14 National STI governance, EU leadership and international commitments

This chapter discusses the governance of Germany's science, technology and innovation (STI) system, including national agenda-setting, inter-ministerial collaboration, federalism and its implications, and Germany's EU and international leadership role in this policy field. The chapter focuses on German STI governance challenges in the context of the twin transitions of sustainability and digitalisation. Critical to guiding Germany's future with those transitions, the section discusses the recommendation on developing a shared vision for Germany for 2030 and 2050.

Introduction

Germany's science, technology and innovation (STI) system is governed by a diverse and well-resourced set of institutions at both the federal and regional levels. These institutions – ministries, research institutions and agencies, higher education institutes, as well as private-sector organisations – have enabled the German innovation system to continuously play an important role in the competitiveness of the economy and by extension socio-economic well-being.

Given its maturity and historical success, it could be argued that ensuring the German innovation system's future success requires only minor improvements and adjustments to its governance. The extent to which this is true, however, depends on the goals policy makers have set for the innovation system. The nature and pace of technological change, combined with time-sensitive contextual and transitional challenges (such as digitalisation of industry and emissions reduction), mean that Germany's structures and processes for STI governance may need to adapt in order to maintain the country's position of strength. In this context, policy makers must respond to specific challenges in STI governance:

- Political and social expectations for the STI system have changed, and competitiveness is no longer the principal rationale for policy intervention. Orienting the STI system towards additional socio-economic "goals" is a more complex objective for governance.
- The political economy of the environmentally sustainable transition is challenging, as the STI governance system is now confronted with policy ambitions that go beyond – and sometimes even run counter to (at least in the short term)– the notion of competitiveness. The STI system must therefore be equipped to navigate emerging tensions and facilitate transitions, e.g. by striking a balance between non-directional and technology-neutral approaches to governance, and those with greater direction.
- A great number of actors are involved in innovation for transition and the STI system must facilitate more multidisciplinary approaches to bring to bear diverse expertise. Governance institutions – whether within federal ministries or research institutions – must also improve co-ordination and collaborative innovation, as cross-ministry collaborations (e.g. between energy, environment, economy and research with regard to sustainable energy) are more important in the new context. The social implications of the digital and sustainability transitions, which may have asymmetrical impacts on employment across sectors and raise the need for certain skills at the expense of others, also requires civil society as well as institutions in charge of social affairs to be more involved.

This section assesses the governance of the German STI system in the context of the challenges outlined above. The section begins with two recommendations. The first concerns the establishment of a whole-of-system "forum" to steer and manage the complexities of STI policy in the context of transitional challenges. It is recommended that the forum undertakes a foresight exercise for the whole of the German STI system, which we refer to as the "Germany in 2030 and 2050" initiative. The second concerns Germany's role as an international leader in STI governance, and looks at how Germany can leverage its international position to support innovation at both the domestic and European levels. The section then proceeds with an assessment of current aspects of the governance system crucial to meeting the challenges discussed throughout this review.

Recommendation 1: Develop a shared vision "Germany 2030 and 2050"

Overview and detailed recommendations:

Most transformational challenges posed by the transition to sustainability and digitalisation challenge Germany's existing innovation governance system. This has resulted in important experiments, notably within the strategy for research and innovation (R&I) (see Chapter 5), to devise new governance arrangements for STI. This recommendation foresees the establishment of a whole-of-system "forum" to steer Germany' STI system towards specific goals and ambitions described in a strategic vision. The proposal offers a time-bound and collaboratively developed vision for Germany. For its implementation, this recommendation complements Recommendation 2 on the creation of a public-private laboratory for innovation policy experimentation.

R1.1 **The government should create a cross-ministerial, federal-state, cross-institutional and cross-sectoral forum to steer the process of developing a shared vision founded on identified key priority areas for action**. The purpose of this forum would be to ensure broad engagement in policy making and identification of priorities, both to promote the type of horizontality and multidisciplinary approaches implicit in the challenges posed by transitions, and to secure the social and political legitimacy of the proposed actions. The forum would also provide an environment where all areas of policy (such as digital policy, social policy, education, environmental and health policies) can be discussed as they interact with STI. Although these issues fall outside traditional STI policy portfolios, they invariably affect the effectiveness of policy interventions.

