlation is also evident in an analysis of the KfW SME Panel,¹²⁷ which includes German companies with a turnover of up to €500 million per year.¹²⁸ As the proportion of employees over 55 in the workforce increases, the probability of producing innovations decreases. However, the participation of older people in mixed-age teams¹²⁹ can be important for the success of innovation.¹³⁰ Data for

dependent employees show that mixed-age teams are more likely to produce innovations. Moreover, the probability of innovation increases with the age difference between the individual team members.¹³¹ Data on US patent applications additionally indicate that mixed-age teams produce higher-quality innovations.¹³²

B1-2 Older people as Skilled Workers

In view of the skilled labour shortage caused by demographic change, the considerable potential innovation contributions of older people, as described in B 1-1, suggest the question of whether, in which areas and how older people can be recruited for continued dependent employment for longer, if necessary also beyond retirement. The answer to this question could help to compensate for the negative effects of demographic ageing on economic innovation.

When older employees with many years of professional experience retire, their comprehensive and often highly specific expertise and experience is no longer available to companies. The standard pension age¹³³ is the determining factor for the retirement of dependent employees. In Germany, it remained unchanged at 65 years for a long time until 2012; since 2012, the standard pension age has been gradually raised to 67 years. However, the actual average pension age is below the statutory standard pension age,¹³⁴ and the employment rate¹³⁵ decreases sharply with increasing age even before the standard pension age is reached. In the age group of 55 to 59 years, the employment rate in 2021 was 81.1 percent, in the age group of 60 to 64 years only 61.4 percent.¹³⁶ The economy and society thus lose considerable innovation potential due to the early retirement of older people.

In its Skilled Labour Strategy (Fachkräftestrategie der Bundesregierung), the German Federal Government has formulated the goal of 'keeping older workers in the labour force as long as possible and individually desired'.¹³⁷ To this end, measures are to be taken, for example, to raise awareness of the so-called Flexi-Rente.¹³⁸ The Federal Government also plans to enter into a social dialogue with employers and union representatives to discuss framework conditions such as flexible age limits in employment contracts and collective agreements.¹³⁹ Already as of January 2023, the Federal Government reformed

the possibilities for earning additional income while drawing a pension. Just like people who have already reached the standard pension age, people who draw their pensions early are now allowed to earn as much additional income as they wish without it being offset against their pension benefits. In the case of reduced earning capacity pensions, the additional earnings limit was raised significantly.¹⁴⁰

Higher Percentage of Older Workers in Jobs with Highly Complex Requirements

The contribution older skilled workers can make to innovation depends on the extent to which the job they perform gives them the opportunity to contribute their knowledge and experience. Among employees engaged in research, development or design activities (cf. figure B 1-3), older individuals¹⁴¹ are employed longer in complex and highly specialized tasks¹⁴² than in less complex tasks.¹⁴³ A similar pattern can also be seen in a sample of only employees with PhD degrees.¹⁴⁴

Digital Transformation as a Challenge for Older Skilled Workers

The digitalization of the world of work is leading to changes that confront all employees with major challenges if they do not have sufficiently developed digital skills.¹⁴⁵ Their job-related digital skills can be continuously improved through in-house and external training.¹⁴⁶ However, empirical evidence shows that in-house training is more likely to be taken up by younger employees. The share of people who completed in-house continuing education and training (CET) in the respective previous year was only 39 percent for people aged 50 to 64 in 2018, while it was 48 percent for people aged 35 to 49.¹⁴⁷ This percentage has increased steadily in all age groups since 2012. The share of CET that is allotted to information and communication technologies (ICT), which are important for the digital transformation, is only 10 percent and hardly differs between the various age groups.¹⁴⁸

The Federal Government has recognized the importance of CET for successful transformation processes and has adopted a National Continuing Education Strategy (Nationale Weiterbildungsstrategie).¹⁴⁹ However, this strategy does not specifically address the challenges that arise from the combination of demographic ageing and digital transfor-

mation and that can hinder continued employment after retirement.¹⁵⁰

Pension Age the Main Reason for Ending Employment

Across all forms of employment, reaching the pension age is the most frequently cited reason for retirement (cf. figure B 1-8). In 2021, 56.6 percent of the respondents who were retired at the time of the survey¹⁵¹ stated that they had retired¹⁵² because they had reached the pension age. Compared to 2014 and 2017, the relevance of the pension age for ending employment has increased significantly.

Also, in 2021, 51.7 percent of the respondents were motivated by personal, health or family reasons to end their employment. Across all years, business or labour market-related reasons for leaving employment were cited significantly less frequently and in decreasing order over time.

Increased Employment in Retirement

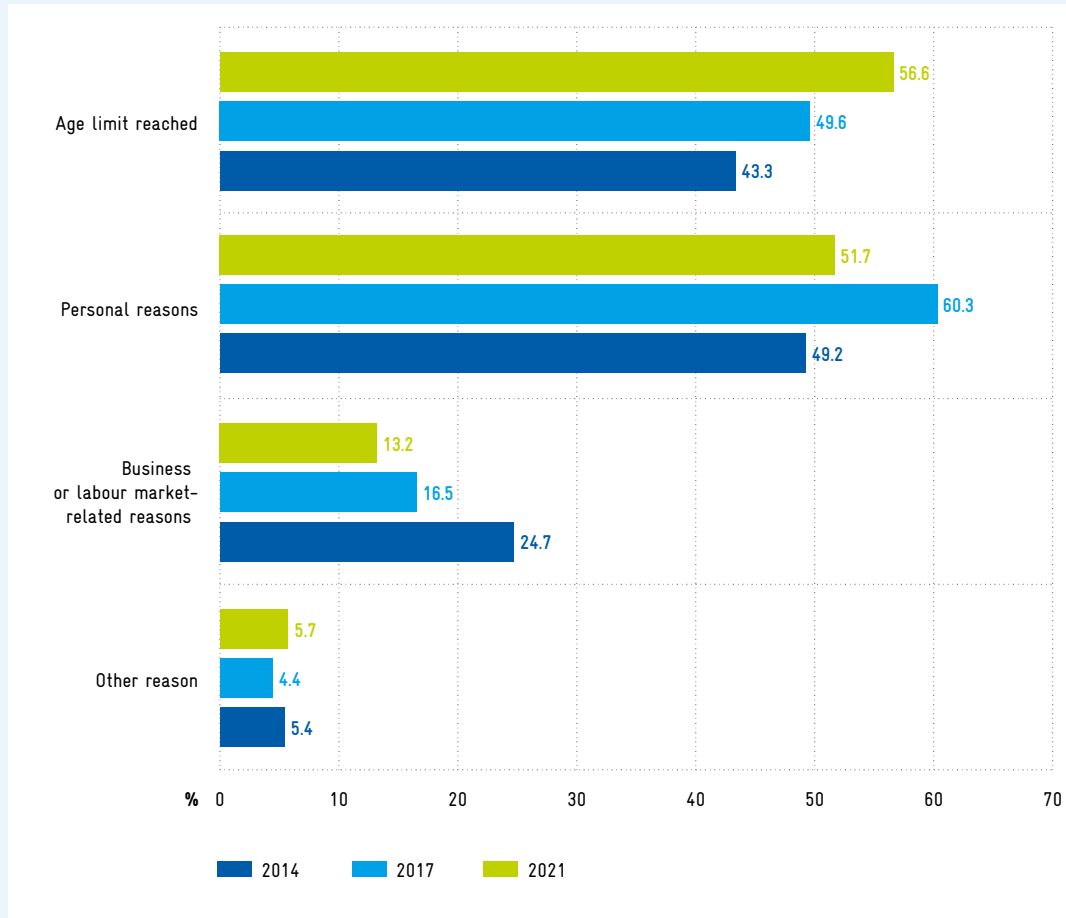
There is a disproportionately high number of people with a high level of education among older dependent employees who are available to businesses as skilled workers beyond retirement.¹⁵³ For companies, continued employment beyond reaching pension age creates opportunities to retain their expertise and thus also to promote innovation.

The share of people who are still employed in retirement has increased from 10.7 percent in 2014 to 11.7 percent in 2021. Of these retired workers, 40.1 percent were dependently employed in 2014 and 29.7 percent in 2021, a decrease of 10.4 percentage points (see table B 1-9).¹⁵⁴ Increasingly, companies are retaining their own retirees. In 2021, at 47.8 percent, almost half of those who continued to work in retirement were employed by or otherwise working for the same employer. Compared to 2014, this corresponds to an increase of 10 percentage points.¹⁵⁵ The fact that many companies have recognized the potential of older skilled workers is also reflected in various initiatives to build up pools of skilled workers that can be drawn on when needed (cf. box B 1-12).



[Download Data](#)

Fig. B 1-8 Reasons for leaving employment by age group in percent



Answer to question: Why did you stop working full-time in your primary occupation? What are the main reasons for you? Question was changed in 2021, therefore categories simplified. No distinction between self-employed or employed possible. Personal reasons include: quitting as early as possible, double burden otherwise too high, partner/spouse is retired, enough time for myself, taking care of sick person, family reasons, health reasons, taking care of children, taking care of grandchildren, preparing for retirement. Company and labour market reasons include: became unemployed, internal company reasons, dissatisfied with labour market situation. Multiple answers possible. No differentiation between self-employed and employed persons before retirement. Legend: In 2021, 56.6 percent of retired persons gave reaching the age limit as the reason for retirement. Source: German Ageing Survey 2014, 2017 and 2021. Own calculations. Own representation. © EFI – Commission of Experts for Research and Innovation 2023.

Quality of Life Decisive Motivation for Employment in Retirement

Employment in retirement is primarily motivated by reasons that create quality of life.¹⁵⁶ In 2021, 81.2 percent of respondents cited enjoyment of work, 72.5 percent contact with other people and 66.8 percent having a purpose as motives for continued employment (cf. figure B 1-10). These intrinsic reasons have gained in importance over the past eight years. The financial situation is of comparatively lesser importance for employment in retirement, but at 31.0 percent still not to be neglected. How-

ever, its importance has decreased since 2014. If age and level of education are also taken into account in these correlations, it becomes apparent that quality of life as a motivation for employment becomes more important with increasing age and higher education, while the financial situation becomes less important.¹⁵⁷

Similar Occupational Activities Before and After Retirement

The opportunities for contributing to the creation of innovations in retirement are greater the more

Tab. B 1-9 Employment in retirement in percent

	2014	2017	2021
Share of employed in retirement	10.7	10.8	11.7
Of which			
Dependently employed	40.1	30.1	29.7
Working for same employer as before retirement (including dependent employees)	37.0	39.2	47.8

Answer to question: Sometimes pensioners and retirees keep working after retirement. What about you: Are you working at the moment? Are you employed as a worker or employee or are you self-employed? And: Are you employed at the same employer like before your retirement? Do you work for your former employer?

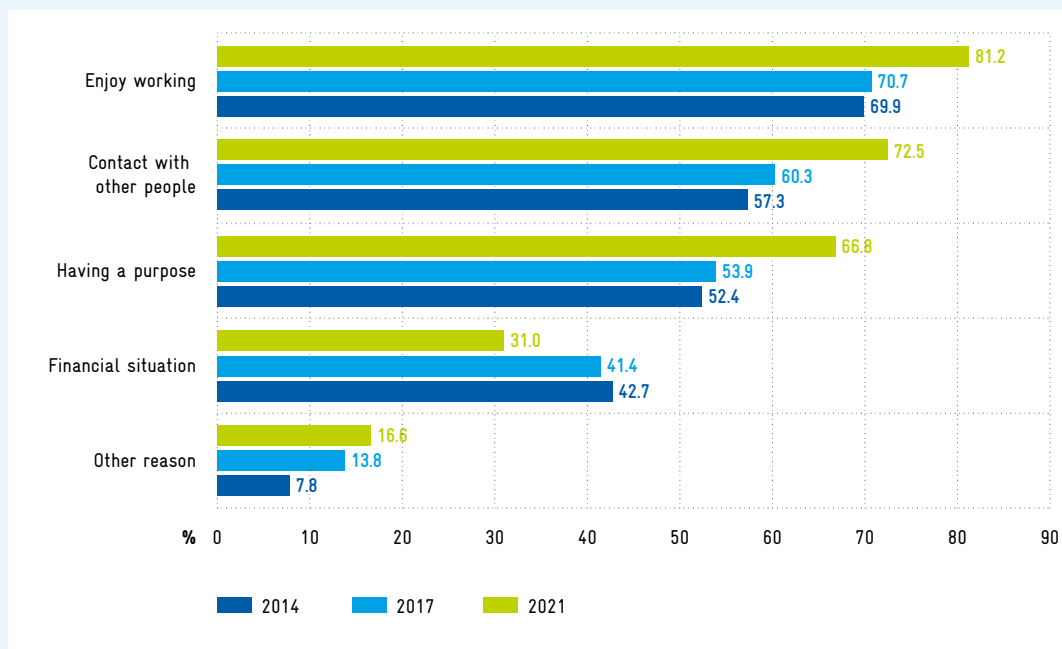
Legend: In 2021, 11.7 percent of people reported being employed in retirement. Of these, 29.7 percent are dependently employed. Of the 11.7 percent who are employed in retirement, 47.8 percent work for the same employer as before retirement (including dependent employees).

Source: German Ageing Survey 2014, 2017 and 2021. Own calculations. Own representation.
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Fig. B 1-10 Reasons for working in retirement in percent



Answer to question: What motivated you to take up work during retirement?

Only dependent employees are taken into account. Multiple answers possible.

Legend: In 2021, 61.2 percent of retirees gave enjoy working as the reason for employment.

Source: German Ageing Survey 2014, 2017 and 2021. Own calculations. Own representation.

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the knowledge and experience acquired during working life can continue to be used. Figure B 1-11 shows the percentage of dependent employees in retirement who are active in the same scope of activities as before retirement. The results indicate that retired workers continue using their expertise

and experience mainly in the jobs they held before retirement. Of those retired workers whose previous occupations were associated with a high level of education,¹⁵⁸ 91.8 percent continue to perform similarly demanding activities in retirement.

Different Labour Law Regulations for Employment in Retirement

After retirement, older people are certainly motivated to continue contributing their experience to the workplace. From the employer's point of view, the continued employment of retirees has the advantage of retaining employees who have already been trained and their expertise, including their organization-specific knowledge, and gaining more time for the transfer of knowledge to junior staff.

For economic reasons, it is often attractive for companies to employ retirees only on a fixed-term basis. The legal conditions for such fixed-term employment depend on the nature of the employment contract. If a retiree decides to enter into an employment contract with a new employer, then an initial fixed-term contract without an objective reason is unproblematic.¹⁵⁹ However, if a new employment contract is established with the same employer, then an initial fixed-term contract without an objective reason is excluded under the Part-Time and Fixed-Term Employment Act (Teilzeit- und Befristungsgesetz, TzBfG)¹⁶⁰ because of the prohibition of so-called 'prior employment'.¹⁶¹ Reaching the pension age is not in itself a permissible objective reason for an effective fixed-term.¹⁶² If it is already agreed before retirement to continue an existing employment contract beyond the pension age, a repeated postponement of retirement is unproblematic.¹⁶³

In Germany there are various company programmes that organize the project-related deployment of retirees in order to continue to use their expertise and to improve the supply of skilled workers. In these so-called senior expert programmes (cf. box B 1-12), databases are kept detailing the competences of retired former employees and, if necessary, suitable retirees are requested for mostly shorter projects. For example, senior expert programmes have been established by the industrial group Thyssenkrupp,¹⁶⁴ the car manufacturer BMW¹⁶⁵ and the conglomerate Bosch.¹⁶⁶ However, access to senior experts is more difficult for SMEs, as they can hardly manage the balance of supply and demand for experts with the required competence profile internally. Only a few service providers exist that offer a placement service for retired experts, such as ASE Automotive within the automotive industry.¹⁶⁷

B 1-3 Older People as Entrepreneurs

Section B 1-1 made it clear that older people play a relevant role in innovative new businesses, especially in the high-tech sector.¹⁶⁸ However, the general propensity to start a business decreases significantly with increasing age.¹⁶⁹ Therefore, the motives of older people to start a business and the difficulties they face in the start-up process are examined in more detail below.

Economic Motives Less Pronounced in Start-ups by Older People

Businesses are established for a variety of reasons. The importance of the various motives can change over the course of a lifetime. Figure B 1-13 shows how pronounced individual start-up motives are depending on the age group. Across all age groups, independence is the most frequently mentioned motive for establishing a business. Turning the business idea into reality is mentioned more frequently as a motive for starting a business in the three age groups of those over 49 than among those under 50.¹⁷² In contrast, the motive of earning a higher income is significantly more important for those aged 18 to 49, at 24.4 percent, than for the older age groups, where the frequency of mention ranges between 11.3 and 18.5 percent.

Difficulties in Business Establishment Less Frequently Perceived by Older People

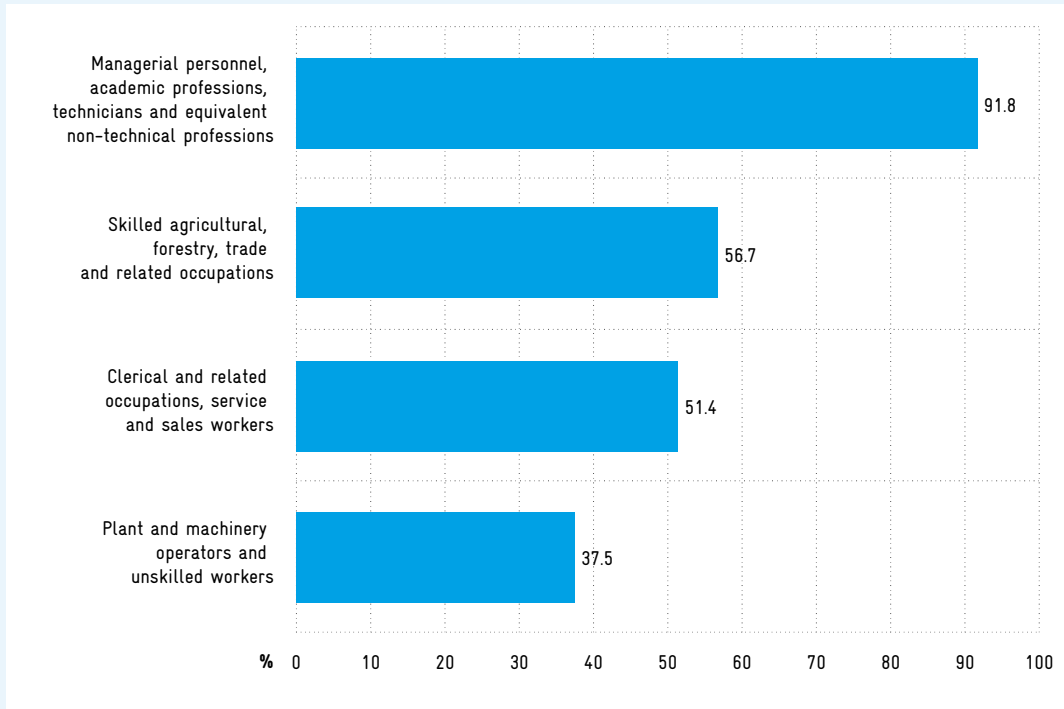
During their start-up project, entrepreneurs are confronted with various difficulties that can delay the start-up project and jeopardize its success. As part of the KfW Entrepreneurship Monitor, entrepreneurs were asked about perceived difficulties during the start-up process. Table B 1-14 shows the percentage of entrepreneurs who experienced the respective difficulty, broken down by age group.¹⁷³

Across all age groups, bureaucratic hurdles and delays are considered the greatest difficulty for start-up projects. While the burden on the family is, unsurprisingly, less of a problem for older people, 16.3 percent in the age group 55 to 59 already perceive their age as a difficulty, compared to 3.2 percent in the age group 18 to 49. Financial risks and financing difficulties do not seem to be disproportionately pronounced for older entrepreneurs. Only 3.7 percent of those aged 60 to 67 have financing difficulties and 14.0 percent have concerns about the high

Fig. B 1-11 Similar occupational activities before and after retirement



[Download Data](#)



Answer to question: Pre-retirement occupational activity according to ISCO88 and occupational activity in retirement according to ISCO88.

Only dependent employees are taken into account. Multiple answers possible.

Legend: 91.8 percent of the dependent employees in retirement in the job roles of managerial personnel, academic occupations, technicians and equivalent non-technical occupations were also employed in the job roles of managerial personnel, academic occupations, technicians and equivalent non-technical occupations in their last job before retirement.

Source: German Ageing Survey 2014, 2017 and 2021. Own calculations. Own representation.

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Box B 1-12 Senior Experts: The Example of Bosch Management Support GmbH

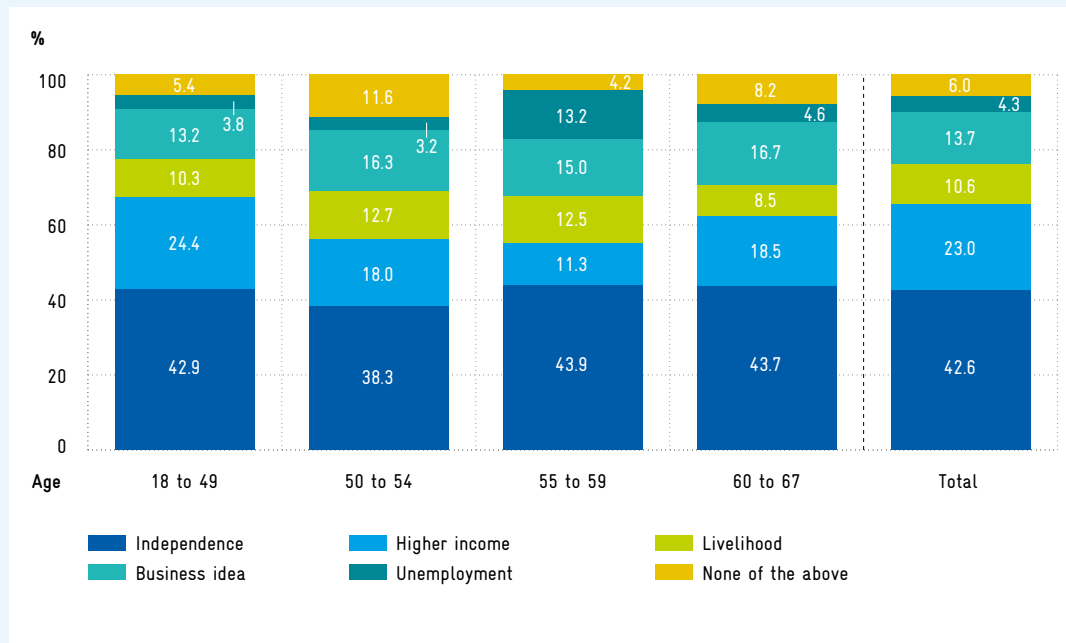
Bosch Management Support GmbH (BMS) was established in 1999 to coordinate the deployment of retired specialists known as senior experts within Robert Bosch GmbH.¹⁷⁰ From the company's point of view, the deployment of senior experts within the context of short-term projects contributes to innovative capacity. The aim is to deploy them in a specialist and problem-oriented manner in accordance with the existing expertise and to transfer knowledge across generations by working together in mixed-age project teams. Only former Bosch employees are deployed as senior experts. As they are familiar with internal work processes, this minimizes the induction period.

Work assignments of BMS senior experts last 40 days on average. In a representative survey, the senior experts name several motives for their work at BMS.¹⁷¹ The appreciation of one's own person associated with passing on experience and the opportunity to contribute to value creation are just as much a motivation for the senior experts as the maintenance of personal performance through challenging activities during retirement. Identification with the company and interesting work locations are also mentioned as motives for working in retirement. For most of the senior experts surveyed, the flexibility resulting from their own decision-making authority regarding the acceptance of assignments and the possibility of working in a home office are also of key importance.

Fig. B 1-13 Motives for establishing a start-up by age group of the entrepreneurs in percent



[Download Data](#)



Averages of the start-up cohort 2016 to 2021 are given. Age categories are based on the age of the interviewee, regardless of whether the new business is an individual or a team start-up.
 Legend: Independence is a motive for 43.7 percent of 60- to 67-year-old entrepreneurs.
 Source: Special evaluation of KfW Entrepreneurship Monitor by KfW Research. Own representation.
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financial risk, while in the age group 18 to 49 the respective percentages are significantly higher at 14.7 percent and 23.6 percent.

Comparable results are seen for respondents who have discarded the plan to establish a business. Here too, bureaucratic hurdles and delays are perceived as the most frequent difficulties. Conversely, financial risks and financing difficulties are perceived more frequently among older people who have abandoned their start-up plan, in contrast to those who have established a business, but not disproportionately frequently compared to younger people.¹⁷⁴ Overall, the data also show that difficulties are perceived less frequently with increasing age.

Start-ups by Older People More Likely to Survive

From a societal perspective, the success of start-ups is even more relevant than their frequency. A general and frequently used measure of success for start-ups is their long-term survival on the market.

Based on actual start-ups, figure B 1-15 shows the likelihood of survival of start-ups in the first five years after establishment for different age groups of entrepreneurs.¹⁷⁵ Start-ups of the under 50s consistently show a lower likelihood of survival than start-ups in other age groups. One year after establishment, 86.7 percent of the start-ups still exist, compared to over 90 percent of the start-ups of people over 50 years of age. After five years, 75.3 percent of the start-ups of those aged 50 to 54 still exist, 71.2 percent of the start-ups of those aged 54 to 59, 62.0 percent of the start-ups of those aged 60 to 67¹⁷⁶ and 57.2 percent of the start-ups of those under 50.

B 1-4 Innovations for an Ageing Society

The demographic ageing of society is not only leading to changes in the labour markets and in the associated innovation activities. It is also changing the markets for goods and services. Older people's de-

Tab. B 1-14 Perceived difficulties by age group of entrepreneurs in percent



[Download Data](#)

	18 to 49 years	50 to 54 years	55 to 59 years	60 to 67 years
Bureaucratic hurdles and delays	39,9	31,2	38,1	28,7
Difficulty in acquisition of orders/customer contacts	27,7	24,0	19,1	19,5
Concerns about age	3,2	6,4	16,3	16,6
Other difficulties	14,7	13,4	17,3	15,7
Concerns about high financial risk	23,6	15,6	14,8	14,0
Concerns about lack of professional qualifications	16,9	8,3	9,2	13,9
Concerns about immature idea	15,3	12,0	6,7	13,1
Concerns about lack of commercial knowledge	20,9	11,9	13,0	12,9
Concerns about economic situation	16,3	16,4	10,6	11,7
Strain on family	30,6	17,2	15,5	10,4
No suitable employees	15,6	11,0	11,6	8,6
Fear of social decline in case of failure	17,0	15,4	15,7	7,9
Concerns about advantages of dependent employment	20,7	10,0	13,8	3,7
Financing difficulties	14,7	14,1	7,5	3,7
Poor infrastructure	12,4	11,8	7,4	3,6
Lack of suppliers	7,3	4,6	2,5	3,4
Lack of co-founders	10,6	4,4	3,1	2,0
Poor image	6,6	7,2	4,2	1,7
Not receiving public funding	9,9	6,3	4,2	0,7

Often Rarely

Perceived difficulties of entrepreneurs. The evaluations are averages of the start-up cohorts from 2016 to 2021. Age categories are based on the age of the interviewee, regardless of whether the start-up is an individual or a team start-up. Abandonment of plans not taken into account here.

Legend: Bureaucracy is a difficulty in the start-up process for 28.7 percent of 60- to 67-year-old entrepreneurs.

Source: Special evaluation of KfW Entrepreneurship Monitor by KfW Research. Own representation.

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mand for goods and services tailored to their needs and preferences will continue to grow in the future. Age-related changes in consumption behaviour, willingness and ability to pay, and preferences for goods and services are causing companies to adapt their market and innovation strategies.¹⁷⁷ In principle, however, these changes do not give rise to any particular need for action in terms of research and innovation policy.

That said, the interaction of demographic ageing and the digital transformation of society creates two fields of action that are relevant for research and innovation policy. These cannot be categorized within the usual pattern of market and system fail-

ure, but they can be justified in socio-political terms. On the one hand, it is important to maintain the social participation of older people in an increasingly digitized environment. On the other hand, digitalization unlocks innovation potential to mitigate the demographically induced rising cost and financial pressures in the health and care system..

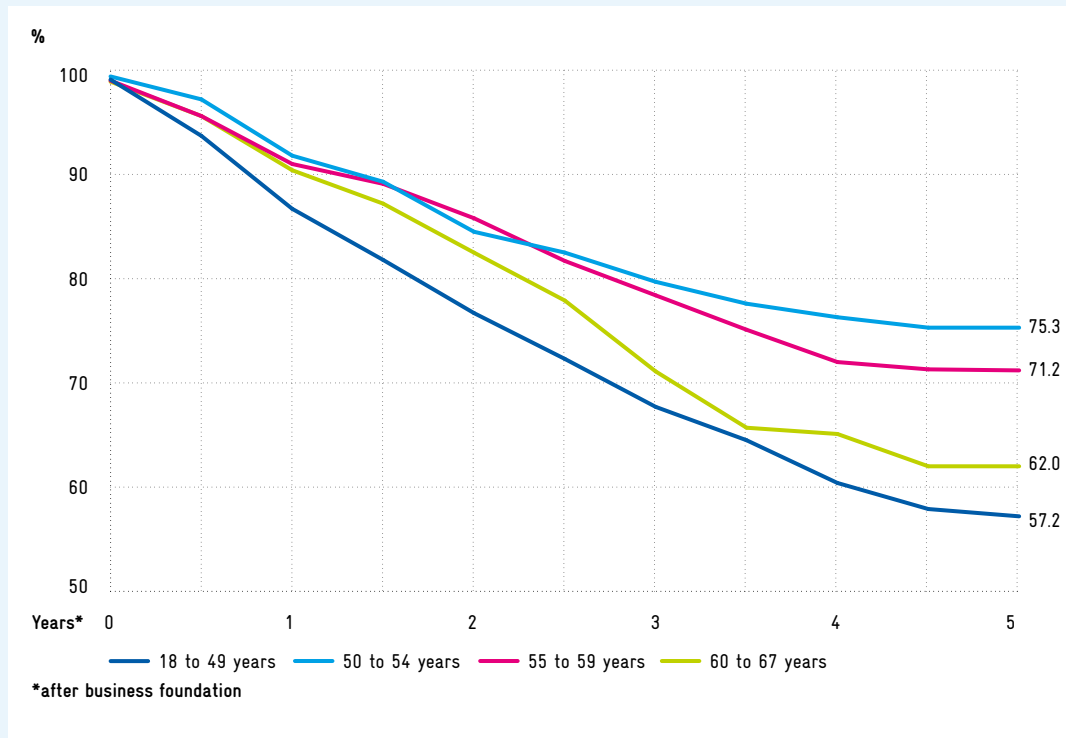
Digital Skills of Older People Significantly Poorer

The advancing digital transformation generates special challenges for the social participation of older people. Digitalization does unlock great potential for innovations that meet the special needs of older

Fig. B 1-15 Probability of survival of start-up projects by age group of entrepreneurs in percent



[Download Data](#)



Kaplan-Meier estimate of the probability of survival of start-up projects in the first five years after founding, by age categories of the interviewed entrepreneurs. Age categories are based on the age of the interviewee regardless of whether it is an individual or team start-up. The analysis is based on start-ups from the surveys from 2016 to 2021 that were no older than five years at the time of the survey.
 Legend: 82.5 percent of the start-up projects of 60- to 67-year-olds still exist two years after the founding of the business.
 Source: KfW Entrepreneurship Monitor: KfW Special evaluation. Own representation.
 © EFI – Commission of Experts for Research and Innovation 2023.

people, for example with regard to their health.¹⁷⁸ Similarly, voice recognition and smart home technologies, digital media and telemedicine allow older people to remain socially integrated in their familiar environment for longer.¹⁷⁹ However, using these innovative services requires nationwide access to digital infrastructures such as broadband and 5G networks, as well as sufficient digital skills among users.

Digital participation describes easy and secure access to digital infrastructures, technologies and developments, which in turn enables access to information, communication and exchange. A prerequisite for digital participation, and consequently for trust in digital technologies and openness towards digital innovations, are basic digital skills.¹⁸⁰ Without these skills, even simple applications with everyday relevance, such as online banking or shopping,

can be challenging. The expansion of digital applications in public administration (e-government) likewise presents serious problems for people without sufficient basic digital skills. A lack of digital skills or skills that are no longer up to date not only have a negative impact on the demand for these services, but also impair participation in social life.¹⁸¹

Especially in parts of the older population, it cannot be assumed that the skills required for digital participation are fully available. Currently, digital literacy is significantly lower among the older population than among younger people. It already decreases significantly in the age group of people aged 56 to 64. After retirement, digital skills acquired during working life are quickly made obsolete by the dynamics of new products and services. In terms of digital literacy, the over 76s are particularly out of touch.¹⁸²

Older people often do not see much benefit for themselves in the use of digital technologies. Only about 50 percent of people aged 56 to 75 agree with the statement that they benefit from digitalization; in the age group of 76 and over, the figure is as low as 24 percent.¹⁸³ However, once digital innovations are experienced as helpful by older people, openness and acceptance increase immediately.¹⁸⁴

In an international comparison, the share of people aged 65 to 74 with at least basic digital skills is only 28 percent in Germany, significantly lower than for example in the Netherlands (61 percent), Switzerland (56 percent) and Norway (55 percent).¹⁸⁵ At the same time, non-European countries with special funding programmes also demonstrate that digital skills can be improved across the board with sufficient funding. One example is the Canadian Digital Literacy Exchange Program (DLEP) (see box B 1-16).

In Germany, the promotion of digital skills among older people is still in its infancy. The Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (Bundesministerium für Familie, Senioren, Frauen und Jugend, BMFSFJ) and the German National Association of Senior Citizens' Organisations (Bundesarbeitsgemeinschaft der Seniorenorganisationen, BAGSO) therefore initiated the Digital Pact for Older People (DigitalPakt Alter). The focus is on personal advice and individual assistance with specific questions about digital applications and devices. The two-year budget for 2021 and 2022 was just

under €1.4 million.¹⁸⁶ A total of about 10,000 older people were contacted in the first year.¹⁸⁷

Digitalization Potential in Healthcare Not Fully Leveraged

The demand for medical goods and services¹⁹⁰ will increase with the demographic ageing of society. Specifically, an increasing demand for care services is to be expected. 4.6 million people in Germany were already dependent on care in 2021. Assuming a constant care rate and the currently forecast population development, the number of people in need of care will rise to 6.5 million by 2050.¹⁹¹ Consequently, the need for skilled workers in care professions will increase.¹⁹² This development, as well as the rising demand for healthcare goods overall, will trigger increased financial pressure on the statutory health and care insurance funds. However, the expected cost increases in the health and care system are not matched to the same extent by increasing contribution payments.

The bottlenecks in funding and skilled labour can be counteracted through digitalization by using digital innovations in medical and nursing services and goods in the form of assistance and support systems as well as stand-alone applications.^{193, 194} For example, the Digital Care Act (Digitale-Versorgung-Gesetz, DVG)¹⁹⁵ passed in 2019 provides for the use of various digital technologies. These include digital health applications, connection to telematics infrastructure, boosting telemedicine and digitization of

Box B 1-16 Promoting Digital Participation: The Canadian Digital Literacy Exchange Program (DLEP)

The DLEP was initiated by the Canadian government in 2018 to improve the digital skills and therefore the digital participation of selected population groups, including older people, members of the Indigenous population and non-native speakers. The DLEP focuses on free public services to promote basic digital literacy. In a first funding period from 2019 to 2022, 36 projects were funded with a total of more than CAD*26

million (approx. €17.9 million).¹⁸⁸ Of the 36 projects funded, 31 were aimed at the target group of people over 65, among others.

In total, the DLEP supported over 400,000 people in their basic digital skills over the three-year period from 2019 to 2022, reaching more than 1 percent of the total population.¹⁸⁹ People over the age of 65 accounted for approximately two-thirds of all participants.

In 2022, the project entered another funding period (2022 to 2025) with a volume of CAD*17.6 million (approximately €12.1 million).

administrative processes, as well as improved usability of health data and opportunities for the promotion of digital innovations by statutory health insurance funds.¹⁹⁶

To exploit the potential of innovations of this kind, innovations must benefit those in need of care. An important prerequisite for the use of innovations is that both recipients and providers of services have the necessary digital skills. This makes the previously mentioned problem of older people's basic digital skills relevant in this context as well. In the provision of services in care, the demands for basic and job-specific digital skills will also increase, which will exacerbate the quantitative bottleneck among care professionals. The Commission of Experts already highlighted this problem for the healthcare system in its 2022 report.

In 2017, the Nursing Professions Act (Pflegerberufegesetz) was introduced, which merged the previous vocational education and training programmes for geriatric nursing, healthcare and nursing, as well as healthcare and paediatric nursing into a single training profession. The aim of this generalization is to make the nursing profession more attractive by providing greater flexibility and later specialization. The coalition parties have recognized that the teaching of digital competences must be integrated into this vocational education and training programme.¹⁹⁷

Regulation of Cost Transfer in the Health and Care System Inhibits Innovation

As a result of the separation of payers of costs and beneficiaries in the health and care system, cost transfer regulations are indispensable to keep costs controllable. The Joint Federal Committee (Gemeinsamer Bundesausschuss, G-BA) decides which medical and nursing services the statutorily insured in Germany can make use of.¹⁹⁸ It is thus incumbent on the G-BA to decide on the introduction of technological innovations in the health and care system. In the G-BA, in addition to the chair and two neutral members, the payers and the service providers are represented by five members each. Nursing professions as well as non-medical healthcare professions are not represented in the G-BA and consequently have no say.¹⁹⁹ Likewise, the beneficiaries have no voice in the G-BA. To promote innovation in the health and care system, the coalition parties have included a reform of the G-BA in their coalition

agreement. This is intended to speed up decisions in self-administration, increase patient representation and expand the opportunities for nursing and other healthcare professions to have a say in relevant decisions.²⁰⁰ Further barriers to the adoption of innovations can be reduced by regulatory changes at the interfaces of the social security systems, for example by improving coordination between outpatient and inpatient care.²⁰¹

B 1-5 Recommendations for Action

Use the Potential of Older Skilled Workers

Longer labour participation can make a significant contribution to reducing the skilled labour shortage threatening the innovative capacity of the German economy in the medium to long term in the wake of demographic ageing. Older employees should therefore be offered attractive conditions to make their expertise and experience available to the labour market for as long as possible and to contribute to innovation. The labour participation of older workers plays only a subordinate role in the Federal Government's Skilled Labour Strategy. The Commission of Experts recommends developing concrete policy measures that go beyond the social dialogue with the employers and union representatives. These include:

- To make the best use of the innovation potential of older people, the general conditions for them to be employed in retirement should be made as administratively and financially attractive as possible.
- The Commission of Experts does not see any particular need for protection when retirees enter into a new employment relationship. For this reason, a fixed-term contract without an objective reason should always be an option, even multiple times.
- The initiation and start-up funding of regional and sector-related platforms should be considered to support SMEs in the recruitment of senior experts.

Systematically Integrate Older People in Start-up Support Formats

Older people also make substantial contributions to the performance of the German innovation system as founders of new companies. The available data do not indicate any special funding needs for older entrepreneurs. The Commission of Experts recommends:

- Access to existing funding formats should be made easier for older potential entrepreneurs. For example, the opening of university start-up funding formats and access to public infrastructure such as incubators should be considered. Stereotypes of ‘young’ entrepreneurs should be eliminated when addressing those interested in establishing a business.

Improving Digital Participation of Older People

The participation of older people in a digital economy and society is enabled by the broadest possible access to new digital products and services. Digital participation requires not only access to digital infrastructure but also the skills to use digital services. Digitalization in the public sector adds to the importance and urgency of this. The Commission of Experts recommends:

- Complementary to the broadband expansion, which the Commission of Experts has already repeatedly called for, systematic support measures are needed to improve the digital skills of older people. The Digital Pact for Older People should serve as a starting point for broader initiatives.
- The overdue digitalization of public administration (cf. chapter A 3) should be directly linked to comprehensive support measures for older people in the use of digital services. This support should also focus on the acquisition of digital skills to counteract the increasing exclusion of older people.

Leverage the Potential of Digital Innovations in the Health and Care System

Demographic ageing is challenging the health and care system due to increasing demand and a simultaneous shortage of skilled workers. Digital innovations can provide relief here. The Commission of Experts recommends:

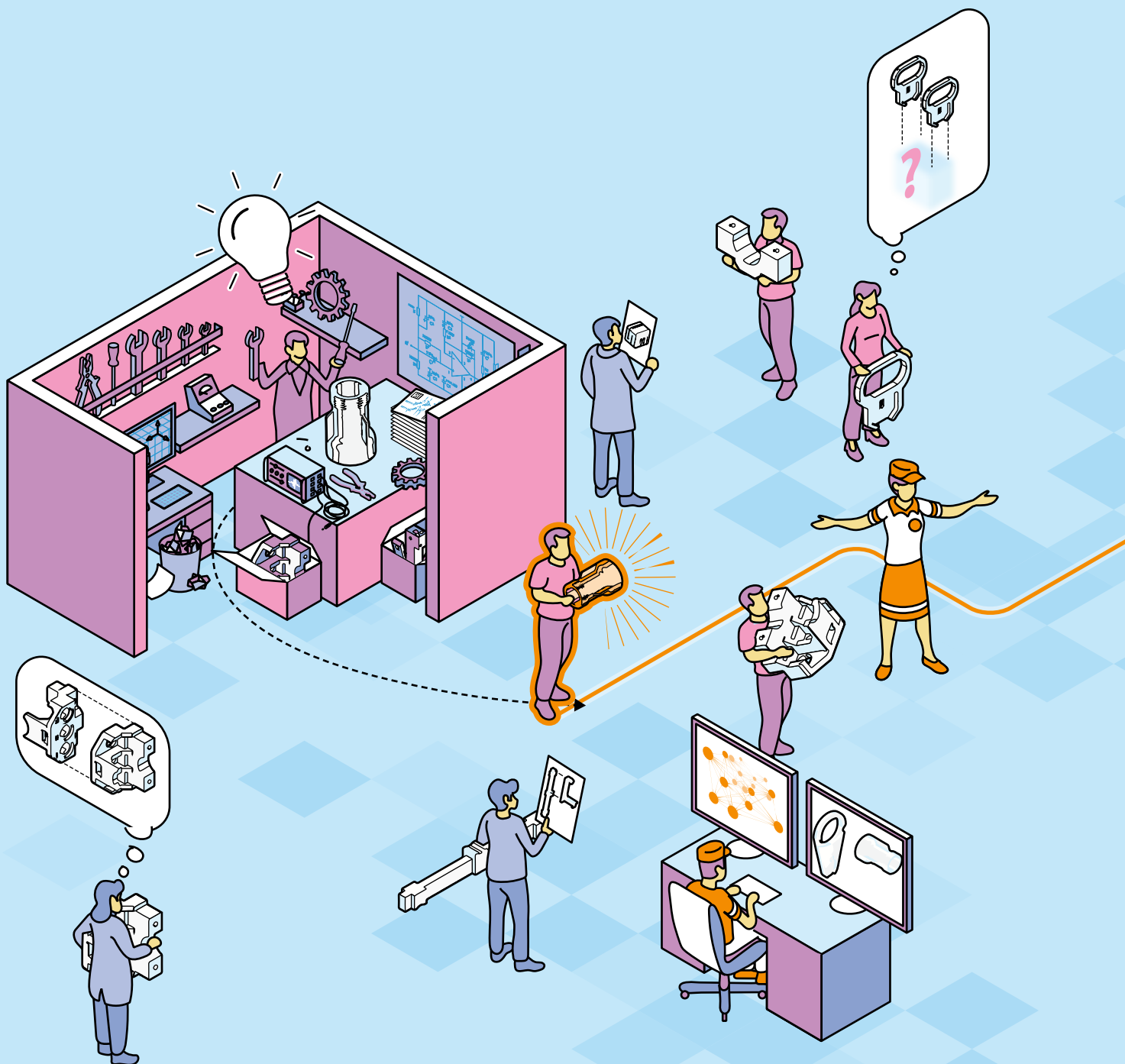
- To optimally leverage digital innovations in the health and care system, professionals working in health and care need basic and job-specific digital competences. Therefore, developments in medical technology should be systematically integrated into the curricula of nursing training.
- The steps adopted in the coalition agreement on innovation-promoting reforms such as those of the Joint Federal Committee (G-BA) should be implemented without delay.

B2 Markets for Technology



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Technological knowledge is traded on markets for technology in the form of intellectual property rights, e.g. patents. Markets for technology provide the opportunity to transfer rights of use of technologies to those companies that can commercialize these technologies better than the previous owner or current licensor. These companies have the complementary skills and resources needed to introduce the technologies to the market. Markets for technology can thus create significant economic and societal benefits. However, since intellectual property rights are usually very specific goods, there are usually only a few matching suppliers and demanders. The search for suitable trading partners is therefore often associated with high costs. It is essential to increase participation in technology trade as well as the functioning of markets for technology.





B2 Markets for Technology

CORE TOPICS 2023

Markets for technology are markets where technological knowledge is traded in the form of intellectual property rights (IP rights). An example of this are markets for patents. Markets for technology enable better exploitation of IP rights and thereby create incentives to invest in research and development (R&D). As such, they promote a more efficient division of labour in the innovation process.

Despite the advantages that markets for technology offer, the participation of German companies in such markets lags far behind that of companies in other European countries. In an international comparison, German companies only occupy a lower mid-table position both as suppliers and as demanders of IP rights.²⁰²

The functioning of markets for technology is limited by several obstacles. For example, it is often difficult for actors on markets for technology to find suitable trading partners or to reliably assess the value of an IP right, especially for small and medium-sized enterprises (SMEs). This is due to information asymmetries between market actors and a lack of trust among actors in the ability of markets for technology to ensure safe and fair transactions. Moreover, the purchase and use of an innovative technology usually require high and specific complementary investments, e.g. in technical knowledge. These difficulties are also reflected in prior studies that point to a large untapped potential of trade in markets for technology.²⁰³

Larger participation in technology trade and improved functioning of markets for technology are associated with great potentials for innovation and value creation. These must be leveraged by means of

suitable framework conditions and a research and innovation policy (R&I policy) that provides individual and institutional incentives in science and economy.

B2-1 Definition and Functioning of Markets for Technology

Actors who create or possess technological knowledge are not necessarily those who are best placed to economically exploit or develop it. If technological knowledge and, where applicable, rights to use it are transferred between different actors, then this opens potential for efficiency and innovation. The transfer can take place in different forms and through different channels (see box B 2-1). One possibility is transactions on markets for technology.

What Are Markets for Technology?

On markets for technology, rights to use technological knowledge are traded.²⁰⁴ These rights of use take the form of IP rights such as patents.²⁰⁵ A patent guarantees a patent holder the sole decision on the use of the new technological knowledge for a certain period and a certain scope of content. In markets for technology, companies and research institutions offer IP rights which are then typically demanded by other companies.²⁰⁶ This can take place by buying and selling IP rights as well as by in-licensing, out-licensing or cross-licensing.^{207, 208}

Markets for technology are characterized by two notable features.²⁰⁹ First, the technological knowledge must be available in a codified²¹⁰ form so that rights of use can be transferred. Second, the transaction must be remunerated. The first characteristic distin-

Box B2-1 Key Forms of Transfer of Knowledge and Rights of Use²¹¹

Education and Labour Market:

Tertiary education institutions and non-university research institutions (NURI) are important training centres for technical-scientific and creative professionals who introduce new research and methodological knowledge into companies. Research and methodological knowledge can be transferred further through the mobility of skilled workers between companies.

Markets for Contract Research:

Contract research enables companies to use the expertise and infrastructure of public and private research institutions to obtain solutions to specific problems.

Cooperations and Networks:

Cooperation, for example in the form of joint ventures or research collaborations, offers com-

panies the option of working together with other companies or research institutions on an issue and sharing in the knowledge of the respective cooperation and network partners.

Markets for Technology:

New technological knowledge can often be protected by patents. The thus documented right to use this knowledge can be traded on markets for technology.

Markets for Companies:

By acquiring or merging with other companies, companies can integrate new knowledge and technologies into their own portfolios.

Spin-offs:

Via spin-offs from existing companies and research institutions, the knowledge of these organizations and their employees can be transferred to new companies.

guishes markets for technology from other forms of knowledge transfer, e.g. through cooperation, where usually also non-codifiable knowledge of the inventor may be exchanged. The second characteristic excludes all transfers that are not directly remunerated, as is sometimes the case in open source software development.²¹²

How Do Markets for Technology Work?

Markets for technology provide the opportunity to transfer rights for the use of technologies to those companies that can commercialize these technologies better than the previous owner or current licensor.²¹³ Especially smaller companies often lack the complementary skills to further develop their technology and establish the necessary manufacturing and marketing capacities to introduce it to the market. Moreover, they often lack other technologies with which to combine the newly developed technology. The prospect of selling a newly developed technology rather than exploiting it themselves gives companies additional incentives to invest in R&D.²¹⁴

Markets for technology thus facilitate a more efficient division of labour by making it easier for firms to specialize in those activities where they have competitive advantages. Consequently, companies that are comparatively good at developing innovative technologies can focus on these activities. Companies that are better at commercializing technologies will specialize accordingly and act as demanders in markets for technology.²¹⁵ This vertical specialization favours a more efficient use of resources in the innovation process.²¹⁶ For technologies with very high product, industry or geographic range of use, a company may not want to or be able to tap into all possible applications of the technologies itself. In this case, it can offer technologies selectively on markets for technology.²¹⁷ For tertiary education institutions and non-university research institutions (NURI), markets for technology offer the possibility of transferring research results into economic applications. Since these institutions are usually not active in the production and marketing of products themselves, they can find buyers for the technologies they have developed on markets for technology.

Data on the use of patents shed light on the practical importance of markets for technology. A survey of inventors from 20 European countries, Israel, Japan and the USA indicates that while the majority of patents applied for and used at the EPO are exploited internally, the share of patents that are licensed or sold is considerable at over 10 percent.²¹⁸ At the

same time, the share of licensed or sold patents in the USA is significantly higher at over 18 percent than that in European countries and Israel at just under 11 percent. Small companies with fewer than 100 employees even license or sell almost 30 percent of their patents.²¹⁹

Box B 2-2 Data

Mannheim Innovation Panel and Community Innovation Survey

As a business survey, the Mannheim Innovation Panel (MIP) can be used to measure the activities of companies in Germany in markets for technology.²²⁰ It is based on the Annual Innovation Survey for the German Economy and includes all legally independent companies based in Germany with at least five employees from selected industries.²²¹

As part of the MIP, companies were asked in 2021 and 2019 whether they had in-licensed²²² or acquired IP rights from third parties in the period from 2018 to 2020 and 2016 to 2018, respectively. These activities represent the demand side of markets for technology. In addition, the companies were asked whether they had licensed out, sold or exchanged their own IP rights to third parties during these periods. These activities represent the supply side of markets for technology. Thus, in this analysis, markets for technology include the acquisition and sale of IP rights as well as their temporary use in the form of in-licensing, out-licensing and cross-licensing. IP rights are defined in the MIP as patents, utility models, design patents, trademarks and copyrights. A company may be active in one or more national and international markets for technology.

The MIP is the German contribution to the Europe-wide Community Innovation Survey (CIS), conducted every two years and coordinated by Eurostat, which forms the data basis for the international comparison of the activities of companies on markets for technology. It addresses companies with ten or more employees in manufacturing industry and in selected service sectors.²²³ The CIS data are available for the period 2016 to 2018.

PATSTAT-INPADOC and Orbis Intellectual Property

The legal status data²²⁴ of the German Patent and Trade Mark Office (Deutsches Patent- und Markenamt, DPMA) and the European Patent Office (EPO) contain information on changes of ownership of IP rights, thus enabling the recording of transfers of these rights.²²⁵ The data basis for the legal status data is the EPO's INPADOC data, which has been integrated into the EPO's PATSTAT patent database since 2010.

Patent data and the associated legal status data describe the market for technology from the viewpoint of a jurisdiction. The basic population is therefore, for example, all patents applied for and traded at the DPMA, irrespective of the origin of the applicants.

Patents can be transferred for various economic reasons. The focus below is on technology trading in the narrower sense, where patents are transferred between independent companies at market conditions. Patent transfers within a group of companies and patent transfers in the context of mergers and acquisitions (M&A) are not considered in this analysis.²²⁶

To identify transfers that take place between independent companies at market conditions, patent and legal status data must be linked with data containing information on the ownership structures of the companies involved. The data basis for this are the Orbis Intellectual Property data (Orbis IP data) from Bureau van Dijk.²²⁷

Markets for technology are defined more narrowly here than in the MIP and the CIS. Only the purchase and sale, i.e. the transfer, of patents are recorded.²²⁸

B2-2 Technology Trading through Transfers and Licensing

Based on a study conducted by the ZEW – Leibniz Centre for European Economic Research (ZEW) on behalf of the Commission of Experts, this section describes the participation of German actors in markets for technology and the development of patent transfers over time. Additionally, the importance of patent transfers by technology field and the characteristics of transferred patents are highlighted. The description of the data on which the analyses are based is provided in box B 2-2.

Participation of German Companies in Markets for Technology Comparatively Low

The percentage of German companies active in markets for technology is lower than in other European countries (see figure B 2-3). In an international comparison based on CIS data, German companies only occupied a lower mid-table position both as suppliers and as demanders of IP rights in the period from 2016 to 2018.²²⁹ Much greater use was made of markets for technology by companies from Sweden, Poland, Austria or France, for example. In Poland, the share of companies in-licensing or acquiring technologies in the period under review was 7.3 percent and in Austria 5.2 percent, while in Germany it was only 4.0 percent. The percentage of German companies out-licensing technologies was also only about half as high as that of the top performers France and Sweden in the period under review. The share of companies that acted as sellers on markets for technology in the period under review was also significantly lower in Germany at 0.9 percent than in Sweden at 2.7 percent. Only 0.4 percent of German companies were involved in a technology exchange. It should be noted that only realized and thus successful activities are considered in these observations. A statement on the extent to which companies have unsuccessfully attempted to offer or request IP rights is therefore not possible.

Transfers of DE Patents Declining

Since 1980, markets for technology in the US have grown significantly in importance.²³⁰ For example, the number of transfers of patents filed at the US Patent and Trademark Office (USPTO) between companies has increased from around 1,000 transactions in 1980 to around 55,000 transactions in 2019 (see figure B 2-4).²³¹ The ratio of transferred

patents to the number of existing patents increased, particularly in the late 1990s. Since then, the ratio has remained relatively constant.²³²

The number of transfers of patents applied for at the EPO (EP patents)²³³ declined in the period from 2000 to 2020 (see figure B 2-5).²³⁴ While it was quite stable at about 4,500 per year until 2011, the number has settled at a lower level of about 3,500 transfers per year since 2014 after a brief increase. In all years, the number of transfers of patents applied for at the DPMA (DE patents) was lower than that of EP patents.²³⁵ At the same time, the decrease in transfers of DE patents was also greater than that of EP patents. The number of transfers of DE patents in 2020, for example, decreased by more than two thirds to approx. 570 compared to approx. 2,700 in 2000.²³⁶ The number of transfers of DE and EP patents also decreased in relation to the respective patent applications.²³⁷ In contrast, the number of transfers of DE and EP patents in the course of M&A activities increased significantly.²³⁸

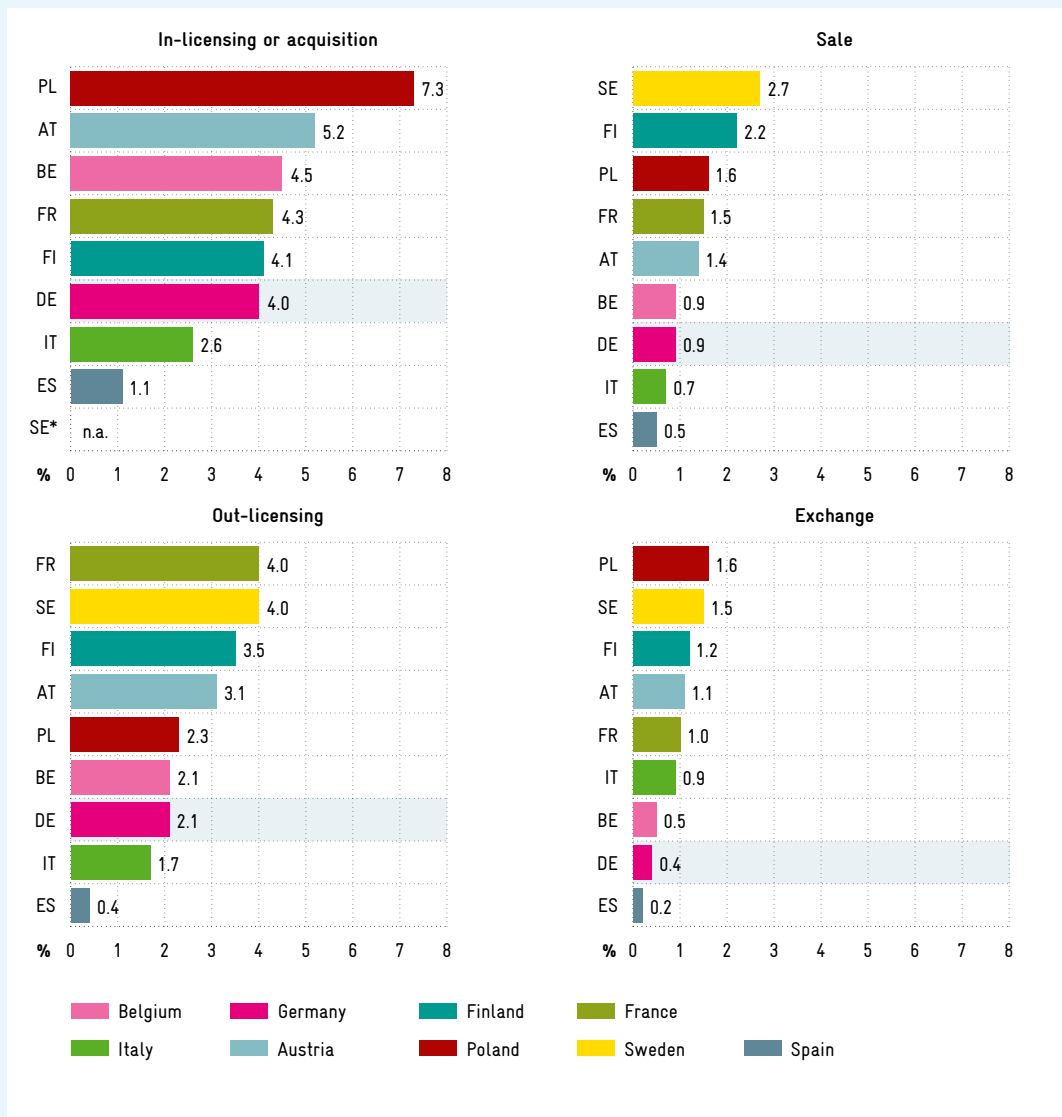
German companies²³⁹ rank first by far among the seller countries of patent transfers recorded at the DPMA.²⁴⁰ The decline in patent transfers recorded at the DPMA is primarily due to a decrease in sales by German companies. In contrast, the number of patent sales by US companies recorded at the DPMA has only slightly decreased during this period, while patent sales by French and Japanese companies have trended upwards since 2016. Patent purchases by German companies recorded at the DPMA have also decreased significantly recently, while purchases by companies from France, Japan, the USA and Switzerland have increased trend-wise in the same period. A remarkable development over time is the number of patent purchases by Chinese companies recorded at the DPMA. China's importance as a buyer has only increased significantly since the mid-2010s. In 2019, China already occupied sixth place in the ranking of buyer countries.²⁴¹

The trade flows of patent transfers recorded at the DPMA have a predominantly national character.²⁴² Since 2000, 90.2 percent of German sellers sold their patent to buyers from Germany.²⁴³ Similarly, 96.5 percent of German buyers acquired their patent from a seller from Germany.²⁴⁴ A similar picture emerged for transfers of patents at the USPTO. For instance, 94.3 percent of German sellers sold their US patent to buyers from Germany and 91.8 percent



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Fig. B2-3 Percentage of companies active in markets for technology in selected countries 2016–2018



*In-licensing and acquisition data not available.
Source: Eurostat, Community Innovation Survey 2018. Calculations by ZEW in Peters et al. (2023a).
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of all US patents acquired by German buyers came from a German seller.

The activities of companies on markets for technology differ depending on the industry. The company-level analysis based on MIP data shows that between 2018 and 2020, markets for technology were most frequently used by companies in research-intensive industries.²⁴⁵ Within research-intensive industries, activities on markets for technology were most prevalent in the pharmaceutical industry, where 27.0 percent of all companies traded on markets for technology, followed by the chemical indus-

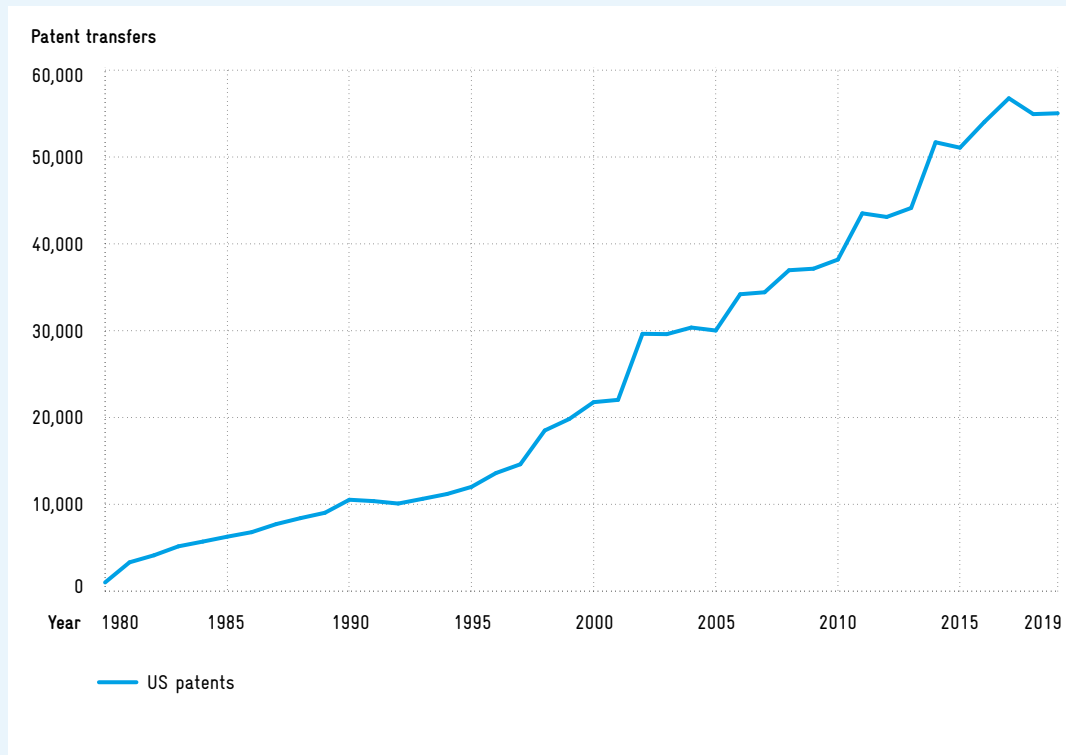
try (18.0 percent) and electronics, metrology and optics (14.5 percent).²⁴⁶ In comparison, companies in the automotive and other vehicle manufacturing industries were significantly less active (4.4 and 7.3 percent, respectively).

A similar picture emerges from the patent-level analysis based on Orbis IP data. Between 2000 and 2020, EP patents were transferred most frequently in the fields of pharmaceuticals at 7.6 percent, medical technology at 7.1 percent and electrical machinery at 5.6 percent. Together with patents in the fields of organic fine chemicals at 4.8 percent,

Fig. B2-4 Number of transfers of patents filed at the United States Patent and Trademark Office 1980–2019



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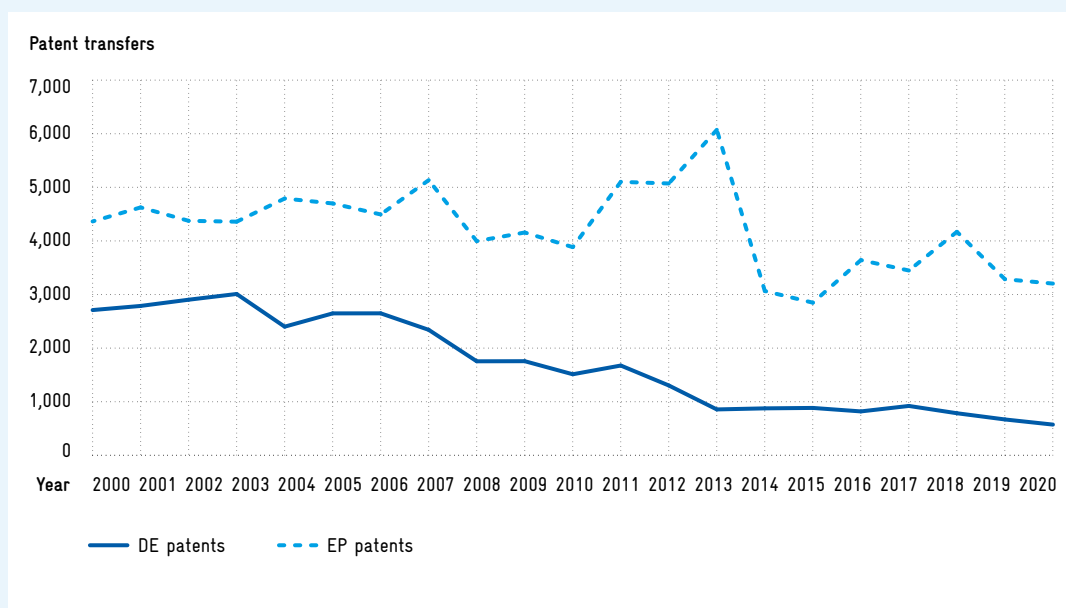


Patent transfers between independent companies.
Source: <https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-assignment-dataset> (accessed on 25 October 2022) and Marco et al. (2015). Own calculations.
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Fig. B2-5 Number of transfers of patents filed at the German Patent and Trade Mark Office and the European Patent Office 2000–2020



[Download Data](#)



Patent transfers between independent companies.
DE patents: Patents filed at the German Patent and Trade Mark Office. EP patents: Patents filed at the European Patent Office.
Source: Orbis IP. Calculations by ZEW in Peters et al. (2023a).
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biotechnology at 4.4 percent, digital communication and computer technology each at 4.3 percent, they accounted for more than a third of all patent transfers.²⁴⁷

Apart from the fields of digital communication, IT methods for management, semiconductors, computer technology, pharmaceuticals and medical technology, patent transfers in the other fields of technology have declined over the past 20 years – similar to the decline in EP patent transfers overall (see figure B 2-6). Sharp declines were also recorded in technology fields in which technology trade

was extensive in the past, such as macromolecular chemistry. Moreover, the decline in patent transfers in most of the technology fields is not due to declining patent applications.