R1.2 **The forum should develop pathways for innovation to realise the desired vision for Germany in 2030 and 2050 , as well as define approaches to deal with future risks and inclusivity issues in orienting innovation policies.** All countries will face important socio-economic transitions resulting from the digital transformation and the ambition to develop environmentally sustainable development pathways, as well as the increased risks – including health threats (such as the COVID-19 pandemic), geopolitical conflicts and climate change – arising from the interconnectedness of the global economy. Defining a shared vision can underpin steadier and more and strategic action, rather than addressing challenges in an ad hoc and reactive manner. The debate on inclusivity should also address the question of potential trade-offs of innovation excellence and inclusivity, and how to best approach these challenges.

R1.3 **The vision and its forum must be recognised as central at the highest level of government, as well as by key industry stakeholders and society, to effectively promote an agenda of change in the STI system**. The forum should receive high-level political support to allow it to engage government ministries and institutions at both the federal and state levels, as well as STI stakeholders more broadly.

R1.4 **Effective implementation requires establishing a public-private budgeted strategic plan for the realisation of the "Germany 2030 and 2050" vision. The plan should focus on key thematic areas for action and the monitoring of progress made at different stages. Core themes will be achieving the digital and environmental sustainability transitions, and the role of innovation and STI more generally in that regard.** Other related topics include preparedness for future disruptions (e.g. supply-chain preparedness), key enabling technologies, the industrial transformation and diversity in the innovation system (gender, age, ethnicity and socio-economic background). More granular topics could be developed, depending on which key priorities are identified for the "Germany 2030 and 2050" vision.

R1.5 **Importantly, implementation defined along key missions should not be top-down, but rather bottom-up and market-driven.** Bottom-up approaches can help accelerate implementing

pathways for realising the "Germany 2030 and 2050" vision. Adopting actor-driven approaches, in particular, can hasten transition efforts that "reward" lead actors in specific states, regions, sectors, cities and policy fields that undertake innovative actions for change. Market-driven dynamics are also a key aspect of the vision's implementation plan, which should identify and agree on transition pathways and partnerships with industry partners. In this manner, both government and industry commit to investments and other contributions or initiatives (such as "fossil-fuel free Sweden'", with its industry roadmaps negotiated between industry and government) that will drive transitions. The "transformation dialogue for the automotive industry" (*Transformationsdialog Automobilindustrie*") is a first attempt in this direction.

R1.6 **Important goals of the forum, and the "Germany 2030 and 2050" vision, would be to draw upon systemic capacities for STI and better co-ordination in mission-oriented approaches.** Germany has developed a number of mission-oriented approaches for STI, but they are not always sufficiently "transformative" and suffer from a lack of coherence and co-ordination among missions.

Relevant global experience

Given that some of the key STI governance challenges stem from the complexities of managing the contributions and expectations of different disciplines and constituencies, German policy makers may benefit from a high-level advisory and governing body such as in in Finland. The principle of a high-level arena, building on system-wide strategic intelligence and advice, and connected to the centre of government, could usefully be transferred to the German context. While the council's scope would need to be wider than in Finland, such a body could generate greater systemic coherence in STI policy interventions, particularly where success in STI is linked to different policy domains.

Finland has historically had a governance model for STI that combines a high-level advisory body with the decision-making power of government. This governance model has been successful in setting STI policy priorities based on a systemic view of the national innovation system (OECD, 2009[1]) (Schwaag-Serger, Wise and Arnold, 2015[2]). Finland's Research and Innovation Council has had various names and compositions. It has, however, consistently been chaired by the prime minister and has included a handful of ministers key to R&I policy, as well as a small set of R&I stakeholders. The council has functioned as a policy "arena" which has access to the strategic intelligence and systemic perspective needed to propose intelligent policies, and has the political legitimacy and power to decide on priorities. In previous iterations, the prime minister made a key contribution the council by raising the level of discussion and decision-making from the ministry level to the whole-of-government level. Another factor of success was that council decisions were limited to high-level, directional questions, leaving the existing R&I structures to handle design and implementation. A third success factor was the broad political agreement about the importance of investing in STI and higher education for economic growth and development. As long as this was agreed, political cycles had little effect on STI policy, because there were no major disagreements between successive governments in this domain.

This construction is not infallible, however, as it depends on the prime minister's interest and willingness to take the leading role. That interest – and the political consensus about using R&I policy to drive economic development and growth, even during periods of recession – was lost over the last decade. As a result, Finnish R&I policy became fragmented and failed to maintain the national effort in research and development (R&D) for key technologies, so that the country lagged behind other countries in devising policies to tackle societal challenges (OECD, 2017[3]). In December 2021, Finland reinstated the target of boosting R&D spending to 4% of gross domestic product (GDP) by 2030 and reached a political agreement to increase public R&D spending to 1.33% of GDP to achieve this target (Finnish Government, 2021[4]).