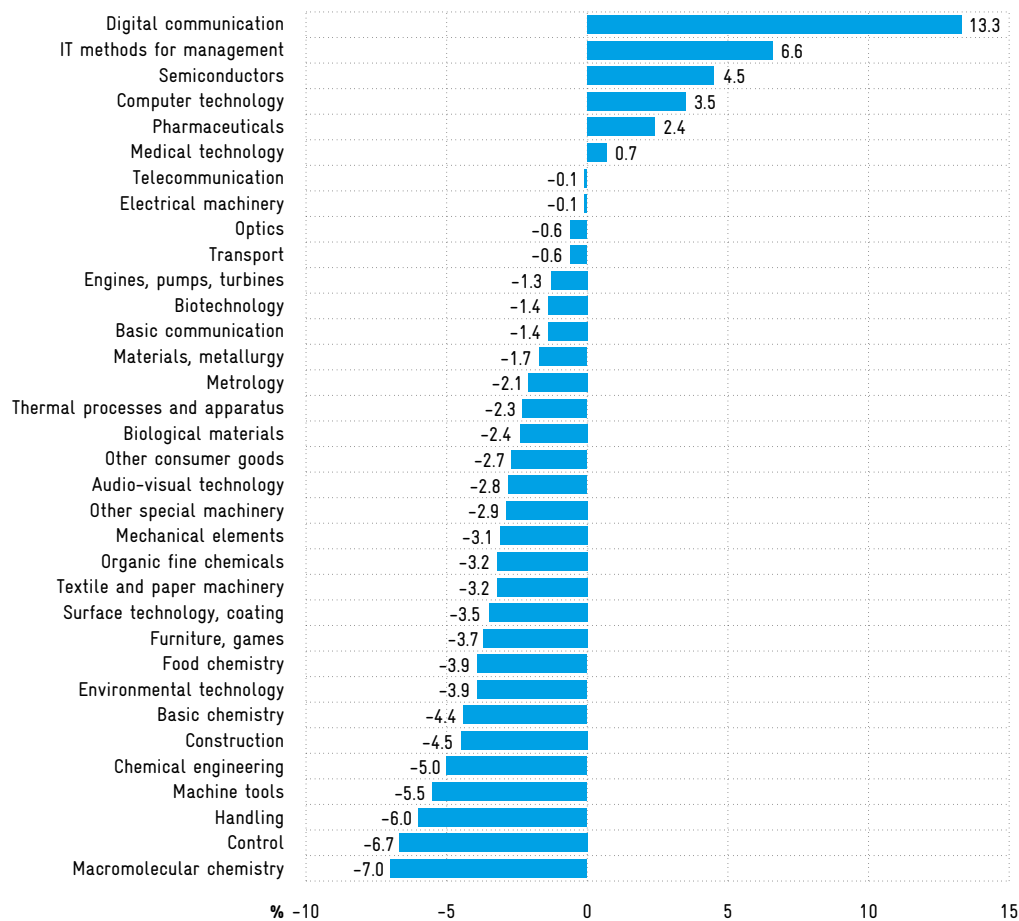
Strong Growth in the Transfer of EP Patents from Tertiary Education Institutions

Annual EP patent applications from tertiary education institutions²⁴⁸ more than doubled from around 2,500 to around 5,600 between 2000 and 2018.²⁴⁹ In the same period, albeit with more significant fluctuations, the number of transferred EP patents from

Fig. B2-6 Average annual growth rates of transfers of patents filed at the European Patent Office by field of technology 2000/2001–2019/2020 in percent



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Calculation of the average annual growth rates using the geometric mean. The calculation is based on transfers between independent companies. To make the growth rate more robust against outlier values at the beginning and end of the period, the average of the patent transfers from two years was formed as the start and end value in each case, i.e. the average value from the years 2000 and 2001 and the average value from the years 2019 and 2020. Distinction of technology fields after Schmoch (2008). Micro and nanotechnology: no information due to very low number of transfers.

Source: Orbis IP. Calculations by ZEW in Peters et al. (2023a).

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tertiary education institutions increased even more: from around 240 to around 1,700 (see also figure B 2-7). The ratio of EP patents from tertiary education institutions transferred in one year to EP patents from tertiary education institutions applied for has increased from 9.6 percent in 2000 to 30.7 percent in 2018.²⁵⁰ Transfers of DE patents from tertiary education institutions show an opposite development to EP patents from tertiary education institutions (see figure B 2-7),²⁵¹ despite a stable number of DE patent applications from tertiary education institutions. A similar picture emerges when NURI are taken into account in the analysis.

An examination at the company level shows that 7.4 percent of companies obtained IP rights from tertiary education institutions or NURI.²⁵² In research-intensive industry, the share was significantly higher at 16.1 percent. Across all industries, 90.4 percent of the companies that licensed or acquired IP rights in the period from 2016 to 2018 obtained them from other companies or private individuals.

Analyses by the EPO show that it is more difficult for research institutions than for companies to identify potential buyers for their inventions, as their inventions are often still at a very early technological stage.²⁵³ However, according to additional studies, the probability of a successful transaction is higher than for companies, provided that potential buyers can be identified.²⁵⁴

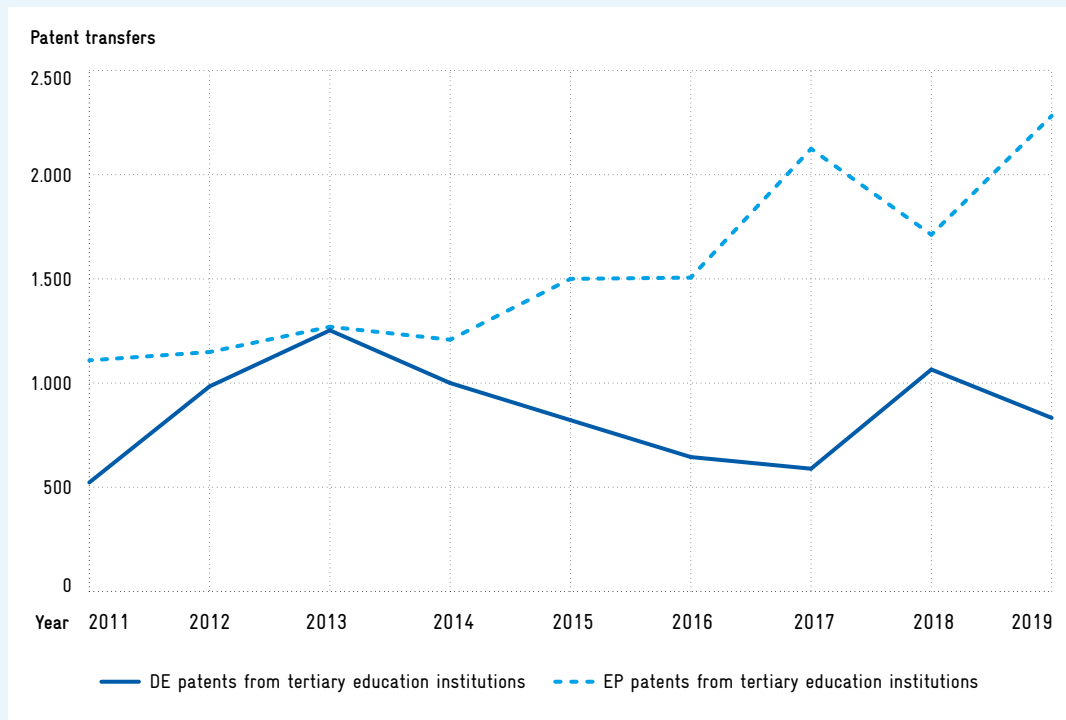
Transferred Patents of Higher Quality

Since the term of patents is limited to 20 years,²⁵⁵ the economic value of a patent decreases over time. Accordingly, it is to be expected that more trade takes place in younger patents than in older ones. In keeping with this, 46.3 percent of the DE patents transferred since 2000 were five years old or less at the time of transfer.^{256,257} Only 5.0 percent of the patents were older than 15 years at the time of transfer.

Fig. B2-7 Number of transfers of patents filed by tertiary education institutions at the German Patent and Trade Mark Office and the European Patent Office 2011–2019



[Download Data](#)



DE patents from tertiary education institutions: patents filed by tertiary education institutions at the German Patent and Trade Mark Office.
 EP patents from tertiary education institutions: patents filed by tertiary education institutions at the European Patent Office.
 Source: PATSTAT-INPADOC. Calculations by ZEW in Peters et al. (2023a).
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Not only patents that have already been granted are transferred on markets for technology, but also patents that have not yet been granted, i. e. patents that have only been applied for. The technological and economic value of a patent that has not yet been granted is associated with greater uncertainty, as the examination of patentability is still pending. The risk that an EP patent not yet granted at the time of transfer will not be granted after the transfer is 42.3 percent.²⁵⁸ For DE patents, the risk is significantly higher at 68.1 percent.²⁵⁹

Various quality indicators were calculated for each EP patent to assess the quality of the transferred patents.²⁶⁰ It turns out that EP patents transferred since 2000 have a higher overall quality than EP patents filed in the same year and in the same technology field, regardless of whether they were transferred or not.²⁶¹ In particular, the transferred EP patents have a broader technological applicability and are cited more frequently than the EP patents of the respective comparison group.²⁶²

B 2-3 Markets for Technology and Innovation

The factors that favour participation in markets for technology and the importance of technology trade for the innovation activities and innovation success of companies in Germany can be examined using the MIP data (see box B 2-2). Activities on markets for technology in this context include the acquisition and sale as well as the in-licensing, out-licensing and cross-licensing of IP rights.

Between 2018 and 2020, a total of 4.9 percent of German companies were active on markets for technology.²⁶³ The share of companies that demanded IP rights was 3.2 percent.²⁶⁴ Of all companies, 2.1 percent acquired IP rights from third parties and 1.8 percent in-licensed IP rights from third parties. At 1.8 percent, the share of companies that offered IP rights was smaller than the share of companies that demanded IP rights in the period under review.^{265,266} At 1.3 percent, the share of companies that licensed out IP rights was the highest, followed by 0.7 percent of companies that sold IP rights and 0.1 percent that exchanged IP rights with third parties.

Companies Active in Innovation Collaborations Are Active on Markets for Technology

Both willingness to invest in innovation and participation in innovation collaborations positively correlate with a company's likelihood of being active on markets for technology.²⁶⁷ Between 2018 and 2020, the share of innovative companies as suppliers (2.8 percent) and demanders (3.9 percent) of IP rights in markets for technology was higher than the share of all companies (1.8 percent and 3.2 percent, respectively) (see figure B 2-8).²⁶⁸ In this context, the percentage of innovative companies with innovation collaborations that were active on markets for technology was significantly higher than the percentage of innovative companies without innovation collaborations. Between 2018 and 2020, 8.1 percent of innovative companies involved in innovation collaborations demanded IP rights and 6.4 percent of them offered IP rights. For innovative companies without innovation collaborations, these figures were 3.0 percent and 2.1 percent, respectively.²⁶⁹

Mixed Picture for SME Participation in Markets for Technology

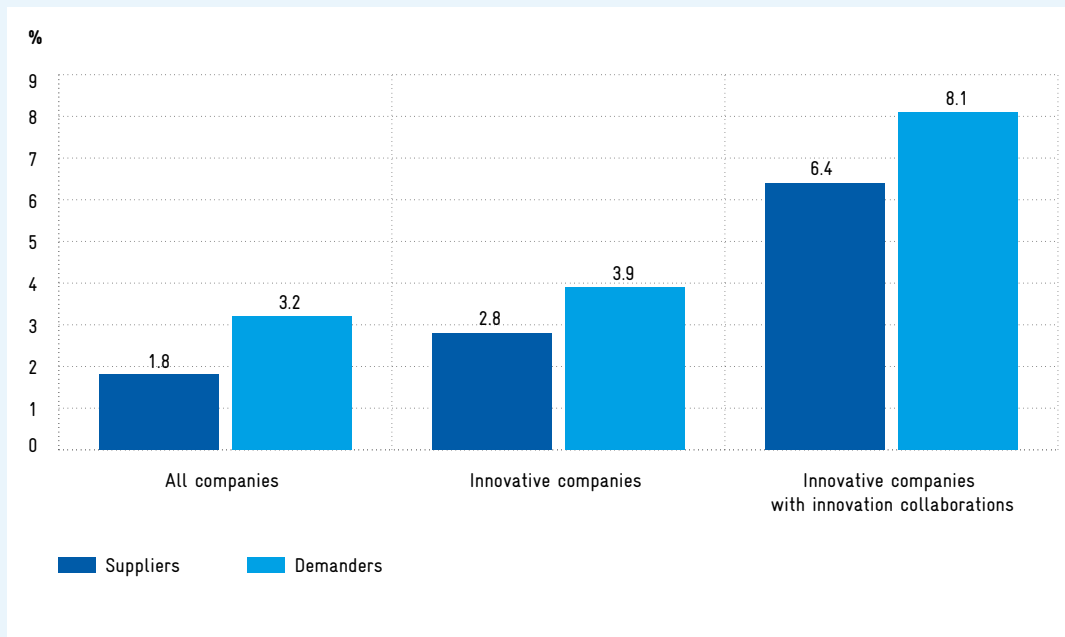
Looking at participation in markets for technology at the company level it becomes apparent that large companies with 1,000 or more employees are more active in markets for technology than SMEs, i. e. companies with fewer than 250 employees. For example, between 2018 and 2020, 19.3 percent of large companies demanded IP rights and 11.7 percent offered IP rights, while the corresponding percentages for SMEs were 2.9 percent and 1.6 percent, respectively (see figure B 2-9).²⁷⁰ The same pattern emerges when only innovative companies are considered.

To measure the difficulties companies face in exploiting IP rights by means of markets for technology, potential participation in markets for technology can be examined in addition to actual participation. The percentage of potential suppliers is approximated here by the percentage of companies that filed IP rights in the period from 2018 to 2020. A comparison of the shares of actual and potential providers shows that just under one in five large companies with IP rights applications also actually acted as a supplier (19.7 percent), while among SMEs it was only around one in nine companies (11.8 percent).²⁷¹

Fig. B2-8 Percentage of German companies active in markets for technology by innovation activities 2018–2020



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Source: Mannheim Innovation Panel, Survey 2021. Calculations by ZEW in Peters et al. (2023a).
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An examination of participation in markets for technology at the patent level, on the other hand, indicates that SMEs are more active as suppliers in markets for technology than large companies.²⁷² A survey of inventors from 20 European countries, Israel, Japan and the USA shows that small companies with fewer than 100 employees licensed out or sold a total of almost 30 percent of their patents filed at the EPO, while the figure for companies with more than 250 employees was only just under 7 percent. Medium-sized companies with 100 to 250 employees reported licensing or selling about 13 percent of their EP patents.²⁷³

SMEs account for 99.8 percent of European companies.²⁷⁴ However, they are less likely to file patents than large companies. In 2018, for example, only one in five patent applications to the EPO was filed by an SME or individual from Europe.²⁷⁵ SMEs consequently have fewer patents to trade on average. This may explain the lower supply-side activity of SMEs in markets for technology when considered at the company level. Nevertheless, SMEs offer a higher percentage of their patents in markets for technology than large companies. There may be several reasons for this. Especially for small companies, which often have a low market share, the

advantages associated with out licensing outweigh the potential risks from the emergence of another competitor. For companies with higher market shares, on the other hand, additional competitors constitute a greater risk. In addition, SMEs are generally less likely than large companies to have the necessary complementary resources and assets to further develop the technology themselves and introduce it to the market.²⁷⁶ In addition, the percentage of patents that remain unused for strategic and other reasons, and are therefore not eligible for patent trading, is almost twice as high for large companies as for SMEs.²⁷⁷

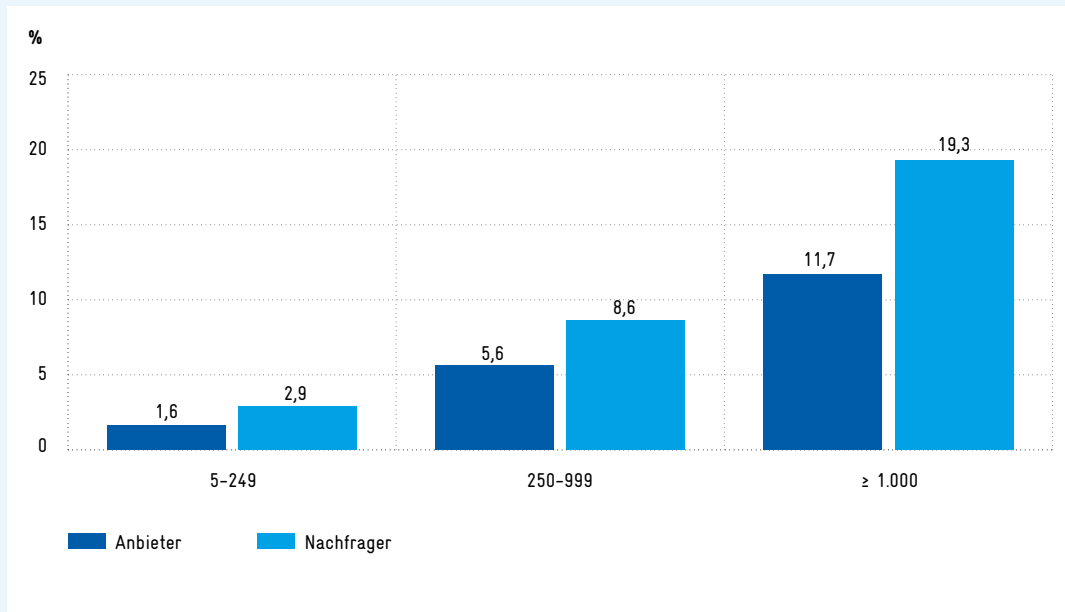
High Significance of Markets for Technology for Innovation Success

Access to IP rights from third parties allows companies to access external knowledge. This external knowledge can increase the innovation success of companies, e.g. by helping to develop a new product, improve an existing product or accelerate innovation processes. The innovation success of companies can be measured by the share of turnover they generate with product innovations or market novelties in the first three years after their market launch. Product innovations are new or improved

Fig. B2-9 Percentage of German companies active in markets for technology by size category 2018–2020



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Source: Mannheim Innovation Panel, Survey 2021. Calculations by ZEW in Peters et al. (2023a).
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products of the company. Market novelties are those product innovations that companies are the first to introduce to the market.

Companies that have obtained IP rights from third parties through acquisition, in-licensing or exchange achieve significantly higher success with their innovations than otherwise comparable companies.²⁷⁸ Thus, innovative companies that have obtained IP rights in this way have a 4.5 percentage point higher share of turnover with product innovations than comparable companies without such IP rights. The difference in the share of turnover with market novelties is 2.4 percentage points on average. In relation to the average share of turnover that companies achieve with their product innovations (23.4 percent) or market novelties (13.1 percent), these differences are comparatively large. In particular, the exchange of IP rights is associated with a significantly higher success of companies with product innovations and market novelties.

Lack of Access to IP Rights a Frequent Cause of Innovation Abandonment

Lack of access to IP rights is considered by companies to be a major obstacle to innovation.²⁷⁹ In

2018, 63.6 percent of companies affected by lack of access to IP rights abandoned planned innovations because of it – no other obstacle to innovation led to abandonment more often as a result. Conversely, almost every fifth company that refrained from innovation projects due to obstacles saw a reason in the lack of access to IP rights (18.3 percent).²⁸⁰ While large companies tended to respond more to the lack of access to IP rights by prolonging innovation projects as their size increased, small companies were more likely to respond by refraining from innovation altogether.²⁸¹

Lack of access to IP rights can be caused by the fact that too few IP rights are filed and offered on markets for technology or that the IP rights offered do not match those in demand. Another conceivable reason is that the matching of suppliers and demanders does not work, for example because the companies making the demand do not have the resources and skills required to find the right IP right.

B2-4 Barriers in Markets for Technology

To generate value from new technological knowledge, a company must be able to combine this

knowledge with complementary competences and resources, e.g. manufacturing and marketing capacities. In principle, markets for technology can create significant economic and societal benefits by enabling efficient and timely matching between new technological knowledge and companies with the respective complementary competences and resources. In practice, however, markets for technology are characterized by various imperfections and inefficiencies, in particular low market participation, information asymmetries, lack of trust and complex contracts.²⁸² These imperfections make it difficult for markets for technology to develop spontaneously and without coordination.

Difficulties in Identifying Suitable Trading Partners

An important criterion for the functioning of markets is market thickness. A market is said to be thick if it attracts a sufficient number of potential market participants who are willing to trade with each other and, as a result, numerous transactions take place.²⁸³ Since IP rights are usually very specific goods, there are usually only a few matching suppliers and demanders.²⁸⁴ Accordingly, a market for technology often comprises many individual markets for specific technologies involving only a few participants on both sides of the market.²⁸⁵ In this case, each of these are so-called thin markets where the search for suitable trading partners, especially from other regions and fields of technology,²⁸⁶ is associated with high costs.²⁸⁷

Due to the low market thickness, competitive prices do not form in these markets. Rather, prices are often the result of bilateral negotiations in which the bargaining power of the trading partners plays a key role. Here, there is often a lack of comparative and empirical values that would otherwise provide guidance in setting prices.²⁸⁸ That means uncertainty prevails about the economic value of the technology, which must be estimated accordingly.²⁸⁹ This can further limit the willingness to use such a market.²⁹⁰

Information Asymmetries between Suppliers and Demanders

Information asymmetries between suppliers and demanders of a technology exist when one trading party is better informed about the functioning and potential of a technology than the other.²⁹¹ As a rule, suppliers of a new technology are better informed

about it than demanders because they possess additional information about the technology that is not publicly available.²⁹² This leads, among other things, to suppliers of less valuable technologies trying to market them as high-value.²⁹³ Suppliers of technologies with above-average value, on the other hand, have problems convincing demanders of the high value, as demanders are guided by the average value of new technologies due to high uncertainty about the actual value. This leaves the suppliers facing a dilemma. On the one hand, they have incentives to disclose the details necessary to convince demanders of the quality of the new technology. On the other hand, they run the risk that demanders will use this information for free and reproduce the new technology in a slightly modified form. However, if demanders do not fully understand the value of the technology and the other necessary information, they will not be willing to pay the price asked for by suppliers.²⁹⁴ This can lead to potential suppliers not even offering their technologies of above-average value on the market.

For actors without knowledge and prior experience of technology trade, dealing with information asymmetries may be particularly difficult. Information asymmetries are less problematic if the trading partners are active in the same product market or industry and have similar technical expertise.²⁹⁵

Lack of Trust in Markets for Technology

The functioning of a market also depends on the trust of market participants in its ability to ensure safe and fair transactions (market safety).²⁹⁶ The safety of a market for technology depends in particular on the effectiveness of patent protection, i. e. on the extent to which patent holders can enforce their rights.²⁹⁷

A lack of trust makes actors reluctant to engage in markets for technology and to disclose the knowledge necessary for a transaction to take place. In secure markets, market participants are more willing to share their information and preferences in search of other market participants. This increases the likelihood that technology trade will occur.

Potential and Limitations of Market Intermediaries

Market intermediaries can reduce the inefficiencies that arise in markets for technology (see box

B 2-10).²⁹⁸ A number of new types of market intermediaries emerged in the 2000s, including digital technology platforms,²⁹⁹ which are being used by an increasing number of companies.³⁰⁰ Digital technology platforms list available technologies, thereby facilitating the search for and trade in technologies – especially across regional borders and beyond own networks.³⁰¹ By systematically evaluating patent data, for example using AI-based methods, they enable participants in digital markets for technology to reduce search costs and to better assess the value of a technology and its applicability and compare it with other technologies. They thus go beyond the functionalities of the public and freely accessible databases of the DPMA and the EPO. The features of digital technology platforms help to increase market thickness and identify more potential matches. However, they cannot eliminate information asymmetries and the associated risk that suppliers try to market less valuable technologies as high value ones.

Another factor limiting the functioning of technology platforms is that due to the exceedingly high

specificity of technologies, trading partners mostly prefer bilateral, face-to-face negotiations, which usually take place offline.³⁰² This leads to the fact that the business model of technology platforms can only be scaled at relatively high costs³⁰³ and the transaction costs of market actors are not significantly reduced. Also, digital technology platforms thereby fail to significantly increase the transparency of the market.³⁰⁴ Furthermore, the publication of a detailed description of a technology, including its functionalities and potential uses, in a standardized form that goes beyond the patent, as is often required by technology platforms, increases the risk of circumvention of the patent for suppliers with valuable technologies.

To counter the risk of suppliers marketing less valuable technologies as high-value ones, digital technology platforms use various screening mechanisms such as upfront payments and disclosure requirements.³⁰⁵ However, such screening mechanisms may in turn deter potential market entrants if they are not willing to make upfront payments or disclose extensive information. According to ex-

Box B 2-10 The Silicon Valley Brokered Patent Market³⁰⁶

The Silicon Valley Brokered Patent Market (BPM) is a patent market that has been active since 2014. It emerged after the failure of the US patent trading platform IPXI (Intellectual Property Exchange International, Inc.). In late 2020, the BPM comprised 220,000 patents with offer prices worth a total of US\$36 billion. Of these, patents worth US\$10.4 billion have already been traded. Most trades are in a price range of US\$0.5 million to US\$2 million.³⁰⁷ The average time required to complete a transaction is approximately one year.

Key players in the BPM are around 130 patent brokers. These freelance patent brokers analyze companies' patent portfolios, identify patents that could be sold, examine patents and important claims and determine appropriate price ranges. They also define terms of sale, due diligence and bidding procedures, develop evidence of use and

support companies in identifying and approaching potential buyers as well as in price negotiations. Experienced brokers have a particularly important role to play in quantifying fair price ranges. In return, the patent brokers, many of whom are former patent attorneys, receive a commission of about 20 percent of the sales price.

On the BPM, mostly patent families or patent bundles consisting of ten to 15 patents are traded. For the patent bundle to be sold, the description of a single representative patent is usually sent to the market participants by email. The information about the patent bundle is supplemented with additional information based on a due diligence conducted by the patent brokers. This check also establishes, among other things, evidence of use, which constitutes an important signal for potential buyers regarding the value of a patent. Patents with specific evidence of use are more likely to be traded.

perts, the maintenance of IP databases is often very time-consuming and cost intensive.

These difficulties may have contributed to the fact that no platform with a high transaction volume has yet emerged for the market for technology³⁰⁸ and that some digital technology platforms have adapted their business model over time, moving from offering a transaction infrastructure with matching mechanisms to a more interactive service provision.³⁰⁹ More recently established providers such as PatentPlus (see box B 2-11) have a somewhat broader scope and, in addition to technology transactions, also pursue the initiation of collaborations and consultancy.

From a broader economic perspective, increased transparency about activities on markets for technology can reduce information asymmetries, but it also carries risks. Detailed information on new technologies can make it easier for foreign companies to imitate technologies and circumvent patents. Transparency about the totality of all transactions allows insights into the strategic decisions of individual actors and the resulting technological development. This in turn can jeopardize the tech-

nological sovereignty of an economy and its competitiveness regarding key enabling technologies.³¹⁰

B 2-5 Recommendations for Action

On markets for technology, technological knowledge is traded in the form of IP rights. Markets for technology enable better exploitation of IP rights and thereby create incentives to invest in R&D. However, the functioning of markets for technology is limited by several obstacles. Actors in markets for technology often find it difficult to find suitable trading partners or to reliably assess the value of an IP right. This is due to information asymmetries between market actors and a lack of trust among actors in the ability of markets for technology to ensure safe and fair transactions. The Commission of Experts recommends the following measures to leverage the potential of innovation and value creation associated with greater participation in technology trade and improved functioning of markets for technology:

Box B 2-11 PatentPlus³¹¹

PatentPlus is a German-based knowledge and technology transfer platform established in 2021. PatentPlus focuses on research institutions as providers of technologies that are sold or licensed through the platform. The platform helps to connect research institutions and companies looking for relevant and available patents.

PatentPlus thus attempts to mitigate or completely overcome various existing market failures. For companies, the aggregation of different providers, simple filter mechanisms and search ads ordered by relevance reduces search costs for identifying suitable technologies and cooperation partners. AI-supported methods are also used here to

analyze portfolios and identify suitable matching partners. Potentially interested parties are informed about the details of various technologies by means of descriptions of the individual research institutions and their patent portfolios. Providers can present their profile and find not only transaction partners for their patents but also potential partners and investors for cooperative research projects and contract research. The platform also provides other services such as trend analyses and benchmarking, i.e. the comparison and evaluation of spin-offs. Since its establishment, PatentPlus has also been successful in acquiring funding.³¹² However, it remains to be seen whether the business model will prove sustainable in the medium to long term.

Encourage Further Development of Patent Office Databases

- To reduce search and transaction costs and enable better matches, R&I policy should drive the further development of the public and freely accessible databases of the patent offices (DPMA and EPO). AI-assisted methods can help to match relevant patent-protected technologies and partners. At the same time, a well edited and up-to-date database offers scientists the opportunity to conduct research on markets for technology using the data.³¹³
- Under the new EU Unitary Patent, which will be applied from the beginning of April 2023, applicants should be given the opportunity to add a description of the technology or of complementary IP rights in the EPO's Espacenet database, in addition to the option of indicating their willingness to license.
- Moreover, the deal database envisioned in the Federal Government's Startup Strategy, which is to document transfers of IP rights, should be established at the patent offices. By linking this to the existing databases at the patent offices, information on transfers of IP rights could be efficiently bundled and made available in a user-friendly manner.
- The Federal Government should initiate and promote an information campaign to provide potential market participants with more information about these databases.

Improve the Information Base on Markets for Technology

- To improve transparency of ownership of IP rights and thus reduce search costs for potential buyers, greater incentives should be provided for reporting transfers of ownership centrally and quickly to the DPMA. In addition, the Commission of Experts suggests examining whether contracting parties can be obliged to publish transfers of ownership.³¹⁴
- Financial incentives in the form of a reduced renewal fee for patents should be provided for the non-binding declaration of willingness to license.

- Uniform standards should be developed and applied to record patent transfers at national patent offices.

Support SMEs in Activities on Markets for Technology

- Low-threshold information and advisory services are particularly important for SMEs. Existing initiatives to promote the patenting and exploitation of inventions, such as the support programme WIPANO – Knowledge and Technology Transfer via Patents and Standards, should be continued and expanded.
- To facilitate rapid technology transfer, contractual standards should be established³¹⁵ that take into account the interests of all actors involved in technology trade. Existing initiatives such as the German Standards Setting Institute (GESSI) can contribute to this by promoting the drafting of standard contracts for the transfer of IP rights.

Further Professionalize Technology Transfer and Exploitation of Patented Inventions

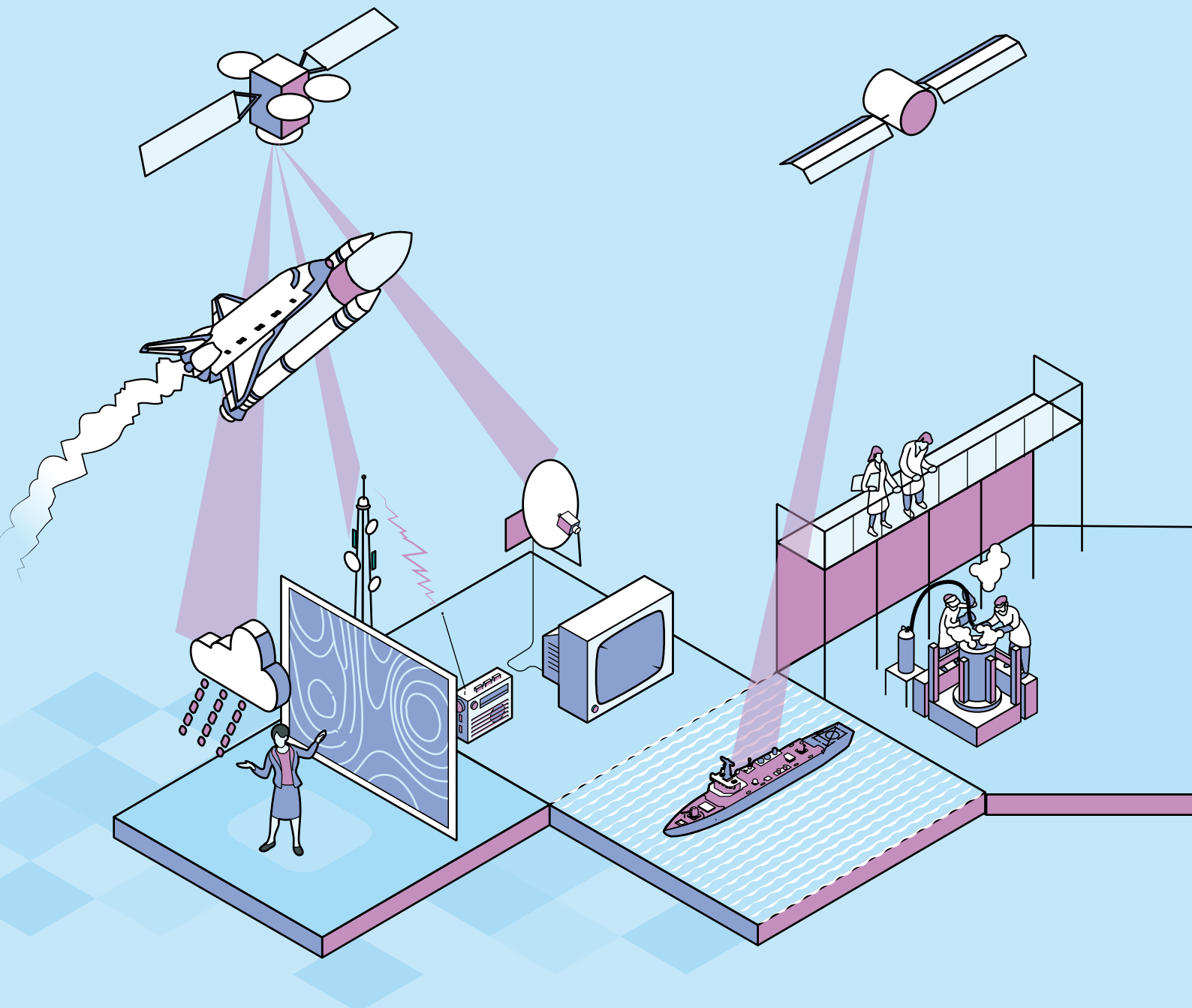
- To promote the transfer and economic utilization of research results, existing utilization structures at tertiary education institutions and NURI, especially technology transfer and exploitation of patented inventions, should be further professionalized and made more entrepreneurial and competitive. To this end, the organizational and incentive structures must be sufficiently flexible, for example by enabling performance-based remuneration.³¹⁶

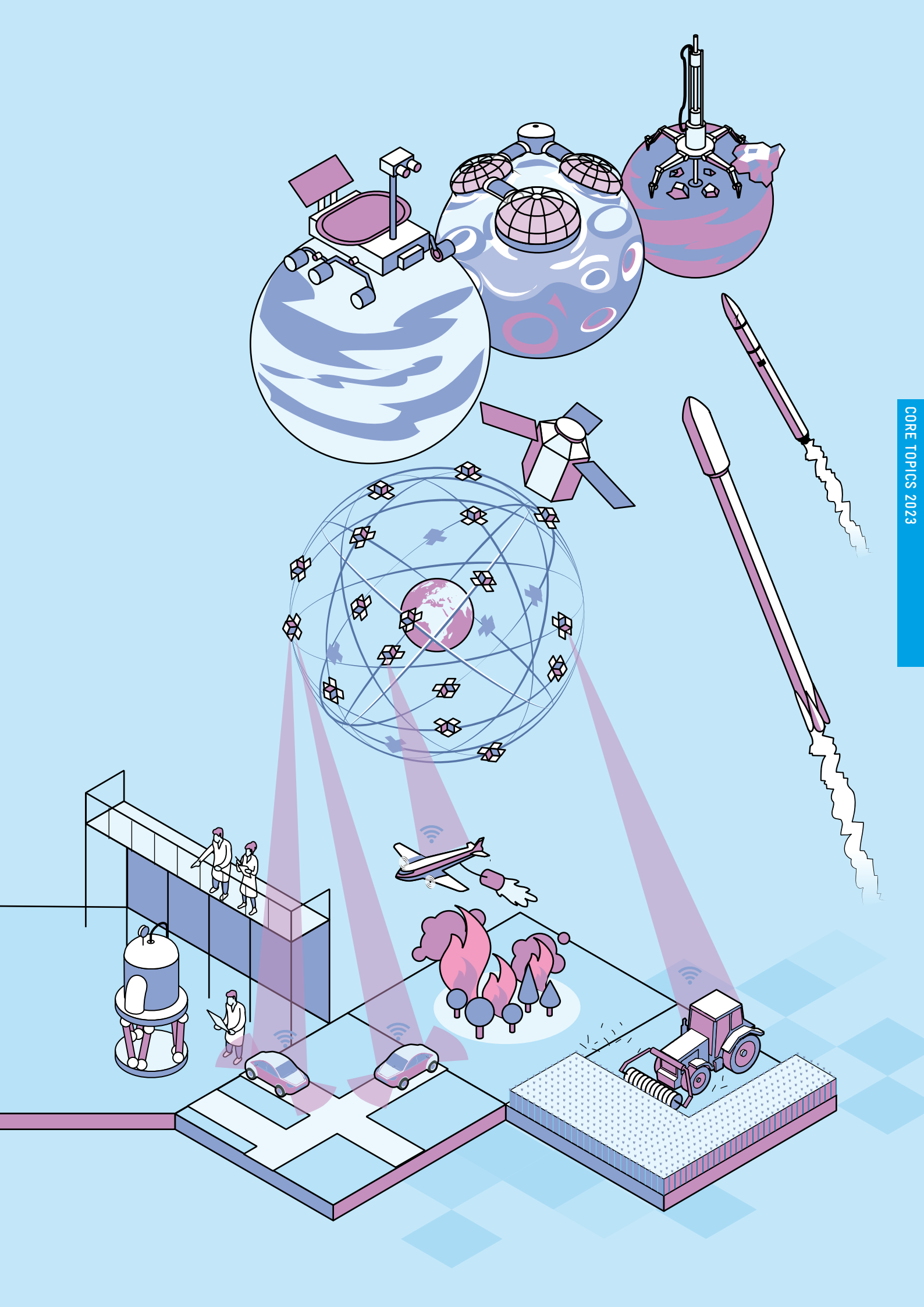
B3 The German Space Sector Between Old and New Space



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The space sector has changed rapidly worldwide in recent decades. Having been mainly state-managed until the 2000s, a strongly private-sector driven space industry is currently developing. However, the state still plays an important role – not least because of the high strategic relevance of space activity for the economy and society as well as the preservation of technological sovereignty. However, the space industry in Germany and Europe operates in an environment determined by pronounced national and supranational interests, a complex funding landscape and, in Germany, uncertainty about the future regulatory framework.





B 3 The German Space Sector Between Old and New Space

CORE TOPICS 2023

The space sector has changed rapidly worldwide in recent decades. Having been mainly state-managed until the 2000s, a strongly private-sector driven space industry has developed in the last decade. However, government agencies continue to play an important role, on the one hand as the driving forces behind major space programmes, and on the other hand as demanders of technologies and services for the civil and military sectors, especially for satellite communications, navigation, and Earth observation.

Space activities and technologies are of huge importance to modern society. Many people associate space activity primarily with basic research and exploration. However, the benefits of space activity now go far beyond this. Satellites have become indispensable for modern communication and navigation. Earth observation data are no longer only of military interest, but also assist in climate change research and disaster prevention. Products and services based on space developments are used in all areas of life. Equally, technologies developed in space are used in many other business sectors. This illustrates the cross-cutting nature of space technologies.

The growing importance of space flight is leading to an increase in both governmental and private activities in space. In turn, this creates new challenges such as collision avoidance and the removal of space debris, for which innovative solutions are needed. This results in opportunities particularly for start-ups and small and medium-sized enterprises (SMEs) to enter new markets.

An analysis of space patent activities shows that the European space industry can certainly keep up with

US-American activities (cf. B 3-3). Nonetheless, Germany is lagging behind in terms of the regulatory framework for the successful commercial use of space flight. Hence, there is an urgent need for an interdepartmental space strategy adapted to the new realities of the space industry, which, among other things, emphasizes the strategic importance of satellite systems as critical infrastructure. In addition, Germany needs a space law to provide companies with a secure legal framework for their investments.

Increasing global challenges make it ever more important to maintain technological sovereignty in the European Union. Therefore, the joint use of satellite services for civil and military purposes should also be given greater focus.

B 3-1 Transformation of Space Flight Blurring Boundaries between Old and New Space

Until the early 2000s, all space activities were essentially conducted by national and supranational space agencies such as NASA and Roscosmos. These traditional space activities, now called Old Space, had their beginnings in the 1950s and 1960s, when the two great powers, the Soviet Union and the USA, competed for technological leadership in space. National prestige played a considerable role in this.³¹⁷ But soon other objectives of public interest were pursued: on the one hand, military reconnaissance through satellite technology was of outstanding interest to the nations operating in space. On the other hand, space flight offered opportunities to observe the Earth from a new perspective for scientific purposes as well as to research the effects of weightlessness on living beings and materials.

However, all these objectives could only be pursued with public funding due to their high costs and the lack of private markets. In the USA, the corresponding contracts were specified by NASA and awarded to large companies such as Martin or Grumman.³¹⁸ From the mid-1970s onwards, other Western states followed this example,³¹⁹ awarding contracts to aerospace companies where the costs plus a fixed profit margin were borne by the state.³²⁰ Although public contracts with high technical and specific requirements were carried out by private companies, no sales markets existed as yet to commercially exploit the technological developments beyond government demand.

This changed in the early 2000s, when private actors became increasingly active in space and have since been driving the commercialization of space activity with verve. This development gave rise to a new kind of space flight, New Space,³²¹ a term that stands for the commercialization of space activity and the growing number of private actors in the space sector. For one thing, the new private providers are tapping into new markets and customers with innovative services. For another, they are also fulfilling public contracts that had previously been performed by established companies. In addition, private-sector actors are emerging as demanders. The fact that public contracts are now also being awarded to young companies is not least due to the technology-open formulation of the tenders, enabling marketable innovations.³²² The space industry has now reached a new stage of development where private suppliers and customers operate on new markets based on the rules of the market economy. However, states continue to play a vital role as customers for products and services in both the military and civil sectors. They also act as contracting authorities and financiers of the space agencies. The dovetailing of traditional space activities with the markets of the new space industry blurs the boundaries between Old and New Space.

European Context Important for German Space Activities

In Germany, the Federal Ministry for Economic Affairs and Climate Protection (Bundesministerium für Wirtschaft und Klimaschutz, BMWK) oversees the Federal Government's space policy (cf. figure B 3-1). One of the Federal Government's objectives is to create framework conditions for an internationally competitive aerospace industry in Germany.³²³

In this, the Federal Government is supported by the Coordinator of German Aerospace Policy based at the BMWK.³²⁴ Under the Space Flight Tasks Transfer Act (Raumfahrtaufgabenübertragungsgesetz), administrative tasks in the field of space were transferred from the Federal Government to the German Aerospace Center (DLR) within the Helmholtz Association – the largest research centre for aerospace in Germany. Tasks include implementing the space strategy, developing and managing the national space programme, and representing German space interests at the international level, especially at the European Space Agency ESA. Other tasks include technology transfer, commercialization of space activity and promotion of the innovation potential of SMEs, which are handled at the DLR in an institution separate from research operations: the German Space Agency at the DLR.³²⁵ To fulfil these tasks, the German Space Agency has the Federal Government's space budget at its disposal and awards funding and grants for space projects to science and industry.

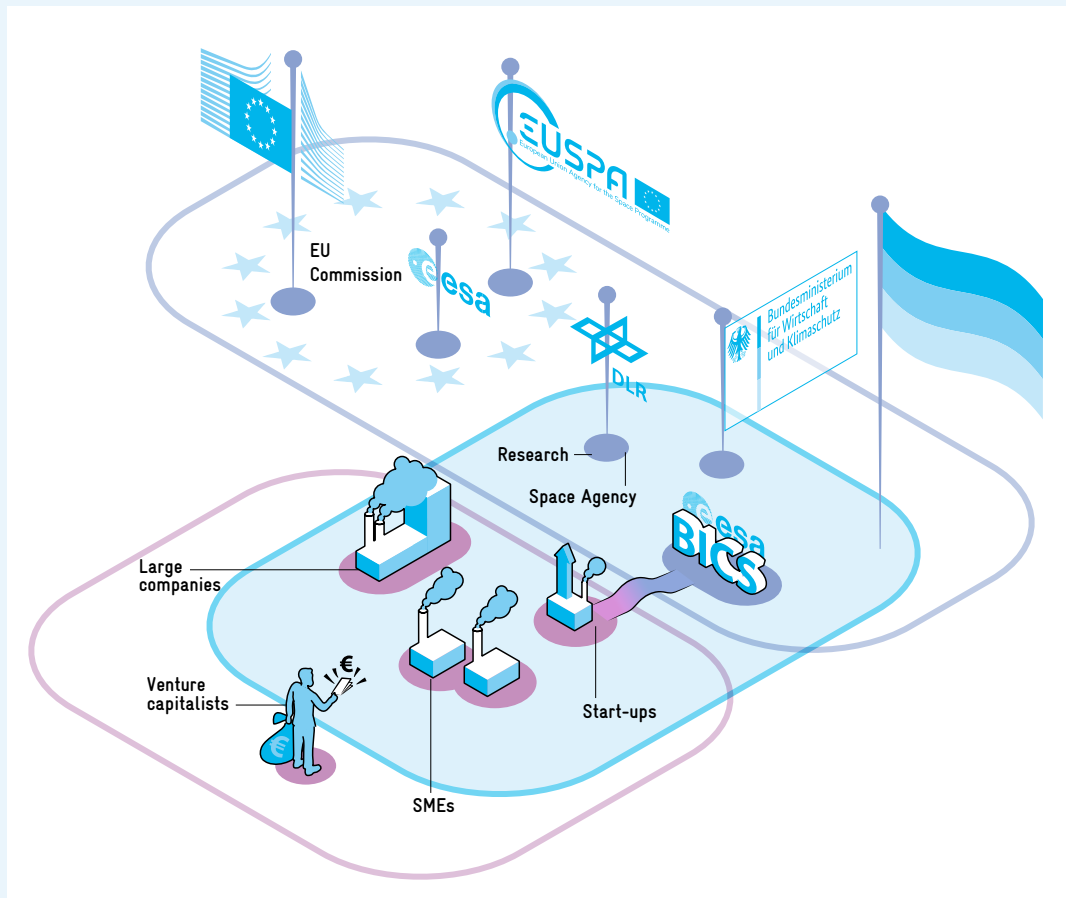
At the same time, the DLR is active in space research with 20 of its total of 55 research institutes and generated revenue of €519 million in 2021.³²⁶ This makes the DLR a key player in space research in Germany (cf. B 3-3). The DLR's research institutions are active in everything from basic research to product development. The Space Agency and the research institutions are assigned to different boards at the DLR. As both units belong to the DLR, the Space Agency cannot award contracts directly to the in-house research institutions, even though relevant expertise is concentrated there. The research institutions can only participate in the awarding of contracts through subcontracts from other parties. This means that the potential of the research institutions is not fully exploited.

Due to the cost-intensive nature of space activities, many projects are not implemented at the national level, but at the European level. This means that, in addition to the German institutions, the European institutions play a key role. The European Commission decides on and coordinates the space policy of the European Union (EU) and prepares a space programme every seven years, most recently for the period from 2021 to 2027. The implementation of the EU space policy is carried out by ESA and the EU Space Programme Agency (EUSPA), established in 2021.³²⁷ EUSPA was created in connection with the new EU space programme and will in future be

Fig. B3-1 Schematic representation of the actors in the German space sector



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Source: Own representation.
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responsible for market development, the operation of all EU space components³²⁸ and their safety accreditation. EUSPA thus takes over responsibilities that previously lay with ESA. EUSPA, unlike ESA, is an agency of the EU and was established to ensure that the EU's investments in space flight result in value-adding activities for the EU.³²⁹ In contrast, ESA is a space agency that is independent and autonomous from the EU. It should be noted that ESA's member states and those of the EU are not identical. Of ESA's 22 member states,³³⁰ Norway, the UK and Switzerland are not members of the EU, while eight EU states are not part of ESA.³³¹ However, ESA, established in 1975, holds much of the space expertise in Europe and therefore remains responsible for the technical design and development of the EU's space programmes.³³² It also conducts major space exploration missions independently and in cooperation with national space agencies. ESA's member states commit to funding the space research programme based on the respective national gross domestic

product (GDP) and may voluntarily participate in further commercial and scientific programmes of ESA.³³³ Although ESA and EUSPA have different objectives, duplicate structures may arise if the two agencies' areas of responsibility are not clearly delineated.

Private Space Actors Mainly in Upstream Segment

According to the DLR's space catalogue (Raumfahrt-katalog), around 400 companies were active in the German space industry in 2018. These included both pure space companies and companies with a space division.³³⁴ The German Aerospace Industries Association (Bundesverband der deutschen Luft- und Raumfahrtindustrie, BDLI) estimates that the German space industry will have a turnover of € 2.4 billion in 2021. Due to delivery bottlenecks, a pandemic-related reduction in the number of launches and delays in the construction of Ariane 6, turnover

fell by € 0.6 billion compared to 2017. In contrast, the number of employees has remained almost constant at 9,300 over the same period.³³⁵

The activities of space actors can be divided into two segments: upstream and downstream. The upstream provides the scientific and technological basis for space programmes and space activities. This includes research on, and the development and production of, launch vehicles, spacecraft, satellites, control and command centres, and related parts and components. As such, the upstream segment provides a basis for downstream products, which includes any form of terrestrial use of space capacities such as data and signals from satellites.³³⁶

Among the space actors listed by DLR, 58 percent are active in the upstream, 19 percent in the downstream, and 16 percent in both segments.³³⁷ The two largest German space companies are the Large System Integrators (LSIs) Airbus Defence and Space GmbH and OHB System AG, whose business model is to integrate subsystems into a whole.³³⁸ In addition, 293 SMEs are listed by DLR, of which 103 are less than ten years old.³³⁹ Some companies, such as Exolaunch, Mynaric, and Morpheus Space, emerged as spin-offs from research operations and offer upstream products.

Industry interests are represented nationally by the BDLI, the Federation of German Industries (Bundesverband der deutschen Industrie, BDI) with its New Space Initiative, and the German Society for Aeronautics and Astronautics (Deutsche Gesellschaft für Luft- und Raumfahrt, DGLR). In addition, there are four space cluster initiatives in Bavaria, Berlin/Brandenburg, the Lake Constance region and Bremen, which promote regional networking between politics, science, and industry.³⁴⁰

Start-ups in particular rely on venture capital providers and private investors in addition to public and European funding. Most investors are based in the USA, where the majority of all investments in early-stage space companies still take place. In Europe, most business angel and venture capital investors active in the space industry come from the UK. Investors from other European countries, including Germany, are much less represented.³⁴¹ ESA has initiated the ESA Business Incubation Centres (ESA BICs) to provide financial support and advisory services to early-stage start-ups. To this end, the ESA BICs are located in the participating member states

at locations relevant to space ventures – in Germany, for example, in Bremen and at several Bavarian locations.³⁴²

Manifold Value-adding and Utilization Potential of Space Activities

The first activities in space began in the late 1950s in the USA and the Soviet Union in the upstream segment with the development of communication, navigation, and Earth observation satellites for military and scientific purposes (cf. box B 3-2). In addition, the first commercial applications quickly developed in the downstream segment, which were initially usually commissioned by the state – primarily in the field of satellite communications. For example, the first satellite-based live television broadcast was transmitted already in the early 1960s. By now, the use of satellite communication for commercial purposes is widespread: satellite television, radio and telephony, and soon a global satellite-based Internet.³⁴³ These applications are mainly demanded by private users, but are also important for state actors.³⁴⁴ Satellite communication competes with terrestrial infrastructures such as fibre optic cables and transmission towers, but in view of the increasing networking of devices in the Internet of Things, it is to be expected that the development of a powerful communication infrastructure will become an important driver of commercial satellite communication systems.³⁴⁵

Satellite-based navigation was initially only used for military purposes and for determining the position of warships. It was not until the late 1960s that navigation satellites could also be used commercially in the downstream segment.³⁴⁶ Nowadays, people around the world can use navigation services as well as positioning and timing systems using GPS or Galileo for orientation. The transformation in the transport system, especially through autonomous driving and sustainable logistics, as well as a growing demand for location-based services and innovations in precision agriculture, suggest increases in demand in this area.³⁴⁷

In the 1950s, developments in the category of Earth observation were still mainly driven by science. Earth observation data were also used for weather forecasting and cartography as early as the 1960s.³⁴⁸ Meanwhile, the large amount of such data³⁴⁹ enables a wide range of downstream applications, such as tracking global changes due to climate

change quickly and over a wide area. Authorities can use satellite data to improve spatial planning, track illegal activities, and manage disasters and crises. Private-sector players include agriculture, which can use it to determine the irrigation needs or maturity of crops, and various industries, allowing them to track logistics chains and find out about competi-

tors' activities.³⁵⁰ Earth observation still accounted for a very small part of global downstream revenue in 2016, at 1.65 percent,³⁵¹ but it has been gaining in importance ever since. Above all, the generally free access to scientific Earth observation data is driving the development of new business models in the downstream segment.³⁵²

Box B 3-2 Classification of Space Activities and Technologies³⁵³

The OECD classifies space activities into the following separate categories:³⁵⁴

Satellite communication comprises the development and use of satellites and related subsystems to send signals to Earth. These systems form the basis for satellite-based TV and radio services, satellite-based voice services and data transmission as an alternative to terrestrial networks.

Positioning, navigation, timing involve the development and use of satellites and related subsystems to determine location and time for terrestrial applications. Satellite-based navigation is an elementary technology, for example, in land, air and maritime transport, and is increasing in importance because of technological developments such as autonomous driving.

Earth observation involves the development and use of satellites and related subsystems to generate data from observation of the Earth's surface, such as data on environmental changes and human activities. Technological developments in recent years have significantly increased the supply of and the demand for products in this field. Examples include military applications as well as the provision and analysis of climate data.

Space transportation includes the development and use of launch vehicles and related subsystems. In addition to launch vehicles, this field also includes spaceports, space tourism, and interorbital transport.

Space exploration includes the development and use of crewed and uncrewed space vehicles such as spacecraft, space stations, rovers and probes to

explore the universe beyond Earth's atmosphere, for example, the Moon, Mars, and asteroids.

Science includes scientific activities related to space flight and the study of space phenomena and other celestial bodies. Examples include research in astrophysics and space-related life sciences.

Space technologies includes specific space system technologies that are used in various space missions. Examples include space nuclear systems for power and propulsion and solar electric propulsion.

Generic technologies or components that may enable space capabilities includes technologies that were not initially intended for use on a specific space system or for a specific space application but may then lead to new products and services, such as artificial intelligence and data analytics software.

In addition, the development of further space activities is to be expected in the future, which are not yet explicitly assigned to the above-mentioned categories. These include, in the medium term, technologies for collision avoidance in space and, in the long term, technologies in space mining and the manufacture of objects in space, so-called in-orbit manufacturing.³⁵⁵

While some categories clearly belong to either the upstream or the downstream, e.g. transport to space belongs to the upstream, most include elements of both the upstream and the downstream segment. In satellite communications, for example, the development and production of satellites is part of the upstream, while their use, for example, for satellite telecommunication services and satellite-based Internet, is part of the downstream.

The demand for communication, navigation, and Earth observation services in the downstream segment is expected to continue to grow. Especially the utilization potential in the public sector has hardly been identified and exploited.³⁵⁶ A functioning satellite infrastructure is also of foremost importance for a high-performance Internet of Things and autonomous driving over a wide area.

In the upstream segment, established large companies have long implemented the specific technical demands of the space agencies. In the 2000s, emerging private companies started to greatly reduce the cost of manufacturing launch vehicles (most notably SpaceX) and payloads through the use of standardized components,³⁵⁷ miniaturization, mass production, and reusable parts.³⁵⁸ The miniaturization of payloads³⁵⁹ has spurred the development of micro-launchers³⁶⁰ that can deliver these payloads directly into target orbit at the desired time.³⁶¹ Cost degression and weight reduction foster competition in the upstream segment between new and established companies.³⁶² Meanwhile, innovations in the upstream segment are enabling business models in both segments. One example of an upstream business model is space tourism, which will continue to be the preserve of a small group of very wealthy individuals well into the future.³⁶³ Further commercial potential lies in the mining of resources on asteroids and planets. Associated with this are visions of populating other planets, but this is likely to be of secondary relevance in the near future due to exorbitant costs and unsolved technical problems.

Being public goods, some potential uses of space activities cannot be commercialized without government demand. These include the protection of the Earth from meteorite and asteroid impacts,³⁶⁴ the removal of space debris and traffic management in space to avoid collisions.³⁶⁵ This opens opportunities for companies to develop and market technological solutions to these problems.

The diversity of potential uses of space activities demonstrates their cross-cutting nature. The technologies developed in this field are applied far beyond the space industry. These include innovations in the field of robotics and sensor technology. Accordingly, the INNOspace initiative of the German Space Agency aims to strengthen the transfer between the space industry and the non-space industry.³⁶⁶

B3-2 Special Characteristics of Space Markets

Market Structures Highly Concentrated in Parts of Upstream Segment

The development of large launch vehicles in the upstream segment is associated with high investment requirements and long research and development periods. Large companies have an inherent competitive advantage here over SMEs and start-ups, as they can produce a wider range of components and exploit synergies.

Innovations in the upstream and downstream segments are mutually reinforcing. Cost reductions in the upstream³⁶⁷ facilitate the construction and cost-effective operation of space infrastructures, which in turn unlocks additional profitable business models in the downstream segment. The resulting increase in demand for satellites, launch vehicles, and ground stations in the upstream segment leads to further production advantages through economies of scale.³⁶⁸ Initial public procurement may be required to trigger these positive reinforcement effects between the upstream and downstream segments.

In parts of the upstream segment, monopolistic or at least highly concentrated market structures can emerge, which negatively affect the downstream segment. In addition to high fixed costs, the number of providers is restricted by the limited capacity of the relevant low earth orbit and a limitation of available radio frequencies.³⁶⁹

Satellite Systems as Critical Infrastructure of Strategic Importance

Not only private-sector activities in the downstream segment are dependent on a functioning space infrastructure. It is also essential for an increasing number of government tasks.³⁷⁰ Satellite-based systems are required where the quality, applicability, and availability of Earth-based alternatives have their limits. For example, radio and wired data transmission are currently still common alternatives to satellite-based communications.³⁷¹ Although substitutes for satellite-based navigation are available and used in aviation, they are not suitable for private navigation applications. No terrestrial alternatives are available in the field of Earth Observation.

The space sector is of strategic importance because a large number of private and public actors depend on a functioning space infrastructure. This justifies calls for a minimum level of technological sovereignty at national or at least European level. The space sector has been identified as a critical infrastructure in the EU's Critical Entities Resilience Directive. The associated security obligations are expected to come into force in Germany in 2023 as part of the Critical infrastructures 'umbrella law' (Kritische Infrastrukturen Dachgesetz, KRITIS).³⁷²

Space-related services such as satellite transports are not provided by all countries but are available on the international market. Yet recent developments like the loss of Russian space transport services due to the war in Ukraine and the increased dependency on SpaceX due to delays in Ariane 6 illustrate the fragility of access to transport options for payloads. Dependencies of this kind can go hand in hand with a loss of technological sovereignty. However, the desire to ensure independence by way of a domestic space infrastructure must be weighed against the high costs of space activities and the inefficiencies of building parallel national infrastructures. This often leads to solutions at the European level, as demonstrated by Galileo, Copernicus, and other programmes.³⁷³

Civil-military Use of Space Flight with Potential

Like many other so-called dual-use technologies, space technologies can be used for both civilian and military purposes.³⁷⁴ This has ambivalent consequences for commercialization. A potential military use increases government demand for space products and services, thereby increasing the potential for commercialization. Likewise, there is potential for synergy effects, such as in the joint civil-military use of space infrastructures. This can make projects profitable that would not pay off if used exclusively for civilian purposes. The potential for military use means that there is often an interest in maintaining or expanding production capacities either domestically or at least in cooperation with partner nations. However, military usability also means that sales to other countries are possible only to a limited extent due to export regulations or, in light of increasing geopolitical tensions, only with a high degree of uncertainty. The uncertainty of international business opportunities for space products limits their commercialization potential.

Against the backdrop of these tensions, physical security and cybersecurity of space infrastructures are also increasingly coming into focus.³⁷⁵ As communications and navigation capabilities are heavily dependent on satellites, these critical infrastructures could be increasingly exposed to potential military attacks.³⁷⁶ Private space activities could thus find themselves exposed to increased business risk.

B 3-3 Space Patent Activities

In the following, patent activities and market shares in the space sector are examined globally and compared to other countries to describe Germany's position in international competition. Patent applications are an important indicator of the innovative strength of an industry and the nations involved. The basis for this is a study conducted by the Commission of Experts on transnational patent applications³⁷⁷ in the space sector for the period from 1980 to 2018.

Patent Activities Increasing Worldwide

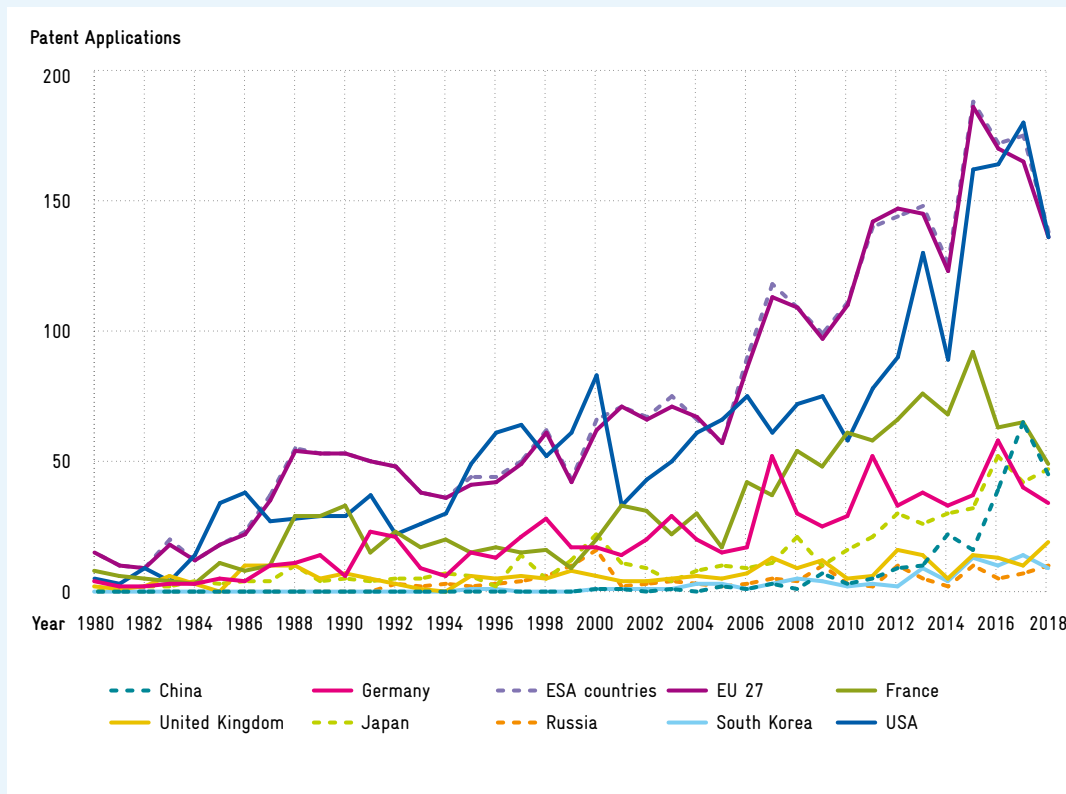
The number of transnational patent applications in space technologies has increased significantly worldwide since 1980 (cf. figure B 3-3). The USA is mostly ahead of France and Germany over the entire period from 1980 to 2018. In the 2000s, Japan and China managed to catch up. A significant increase in patent applications has been observed in the USA, especially since 2001. Countries such as France, Japan, and, to a lesser extent, Germany have also seen a strong increase in patent applications since 2005. Adding up the patent applications of the ESA member states or the EU 27 including the UK³⁷⁸ shows that European patent activities have been at a higher level than those of the USA in most years since 1980.