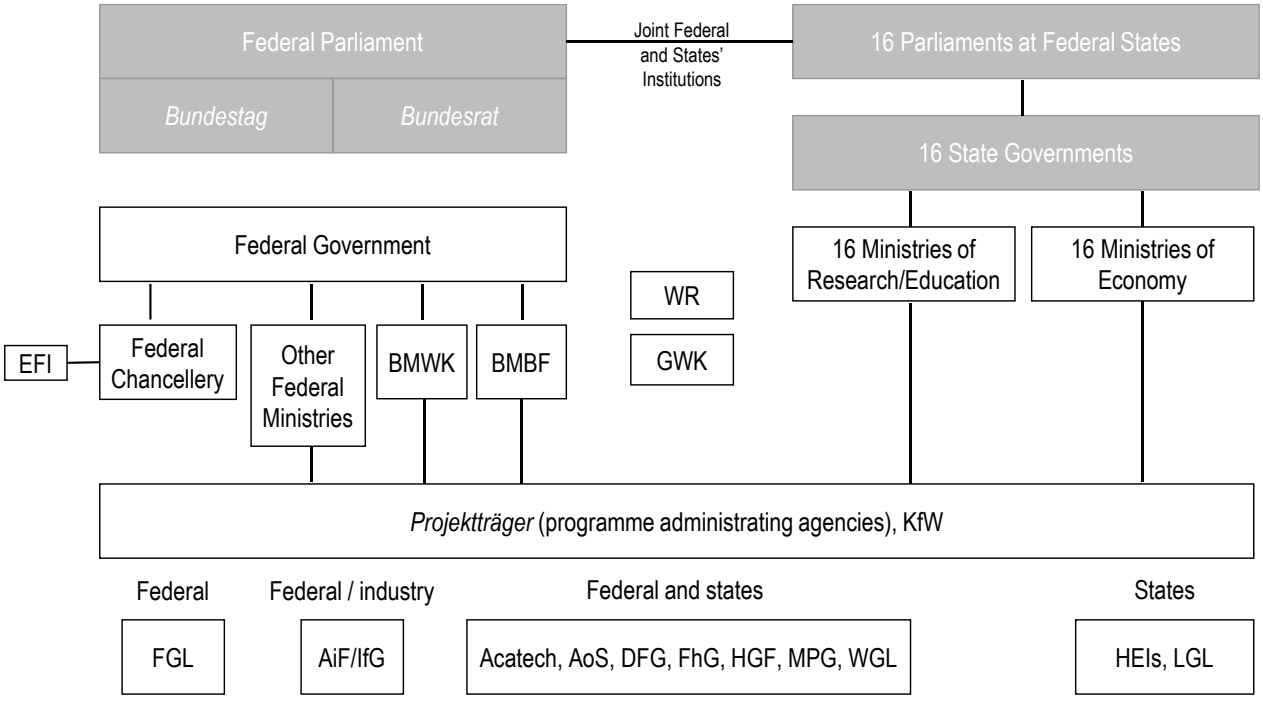
14.1. Overview of STI governance

The following section assesses STI governance in Germany, including its ability to manage the added pressures placed upon the STI system by the transitional challenges of climate change and digitalisation.

14.1.1. R&I governance structures in Germany

In general, the organisational structure for R&I governance in Germany follows a fairly standard division of labour. R&I policy is overseen by several line ministries, with input from external expert bodies, such as the Commission of Experts for Research and Innovation (EFI). Germany differs from other countries in the strong role of regional STI governance, with parallel institutions in the regions endowed with a high degree of policy and strategic autonomy (Figure 14.1).

Figure 14.1. German research, development and innovation (RDI) governance structure



Acatech: German Academy of Science and Engineering
AiF: Association of Industrial Research Institutes
AoS: German National Academy of Sciences Leopoldina
BMBF: Federal Ministry of Education and Research
BMWK: Federal Ministry for Economic Affairs and Climate Action
DFG: German Research Foundation
EFI: Commission of Experts for Research and Innovation
FhG: Fraunhofer Society
FGL: Federal Government Research Organisations
GWK: Joint Science Conference of the Federal Government and the Federal States
HEIs: Higher Education Institutions
IfG: Institutes of Cooperative Industrial Research
KfW: KfW Banking Group (state-owned investment and development bank)
LGL: State Government Research Organisations (State Agencies and other research organisations funded by State governments)
MPG: Max Planck Society
WGL: Leibniz Association
WR: German Science and Humanities Council