A distinction between the upstream and downstream segments reveals that there have been more transnational patent applications in the upstream segment worldwide over the entire period.³⁷⁹ Furthermore, significant growth rates in global patent activity were observed in the upstream technologies from 2010 onwards, but in the downstream technologies not before 2014. The reason for this time lag is that developments in the downstream segment can only emerge after a successful development in the upstream segment.

Fig. B 3-3 Number of transnational space patent applications of selected countries and regions 1980–2018



[Download Data](#)



Source: PATSTAT. Own calculations.
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High Quality of German Space Patents

Based on the analysis of highly cited transnational patent applications in the field of space flight with at least ten citations³⁸⁰ as a quality characteristic, Europe was able to catch up with the USA in the period from 2000 to 2018 (cf. figure B 3-4). In the country comparison, the USA leads by a clear margin. Germany is only just behind France in third position. Between 2000 and 2018, the number of highly cited transnational patent applications in the field of space technologies from Germany increased by a factor of 1.49 compared to the period from 1980 to 1999. Thus, Germany has the highest change factor (CF) of the three leading filing countries. South Korea and Russia have larger change factors but are at a lower level in absolute terms. These figures suggest that Germany is a strong innovator in space technologies.

Germany Specializing in Transportation and Navigation

An analysis of transnational patent applications for the categories defined by the OECD (cf. box B 3-2) shows that most patent applications between 1980 and 1999, both worldwide and in Germany, were in the categories of space transportation, satellite communications, navigation, and Earth observation (cf. figure B 3-5). The most dynamic development, measured by the change factors, can be seen worldwide and in Germany in the categories of navigation and Earth observation.

The normalized relative patent shares (RPS) reflect the degree of specialization of the countries within the space technologies. Figure B 3-6 illustrates the development in the four categories with the highest number of worldwide patent applications. From 1980 to 1999, Germany shows a below-average degree of specialization in these categories.

Between 2010 and 2018, Germany then specialized in transportation and navigation. The ESA countries considered in the analysis (Germany, France, the UK) jointly cover all four categories with their specializations, while the USA only specializes in transportation and satellite communications.

Large Companies and Space Agencies Lead in Patent Applications

Among the organizations with the most transnational patent applications in the field of space technologies, Airbus leads with 695 patent applications, well ahead of Thales and Boeing (cf. figure B 3-7). The 25 strongest applicants include large companies, most of which are active not only in astronau-

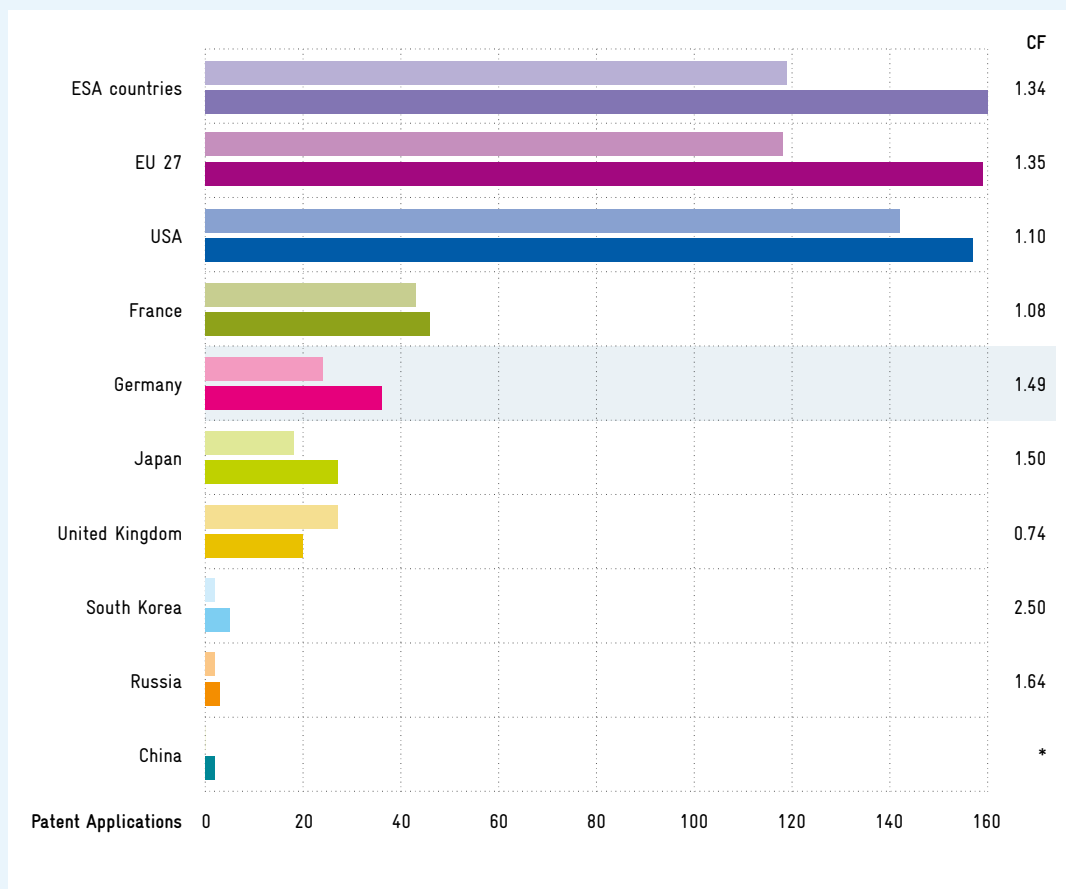
tics but also in aeronautics and armaments, as well as a few space agencies and research institutions. These include, in particular, the French space agency CNES in fourth place and the DLR in 12th place.³⁸¹ The 25 strongest applicants account for a share of 50.7 percent of the total transnational patent applications between 2000 and 2018.

Looking at the patent applications with German participation, the ten strongest applicants mainly include large organizations whose main activity is in aerospace (cf. figure B 3-8). The list is headed by Airbus, followed by the DLR. The DLR, the Fraunhofer-Gesellschaft and the Technical University of Dresden are the only research institutions among the top 10 applicants. In addition to these organi-

Fig. B3-4 Number of highly cited transnational space patent applications of selected countries and regions 1980–1999 and 2000–2018



[Download Data](#)



* is used if no change factor (CF) can be calculated due to a lack of data. The lighter shade shows the number of patent applications in the years 1980–1999, the darker shade those in the years 2000–2018.
 Legend: The USA had a total of 142 highly cited transnational patent applications in the space field in the period 1980–1999 and a total of 157 in the period 2000–2018. This corresponds to a change factor of 1.10.
 Source: PATSTAT. Own calculations.
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zations, Henkel, a company not directly involved in the aerospace industry, is also listed, in 7th place.³⁸² The only younger German companies³⁸³ that filed transnational patents between 2000 and 2018 are Exolaunch and Morpheus Space, each with one patent application.

B3-4 General Conditions for the Space Industry in Germany

New Space Strategy Initiated

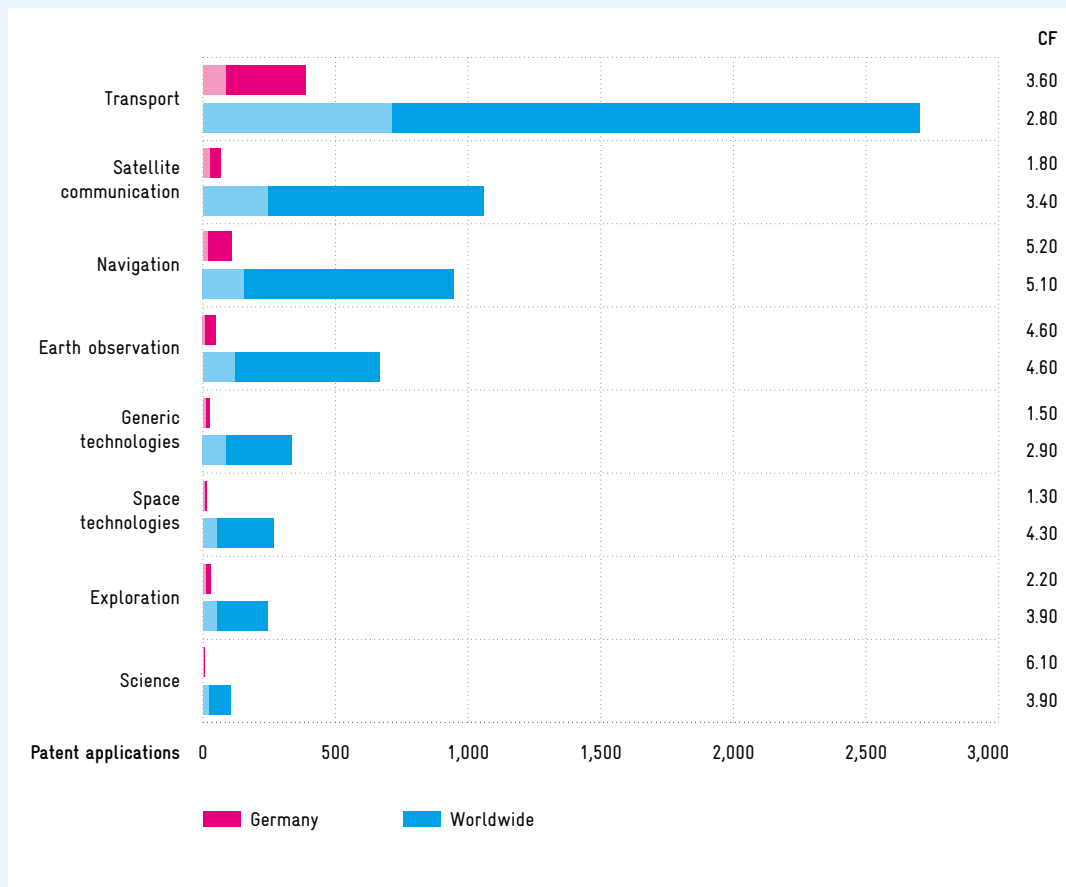
The Federal Government’s currently valid space strategy dates from 2010 and therefore takes insufficient account of many current developments,

in particular the increasing commercialization of space activity.³⁸⁴ In autumn 2022, the Coordinator of German Aerospace Policy launched the process of drawing up a new space strategy. An impulse paper by the BMWK on the new space strategy from October 2022 defines six priority fields of action.³⁸⁵ Commercialization in the space sector is at the forefront of the impulse paper and throughout all the fields of action named there. In contrast to the 2010 space strategy, however, the need for a German space law is not mentioned. Since the space sector relies heavily on government contracts, the current lack of clarity about the new space strategy increases the already existing uncertainties about the market potential of their business models, especially for SMEs and start-ups.

Fig. B3-5 Number of transnational space patent applications by OECD classes worldwide and in Germany 1980–1999 and 2000–2018



[Download Data](#)



The lighter shade shows the number of patent applications in the years 1980–1999, the darker shade those in the years 2000–2018. Legend: In the field of transport, just under 710 transnational patents were filed worldwide in the period 1980–1999, compared to a total of 1,992 applications for the period 2000–2018. The change factor (CF) shows that the number of patents in transport has increased by a factor of 2.80 worldwide. Source: PATSTAT. Own calculations. © EFI – Commission of Experts for Research and Innovation 2023.

German Space Law Not Yet in Sight

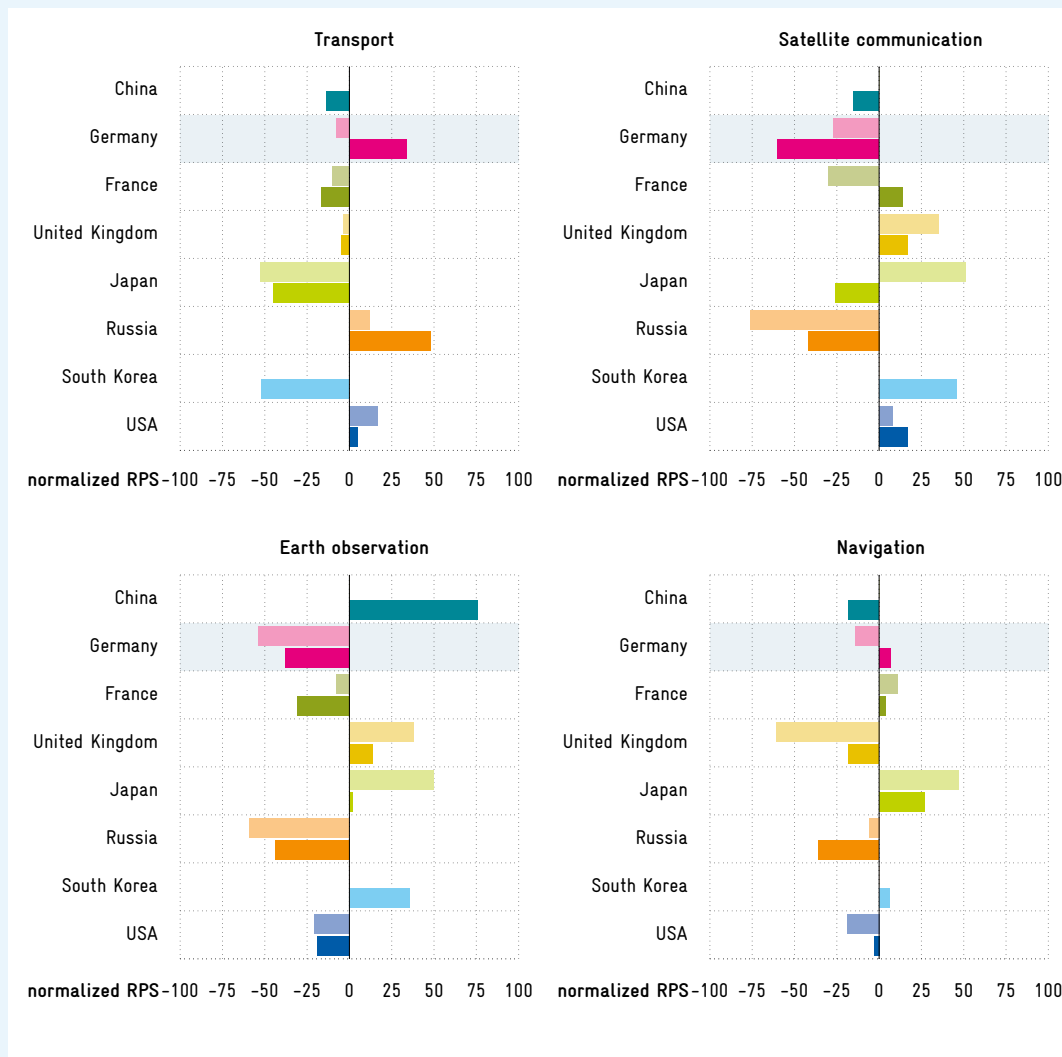
Under international law, the German state bears responsibility for all space activities on German territory and by German actors, including non-state actors. This responsibility includes liability for damage to third parties. However, a national space law that regulates at least core elements such

as a registration and licensing obligation as well as private (co-)liability is still missing. A national register for space objects does exist, but in the absence of a law, there is no registration obligation. In this respect, Germany is failing to adequately fulfil its obligations under international law arising from the Outer Space Treaty of 1967. A uniform space law at the EU level is not to be expected.³⁸⁶ Nevertheless,

Fig. B3-6 Normalized relative patent shares of selected countries by OECD class 1980–1999 and 2000–2018



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Normalized RPS of the individual classes measured against all space patents. The lighter shade shows the normalized RPS for the period 1980–1999, the darker shade that for the period 2000–2018. No RPS can be calculated for China and South Korea for the period 1980–1999. The (non-normalized) RPS for technology field *j* in country *i* is calculated as follows: $RPS = (p_{ij} / \sum_i p_{ij}) / (\sum_j p_{ij} / \sum_i \sum_j p_{ij})$. The normalized RPS is calculated from the (non-normalized) RPS as follows: Normalized RPS = $100 * \tanh \ln (RPS)$. Cf. Sievers and Grimm, 2022.

Legend: The USA has a normalized RPS of 17 for transport in the period 1980–1999. This is based on a non-normalized RPS of 1.184. This value indicates that the USA's share of all space patents in the field of transport during this period is 118.4 percent of the USA's share of all space patents – which is above average.

Germany has a normalized RPS of -38 for Earth observation in the period 2000–2018. This is based on a non-normalized RPS of 0.667. This value indicates that Germany's share of all space patents in the field of Earth observation during this period is 66.7 percent of Germany's share of all space patents – which is below average.

Source: PATSTAT. Own calculations.

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there are calls for coordination at the European and wider international level to prevent a race to the weakest regulation.³⁸⁷

To ensure that private actors adequately address the risks of their space projects, national space laws typically provide for (co-)liability coupled with compulsory insurance. If the state is held liable for damage by a private actor, the state can take recourse against the perpetrator up to the amount of the compulsory insurance. If the actor is held liable for the damage under civil law, they are liable up to the amount of the compulsory insurance, above which the state is liable as guarantor. High liability limits can lead to insurance costs that represent a barrier to market entry, for example for micro-satellite

projects.³⁸⁸ Internationally, liability limits around € 60 million are common.³⁸⁹

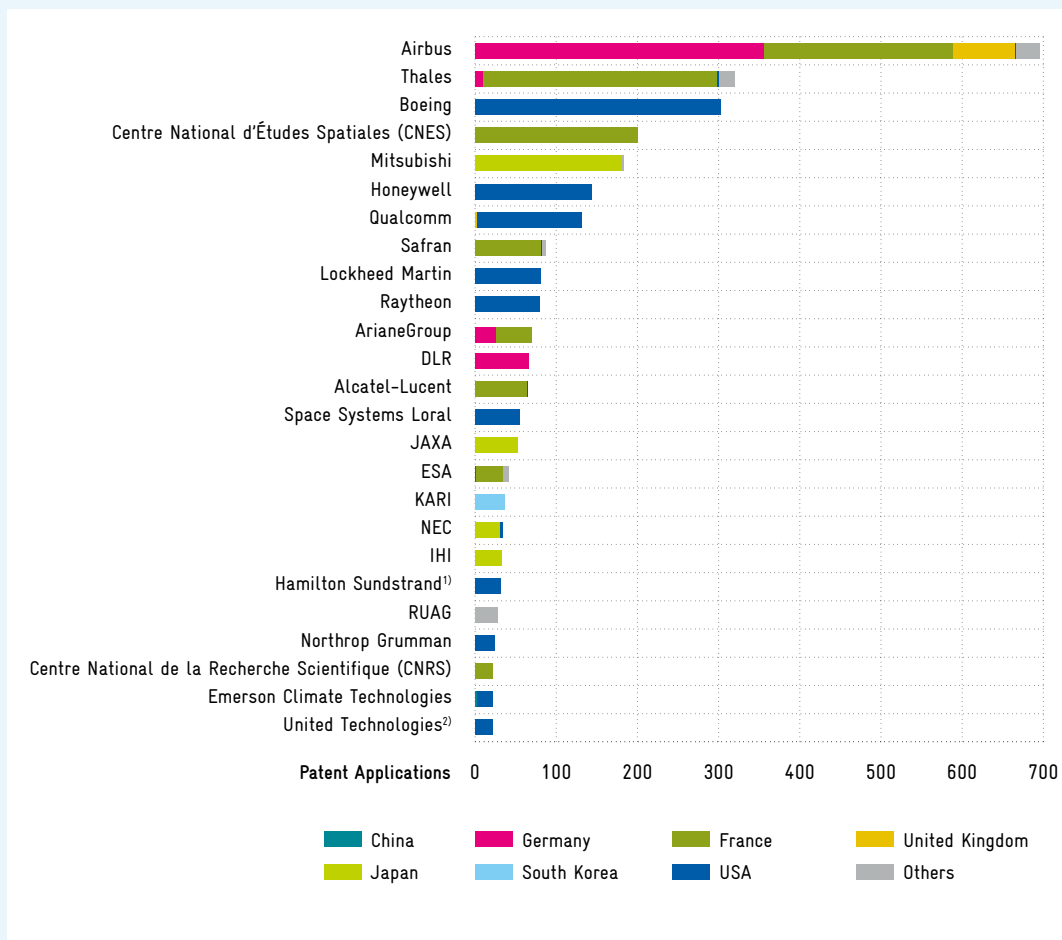
A study commissioned by the Commission of Experts³⁹⁰ identifies further elements that a national space law should contain as a minimum, such as regulations on the avoidance and disposal of space debris. It also advocates the establishment of an authority with sufficient budget and staff to be responsible for licensing procedures and monitoring the legal framework.

The Satellite Data Security Act of 2007 regulates private remote sensing and the commercialization of data in Germany. The law provides for a mandatory permit for the generation of security-relevant data

Fig. B3-7 Number of transnational space patent applications by top applicants 2000–2018



[Download Data](#)

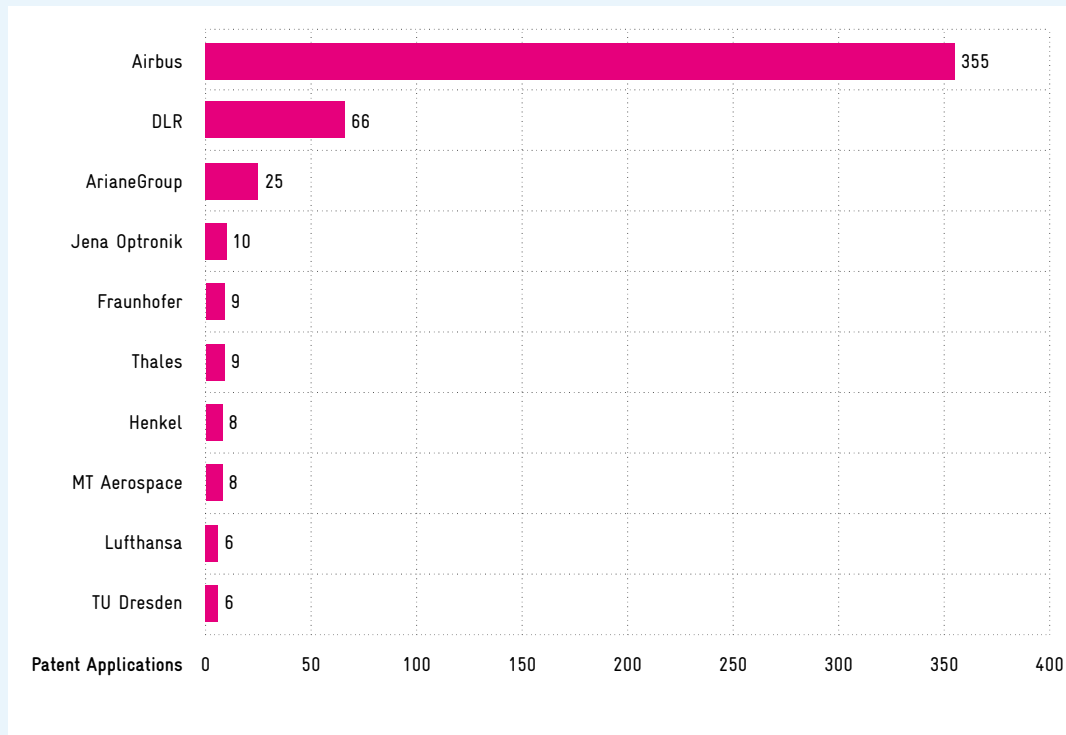


¹⁾ Hamilton Sundstrand was merged with Goodrich Corporation in 2012 to form UTC Aerospace Systems.
²⁾ United Technologies was merged with Raytheon in 2020.
 The patent applications of the institutions are arranged based on participation of the selected countries.
 Source: PATSTAT. Own calculations.
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Fig. B3-8 Number of transnational space patent applications by German organizations 2000–2018



[Download Data](#)



For multinational companies such as Airbus, ArianeGroup and Thales, the respective patent applications of the German subsidiaries are counted.

Source: PATSTAT. Own calculations.

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with high information content, such as high-resolution imagery. However, the technical thresholds in the associated ordinance, above which a sensitivity check of Earth observation data must take place, are no longer up to date. For example, data for which a permit is still required in Germany is freely available on the market. This weakens the competitive position of German data providers.³⁹¹

Public Funding Focused on Europe

Funding for space projects in Germany can be provided by the Federal Government, within the scope of the National Programme for Space and Innovation (Nationales Programm für Weltraum und Innovation, NPWI), as well as by the EU and ESA. A cross-cutting topic in these funding programmes is the commercialization of space activity, which is to be promoted on the one hand by supporting start-ups and SMEs and on the other hand by supporting technology transfer. Examples of specific support for new companies and SMEs include the ESA BICs and the

EU's € 1 billion CASSINI programme, as well as the INNOspace initiative and the German Space Agency's Microlauncher competition.³⁹²

Through the NPWI, projects and contracts worth € 340 million will be implemented in the German space sector in 2023, whereby the NPWI currently still follows the 2010 space strategy. An evaluation of the NPWI for the period from 2011 to 2018 identified a focus on projects in the upstream segment. According to the evaluation report, 44.7 percent of programme funds were allocated to large enterprises, while SMEs received only 4.4 percent. 49.8 percent of programme funds went to research institutions.³⁹³

In 2022, the German budget for ESA was € 1,017.5 million. France was the strongest contributor to ESA with € 1,178.2 million,³⁹⁴ even though Germany had promised higher contribution payments than France at the past ESA Ministerial Council conferences.³⁹⁵ Comparing the countries' contributions to their respective GDPs, the high importance of the space in-

dustry for France becomes particularly evident. For example, France and Germany spent 0.043 percent and 0.027 percent of their GDP respectively on ESA in 2021.³⁹⁶

By way of geographical return, ESA invests amounts roughly equivalent to the national contribution to ESA's budget in the context of industrial contracts in each member state. The principle of geographical return of funds is seen as necessary by both policy makers and industry to provide incentives especially for small member states to participate in ESA's programmes. At the same time, large companies, most notably Thales and Airbus, have set up subsidiaries in different member states and at different points in the value chain.³⁹⁷ This makes it possible for a considerable proportion of ESA contracts to be awarded to these same large companies in compliance with the principle of geographical return. The large companies in turn award subcontracts taking into account the ESA procurement rules including the SME participation rate.³⁹⁸ A control of the award procedures by ESA is intended to prevent³⁹⁹ large companies from favouring their own subsidiaries in the award process.

The EU Space Programme estimates a budget of € 14.88 billion over the period 2021 to 2027, in which Germany indirectly participates with around one fifth in accordance with its share of the EU budget.⁴⁰⁰ It is intended to reinforce the European space infrastructure, especially in the fields of Earth observation, satellite navigation, and space research.⁴⁰¹ The awarding of EU contracts by EUSPA does not follow the principle of geographical return, as is the case with ESA, but via competitive tenders.

In addition to the limited participation in ESA and EUSPA contracts, the development of space start-ups and SMEs in Europe is also hampered by the lack of access to venture capital. This increases incentives for companies to move at least part of their operations to the USA, for example Morpheus Space.⁴⁰² While countries such as France and Luxembourg have already established public space venture capital funds, Germany has the DeepTech & Climate Fund, which supports companies in the growth phase. However, this fund does not have sufficient resources and expertise to finance deep-tech projects in the space sector.⁴⁰³

Space Industry Calls for State as Anchor Tenant

Calls from the German space industry for contracts with the Federal Government as an anchor tenant, like the US-American model, have intensified in recent years (cf. box B 3-9).⁴⁰⁴ The industry hopes that this will provide it with the necessary financial resources as well as a certain degree of planning security for the implementation of its commercial projects. The idea is that the state, instead of giving public grants to companies, creates demand by ordering space products and services that are of public benefit. Such public anchor tenancy contracts can provide positive signals to private investors, which is of particular importance for emerging companies.⁴⁰⁵ On the other hand, there is a risk that governments will continue to subsidize products that are not marketable in the long term. NASA already takes this problem into account in its anchor tenancy contracts. As a public contracting authority, it reserves the right to terminate contracts prematurely if agreed conditions or milestones are not met by the contractor (cf. box B 3-9). In Germany, however, the US-American anchor tenancy model can only be replicated to a limited extent due to European tendering rules.

B 3-5 Recommendations for Action

Commercialization in the space sector means that space products and services are increasingly being used by private companies as well as end consumers. Nevertheless, public demand will remain important for the space industry in the future – not least because space activities have a high strategic relevance for the state and technological sovereignty must be preserved, especially in the fields of satellite communications, navigation, Earth observation, and transportation to space. In terms of innovation activity in aerospace, Europe is on a par with the USA. However, companies in the space industry in Germany and Europe are still operating in an environment determined by pronounced national and supranational interests and a complex funding landscape. In Germany, companies are also confronted with uncertainty about the future regulatory framework. Moreover, start-ups and SMEs in the space industry are struggling with financial difficulties, which are particularly acute in the case of technologically sophisticated products with long development cycles. Given the increasing importance of space activities

for the state, economy, and society, the Commission of Experts recommends the following measures:

Swiftly Launch the Space Strategy

- In view of the strategic relevance and increasing international importance of space activities, the Federal Government must swiftly adopt and implement the space strategy. It must be closely coordinated with the objectives of the Future Strategy for Research and Innovation.
- The current and future fields of development and action to be taken into account in the space strategy concern various ministries. The Federal Government must therefore create suitable structures for interdepartmental cooperation in the implementation and further development of the space strategy.
- Likewise, the Federal Government must take a position in its strategy on how to improve the security of critical infrastructures in space.

Coordinate Public Demand and Intensify Cooperation between Civilian and Military Actors

- The Federal Government should coordinate public demand for innovative products and services of the space industry across ministries. An institution such as the Competence Centre for Innovative Procurement can play a key role in this.

- Cooperation between civilian and military actors in the provision and operation of space infrastructure should be intensified and synergies created through joint use.

- The Federal Government should consider concluding anchor tenancy contracts for clearly specified but technologically open contracts with companies in the space industry and in coordination with the space agencies. An anchor tenancy contract must be preceded by a competitive procedure and clear criteria must be defined as to when funding is continued or terminated.

Improve General Conditions for Private Actors

- Germany should adopt a national space law that regulates the approval and monitoring of space activities, the registration of space objects, and liability in the event of damage.
- The infrastructure required to implement this space law should be integrated into the German Space Agency. The Space Agency, in turn, should be disaffiliated from the German Aerospace Center (DLR) and set up as an independent actor.
- It should be reviewed how the financial and staff resources of the DeepTech & Climate Fund can be increased to enable investments in deep-tech projects in the space sector.

Box B 3-9 The US-American Anchor Tenancy Model⁴⁰⁶

To support commercialization in the space sector, the USA has introduced the anchor tenancy model as a procurement tool for NASA. As an anchor tenant, NASA procures products from a commercial company as needed so that this company becomes profitable.

The contracts have a maximum term of ten years and include a fixed price. The prerequisites for a contract with NASA as an anchor tenant are that

- the (technical) requirements for the mission are met,
- the product is cost-effective,

- there is a potential or existing customer base for the product,
- the company is not dependent on the government as a long-term customer,
- the product has been competitively procured, and
- private capital is at risk in the venture.

In the event of non-performance or anticipated non-performance of the contractual agreement, NASA reserves the right to terminate the contract. Examples of companies that have NASA as an anchor tenant include Axiom Space and Collins Aerospace for the development of the spacesuit on the planned lunar mission and SpaceX for crew transportation to the ISS.

A European Approach to Space Flight

- Technological sovereignty in the field of space must be thought of in European terms to keep efficiency losses to a minimum.
- The Federal Government should lobby the EU to ensure that the critical space infrastructure used in the European network is effectively protected.
- The Federal Government should work towards a clear and complementary division of tasks between ESA and EUSPA.
- The possibility of relaxing the principle of geographical return of ESA funds in favour of efficiency criteria should be examined.
- The Federal Government should work towards organizing military reconnaissance in a European network and exploit synergies between civil and military use.
- The Federal Government should also lobby the EU for free access to data generated in space, as is already possible within the scope of the Copernicus project.

C

STRUKTUR UND TRENDS

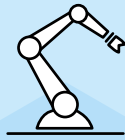




Human Capital



**Research and
Development**



**Innovation Behaviour
of the Economy**



**New Businesses
and Financing**



Patents



Scientific Publications



**Value Added and
Specialization**

R&I-Dashboard

Documenting the performance of Germany as a location for research and innovation is an integral part of the Commission of Experts' reporting. The representation is based on various indicators that enable an understanding of the performance and dynamics of the German research and innovation system at the national level and in international comparison with important economies.

Until now, this representation was provided in the chapter 'Structure and Trends' in the Commission of Experts' Annual Report. As of the 2023 reporting year, this part of the reporting will be transferred to the newly developed R&I Dashboard of the Commission of Experts. The R&I Dashboard includes interactive charts of 21 indicators from the seven thematically structured indicator categories Human Capital, Research and Development, Innovation Behaviour of the Economy, New Businesses and Financing, Patents, Scientific Publications, and Value Added and Specialization.

The interactive preparation of the indicators allows users to select the variables, observation periods and comparison groups they want to see. The dynamics are mapped by illustrating the rates of change of the indicators. In addition, the dashboard offers the possibility to download all charts as well as all indicators in the form of data tables.

The indicators are updated continuously on the R&I Dashboard, so that they are not limited in their relevance by the publication cycle of the Annual Report.

Most indicators derive from the studies on the German innovation system commissioned by the Commission of Experts. In addition to the indicators presented here, the studies include other comprehensive indicator and analysis material and can be viewed and downloaded from the Commission of Experts' website.

The R&I Dashboard can be accessed at <https://www.e-fi.de/en/dashboard> and using the following QR code:



D

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D2 List of Abbreviations

AI	Artificial Intelligence
ASE	Automotive Senior Experts
BA	Federal Employment Agency (Bundesagentur für Arbeit)
BAGSO BA	Federal Association of Senior Citizens' Organisations (Bundesarbeitsgemeinschaft der Seniorenorganisationen e.V.)
BAuA	Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin)
BDI	Federation of German Industries (Bundesverband der Deutschen Industrie e.V.)
BDLI	German Aerospace Industries Association (Bundesverband der Deutschen Luft- und Raumfahrtindustrie e.V.)
BIBB	Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung)
BIC	Business Incubation Centre
BMAS	Federal Ministry of Labour and Social Affairs (Bundesministerium für Arbeit und Soziales)
BMBF	Federal Ministry of Education and Research (Bundesministerium für Bildung und Forschung)
BMF	Federal Ministry of Finance (Bundesministerium der Finanzen)
BMFSFJ	Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (Bundesministerium für Familie, Senioren, Frauen und Jugend)
BMG	Federal Ministry of Health (Bundesministerium für Gesundheit)
BMI	Federal Ministry of the Interior and Community (Bundesministerium des Innern und für Heimat)
BMS	Bosch Management Support GmbH
BMWi	Federal Ministry for Economic Affairs and Energy (Bundesministerium für Wirtschaft und Energie)
BMWK	Federal Ministry for Economic Affairs and Climate Action (Bundesministerium für Wirtschaft und Klimaschutz)
BPM	Brokered Patent Market
BSI	Federal Office for Information Security (Bundesamt für Sicherheit in der Informationstechnik)
CET	Continuing Education and Training
CF	Change Factor

CIS	Community Innovation Survey
CNES	Centre National d'Etudes Spatiales
CO ₂	Carbon dioxide
COP 27	27th Conference of the Parties
COVID-19	Coronavirus Disease 2019
CPC	Cooperative Patent Classification
D21	Germany and Digitalization in the 21st Century (Deutschland und Digitalisierung im 21. Jahrhundert)
DART	Double Asteroid Redirection Test
DATI	German Agency for Transfer and Innovation (Deutsche Agentur für Transfer und Innovation)
DEAS	German Ageing Survey (Deutscher Alterssurvey)
DESI	Digital Economy and Society Index
DGLR	German Society for Aeronautics and Astronautics (Deutsche Gesellschaft für Luft- und Raumfahrt)
DGP	German Society for Human Resource Management (Deutsche Gesellschaft für Personalwesen e. V.)
DLEP	Digital Literacy Exchange Program
DLG	German Agricultural Society (Deutsche Landwirtschafts-Gesellschaft e. V.)
DLR	German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt e. V.)
DPMA	German Patent and Trade Mark Office (Deutsches Patent- und Markenamt)
DRG	Diagnosis Related Groups
DVG	Digital Care Act (Digitale-Versorgung-Gesetz)
EFI	Commission of Experts for Research and Innovation
EGNOS	European Geostationary Navigation Overlay Service
EIB	European Investment Bank
EPO	European Patent Office
EPR	Electronic Patient Record
ERP	European Recovery Program
ESA	European Space Agency
ETB	Employment Survey (Erwerbstätigenbefragung)
EU	European Union
EUSPA	European Union Agency for the Space Programme
G7	Group of Seven
G-BA	Federal Joint Committee (Gemeinsamer Bundesausschuss)
GDP	Gross domestic product
GEM	Global Entrepreneurship Monitor
GESSI	German Standards Setting Institute
GEW	Education and Science Workers' Union (Gewerkschaft Erziehung und Wissenschaft)
GGR	Health Management National Accounts (Gesundheitswirtschaftliche Gesamtrechnung)
GOVSATCOM	European Union Governmental Satellite Communications
GPS	Global Positioning System
IAB	Institute for Employment Research (Institut für Arbeitsmarkt- und Berufsforschung)
ICT	Information and Communication Technology

IIPED	IAB-INCHER Project of Earned Doctorates
INPADOC	International Patent Documentation
INV-BIO ADIAB	Inventor Biography Data linked to Administrative Data of the IAB
IP	Intellectual Property
IPXI	Intellectual Property Exchange International
IRIS	Infrastructure for Resilience, Interconnectivity and Security by Satellite
ISCED	International Standard Classification of Education
ISED	Innovation, Science and Economic Development Canada
ISIC REV	International Standard Industrial Classification of All Economic Activities Revision
ISRO	Indian Space Research Organisation
ISS	International Space Station
JAXA	Japan Aerospace Exploration Agency
KARI	Korea Aerospace Research Institute
KfW	Kreditanstalt für Wiederaufbau
KldB	Classification of occupations (Klassifikation der Berufe)
KOINNO	Competence Centre for Innovative Procurement (Kompetenzzentrum innovative Beschaffung)
KRITIS	Critical Infrastructures (Kritische Infrastrukturen)
LSI	Large System Integrator
M&A	Mergers & Acquisitions
MIP	Mannheim Innovation Panel (Mannheimer Innovationspanel)
NASA	National Aeronautics and Space Administration
NGAWiss	Network for Good Work in Science (Netzwerk für gute Arbeit in der Wissenschaft)
NPE	Non-Practicing Entity
NPWI	National Space and Innovation Programme (Nationales Programm für Weltraum und Innovation)
NURI	Non-University Research Institution
OECD	Organization for Economic Co-operation and Development
OZG	Online Access Act (Onlinezugangsgesetz)
PASS	Labour Market and Social Security Panel (Panel Arbeitsmarkt und soziale Sicherung)
PATSTAT	Patent Statistical Database
PCT	Patent Cooperation Treaty
R&D	Research and Development
R&I	Research and Innovation
RPS	Relative Patent Share
RTI	Research, Technology and Innovation
SGB	Social Code (Sozialgesetzbuch)
SME	Small and Medium-sized Enterprises
SSA	Space Situational Awareness
TEATEC	Total Early Stage Entrepreneurial Activity in a Technology Sector
TIROS	Television and Infrared Observation Satellite
TV	Television

TzBfG	Part-time and Fixed-term Employment Act (Teilzeit- und Befristungsgesetz)
UPC	Unified Patent Court
USA	United States of America
USPTO	United States Patent and Trademark Office
UTC	United Technologies Corporation
VDMA	German Mechanical and Plant Engineering Association (Verband Deutscher Maschinen- und Anlagenbau e.V.)
VET	Vocational Education and Training
WIPANO	Knowledge and Technology Transfer through Patents and Standards (Wissens- und Technologietransfer durch Patente und Normen)
WissZeitVG	Act on Temporary Contracts in Science (Wissenschaftszeitvertragsgesetz)
ZEW	ZEW – Leibniz Centre for European Economic Research (ZEW – Leibniz-Zentrum für Europäische Wirtschaftsforschung GmbH)
ZIM	Central Innovation Programme for Small and Medium-sized Enterprises (Zentrales Innovationsprogramm Mittelstand)

D3 Glossary

Act on Temporary Contracts in Science (Wissenschaftszeitvertragsgesetz)

This act establishes the framework conditions for the conclusion of fixed-term employment contracts with academic and artistic staff at universities and non-university research institutions.

Carbon Capture and Storage

Carbon capture and storage refers to the capture of CO₂ during the combustion of fossil fuels or biomass before it is released into the atmosphere, and storage in gas-tight soil formations or trapping through adsorption processes.

Cluster Risk

In finance and banking, the term cluster risk is understood to mean the strong concentration of investment assets in a particular industry, currency or asset class.

CO₂ Border Adjustment

A CO₂ border adjustment is intended to prevent the relocation of CO₂-intensive production abroad. For this purpose, CO₂-intensive imports are subject to a CO₂ tax or emission certificates must be purchased for them. The amount of the tax or the number of certificates depends on the emissions generated during production. The competitiveness of low-CO₂ domestic industry can be maintained in this way.

Community Innovation Survey (CIS)

The Community Innovation Survey (CIS) is an innovation survey in the European Union as well as Iceland and Norway that has been conducted regularly since 1993 according to a uniform methodological standard.

Copernicus

Copernicus is the EU's Earth observation programme, jointly managed by ESA and EUSPA. Data collected under the Copernicus programme is freely available and used for various purposes such as

environmental protection, climate monitoring and natural disaster assessment.

Critical Entities Resilience Directive

Adopted in 2022, the EU's CER Directive replaces the 2008 European Critical Infrastructure Directive. The CER Directive regulates resilience in critical infrastructure operators with the aim of mitigating the risk of failure of critical infrastructure.

Deal Database

The Deal Database is a database provided for in the Federal Government's Startup Strategy, which is to document transfers of intellectual property rights (cf. there).

Deep Tech

Deep Tech are technologies with high innovative potential that are costly and take a lot of time to develop. Deep tech often provides the solutions to challenging problems.

DeepTech & Climate Fund

The DeepTech & Climate Fund is an investment fund that co-finances high-tech companies and has access to funding of €1 billion over the next ten years. The DeepTech & Climate Fund is financed by the Future Fund and the ERP Special Fund.

Deglobalization

The term deglobalization (as an opposite term to globalization) describes a development towards less international integration of trade flows and a decrease in direct investment abroad.

Demographic Ageing

Demographic ageing is a change in the age structure of the population in favour of older age groups.

Digital Care Act (Digitale-Versorgung-Gesetz, DVG)

The Digital Care Act was passed in December 2019. Among other things, the law is intended to simplify the use of health apps on prescription and online

consultations. In addition, the law is to enable patients to use the electronic patient record (ePR) (cf. there) nationwide. And a connection to the telematics infrastructure (cf. there) is to become mandatory for pharmacies and hospitals.

Digital Infrastructures

Digital infrastructures are infrastructures based on information and communication technologies. Digital infrastructures are the basis for digital transformation (cf. there).

Digital Pact for Older People (DigitalPakt Alter)

Initiated by the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFS-FJ) and the Federal Association of Senior Citizens' Organisations (Bundesarbeitsgemeinschaft der Seniorenorganisationen e.V.), the Digital Pact for Older People aims to increase the social participation and engagement of older people in a digitalized world. The focus of the Digital Pact for Older People is on improving digital participation and is being implemented together with partner organizations from all areas of society.

Digital Transformation

The ongoing development and adaptation of digital technology and its diffusion within society, industry and companies is described as digital transformation. Digital transformation can help optimize operational processes, develop new business models and simplify these by means of apps, digital platforms for communication and virtual forms of work.

Digitalization Governance

Digitalization governance refers to the control and regulation system of a political-social unit such as the state, public administration, municipality, private or public organizations for the field of digitalization.

Direct Air Capture

Direct air capture refers to the extraction and separation of CO₂ (and potentially other greenhouse gases) directly from the atmosphere with the aim of storing it or making it usable for further applications. This process should make it possible in the future to reduce the amount of CO₂ from diffuse emission sources.

Disruptive Technologies

Innovations are defined as disruptive technologies if they replace a successful series of existing tech-

nologies, products or existing services or completely displace these from the market and render the investments of previously dominant market participants obsolete.

Dual Use

Dual use goods are goods, software and technology that are usually used for civilian purposes but can also be used in the military sector.

E-government

E-government (electronic government) stands for the handling of government and administrative processes with the help of information and communication technologies via electronic media. In the context of e-government, government services and administrative matters are digitized and offered online.

E-health

The term e-health refers to the use of electronically interconnected devices to provide medical care and to manage other tasks in the healthcare system.

Electronic Patient Record

An electronic patient record (ePR) records the most important health-related information of insured persons in a digital documentation system and makes this information available to service providers across disciplines, institutions and sectors. The ePR is a core element of a digitalized healthcare system.

Employment Rate

The employment rate refers to the percentage of gainfully employed persons in the population or in the working-age population.

ERP Special Fund (ERP-Sondervermögen)

In Germany, the ERP Special Fund refers to a special fund from the European Recovery Program (ERP) administered by the Federal Government. The special fund was originally created from funds of the so-called Marshall Plan for the reconstruction of the German economy after World War II. Since 1948, the German economy has been supported with funds from the ERP Special Fund.

Espacenet

Espacenet is a public and freely accessible database of the European Patent Office that provides access to over 140 million patent documents. It provides information on inventions and technical develop-

ments from 1782 to today, e.g. whether a patent has been granted and whether it is still in force.

Flexi Pension

The keyword Flexi Pension (Flexi-Rente) summarizes various changes to the statutory pension, which are set out in the Act on the Flexibilization of the Transition from Working Life to Retirement and on Strengthening Prevention and Rehabilitation in Working Life (Gesetz zur Flexibilisierung des Übergangs vom Erwerbsleben in den Ruhestand und zur Stärkung von Prävention und Rehabilitation im Erwerbsleben). The law was passed by the German Bundestag in autumn 2016. It includes the option of working beyond pension age and has also improved the supplementary earning opportunities for early retirees. The regulations have made the transition from working life to retirement more flexible, especially through the introduction of a gradual partial pension for early retirees.

Galileo

Cf. Global Navigation Satellite System.

Global Navigation Satellite System (GNSS)

GNSS is a system for determining positions and navigation using satellite signals. The American GPS is the most widely used system. Since 2016, the European Union's global navigation satellite system Galileo has been available as an alternative.

Green Power

Green electricity or green power is electricity that is generated entirely from renewables, such as wind and solar energy.

Ground Station

A ground station is a station located on Earth that is used to observe, monitor and exchange data with rockets, spacecraft and satellites in and outside Earth orbit.

Gross Domestic Product (GDP)

Gross domestic product (GDP) is the value of all goods and services produced by an economy within one year. GDP is an indicator of the economic performance of an economy in international comparison.

In-licensing

This is an agreement between two parties (e.g. companies) in which one party grants another party the right to use parts of its intellectual property. The

party granted access to parts of intellectual property by the other party in-licenses intellectual property.

In-orbit Demonstration/Validation

In-orbit demonstration/validation describes the demonstration and validation of technologies and systems in space. A successful test of technologies in space is understood as a credential by the space industry.

In-orbit Manufacturing

In-orbit manufacturing describes the ability to manufacture or repair and maintain systems such as spacecraft or satellites and their components in space.

Incremental Innovation

An innovation by improving an existing product is called incremental. In contrast, radical innovation refers to fundamental innovations that lead to completely new product concepts and technical solutions.

Information Asymmetries

Information asymmetries exist when one side of the market is better informed than the other. This occurs, for example, in the financing of R&I activities by third parties. External investors can assess the chances of success of R&I projects less reliably than the companies engaging in R&I.

Intellectual Property

Intellectual property refers to rights to intangible goods such as ideas, concepts and inventions. These goods are legally protected if the legal system grants corresponding rights, e.g. through patents or copyrights. The holder of such a right is, for example, the applicant for a patent or the creator of a copyrighted work.

Internet of Things

The use of information and communication technologies in everyday objects has created the link between the real and virtual worlds. This linking of devices with people is called the Internet of Things (IoT) or the Internet of Things and Services. Examples include embedded computer systems that monitor the wearer's vital signs in clothing, imprinted chip codes that allow parcel tracking over the internet, and refrigerators that autonomously regulate the reordering of food when stocks are low.

IP Rights

Intellectual property rights (IP rights) are rights to protect intellectual property (cf. there). One example of this is patents.

Joint Federal Committee (Gemeinsamer Bundesausschuss, G-BA)

The Joint Federal Committee (G-BA) is the highest decision-making body of the common self-administration in the German healthcare system. In the form of guidelines, the G-BA determines which medical services the insured can claim, as well as the quality assurance measures of practices and hospitals. The G-BA was established on 1 January 2004 by the GKV Modernization Act (GKV-Modernisierungsgesetz).

Key Enabling Technologies

Key enabling technologies are characterized by a wide range of applications and a high innovative potential.

Large System Integrator (LSI)

LSI are aerospace companies that specialize in assembling subcomponents and subsystems into complete systems and ensuring that they work together as a unit.

Launch Vehicle

Launch vehicles are missiles that carry payloads (e.g. satellites and space capsules) into space.

Low Earth Orbit (LEO)

LEO refers to Earth-centred orbits located at a low altitude above the Earth's surface. NASA considers Earth orbits up to an altitude of 2,000 km to be LEO, while ESA defines Earth orbits between 160 km and 1,000 km above the Earth's surface as LEO.

Mannheim Innovation Panel

The Mannheim Innovation Panel (MIP) is the innovation survey conducted annually since 1993 by ZEW – Leibniz Centre for European Economic Research. Data from the MIP represent the German contribution to the CIS (cf. Community Innovation Survey, CIS). However, in addition to the data to be reported to Eurostat, the MIP also includes data for enterprises with five to nine employees.

Market Intermediaries

Market intermediaries mediate between supply and demand on markets. For example, financial intermediaries such as banks, insurance companies and

investment companies mediate between suppliers and demanders of capital.

Market Novelties

New or significantly improved products and services of a company that were not previously available in the market in which the company operates are called market innovations.

Market Thickness

Market thickness is a criterion for the functioning of markets. A market is said to be thick if it attracts enough potential market participants who are willing to trade with each other and, as a result, numerous transactions take place. The opposite of a thick market is a thin market (cf. there).

Markets for Technology

Markets for technology are markets where technological knowledge is traded in the form of intellectual property rights (IP rights, cf. there). An example of this are markets for patents.

Microlauncher

Microlaunchers are launch vehicles that can carry payloads of up to 350 kg into orbit. They are the smallest launch vehicles and are of particular interest to operators of small satellites.

National Space and Innovation Programme (Nationales Programm für Weltraum und Innovation)

With the National Programme for Space and Innovation, the BMWK supports companies, research institutions and universities that are active in space. For this purpose, €340 million is available in 2023, managed by the German Space Agency at the DLR.

New Mission Orientation

New Mission Orientation is an approach to R&I policy that focuses on addressing grand societal challenges and aims at transformative change in the economy and society. To this end, so-called missions are formulated that contain specific transformation goals to be implemented by way of R&I policy and complementary policy measures.

New Space

New Space stands for an increase in the activities of private actors and the accompanying commercialization in space.

Nodal Pricing

In nodal pricing, electricity is traded based on node-specific prices.

Nursing Professions Act (Pflegerberufegesetz)

The Nursing Professions Act merges the previous vocational training professions of geriatric nursing, healthcare and nursing, and healthcare and paediatric nursing into one uniform vocational training profession. The VET programme comprises a common, generalized training; the area of specialization is chosen in the practical part of training. The Nursing Professions Act came into force on 1 January 2020.

Old Space

In the pre-New Space era, space activities were primarily conducted by government space agencies. The only private actors were companies that built space components on behalf of governments under the supervision of the space agencies.

Online Access Act (Onlinezugangsgesetz, OZG)

The Act to Improve Online Access to Administrative Services (abbr: Online Access Act, OZG) was enacted in 2017. It obliged the Federal Government, the Länder and local authorities to offer their administrative services digitally via administrative portals by the end of 2022.

Open Source Software Development

Open source software development is the collaborative development of software that anyone is free to study, use, modify and copy as they wish.

Out-licensing

This is an agreement between two parties (e.g. companies) in which one party grants another party the right to use parts of its intellectual property. The party granting the other party access to parts of its intellectual property licenses out intellectual property.

Patenting Rate

The patenting rate reflects the average number of patents per year and inventor.

Project Executing Agencies

In their role as administrative agencies, project executing agencies support the project funding of the ministries. This is done, for example, by providing technical and administrative advice to applicants, preparing funding decisions, administering funding and controlling.

Relative Patent Shares (RPS)

RPS are a measure of specialization in a particular patent field. In terms of aerospace technologies, for example, RPS indicate the ratio between a country's share of all patents in a specific area of aerospace technologies and the country's share of all aerospace patents.

Research and Development (R&D)

Research and development (R&D) and research and innovation (R&I, cf. there) are not used synonymously. The OECD's so-called Frascati Manual defines R&D as systematic, creative work to increase the stock of knowledge – also with the aim of finding new applications. The term R&D covers the three areas of basic research, applied research and experimental development.

Research and Innovation (R&I)

Research and innovation (R&I) and research and development (R&D, cf. there) are not used synonymously. R&D is only one aspect of R&I activities. Innovation, as defined in the OECD's Oslo Manual, involves the introduction of new or significantly improved products (goods and services) or processes.

Senior Experts

Senior Experts are (former) employees who pass on their job-specific expertise on a project basis or as (temporary) employees after retirement at the same or a new employer.

Smart Meters

Smart meters are electronic electricity meters that can typically read consumption and generation data in real time by means of a communication unit and make it available (for end users and grid operators, etc.).

Social Security Systems

The social security systems include statutory health insurance, statutory pension insurance, statutory accident insurance, unemployment insurance and statutory care insurance.

Space Flight Tasks Transfer Act (Raumfahrtaufgabenübertragungsgesetz)

The Space Flight Tasks Transfer Act grants the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt, DLR) the authority to perform administrative tasks in the field of space flight in its own name and in the forms of action under public law. This includes the preparation of German space

planning, the implementation of German space programmes and the representation of German space interests in the international arena.

Start-ups

Start-ups are young companies with innovative business ideas and high growth potential.

Telematics Infrastructure

The technical basis for the digital transformation of the healthcare system is the so-called telematics infrastructure (TI), which networks the stakeholders in the healthcare system and enables the secure, cross-organizational exchange of information and data.

Telemedicine

Telemedicine comprises medical care across spatial and temporal (asynchronous) distances as well as general care concepts for the provision of medical services with the help of information and communication technologies.

Tenure Track

Tenure track refers to academic careers that provide for immediate transition to a lifetime professorship after a successful probationary period.

Thin Market

A market is said to be thin if it does not attract enough potential market participants willing to trade with each other and, as a result, few transactions occur.

Transnational Patent Applications

Transnational patent applications are applications in patent families with at least one application to the World Intellectual Property Organization (WIPO) via the PCT procedure (Patent Cooperation Treaty, PCT) or one application to the European Patent Office (EPO). For the export-oriented German economy, such patents are of particular importance because they ensure the protection of the invention beyond the home market.

Venture Capital

Venture or risk capital is the seed capital for start-ups and young companies. This also includes funds that are used to support the equity base of small and medium-sized enterprises so they can expand and implement innovative, sometimes high-risk projects. For investors, the investment of venture capital is also high-risk, hence the term risk capital.

Equity capital in the form of venture capital is often provided by special venture capital companies (capital investment companies). A distinction is made between the seed, start-up and later stages.

D4 Recent Studies on the German Innovation System

The Commission of Experts for Research and Innovation (EFI) regularly commissions studies on topics that are relevant to innovation policy. These studies can be accessed via the EFI website (www.e-fi.de) in the series 'Studies on the German innovation system' (Studien zum deutschen Innovationssystem). The findings are integrated into the Report of the Commission of Experts.

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D6 Endnotes

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- 1 Cf. EFI (2021: chapter B 1).
- 2 Cf. EFI (2020: chapter B 3).
- 3 Cf. EFI (2022: chapter B 1).
- 4 Cf. EFI (2022: chapter B 1).
- 5 Cf. EFI (2021: chapter B 1).

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- 6 Cf. here and below EFI (2021: chapter B 1).
- 7 Nor can this task be taken over by the Future Council of the Federal Chancellor or the Alliance for Transformation, as these involve people who are not members of the Federal Government. The Future Council acts in an advisory capacity and develops proposals to reinforce resilience and technological sovereignty in key enabling technologies and in digitalization. In addition to government representatives, it also includes representatives from industry, science and society among its members. Cf. <https://www.acatech.de/projekt/zukunftsrat-des-bundeskanzlers/> (last accessed on 16 January 2023). The Alliance for Transformation is a dialogue format in which government representatives meet with leaders from industry, trade unions, associations, academia and civil society to consult on key transformation fields. Cf. <https://www.bundesregierung.de/breg-de/themen/klimaschutz/allianz-fuer-transformation-2052168> and <https://www.bundesregierung.de/breg-de/suche/allianz-fuer-transformation-2135012> (each last accessed on 16 January 2023).
- 8 The government committee for innovation and transformation should be permanent and meet regularly, at relatively short intervals.
- 9 For example, Austria has a ‘Task Force RTI’, which is located at the Chancellor’s Office. Cf. https://www.bundeskanzleramt.gv.at/themen/forschungskoordination_fti/task-force-fti.html (last accessed on 16 January 2023). And Japan has a Council for Science, Technology and Innovation headed by the Prime Minister and the Minister of State for Science and Technology Policy. Cf. <https://www8.cao.go.jp/cstp/english/index.html> (last accessed on 16 January 2023).

- 10 BMBF (2022b: 4), own translation.
- 11 Cf. BMBF (2022b: 4)
- 12 Leap innovations are innovations that bring about far-reaching change in markets, organizations and societies and open up enormous potential for value creation. Cf. EFI (2018: 23).
- 13 Cf. <https://www.sprind.org/de/> (last accessed on 16 January 2023).
- 14 Until the founding of SPRIND GmbH, there was well-functioning funding for evolutionary innovation processes, but no funding structures that explicitly focused on generating leap innovations. Cf. EFI (2018: 23).
- 15 Cf. SPD et al. (2021). The legal framework is to be improved by means of a SPRIND Freedom Act. Cf. <https://www.bmbf.de/bmbf/shareddocs/pressemitteilungen/de/2022/03/140322-SPRIND.html> (last accessed on 16 January 2023).
- 16 Cf. e.g. EFI (2021: chapter B 3) and EFI (2022: chapter B 4).
- 17 Cf. No author (2022a) and Bertschek et al. (2022).
- 18 Cf. Deutscher Bundestag (2022c).
- 19 Even the administration of the various programme lines of the same support programme is not necessarily the responsibility of only one project-executing agency. For example, three different project-executing agencies are active for the Central Innovation Programme for SMEs (Zentrales Innovationsprogramm Mittelstand, ZIM). Cf. <https://www.zim.de/ZIM/Redaktion/DE/Textsammlungen/Ansprechpartner/ansprechpartner.html> (last accessed on 16 January 2023).
- 20 The Cabinet decision on the Future Strategy was still pending when the EFI Annual Report 2023 went to press. A draft of the document was published in advance on the BMBF website. Cf. BMBF (2022c).
- 21 Cf. BMWK (2022a).
- 22 Cf. BMWK (2022a).
- 23 Cf. here and below No author (2022b).
- 24 Cf. Die Bundesregierung (2018) and Die Bundesregierung (2014).
- 25 Cf. <https://www.bundesregierung.de/breg-de/themen/digitaler-aufbruch/gigabitstrategie-2017464> (last accessed on 16 January 2023).

- 26 BMG: At least 80 percent of those with statutory health insurance should have an electronic patient file. BMI: Creating secure and user-friendly digital identities. BMJ: Abolition of donation receipts through complete digitization of the donation receipt procedure. Cf. No author (2022b) and <https://digitalstrategie-deutschland.de/leuchtturm-projekte/> (last accessed on 16 January 2023).
- 27 Cf. No author (2022b) and <https://digitalstrategie-deutschland.de/ueber-die-digitalstrategie/> (last accessed on 16 January 2023).
- 28 Cf. here and below Die Bundesregierung (2022).
- 29 Cf. BMAS and BMBF (2019).
- 30 Cf. BMAS and BMBF (2022).
- ## A 2
- 31 Cf. EFI (2021: chapter B 1). There is now the concept of transformative R&I policy as a mission-oriented policy expanded to include systemic elements. Cf. Haddad et al. (2022).
- 32 Cf. BMBF (2022b).
- 33 Cf. EFI (2021: chapter B 1).
- 34 Cf. BMBF (2022b).
- 35 In the accompanying research on the High-Tech Strategy 2025, it was stated regarding mission formulation: ‘Shortcomings and inadequacies that occur in this phase can rarely be compensated for in the subsequent process steps [...]’ (own translation). Roth et al. (2021: 14). Cf. also Roth et al. (2021: 27).
- 36 Cf. BMBF (2022b).
- 37 In addition to the Federal Government, the EU Commission too pursues a mission-oriented R&I policy. This can lead to interactions. Cf. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe/eu-missions-horizon-europe_en (last accessed on 16 January 2023).
- 38 Cf. EFI (2022: chapter B 2).
- 39 The New Mission Orientation policy approach is extraordinarily complex. Therefore, it is not only necessary to look at the impact of the individual R&I policy instruments, but also to evaluate the interaction of the measures and initiatives in the policy mix. Cf. EFI (2021: 44).
- 40 Cf. Roth et al. (2021) and Wittmann et al. (2021).
- 41 Cf. <https://www.bundesregierung.de/breg-de/aktuelles/energiepreisbremsen-2145728> (last accessed on 16 January 2023).
- 42 Cf. <https://www.europarl.europa.eu/news/de/press-room/-20221212IPR64509/eu-einigung-uber-co2-grenzausgleichsmechanismus-cbam> (last accessed on 16 January 2023).
- 43 Cf. G7 Germany (2022a) and G7 Germany (2022b).
- 44 Cf. <https://unfccc.int/cop27> (last accessed on 16 January 2023).
- 45 A study commissioned in 2018 by the then BMWi compares zonal and nodal electricity pricing systems. Cf. Hirth et al. (2018).
- 46 Cf. EFI (2019: chapter B 1).
- ## A 3
- 47 Cf. EFI (2022: chapter B 1).
- 48 Examples are the funding commitments for a chip factory of the company Intel in Magdeburg, a battery production facility of the company Opel in Kaiserslautern and a battery production facility of the company Northvolt in Schleswig-Holstein. Cf. Frankfurter Allgemeine Zeitung (2022a), Handelsblatt (2021) and Handelsblatt (2022a).
- 49 Cf. Handelsblatt (2023b).
- 50 Cf. Handelsblatt (2022b), Frankfurter Allgemeine Zeitung (2022b) and <https://background.tagesspiegel.de/energie-klima/resoluter-gegenueber-china> and <https://background.tagesspiegel.de/digitalisierung/neuer-anlauf-fuer-europaeische-champions-mit-der-chinastrategie> (each last accessed on 16 January 2023).
- 51 Cf. Deutscher Bundestag (2022b) and Handelsblatt (2022b).
- 52 Cf. Handelsblatt (2022b).
- 53 Cf. Handelsblatt (2022b).
- 54 Cf. EFI (2022: chapter B 1).
- 55 Cf. EFI (2022: chapter B 1).
- 56 Cf. Deutscher Bundestag (2022b) and <https://www.verfassungsschutz.de/SharedDocs/hintergruende/DE/wirtschafts-wissenschaftsschutz/chinas-neue-wege-der-spionage.html;jsessionid=37B935E18C0DF7B1F60C579C10EDABEE.intranet672#doc812070bodyText5> (last accessed on 16 January 2023).
- 57 Cf. EFI (2020: chapter B 3) and BAFA (2021).
- 58 Cf. <https://www.bmbf.de/bmbf/de/europa-und-die-welt/vernetzung-weltweit/asiatisch-pazifischer-raum/china/china.html> and https://www.bmbf.de/bmbf/shareddocs/bekanntmachungen/de/2021/06/3684_bekanntmachung.html (each last accessed on 16 January 2023).
- 59 Cf. EFI (2020: 71f.).
- 60 Two months before the implementation deadline, only 33 of 575 administrative services were available online in the majority of the Länder. Cf. NKR(2022: 31f.).

- 61 As a result, no uniform technical standards and interfaces are enforced and the one-for-all principle (nationwide adoption of already existing, functioning solutions) is not applied. While Finland, Denmark and the UK have first created a platform core for basic services and binding standards for interfaces, thereby providing the basic infrastructure for data, services and authentication on which municipalities, for example, can build, in Germany it is the other way round. Here, each Land and each municipality developed its own digital service in the front end, with the result that these services remain fragmented alongside each other due to inconsistent standards and a lack of interfaces (in the back end). Basic user requirements such as universal access to all government services and a secure digital identity are therefore still missing. Furthermore, the digitization of existing analogue processes is not used as an opportunity to make complicated processes simpler, faster and cheaper. Instead, complicated analogue processes are often simply copied over one-to-one into the digital format. Cf. <https://www.egovernment.de/warum-das-ozg-20-ein-erfolg-wird-a-fcc7985a960df-be32651214961776790/>, <https://www.insm.de/insm/themen/digitalisierung/deutschland-scheitert-beim-e-government> and <https://netzpolitik.org/2022/onlinezugangsgesetz-ohne-schnittstellen-ist-kein-digitaler-staat-zu-machen/> (each last accessed on 16 January 2023).
- 62 Cf. NKR (2022).
- 63 One-for-all principle: Nationwide adoption of already existing, functioning solutions.
- 64 Cf. <https://background.tagesspiegel.de/smart-city/nimmt-das-ozg-2-0-langsam-formen-an> and <https://netzpolitik.org/2022/reform-des-onlinezugangsgesetzes-entscheidende-standards-fehlen-noch-immer/> and <https://background.tagesspiegel.de/digitalisierung/ozg-2-0-das-wird-neu> (each last accessed on 16 January 2023).
- 65 In this context, the Commission of Experts repeats its call for the establishment of a digital ministry worthy of the name. By creating a ministry, the topic of digitalization would be prominently represented in the Federal Cabinet and the coordination competence between the ministries would be clearly assigned. Cf. Bertschek et al. (2021).
- 66 Cf. Deutscher Bundestag (2022d).
- 67 Cf. <https://www.bundestag.de/dokumente/textarchiv/2022/kw17-de-grundgesetz-889618> (last accessed on 16 January 2023).
- 68 Cf. Acosta et al. (2011) and Moretti et al. (2019).
- A 4
- 69 A ZEW study published in May 2022 illustrates the prevalence of various barriers to innovation in SMEs (i.e. firms with up to €500 million in annual turnover) for the periods 2004 to 2006, 2008 to 2010, 2012 to 2014 and 2016 to 2018, including for the barriers to innovation Laws/Regulation and Long Administrative Procedures. Over time, the prevalence of both barriers to innovation increased. In the case of the innovation barrier Laws/Regulation, for which the value for the period from 2016 to 2018 increased massively compared to the values for earlier periods, comparability is limited due to a change in the question. Companies with a high innovation intensity (i.e. with high innovation expenditure in relation to turnover) reported an impediment to their innovation activities more frequently than other companies for most legal areas. Cf. ZEW (2022b).
- 70 Cf. BMWK (2022c).
- 71 Cf. BMWK (2022d).
- 72 Cf. BMWK (2022a).
- 73 The key contents of the Data Strategy were to be presented already at the Digital Summit on 8/9 December 2022. Cf. <https://background.tagesspiegel.de/digitalisierung/ressorts-stemmen-sich-gegen-wissings-datenstrategie> and <https://background.tagesspiegel.de/digitalisierung/der-digitalfahrplan-der-bundesregierung-2023#:~:text=Die%20digitalpolitische%20To%2DDo%2DListe,sich%20die%20Ampel%20viel%20vorgenommen> (each last accessed on 16 January 2023).
- 74 Cf. Frankfurter Allgemeine Zeitung (2022c).
- 75 Cf. Interim report with initial recommendations from the founding committee, which proposes to launch use cases and pilot projects. Cf. BMWK and BMI (2022).
- 76 The founding committee recommends that the data institute should take on the following tasks: 1.) The data institute promotes data sharing and data evaluation, especially across sectors, 2.) It drives the development of governance models to promote data sharing, 3.) The implementation of use cases generates knowledge and practical experience on data sharing issues, which can also be used for the implementation of other use cases, 4.) It contributes to solutions for the common good of social and/or politically relevant problems, 5.) It contributes to reference and evidence-based policy decisions based on data, 6.) It drives open data according to FAIR principles and data trust models, 7.) It develops and scales data products and makes proposals for

sustainable and lasting usability, quality assurance and maintenance of data products. Cf. BMWK and BMI (2022).

- 77 Cf. EFI (2022: 29).
- 78 Cf. VDMA (2022).
- 79 Cf. Plattform Industrie 4.0 (2022).
- 80 Cf. BMI (2022b).
- 81 Cf. BMWK (2022a: 2 and 9).
- 82 The Startup Strategy is divided into the following subject areas: 1.) Improving funding for start-ups, 2.) Facilitating the recruitment of talent for start-ups – making employee equity participation more attractive, 3.) Inspiring a spirit of entrepreneurship – making start-ups easier and more digital, 4.) Encouraging female start-up founders and diversity in start-ups, 5.) Facilitating start-up spin-offs from science, 6.) Improving the framework conditions for start-ups dedicated to the common good, 7.) Mobilizing start-up skills for public procurement, 8.) Facilitating data access for start-ups, 9.) Boosting real-world laboratories – facilitating access for start-ups, 10.) Making start-ups the centre of attention. Cf. BMWK (2022a: 4).
- 83 Cf. BMWK (2022a: 4).
- 84 Cf. <https://dpcf.de/> (last accessed on 16 January 2023).
- 85 Cf. BMWK (2022a: 9).
- 86 Cf. No author (2022c).
- 87 Cf. Handelsblatt (2023a).

A 5

- 88 Cf. here and below EFI (2021: chapter A 3) and EFI (2022: chapter A 3).
- 89 The Commission of Experts set this out in detail in its Annual Report 2021. Cf. EFI (2021: chapter B 2).
- 90 Cf. Die Bundesregierung (2022: 24).
- 91 Cf. here and below No author (2022d). Cf. also Barišić et al. (2023).
- 92 Cf. here and below EFI (2022: chapter A 3).
- 93 Cf. Die Bundesregierung (2022).
- 94 The Vocational Training Act states: ‘To fulfil the contractual obligations of the training providers, several natural or legal persons may cooperate in a training alliance, insofar as responsibility for the individual training stages and for the training period as a whole is ensured (collaborative training)’ (Section 10 subs. 5 BBiG), own translation. There are four models of collaborative training, namely lead company with partner company, contract training, training consortium and training association. Cf. BMBF (2011).

- 95 Cf. BMBF (2022a).
- 96 As part of the InnoVet Plus competition planned by the BMBF, support is to be provided for the development and testing of attractive qualification offers in vocational, continuing and advanced education and training. The aim is to create career paths with many opportunities and permeability through interlinking, which offer different development opportunities for graduates. In addition, new avenues are to be created for the transfer of knowledge and current developments from tertiary education institutions and research institutions into company practice via vocational and continuing education and training, especially in small and medium-sized enterprises (SMEs). Cf. BMBF (2022a).
- 97 Cf. here and below EFI (2021: chapter B 2) and EFI (2022: chapter A 3).
- 98 As a rule, junior academic staff are employed on a fixed-term basis. When concluding fixed-term contracts with academic and artistic staff, the Act on Temporary Contracts in Science (WissZeitVG), in force since 2007, is relevant. It was amended in 2016 to prevent improper short-term fixed-term contracts. Since then, fixed-term contracts without an objective reason have only been permissible in connection with an academic or artistic qualification, and the duration of the fixed-term contract must be designed in such a way that it is appropriate to the qualification sought, such as a doctorate or a habilitation. In the case of third-party funding, the duration of the fixed term should correspond to the duration of the project.
- 99 The evaluation of the WissZeitVG, amended in 2016, was commissioned by the BMBF and conducted by the HIS-Institut für Hochschulentwicklung (HIS Institute for Higher Education Development, HIS-HE) and Interval GmbH. Cf. Sommer et al. (2022). The evaluation showed that after the amendment of the WissZeitVG, tertiary education institutions and NURI had initially changed their fixed-term contract practice in favour of the employees. However, the evaluation study also shows that a complete adjustment of contract periods to qualification time periods has not yet occurred. Moreover, according to the evaluation, the development was not sustainable and average contract periods have been decreasing again since 2018. The decline was particularly sharp in 2020, a year marked by the Covid-19 crisis. In addition to the evaluation of the WissZeitVG commissioned by the BMBF, there are also alternative and supplementary evaluations on employment conditions, including that of the Netzwerk für Gute Arbeit in der Wis-

senschaft (Network for Good Work in Science, NGAWiss), as well as far-reaching statements on and requirements for the upcoming amendment of the WissZeitVG and specific analyses. Cf. Kuhnt et al. (2022) and Kauhaus et al. (2018). In addition to contract periods, for which results are equivalent to those of the official evaluation, the NGAWiss examines other dimensions of good working conditions and identifies several problems and undesirable developments. In contrast to the official evaluation, the NGAWiss study also formulates recommendations for action. These include unconditional tenure following the PhD and thus the establishment of more permanent positions, an earlier decision for or against an academic career (already at the end of the PhD phase) and the replacement of the chair model with a department model. These demands are largely shared by other groups such as the GEW, the DGP and a group called 'Bahr-Eichhorn-Kubon' as well as the initiative #IchBinHannah.

- 100 Cf. Deutscher Bundestag (2022a).
- 101 Such a career interview should discuss the personal prerequisites for an academic career in the tertiary education and science system, alternative career options as well as the time horizons. Only when one has gained this experience can one assess well enough for oneself whether one should give up the academic career or pursue it further. If the decision is in favour of the academic career, the employment contract should be extended or concluded up to the maximum limit according to the WissZeitVG. Otherwise, the contract period should be extended by another year to support the search for positions and tasks outside of research and teaching.
- 102 It should be borne in mind here that one could have had between seven and twelve PhD projects (depending on the PhD duration of three, four or five years) on each permanent post occupied by a postdoc aged 30 until retirement at around 65.
- 103 Not every task that arises regularly corresponds to a permanent task - for example, in teaching, when the content must be continuously adapted to further developments in the discipline. In addition, faculties should develop a permanent position concept and make it transparent, describing the number and orientation of permanent positions in terms of content and justifying them in terms of structural strategy.

B 1

- 104 The projected development of the population aged 67 and over is based on Variant 2 (Moderate development of fertility, life expectancy and migration (G2-L2-W2)) of the 14th Coordinated Population Projection for Germany. Variant 2 is based on a birth rate of 1.55 children per woman, a life expectancy at birth in 2060 of 84.4 years for boys and 88.1 years for girls, and an average annual net migration of 221,000 persons. Cf. <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsvorausberechnung/Methoden/Erlaeuterungen/VariantenListe.html> (last accessed on 16 January 2023). With the 15th Coordinated Population Projection, updated forecasts for population development do exist for Germany, cf. <https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Bevoelkerung/Bevoelkerungsvorausberechnung/begleitheft.html?nn=208696#ergebnisse> (last accessed on 16 January 2023), but these are not available for the development of the labour force. To guarantee comparability, data from the 14th Coordinated Population Projection for Germany were therefore used. The projected development of the labour force is based on Variant 2 (moderate migration with a constant labour force participation rate (W2-EQ1)) of the Labour Force Projection 2020. Cf. Estates (2020).
- 105 European Commission (2018).
- 106 The following observations focus on the direct contributions of older people to innovation. However, indirect contributions by older people should not be overlooked, for example in voluntary work or by looking after grandchildren.
- 107 Cf. Baltés (1999).
- 108 Cf. Kruse (2006).
- 109 Since 2012, the standard pension age has been gradually increased to 67 years by 2031. Due to data availability, the age group 65 years and older is shown. Cf. <https://www.demografie-portal.de/DE/Fakten/renteneintrittsalter.html> (last accessed on 16 January 2023).
- 110 The calculations are based on the Employment Survey (Erwerbstätigenbefragung, ETB) conducted by the Federal Institute for Vocational Education and Training (Bundesinstitut für Berufsbildung, BIBB) and the Federal Institute for Occupational Safety and Health (Bundesanstalt für Arbeitsschutz und Arbeitsmedizin, BAuA). This comprises a sample of around 20,000 employed persons aged 15 and over in Germany with more than ten paid working hours per week. The survey is conducted by telephone,

whereby the sampling of landline and mobile phone numbers ensures representativeness for the target group. It has been conducted every six years since 1979. Cf. <https://www.bibb.de/de/12138.php> (last accessed on 16 January 2023). This and subsequent ETB-based analyses cover the survey years 2006, 2012 and 2018. The analysis presented here includes as employees blue-collar workers, white-collar workers and civil servants. The classification 'frequently' is not further defined in the questionnaire. Respondents can choose between the answer options 'never', 'sometimes' and 'often'. The classification is up to the respondent.

- 111** The data basis is the Global Entrepreneurship Monitor (GEM) for the years 2012 to 2018. The TEATEC (Total Early Stage Entrepreneurial Activity in a Technology Sector) is shown. This takes into account entrepreneurs who, at the time of the survey, are in a start-up process or are the owner of a business in the mid- or high-tech sector that is no more than 42 months old. The sector reference groups are the no-tech and low-tech sectors. Cf. <https://www.gemconsortium.org/about/wiki> (last accessed on 16 January 2023).
- 112** Definition of mid- and high-tech start-ups according to OECD ISIC REV classification. The allocation to the technology sector is made based on mathematical calculations that, among other things, relate R&D expenditures to production. According to this definition, the high-tech sector includes, among others, the aerospace industry and the pharmaceutical industry, while the mid-tech sector includes, among others, the automotive industry and mechanical engineering. Cf. OECD (2011).
- 113** A special GEM analysis for the years 2019 to 2021 shows for Germany that 16 percent of all start-ups in the mid- and high-tech sector take place in the age group of at least 60 years, while start-ups in the age group of under 60 years account for 10 percent. Data source is the GEM Germany, Adult Population Surveys 2019-2021.
- 114** The start-up rate indicates the number of business start-ups in the mid- and high-tech sector in relation to the working-age population.
- 115** Own calculations based on GEM from 2012 to 2018. GEM data for Germany are available for ages up to and including 64.
- 116** The data is based on a special evaluation by the IAB/ZEW Start-up Panel Report in the period from 2013 to 2020. The data set contains more than nine million enterprises that are or were economically active in Germany. Projections are made based on start-up cohorts (start-up date) or on the stock of start-ups at the end of a year. Cf. <https://www.gruendungspanel.de/iab/zew-gruendungspanel/startseite> (last accessed on 16 January 2023). The age groups of the following analyses are defined based on the age at the time the business was founded. For team start-ups, the age of the oldest team member is used.
- 117** The high-tech sector is defined here using the following industries: cutting-edge technology in manufacturing, high-value technology in manufacturing, and technology-intensive service providers and software. Cf. ZEW (2022c).
- 118** Non-high-tech sector is defined by the following industries: non-technology-intensive industries in manufacturing, knowledge-intensive service providers, creative consumer-related service providers, construction and finishing trades. Cf. ZEW (2022c).
- 119** Market innovations are new or significantly improved products (including services) of a company that were not previously available on the markets in which the company operates market. Cf. ZEW (2022a: 14).
- 120** Special evaluation of the IAB/ZEW Start-up Panel Report for the periods 2006 to 2012 and 2013 to 2020, pooled in each case.
- 121** Age of the entrepreneurs at the time of company establishment.
- 122** Cf. here and below Kaltenberg et al. (2023).
- 123** Innovations are defined as disruptive technologies that replace a successful range of existing technologies, products or existing services or completely displace these from the market and render the investments of previously dominant market participants obsolete.
- 124** Cf. Buhr et al. (2023: 23). Age-dependent patenting rates cannot be calculated based on the INV-BIO ADIAB data set. The increase in the percentage of patent applications by inventors who are at least 60 years old may therefore also be due to a demographic effect.
- 125** Special evaluation of the IAB/ZEW Start-up Panel Report for the period 2005 to 2020, pooled.
- 126** Cf. Hammermann et al. (2019).
- 127** The evaluations are based on the KfW SME Panel, which includes SMEs. The results are based on a KfW Special Evaluation up to 2022 and correspond in their approach to the analysis by Zimmermann (2016). The study does not allow any causal conclusions to be drawn regarding the age of the workforce and the company's inclination to innovate.
- 128** Cf. KfW (2022).
- 129** Age-mixed teams are defined by the age distribution. The higher the age difference between the

- individual team members, the more age-mixed the teams are.
- 130 The average age of inventor teams is not the same as the age distribution in inventor teams.
- 131 Cf. Hammermann et al. (2019).
- 132 Cf. Kaltenberg et al. (2023). Measured by the number of citations of patents.
- 133 The standard pension age for insured persons born before 1 January 1947 is 65 years. For insured persons born between 1947 and 1963, the threshold is between 65 and 67 years of age. Insured persons born in 1964 and later will reach the standard pension age when they turn 67. Hereinafter, the pension age refers to the completion of a certain year of life as a prerequisite for a pension entitlement. Cf. <https://www.deutsche-rentenversicherung.de/SharedDocs/Glossareintraege/DE/A/altersgrenze.html> (last accessed on 16 January 2023). Pension age thresholds for early retirement pensions apply to persons insured for a particularly long time. Persons who have been insured in the statutory pension insurance for at least 45 years. Since 1 July 2014, they have been able to retire at the age of 63 without financial loss. The pension age was raised gradually from 2016 starting with the 1953 birth cohort. For insured persons born in 1964 or later, the pension age has since been 65.
- 134 In 2020, for example, men on average drew their first old-age pension at 64.1 years of age and women at 64.2 years of age. The pension age threshold is currently at 65.8 years. Since 2014, the gap between the age of retirement and the standard pension age has been increasing again (in 2014, the difference for men was 1.1 years). One reason for this may be the deduction-free pension at age 63 (introduced in July 2014), which is possible if 35 years (or 45 years in the case of those insured for a particularly extended period) of statutory contributions to pension insurance have been completed. Cf. <https://www.demografie-portal.de/DE/Fakten/renteneintrittsalter.html> (last accessed on 16 January 2023).
- 135 The employment rate refers to the percentage of gainfully employed persons in the working-age population. Cf. <https://www.destatis.de/DE/Themen/Arbeit/Arbeitsmarkt/Glossar/erwerbstaetige.html> (last accessed on 16 January 2023).
- 136 Cf. <https://www.destatis.de/DE/Themen/Arbeit/Arbeitsmarkt/Erwerbstaetigkeit/Tabellen/erwerbstaetige-erwerbstaetigenquote.html> (last accessed on 16 January 2023). Labour participation among 60-year-olds increased between 2011 and 2021. By 2021, 61 percent of people aged 60 to 64 were gainfully employed, compared with 44 percent in 2011. During the same period, the labour participation rate of persons aged 65 or older increased from 5 to 7 percent. Cf. <https://www.destatis.de/DE/Themen/Querschnitt/Demografischer-Wandel/Aeltere-Menschen/erwerbstaetigkeit.html> (last accessed on 16 January 2023).
- 137 Cf. Bundesregierung (2022: 24), own translation.
- 138 The keyword Flexi Pension (Flexi-Rente) summarizes various changes to the statutory pension, which are set out in the Act on the Flexibilization of the Transition from Working Life to Retirement and on Strengthening Prevention and Rehabilitation in Working Life (Gesetz zur Flexibilisierung des Übergangs vom Erwerbsleben in den Ruhestand und zur Stärkung von Prävention und Rehabilitation im Erwerbsleben). The law was passed by the German Bundestag in autumn 2016. It includes the option of working beyond pension age and has also improved the supplementary earning opportunities for early retirees. The regulations have made the transition from working life to retirement more flexible, especially through the introduction of a gradual partial pension for early retirees.
- 139 Cf. SPD et al. (2021).
- 140 Cf. BMAS (2022).
- 141 Older gainfully employed persons are defined here as persons aged 55 and over.
- 142 Classification of occupations into four requirement levels based on the Classification of Occupations (Klassifikation der Berufe, KldB). The lowest requirement level is defined by auxiliary and semi-skilled work, followed by specialist work. A high requirement level is defined by complex specialist jobs and highly complex work. Examples of highly complex work in the research and development sector include research group management, patent engineers and innovation managers. Cf. BA (2021).
- 143 Cf. ETB Data Set, own calculations.
- 144 Cf. Special evaluation by the IAB-INCHER Project of Earned Doctorates (IIPED).
- 145 Initiative D21 (2021).
- 146 An EU comparison shows that the digital skills of German professionals are below average. Cf. No author (2022b).
- 147 Cf. BIBB (2022) and Rohrbach-Schmidt and Hall (2020).
- 148 Cf. Janssen and Wölfel (2017).
- 149 Cf. BMAS and BMBF (2019).
- 150 Cf. BMAS and BMBF (2022).
- 151 No distinction is made here based on age, age at retirement or time since retirement began. The evaluations are based on the answers of those respondents who were retired at the time of the survey.

- 152 The following evaluations are based on the German Ageing Survey (Deutscher Alterssurvey, DEAS). The data set is funded by the Federal Ministry for Family Affairs, Senior Citizens, Women and Youth (BMFSFJ) and since 1996 has systematically recorded the circumstances and ageing trajectories of people who are at least 40 years old. In a Germany-wide representative cross-sectional and longitudinal survey, several thousand older people are interviewed per wave on objective and subjective life circumstances. The data set does not differentiate by age of retirement, but categorizes the respondents based on whether they are retired or not. In the data set, retired persons are described as follows: Retired persons are persons aged 60 and over who answer the question about receiving their private old-age pension/state pension in the affirmative or who describe themselves as early retirees/early pensioners. The allocation to this category is made irrespective of potential gainful employment in retirement, as this is recorded in the main status. Evaluations are based on DZA (2022). Cf. Engstler et al. (2022).
- 153 Evaluations based on DZA (2022), (pooled over the years 2014, 2017 and 2021). The data structure enables an evaluation according to ISCED education level. Gainfully employed retired persons with a high level of education are significantly more likely to be employed (13 percent) than persons with a low level of education (5 percent). Higher educational attainment is often associated with longer participation in the labour force.
- 154 The analyses are based on DZA (2022) (pooled over the years 2014, 2017 and 2021) and are based on the questions: One can still be gainfully employed as a pensioner or retiree. How about you? Are you currently gainfully employed? Are you employed as a manual or white-collar worker or are you self-employed? And are you working for the same employer as before retirement? A breakdown by mini jobs, for example, is not made. The type of employment contract (service contract, fixed-term contract, etc.) is also not surveyed. This can lead to distortions in terms of incorrect recording, e.g. of mini jobbers. Cf. Engstler et al. (2022).
- 155 Cf. also Westermeier (2019).
- 156 The question in the questionnaire allows multiple answers.
- 157 Romeu Gordo et al. (2022) also arrive at comparable results, based on the IAB's Panel Study Labour Market and Social Security (PASS).
- 158 Such as managers, academic occupations, technicians and non-technical occupations of equal rank.
- 159 The calendar-based limitation of an employment contract without the existence of an objective reason is permissible for a period of up to five years if the employee has reached the age of 52 at the start of the fixed-term employment relationship and has been unemployed for at least four months within the meaning of Section 138 subs. 1(1) of the Third Book of the Social Code directly before the start of the fixed-term employment relationship. See Section 14 subs. 3 Part-Time and Fixed-Term Employment Act (Teilzeit- und Befristungsgesetz, TzBfG).
- 160 Cf. Section 14 subs. 2 TzBfG.
- 161 Cf. Section 14 subs. 2(2) TzBfG.
- 162 Rather, it is necessary that the employee is entitled to claim a retirement pension. A project-related bringing back of former employees who have already retired must therefore fulfil these requirements of a permissible fixed-term contract. Cf. Bundesarbeitsgericht (2015).
- 163 Furthermore, in the case of employment relationships that do not include an age limit provision, the employment relationship continues despite the employee reaching the standard pension age.
- 164 Cf. <https://www.thyssenkrupp.com/de/senior-experts> (last accessed on 16 January 2023).
- 165 Cf. <https://www.bmwgroup.jobs/de/de/about-us/benefits/senior-expert.html> (last accessed on 16 January 2023).
- 166 Cf. https://www.bosch-management-support.com/de/bms/home/home_1.html (last accessed on 16 January 2023).
- 167 Cf. <https://www.ase-automotive.com/> (last accessed on 16 January 2023).
- 168 In fact, evidence from the USA also shows that particularly successful start-ups with growth ambitions, i.e. those companies that later hired at least one person, are not led by young people, but rather by people in middle age. For example, between 2007 and 2014, the average age of all 2.7 million start-up entrepreneurs in the USA who later hired at least one employee was 41.9 years, while the average age for the 0.1 percent fastest-growing companies, as measured by employment growth, was 45.0 years. Similarly, for start-ups with high-tech employees, those that received venture capital and those that patented, the average age was higher, at 45.9, 43.4 and 46.2 years respectively, than for all start-ups with these start-up characteristics, at 43.2, 42.4 and 44.4 years, respectively. In addition, a 50-year-old entrepreneur was 1.8 times more likely to start a business with growth in the upper range compared to a 30-year-old entrepreneur. The results thus contradict the assumption that young entrepreneurs

- establish the particularly high-growth firms. Cf. Azoulay et al. (2020).
- 169 Cf. Sternberg et al. (2022).
- 170 Cf. here and below Schrödl and Hanen (2019).
- 171 Cf. Schrödl and Hanen (2019).
- 172 The analyses are based on a special evaluation by the KfW Entrepreneurship Monitor for the years 2016 to 2021. The KfW Entrepreneurship Monitor uses a cross-sectional survey to map start-up activity and start-up dynamics in Germany. The sampling of 50,000 people from all possible landline telephone numbers in Germany ensures that the sample is almost entirely representative of the target group. The sample is based on an annual computer-assisted telephone survey of German residents aged 18 to 64.
- 173 The question in the questionnaire allows multiple answers.
- 174 In the age group 60 to 67, those who abandoned their plans most frequently give the following five reasons (multiple answers possible) for their abandonment: 47.8 percent say they abandoned the plan because of bureaucratic hurdles and delays. Concerns about too much financial risk are reported by 42.8 percent, followed by concerns about high burden on family (39.8 percent) and concerns about being too old (39.7 percent). 35.6 percent of those who abandoned their start-up plan gave financing difficulties as a reason.
- 175 The analysis is based on new businesses from the KfW Entrepreneurship Monitor surveys 2016 to 2021 that were no older than five years at the time of the survey.
- 176 In addition to economic factors that can lead to business closure, reaching the standard retirement age can be a factor, especially in the age group of 60 to 67 years.
- 177 Cf. Cravino et al. (2022).
- 178 Cf. Deutscher Bundestag (2020).
- 179 Most people in need of long-term care are currently cared for on an outpatient basis (81.7 percent in 2021), but as the level of care increases, so does the proportion of people receiving inpatient care. Cf. BMG (2022). This also has an impact on costs, as inpatient care places a much greater burden on social security systems than outpatient care.
- 180 Digital skills are recorded as knowledge in various IT-related applications with varying depth, e.g. internet research, operating clouds, reading simple codes, managing privacy settings, identifying technical problems.
- 181 Cf. Deutscher Bundestag (2020).
- 182 Cf. Initiative D21 (2022).
- 183 Cf. Initiative D21 (2022).
- 184 Cf. Deutscher Bundestag (2020: 66 ff.).
- 185 Cf. https://ec.europa.eu/eurostat/databrowser/view/ISOC_SK_DSCL_I21__custom_3883463/default/table?lang=en (last accessed on 16 January 2023).
- 186 Cf. Deutscher Bundestag (2022e: 105–106).
- 187 Cf. <https://www.digitalpakt-alter.de/> (last accessed on 16 January 2023). The DigitalPakt Alter comprises ten partners, 150 contact points and a total of 287 digital support services.
- 188 Cf. <https://ised-isde.canada.ca/site/digital-literacy-exchange-program/en> (last accessed on 16 January 2023).
- 189 Cf. ISED (2021).
- 190 Medical supplies and services also include nursing services and nursing care supplies. Outpatient and inpatient care are allocated to the sub-sector Medical Care in the Health Management National Accounts (Gesundheitswirtschaftliche Gesamtrechnung, GGR). Cf. <https://www.bmwk.de/Redaktion/DE/Artikel/Branchenfokus/Wirtschaft/branchenfokus-pflegewirtschaft.html> (last accessed on 16 January 2023).
- 191 Cf. BMG (2022: 20).
- 192 Cf. BA (2022).
- 193 Feasible options here are the use of telemedicine, the use of app and/or software applications to reduce administrative tasks, and the digital transmission of medications and diagnoses between actors, as well as robotics and ambient assisted living.
- 194 Cf. EFI (2022: chapter B 4).
- 195 Adopted by the Bundestag in November 2019 and enshrined in the Fifth Book of the Social Code (SGB).
- 196 Cf. EFI (2022: chapter B 4).
- 197 Cf. SPD et al. (2021).
- 198 The highest decision-making body of the common self-administration in the German healthcare system.
- 199 Reform Commission G-BA of the Münch Foundation.
- 200 Cf. SPD et al. (2021).
- 201 There is a need for cross-sectoral cooperation between the social security systems to be able to meet the current and future need for care in a high-quality manner. Cf. Messerle and Schreyögg (2021). Equal remuneration across sectors, the objective of which is balanced cross-sectoral care, is enshrined in the current coalition agreement. The coalition agreement mentions so-called hybrid DRGs (Diagnosis Related Groups). Currently, different service catalogues and thus billing tables are used in outpatient and inpatient care. These are to be standardized by the so-called hybrid DRGs. Cf. SPD et al. (2021).

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- 202 Cf. Peters et al. (2023a: 100).
- 203 A survey of inventors from 20 European countries, Israel, Japan and the USA shows, for example, that 13 percent of the patents applied for at the European Patent Office are so-called dormant patents, i. e. patents that are not commercially exploited but are also not held for strategic reasons. Cf. Torrisi et al. (2016). Another study from 2005 involving inventors in six European Union (EU) Member States shows that 36 percent of them were unable to commercialize even their most valuable patented technology, neither by using it themselves nor by licensing it or selling it to third parties. Cf. Gambardella et al. (2005). A survey of European SMEs from 2019 shows that 33 percent of SMEs have not yet commercially exploited their patents. While around 65 percent of the SMEs surveyed cited the fact that the inventions were still in the development phase or that potential exploitation opportunities were still being explored as the reason for non-exploitation, 32 percent said that a lack of resources was the cause. 19 percent cited a lack of skills or contacts, 14 percent insufficient exploitation potential, 8 percent lack of IP protection and 5 percent lack of freedom to act as reasons for non-exploitation. Cf. EPO (2019).
- 204 Cf. Arora et al. (2001).
- 205 IP rights are intangible assets, i.e. assets that are not physically tangible. The value of intangible assets is much more difficult to assess than the value of tangible assets.
- 206 Cf. Peters et al. (2023a: 21).
- 207 Cross-licensing is where two parties agree to grant each other access to parts of their intellectual property. In this case, ownership remains unchanged and both parties act as both licensee and licensor. Cf. Grindley and Teece (1997). Hereinafter, cross-licensing will be used synonymously with the exchange of IP rights.
- 208 In addition to activity in markets for technology, there are other options for companies to unlock innovation processes in the sense of open innovation. Cf. Chesbrough (2003). Cooperative relationships such as with tertiary education institutions, customers and suppliers are one such possibility. Cf. Grimpe and Sofka (2016).
- 209 Cf. here and below Conti et al. (2013).
- 210 Codified means that the technological knowledge must be expressed in an understandable form so that it can be evaluated, used and stored following the transaction without further input from the seller. Cf. Conti et al. (2013).
- 211 Cf. below EFI (2019) and EFI (2017).
- 212 Defining markets for technology in a broader sense to include additional forms of technology transfer such as contract research and company acquisitions is possible in principle but makes it difficult to clearly isolate the market mechanisms for technology transfer. Cf. Peters et al. (2023a: 21). In the following, therefore, only the narrower definition is used to facilitate the empirical measurability of the trade in IP rights.
- 213 Cf. Arora et al. (2001), Gans et al. (2008), Teece (1986) and Gans et al. (2002). Cf. also Peters et al. (2023a: 22f.).
- 214 Cf. Figueroa and Serrano (2019).
- 215 Cf. Gambardella (2021).
- 216 Cf. Allain et al. (2016).
- 217 Cf. Gambardella et al. (2021).
- 218 Overall, 61 percent of the patents filed at the EPO are commercially exploited. Correspondingly, 39 percent of the patents remain unused. Patents can be held for strategic reasons, for example to block competitors' innovations. This is the case for 26 percent of patents. Around 13 percent are dormant patents. Cf. Torrisi et al. (2016) and Gambardella (2021). Patents can also be used as leverage for collecting royalties by so-called patent trolls who do not conduct any research or production themselves but acquire patent rights and aggressively enforce them in court proceedings. Cf. Harhoff (2009).
- 219 Cf. Torrisi et al. (2016) and Gambardella (2021).
- 220 Cf. here and below Peters et al. (2023a: 84ff.). Below, the term German companies is used in a simplified form in some cases.
- 221 For the specific business sectors, cf. Peters et al. (2023a: 84f.). All evaluations are based on extrapolated values.
- 222 Without software licences.
- 223 Cf. Peters et al. (2023b).
- 224 These data provide information on various (legal) events concerning an IP right, e.g. a patent. For instance, it is recorded here whether oppositions to a patent were filed in time or whether the review of a patent application led to it being granted. The transfer of ownership of a patent is likewise recorded.
- 225 Cf. here and below Peters et al. (2023a: 29ff.).
- 226 Intra-group patent transfers are used, for example, for tax optimization of R&D expenditures or licensing income, but do not provide information on activities in markets for technology. In patent transfers that take place during M&A activities, the patent transfer is not necessarily in the spotlight.
- 227 Orbis IP links patent data from currently around 115 million patents from 109 countries with Orbis

- company information. Orbis IP contains a variable that provides information on whether a company's patent has been transferred. Cf. Peters et al. (2023a: 32). However, the Orbis IP data only provide information on the economic context for just under a quarter of the patent transfers registered in INPADOC. INPADOC recorded around 1.4 million transfers at patent family level between 2000 and 2020, compared to around 294,000 patent family transfers in Orbis IP. However, the Orbis IP data does not appear to be subject to any significant selection and is therefore meaningful for the analysis. Intra-group transfers accounted for about 45 percent of all patent transfers at the patent family level in the period from 2010 to 2020. 37 percent of patents were transferred during M&A activities and 17 percent between independent companies at market conditions. Cf. Peters et al. (2023a: 37ff.).
- 228** The INPADOC data do contain licence information, but this is very incomplete. Moreover, they also contain utility models in addition to patents.
- 229** Cf. here and below Peters et al. (2023a: 98ff.).
- 230** Cf. e.g. Graham et al. (2018) and Athreye and Cantwell (2007). Athreye and Cantwell (2007) have systematically collected data on royalty income and shown that it has risen sharply since the 1980s, along with an increase in patenting. Cf. also Peters et al. (2023b).
- 231** Cf. Graham et al. (2018) and own calculations based on <https://www.uspto.gov/ip-policy/economic-research/research-datasets/patent-assignment-dataset> (accessed on 25 October 2022).
- 232** For the period up to 2015, see Graham et al. (2018) and Marco et al. (2015). For the period from 2015 onwards, the data on the development of the USPTO patent portfolio have not been continued. Instead, the patent transfers are set in relation to the number of patent applications per year. Own calculations based on <https://www.uspto.gov/ip-policy/economic-research/research-datasets/historical-patent-data-files> (accessed on 9 December 2022).
- 233** Transfers of EP patents are recorded in the EPO register before grant and in the register of the respective national patent offices after grant. This analysis relies on the DPMA register to record post-grant transfers of EP patents, as Germany is the country with the highest share of validated patents and thus the most complete source of ownership changes of EP patents. In the Orbis IP data, however, the transfers are in many cases recorded as transfers of the EP patent from the Bureau van Dijk, even if the transfer was reported to the DPMA after grant.
- 234** Cf. here and below Peters et al. (2023a: 40ff.). It is possible that licensing activities have increased over the period under consideration and have substituted purchases and sales of IP rights.
- 235** The absolute number of transfers is underestimated here, as the Orbis IP data provide information on the economic context for only just under a quarter of all transfers. See also box B 2-2. It should be noted that transfers reported to the DPMA in the national phase were generally assigned to the original EP patent in the Orbis IP data, but not to the DE patent if it is a patent family.
- 236** The results of the study conducted by ZEW, which are based on the MIP, confirm the declining trend in German companies' activities on markets for technology revealed by the patent data. A comparison of the activities of German companies on markets for technology between 2016 and 2018 with those between 2018 and 2020 shows that both the demand for technology and the supply of technology by German companies have fallen recently. Cf. Peters et al. (2023a: 86ff.).
- 237** It may happen that a transfer is recorded only once for a patent family. Random analyses have confirmed this in some cases. In these cases, the transfer was preferably recorded in the EP patent. A comparison at patent level with the DE or EP patent applications can therefore lead to distortions.
- 238** M&A activities are only recorded in the Orbis IP database from 2010 onwards.
- 239** Since most patent applications at the DPMA are filed by companies, the Commission of Experts refers to companies in a simplified manner, although the actors also include individuals and research institutions (tertiary education institutions and NURI).
- 240** In 2020, for example, 30,679 of the patents were sold by German companies, 6,086 by US-American companies, 3,725 by Japanese companies and 1,435 by French companies. The analyses of the temporal development of patent sales and patent purchases recorded at the DPMA by country of origin of the sellers and buyers are based on the PATSTAT-INPADOC data and refer to the totality of all transfers, i.e. also to intra-group transfers and transfers during M&A activities, and not only to transfers between independent companies. Cf. here and below Peters et al. (2023a: 44ff.).
- 241** The number of annual patent purchases of transfers recorded at the DPMA in 2019 was 13,973 for buyers from Germany, 6,849 from the USA, 3,817 from Japan, 2,835 from Switzerland, 1,978 from France and 1,298 from China.

- 242 National trade flows describe a patent transaction where the seller and buyer of the patent are from the same country. The analyses on the countries of origin of the transaction partners of German sellers or buyers are based on the PATSTAT-INPADOC data and refer to the totality of all transfers, i. e. also to intra-group transfers and transfers during M&A activities, and not only to transfers between independent companies. Cf. here and below Peters et al. (2023a: 47ff.).
- 243 This may be a DE patent, but also an EP patent, provided the latter has already been granted and the transfer has been recorded in the DPMA register. The most important buyer country outside Germany is Luxembourg at 1.7 percent. The second most important foreign buyer country is the USA at 1.5 percent, followed by Switzerland at 1.1 percent.
- 244 This may be a DE patent, but also an EP patent, provided the latter has already been granted and the transfer has been recorded in the DPMA register. The most foreign sellers are from the USA (0.8 percent), Switzerland (0.5 percent) and the Netherlands (0.4 percent).
- 245 Only the purchase of IP rights was higher in other industry than in research-intensive industry between 2018 and 2020. Cf. here and below Peters et al. (2023a: 92).
- 246 Companies in the pharmaceutical and chemical industries frequently license in IP rights (12.5 and 8.5 percent, respectively). On the supply side, out-licensing (9.1 percent) plays a greater role than selling (2.1 percent) for companies in the chemical industry, while selling (6.8 percent) is more important than out-licensing (2.6 percent) for companies in the pharmaceutical industry.
- 247 Cf. here and below Peters et al. (2023a: 52ff.).
- 248 The KU Leuven applicant name classification algorithm was used to identify EP patents filed and, where applicable, transferred by tertiary education institutions (as the first applicant listed). Cf. Eurostat (2011).
- 249 EP patent applications for 2019 are still incomplete.
- 250 Cf. here and below Peters et al. (2023a: 79ff.).
- 251 Before 2011, the annual number of observed transfers of DE patents from tertiary education institutions was only in the double-digit range. Since tertiary education institutions from Germany filed more patent applications and were thus able to transfer patents only after the abolition of the university lecturers' privilege in 2002, this strong increase may represent a real development. However, since it cannot be ruled out that a change in the registration at the DPMA led to this, years before 2011 are not considered here.
- 252 The remaining IP rights were obtained from other institutions, e.g. associations, federations and public bodies. Cf. here and below Peters et al. (2023a: 112ff.).
- 253 Cf. EPO (2020).
- 254 Cf. among others Agrawal et al. (2015).
- 255 A patent is valid for a period of 20 years after its grant, starting from the filing date.
- 256 The patent age is measured as the time in years between filing and transfer.
- 257 Most frequently, transfers of DE patents took place at the age of three and four years. In other economic contexts, such as transfers within a corporate group or during M&A activities, the transfer of patents takes place significantly later. While intra-group patent transfers occur relatively evenly over the patent term, with most transferred patents at the age of eight years, an increasingly high patent age can be observed in patent transfers during M&A activities. Cf. here and below Peters et al. (2023a: 64f.).
- 258 In total, 89.6 percent of EP patents transferred since 2000 were granted, 75.5 percent before the transaction and 14.1 percent after the transaction. Cf. here and below Peters et al. (2023a: 65ff.).
- 259 Transferred DE patents have a lower overall grant rate of 73.5 percent, with 61.1 percent of transferred DE patents granted before the transaction and 12.4 percent after the transaction.
- 260 The indicators generality, forward citations after five and seven years, originality, radicality, number of claims and a combined quality index were calculated. The generality of patents describes the breadth of their technological applicability. Forward citations show the number of citations a patent has received by subsequent patent applications. The originality of a patent describes the breadth of the fields of technology on which a patent is based. The radicality of a patent refers to the number of earlier patents from other classes cited in the patent. An invention is considered more radical the earlier patents from other classes are cited. Claims describe the expressed patent claims and define the limits of a patent holder's exclusive rights. The combined quality index is composed of forward citations after five years, patent family size, number of claims and generality of a patent and is defined for granted patents only. Cf. here and below Peters et al. (2023a: 69ff.).
- 261 Cf. here and below Peters et al. (2023a: 74ff.).
- 262 Furthermore, the number of expressed patent claims and the radicality of the transferred patents

- suggest a slightly higher patent quality. In contrast, there are hardly any differences in originality and the combined quality index.
- 263 The share was slightly higher at 5.0 percent between 2016 and 2018. Cf. here and below Peters et al. (2023a: 86ff.).
- 264 Between 2016 and 2018, the share of companies that demanded IP rights was 3.4 percent.
- 265 The share of companies that offered IP rights between 2016 and 2018 was 1.8 percent.
- 266 On the one hand, this is because licences are not necessarily granted on an exclusive basis, and on the other hand, it is because demanders have in part obtained their IP rights from foreign players who are not recorded here as suppliers. Most companies act either as suppliers or as demanders of technologies, but not in both capacities.
- 267 Cf. Peters et al. (2023a: 103ff.).
- 268 Cf. Peters et al. (2023a: 88f.).
- 269 Cf. Peters et al. (2023a: 95ff.).
- 270 Cf. Peters et al. (2023a: 89ff.). Estimates confirm a significant positive influence of company size on the probability of becoming active in markets for technology. Cf. Peters et al. (2023a: 102f.).
- 271 Cf. Peters et al. (2023a: 91).
- 272 Cf. here and below Torrisi et al. (2016) and Gambardella (2021).
- 273 The percentage of total patents used was also higher for SMEs than for large companies. SMEs used a total of around 77 percent of their patents, while large companies used only 56 percent.
- 274 Cf. https://www.ifm-bonn.org/fileadmin/data/re_daktion/statistik/mittelstand_im_einzelnen/dokumente/Unternehmen_EU-27_ZR_2012-2022Sch.pdf (last accessed on 16 January 2023).
- 275 Cf. EPO (2019).
- 276 Cf. Gambardella et al. (2007).
- 277 Cf. Torrisi et al. (2016).
- 278 As companies that use third-party IP rights can be a group of companies that (strongly) differ in their company characteristics from the group of non-users, and these characteristics can influence both the use of third-party IP rights and innovation success, so-called entropy balancing is used in the estimation. This means that only companies with similar observable characteristics are considered. Cf. here and below Peters et al. (2023a: 120ff.).
- 279 Cf. here and below Peters et al. (2023a: 127ff.).
- 280 In total, 8.6 percent of the companies were impeded in their innovation activities by a lack of access to IP rights. A lack of skilled staff or a lack of external financing, for example, were obstacles to innovation for 34 and 19 percent of the companies, respectively. Among the innovative companies, it was almost every tenth company (9.6 percent) that was impeded in its innovation activities by a lack of access to IP rights.
- 281 The influence of company size on the probability of being impeded in own innovation activities by the lack of access to IP rights is non-linear. Cf. Peters et al. (2023a: 130ff.).
- 282 Agrawal et al. (2015) find evidence of some of these difficulties in markets for technology. They divide the licensing process into three stages and, based on a survey of executives of various companies regarding licensing negotiations, have assigned the sources of failure of licensing negotiations to the three stages of the licensing process. In the first stage, where a buyer or seller needs to be identified, a lack of market thickness emerges as a major source of failure. Failure in the second stage, where negotiations are initiated, correlates strongly with negotiation frictions. In the third phase of the licensing process, where an agreement is reached, the lack of market safety constitutes the biggest problem. Cf. Agrawal et al. (2015) and Peters et al. (2023b).
- 283 Cf. Roth (2008) and Gans and Stern (2010).
- 284 In extreme cases, a patent-protected technology has only one supplier, the patent owner (bilateral monopoly).
- 285 Cf. e.g. Conti et al. (2013).
- 286 Cf. Agrawal et al. (2015).
- 287 Search costs are part of the transaction costs. The search is even more difficult in the case of a so-called IP thicket, i.e. when the IP rights relevant to the use of the technology are held by several different patent holders. Cf. Peters et al. (2023b).
- 288 Cf. Dushnitsky and Klueter (2011) and Hagi and Yoffie (2013).
- 289 Cf. Rosenberg (1996) and Arora and Gambardella (2010).
- 290 Cf. Conti et al. (2013).
- 291 A recent study concludes that patents and employees of failed start-ups sometimes move to a new organization together. Cf. Serrano and Ziedonis (2019).
- 292 One reason for this is that patent specifications are often very vague and neither all the technical or substantive details of an invention nor the complementary knowledge (of the inventor) necessary for its implementation can be protected. However, it is also possible that potential buyers are better informed than the sellers because they have privileged information about potential fields of application of the technology. Cf. Arora and Gambardella (2010).

- 293 Cf. here and below Dushnitsky and Klueter (2011) and Dushnitsky and Klueter (2017).
- 294 Cf. Arrow (1962) and Peters et al. (2023b).
- 295 Cf. Arora and Gambardella (2010).
- 296 Cf. Roth (2008) and Gans and Stern (2010).
- 297 Cf. also Agrawal et al. (2015).
- 298 Cf. Gambardella et al. (2007). At the same time, inefficient markets also offer profit opportunities for intermediaries. Cf. Agrawal et al. (2016).
- 299 Cf. Hagiu and Yoffie (2013). In addition to platforms, so-called non-practicing entities (NPEs) have recently gained in importance for markets for technology. NPEs are financial investors that buy patents to legally punish patent infringements and enforce penalty payments. The role of NPEs is ambivalent. On the one hand, they do not use the purchased technologies themselves and can thus block innovations. On the other hand, they provide liquidity in markets for technology and can create incentives for innovation activities through the prospect of potential trade. The establishment of the Unified Patent Court (UPC) in early April 2023 could increase Europe's attractiveness for NPEs due to improved prosecution of patent infringements. At the same time, the UPC could also reduce the incentives for NPEs, as the losing party will bear the costs before the UPC. Cf. Momtaz (2022).
- 300 Cf. Agrawal et al. (2015). The number of digital technology platforms varies systematically by industry. Digital technology platforms tend to emerge in industries with high search costs, high potential for uncertainty in the applicability of technologies and high IP protection, such as the pharmaceutical industry. Cf. Dushnitsky and Klueter (2017).
- 301 Cf. here and below Dushnitsky and Klueter (2011) and Dushnitsky and Klueter (2017). For a definition of digital platforms see also EFI (2022: chapter B 3).
- 302 Cf. EPO (2019), Akcigit et al. (2016), Hagiu and Yoffie (2013) and Dushnitsky and Klueter (2017).
- 303 In addition, there is the problem that IP rights are not standardized products and the needs of demanders are quite different. Cf. Lopez and Vanhaverbeke (2009).
- 304 Cf. here and below Hagiu and Yoffie (2013).
- 305 A survey of 14 online knowledge marketplaces shows that over 70 percent of them use upfront payments. These must be paid in particular by actors who want to offer their technologies on the platform. 14 percent of the surveyed online knowledge marketplaces use disclosure requirements and 14 percent of them do not use either of the screening mechanisms. Cf. Dushnitsky and Klueter (2011).
- 306 Cf. below Momtaz (2022).
- 307 A traded patent has an average price of US\$ 178,000, a patent family has an average price of US\$ 418,000. The average price of patents filed at the USPTO is higher at US\$302,000.
- 308 The literature so far has a mixed record on digital technology platforms. Some studies conclude that digital platforms have not yet succeeded in penetrating the market. Cf. e.g. Akcigit et al. (2016) and Hagiu and Yoffie (2013). Other studies conclude that some of the technology platforms operate quite successfully and have been able to attract well-known institutions as participants, e.g. NASA. Cf. Dushnitsky and Klueter (2017).
- 309 A prominent example of a digital technology platform that has changed its business model significantly over time is Yet2.com. Cf. Hagiu and Yoffie (2013).
- 310 Cf. EFI (2022: chapter B 1).
- 311 Cf. below <https://www.patentplus.io/> (last accessed on 16 January 2023).
- 312 Cf. <https://www.crunchbase.com/organization/patentplus> (last accessed on 16 January 2023).
- 313 Cf. also Gambardella (2021).
- 314 Cf. also Lemley and Myhrvold (2007).
- 315 Cf. also Gambardella (2002).
- 316 Cf. EFI (2017).
- ### B 3
- 317 Cf. Weinzierl and Sarang (2021).
- 318 Now Lockheed Martin and Northrop Grumman, respectively.
- 319 The Indian space agency ISRO was established in 1969, followed by the ESA in 1975, the South Korean space agency KARI in 1989 and the Japanese space agency JAXA in 2003. Cf. <https://www.unoosa.org/oosa/en/ourwork/space-agencies.html> (last accessed on 16 January 2023).
- 320 Cf. Schneider (2018).
- 321 In addition to 'New Space', the spelling 'NewSpace' can also be found in the literature.
- 322 Cf. Schneider (2018).
- 323 Cf. <https://www.bmwk.de/Redaktion/DE/Dossier/luft-und-raumfahrt.html> (last accessed on 16 January 2023).
- 324 Cf. Menzenbach et al. (2008).
- 325 Cf. https://www.dlr.de/rd/desktopdefault.aspx/tabid-2099/3053_read-4706 (last accessed on 16 January 2023).
- 326 Cf. Kind et al. (2020), <https://www.dlr.de/content/de/artikel/das-dlr.html>, <https://www.bmwk.de/Redaktion/DE/Artikel/Branchenfokus/branchen>

- fokus-luft-und-raumfahrt-10.html, <https://www.dlr.de/DE/organisation-dlr/medien-und-dokumente/fakten/dlr-in-zahlen.html> (last accessed on 16 January 2023).
- 327** EUSPA evolved from the European Global Navigation Satellite System Agency, which is responsible for the market development of Galileo, the European global navigation satellite system. Cf. <https://www.gsc-europa.eu/news/gsa-celebrates-15-years>; <https://www.euspa.europa.eu/about/about-euspa> (last accessed on 16 January 2023).
- 328** This includes Galileo, EGNOS, GOVSATCOM and Copernicus. Cf. <https://www.euspa.europa.eu/about/what-we-do/services> (last accessed on 16 January 2023).
- 329** Cf. <https://www.euspa.europa.eu/about/what-we-do> (last accessed on 16 January 2023).
- 330** The 22 ESA member states are: Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Luxembourg, the Netherlands, Norway, Poland, Portugal, Romania, Spain, Sweden, Switzerland and the UK. Cf. https://www.esa.int/Space_in_Member_States/Germany/Die_ESA_Fakten_und_Zahlen (last accessed on 16 January 2023).
- 331** The EU Member States Bulgaria, Croatia, Cyprus, Latvia, Lithuania, Malta, Slovakia and Slovenia are not part of ESA.
- 332** EUSPA is responsible for the operational side and ESA for the technical side, i. e. the development and operation of the Copernicus, EGNOS and Galileo satellites. Cf. Directorate-General for Defence Industry and Space (2022), https://ec.europa.eu/commission/presscorner/detail/en/MEMO_18_4023, <https://www.euspa.europa.eu/newsroom/news/new-european-union-space-programme-successful-european-cooperation-paradigm>, <https://www.gsc-europa.eu/news/eu-space-on-a-new-trajectory-with-launch-of-euspa> (each last accessed on 16 January 2023).
- 333** Cf. ESA (2021), ESA (2022), https://www.esa.int/Space_in_Member_States/Germany/Die_ESA_Fakten_und_Zahlen (last accessed on 16 January 2023). Examples of ESA's optional programmes are Artes 4.0, Future EO and Science Core Technology Programme. Cf. https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises/ESA_programmes_and_activities_of_interest_to_SMEs, https://www.esa.int/Enabling_Support/Space_Engineering_Technology/About_ESA_technology_programmes (each last accessed on 16 January 2023).
- 334** Cf. DLR (2019).
- 335** Cf. BDLI (2018), BDLI (2019), BDLI (2020), BDLI (2021) and BDLI (2022). By comparison, approximately 1,700 companies were active in the space sector in France in 2020, employing 33,200 people and generating a turnover of €10.2 billion. Of these, 60 companies generated three quarters of the turnover. Cf. <https://www.insee.fr/en/statistiques/6652352> (last accessed on 16 January 2023).
- 336** Cf. OECD (2022).
- 337** The remaining 7 percent cannot be assigned. Cf. DLR (2019).
- 338** By ESA's definition, LSIs have a current main contract of over €200 million. Cf. https://www.esa.int/About_Us/Business_with_ESA/Large_System_Integrators (last accessed on 16 January 2023).
- 339** Cf. DLR (2019).
- 340** Cf. Kind et al. (2020).
- 341** Cf. Bryce Tech (2022).
- 342** Cf. <https://commercialisation.esa.int/bic/> (last accessed on 16 January 2023).
- 343** Cf. Whalen (2010). The two best-known providers of satellite-based internet are currently OneWeb and Starlink. SpaceX is aiming for a satellite network of around 12,000 satellites by 2025 with its Starlink project. Cf. Venkatesan et al. (2020) and <https://www.deutschlandfunk.de/gigantisches-projekt-starlink-der-schrecken-der-40-100.html> (last accessed on 16 January 2023).
- 344** In future, the EU's GOVSATCOM programme will provide communication capacities for safety-critical communication of the EU Member States and EU institutions. To this end, the establishment of the EU satellite constellation IRIS2 was agreed in November 2022. Cf. <https://www.euspa.europa.eu/european-space/govsatcom>, <https://www.consilium.europa.eu/de/press/press-releases/2022/11/17/council-and-european-parliament-agree-on-boosting-secure-communications-with-a-new-satellite-system> (last accessed on 16 January 2023).
- 345** Cf. <https://blog.bosch-si.com/internetofthings/-10-benefits-satellite-communications-brings-to-the-iot/> (last accessed on 16 January 2023).
- 346** Cf. Bonnor (2012).
- 347** Cf. DLG (2018) and <https://www.gsc-europa.eu/news/central-role-for-robust-gnss-in-autonomous-driving-2> (last accessed on 16 January 2023).
- 348** The first Earth observation satellite, TIROS-1, was a weather satellite. Cf. https://www.esa.int/About_Us/ESA_history/50_years_of_Earth_Observation (last accessed on 16 January 2023).
- 349** Earth observation generates ten terabits of data per day. Cf. Tatem et al. (2008).
- 350** For a detailed list of examples, see Kind et al. (2020).

- 351 Cf. Kind et al. (2020), Strada and Sasanelli (2018).
- 352 Cf. Moranta (2022) and <https://www.copernicus.eu/de/datenzugriff>, <https://www.euspa.europa.eu/european-space/euspace-market/earth-observation-market> (last accessed on 16 January 2023).
- 353 Cf. OECD (2022).
- 354 The OECD refers to the fields as sectors, but not according to the relevant economic definition. Therefore, the term ‘categories’ is used here.
- 355 In-orbit manufacturing describes the ability to manufacture or repair and maintain components in space. Cf. Makaya (2022).
- 356 Cf. <https://www.bmwk.de/Redaktion/DE/Artikel/Technologie/anwendungen.html> (last accessed on 16 January 2023).
- 357 These are also referred to as commercial-off-the-shelf components.
- 358 Cf. Kind et al. (2020) and <https://knowledge.wharton.upenn.edu/article/commercial-space-economy/> (last accessed on 16 January 2023).
- 359 The newer small satellites weigh less than 100 g to a maximum of 500 kg and are mainly used in low Earth orbit, where they perform their tasks well despite their comparatively weak sensors and solar cells. Cf. <https://www.nasa.gov/content/what-are-smallsats-and-cubesats> (last accessed on 16 January 2023).
- 360 Microlaunchers are launch vehicles designed to carry small payloads of up to 350 kg.
- 361 Until now, providers of smaller payloads had to rely on ridesharing services from medium- and heavy-lift rockets, in which they could only fly as secondary payloads and could not determine their own timing or orbit. Cf. https://www.dlr.de/content/en/articles/news/2021/02/20210430_small-launchers-big-market.html, <https://www.spacotec.partners/the-growing-demand-for-micro-launcher-services/> (each last accessed on 16 January 2023).
- 362 One example is the development of SpaceX’s Falcon 9, which is in direct competition with Ariane Group’s Ariane 5 and has triggered the development of Ariane 6.
- 363 Cf. Kind et al. (2020).
- 364 An important milestone in this regard was recently achieved by the NASA-operated DART project. Cf. <https://www.nasa.gov/press-release/nasa-confirms-dart-mission-impact-changed-asteroid-s-motion-in-space> (last accessed on 16 January 2023).
- 365 Cf. Boley and Byers (2021).
- 366 The initiative includes the three networks space2motion, space2health and space2agriculture. Cf. https://www.dlr.de/rd/desktopdefault.aspx/tabid-17511/27806_read-72032/ (last accessed on 16 January 2023).
- 367 It took SpaceX only five years from the announcement of Falcon 9 to the first successful launch. The estimated cost was approximately US\$443 million. In contrast, development of Ariane 6, a newer version of Ariane 5, has been ongoing since ESA commissioned it in 2015/2016. Most recently, ESA postponed the first flight to the fourth quarter of 2023. At the same time, the costs of Ariane 6 now add up to €4 billion. One reason for the significantly lower costs at SpaceX is the vertically integrated production. Cf. NASA (2011), NASA (2017) and <https://www.aerospace-technology.com/projects/ariane-6-launch-vehicle/>, <https://spacenews.com/ariane-6-first-launch-slips-to-late-2023/>, <https://www.businessinsider.in/strategy/news/how-elon-musk-drives-vertical-integration-across-companies-like-spacex-and-tesla-and-what-you-can-learn-from-it/articleshow/72336779.cms> (each last accessed on 16 January 2023).
- 368 Cf. Kind et al. (2020).
- 369 Cf. Weinzierl and Sarang (2021), <https://www.sciencetimes.com/articles/31438/20210529/spacex-competitor-fears-elon-musks-company-monopolizing-space-warning-remain.htm> and <https://washingtonmonthly.com/2021/11/07/why-are-we-letting-monopolists-corner-space/> (each last accessed on 16 January 2023).
- 370 Cf. BSI (2022), Göge and Wörner (2015).
- 371 Cf. Kind et al. (2020).
- 372 Cf. BMI (2022a) and <https://www.openkritis.de/it-sicherheitsgesetz/kritis-dachgesetz-sicherheitsgesetz-3-0.html> (last accessed on 16 January 2023).
- 373 Cf. Fiott (2020).
- 374 Cf. Froehlich (2018) and Scheffran (2020).
- 375 Cf. BMI (2022a), Froehlich (2018), BSI (2022) and <https://www.openkritis.de/it-sicherheitsgesetz/eu-kritis-europa.html> (last accessed on 16 January 2023).
- 376 Cf. BSI (2022).
- 377 Transnational patent applications are applications in patent families with at least one application to the World Intellectual Property Organization via the PCT procedure or one application to the European Patent Office. Patent applications were identified using the CPC classification and a keyword search.
- 378 In the following figures, the EU includes the UK, as the observation period ends before the UK leaves the EU.
- 379 One explanation for this could be that developments in the upstream space segment are heavily technology-based, while applications are developed in the downstream space segment, which are less likely to be patented.

- 380 10.5 percent of all patent applications fall into the highly cited category.
- 381 NASA is not listed among the top 25 applicants for transnational patents but is filing more with the US Patent and Trademark Office (USPTO). Between 2000 and 2008, more than 8,000 space patents were filed there, of which NASA filed 5.79 percent, ranking third. The fact that NASA's share of transnational patents is particularly low compared with US-American companies that file patents both at the USPTO and transnationally speaks for a NASA patenting strategy in which transnational patents play a subordinate role.
- 382 Henkel is represented in the list with patents in materials research and data processing.
- 383 Definition based on the following criteria: Established after 1 January 2000 and fewer than 100 employees.
- 384 Cf. BMWi (2010).
- 385 The six fields of action are 'Limiting the Climate Crisis, Protecting Resources and the Environment', 'High-tech and New Space: Space as a Growth Market', 'International Space Research and Exploration', 'Sustainability in Space', 'Security, Strategic Capability and Global Stability', 'Future Technologies and Talent'. Cf. BMWK (2022b).
- 386 Art. 189, para. 2 of the Treaty on the Functioning of the European Union explicitly excludes the harmonization of EU Member States' laws on space. Cf. Baumann et al. (2023).
- 387 Cf. Baumann et al. (2023).
- 388 Cf. Baumann et al. (2023).
- 389 The liability limit in France is between €50 and €70 million, with damage in space not covered by the liability limit. In the UK, the type and amount of compulsory insurance and thus the liability limit of private actors are only determined during the licensing process. Cf. Baumann et al. (2023).
- 390 Cf. Baumann et al. (2023).
- 391 Cf. Baumann et al. (2023).
- 392 Cf. ESA (2021), https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises, https://defence-industry-space.ec.europa.eu/eu-space-policy/space-entrepreneurship-initiative-cassini_en, <https://www.dlr-innospace.de/> (each last accessed on 16 January 2023). A special type of support for SMEs, start-ups and research institutions is the In-Orbit Demonstration and Validation (IOD/IOV) programme. Here, start-ups, SMEs and research institutions are given the opportunity to test their products and developments and demonstrate their marketability. The DLR is pursuing the same objective by purchasing the first two launches of the winners of the Microlauncher competition. Cf. DLR (2021) and https://defence-industry-space.ec.europa.eu/eu-space-policy/eu-space-research/orbit-demonstration-and-validation-iodiov_en (last accessed on 16 January 2023).
- 393 Cf. Institut für Innovation und Technik et al. (2021). The exploration and sustainable use of space is to be promoted as a mission in the Future Strategy for Research and Innovation. Cf. BMBF (2022b).
- 394 ESA's total estimated budget for 2022 was €7.15 billion. Cf. https://www.esa.int/ESA_Multimedia/Images/2022/01/ESA_budget_2022 (last accessed on 16 January 2023).
- 395 Cf. https://www.esa.int/About_Us/Corporate_news/Ministers_back_ESA_s_bold_ambitions_for_space_with_record_17_rise (last accessed on 16 January 2023).
- 396 Own calculations based on <https://www.destatis.de/Europa/DE/Staat/EU-Staaten/Frankreich.html> and https://www.esa.int/ESA_Multimedia/Images/2021/01/ESA_budget_2021 (each last accessed on 16 January 2023).
- 397 Cf. Lamine et al. (2021).
- 398 Cf. https://www.esa.int/About_Us/Business_with_ESA/How_to_do/Best_practices_for_ITTs_published_by_prime_contractors and https://www.esa.int/About_Us/Business_with_ESA/Small_and_Medium_Sized_Enterprises/Opportunities_for_SMEs/Procurement_policy_on_fair_access_for_SMEs_-_the_C1-C4_Clauses (each last accessed on 16 January 2023).
- 399 Cf. https://www.esa.int/About_Us/Business_with_ESA/How_to_do/Best_practices_for_ITTs_published_by_prime_contractors (last accessed on 16 January 2023).
- 400 Cf. https://ec.europa.eu/info/funding-tenders/find-funding/eu-funding-programmes/european-space-programme_en and <https://www.bundesfinanzministerium.de/Web/DE/Service/Quiz/Euroquiz/frage4.html> (each last accessed on 16 January 2023).
- 401 Specifically, these are the Galileo, Copernicus, EGNOS, and the GOVSATCOM and Space Traffic Management and Space Situational Awareness (SSA) programmes, which are in the planning stage. As these are highly complex systems, large companies are commonly commissioned.
- 402 Cf. EIB (2019).
- 403 The DeepTech & Climate Fund is part of the Future Fund and focuses on Industry 4.0. The fund can co-finance up to €30 million per company. Cf. <https://dtcf.de/> (last accessed on 16 January 2023).
- 404 Cf. BSI (2022).

405 Cf. EIB (2019).

406 Cf. <https://www.acquisition.gov/nfs/subpart-1812.70-commercial-space-hardware-or-services>, <https://www.axios.com/2022/06/07/nasa-space-suit-contracts-axiom-collins> and <https://www.nasa.gov/offices/c3po/home/index.html>, <https://space-news.com/nasa-anchor-tenancy-change-encourages-commercial-space-backers/> and <https://blogs.nasa.gov/commercialcrew/2021/12/03/nasa-to-secure-additional-commercial-crew-transportation/> (each last accessed on 16 January 2023).

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