Source: OECD elaboration

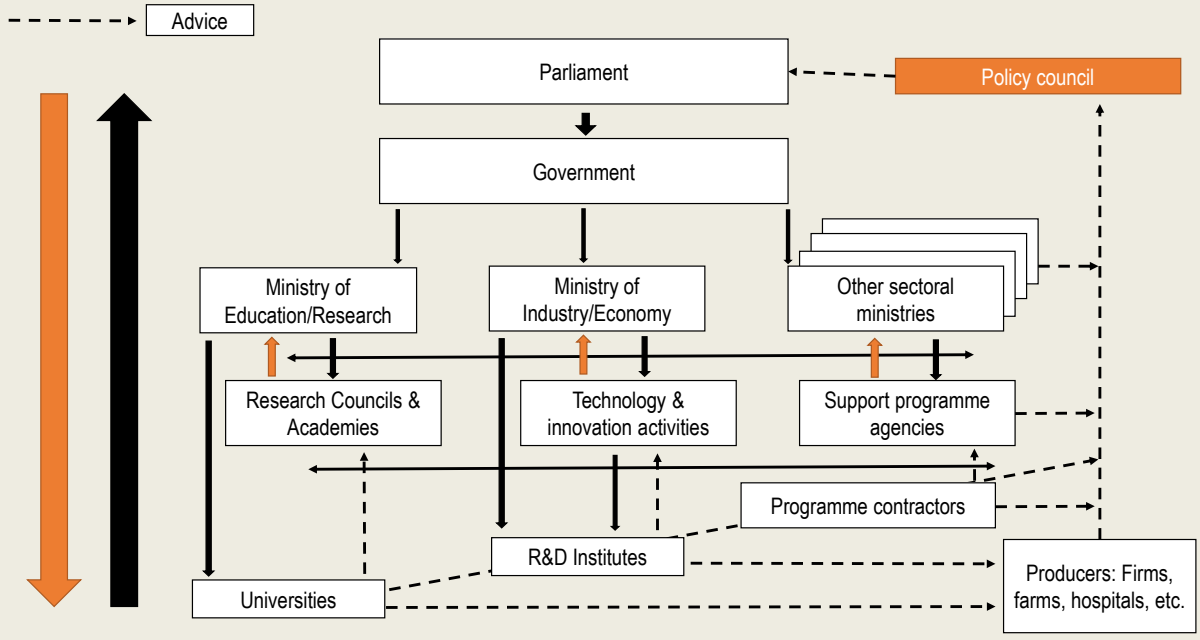
One strength of the German R&I governance system is that temporal inconsistency – i.e. the misalignment between short political cycles and longer time frames for R&D – does not appear to present a major

problem, as it might in other economies (Box 14.1). R&I policy evolves incrementally, rather than being subject to major discontinuities. There are several high-level organisations that provide advice to government, but none of them serves as a "highest instance" or involves members of the government. Importantly, there is no single ministry in charge of overall R&I.

Box 14.1. Standard governance structures for STI

Figure 14.2 shows a generic structure for STI governance in developed economies. Black downward arrows indicate delegation of tasks and authority; red upward arrows indicate flows of information and accountability. It is immediately obvious that this form of organisation creates ministry-based "silos".

Figure 14.2. Schematic of a generic STI governance structure



Source: OECD elaboration

This generic structure has implications for STI. An overview of key pillars of the generic governance structure is as follows:

- Governance structures can suffer from temporal inconsistencies between the shorter political cycles that affect the parliament and government, and the much longer natural R&I cycles. This creates a need for some consensus and consistency about R&I policy across political parties to avoid policy changes so radical that each government can undo the achievements of past governments during a single government period. Countries with successful policies tend to experience little political controversy about R&I; successive governments tend to make incremental adjustments to policy, rather than radical changes in approach.
- Most R&I systems are "two-pillar" systems, where two categories of ministries dominate government R&I expenditure: the education and research ministries generally focus on academic (often misleadingly referred to as "basic") research, while the industry ministry has a strong interest in applied R&I. To the extent that these ministries respectively act as proxies for

the academic community and industry (which have different value systems), they are engaged in a constant tussle for attention and resources.

- Traditionally, governments rely on a high-level policy council for advice. Such a solution provides a foundation for decision-making and co-ordination, and an arena in which policy alternatives can be debated within government and with key non-governmental stakeholders (OECD, 2009[1]) (Schwaag-Serger, Wise and Arnold, 2015[2]). Until about 2010, the Finnish Science and Technology Policy Council (now restructured and renamed "Research and Innovation Council") was widely regarded as the international best practice (see above).
- The widespread use of agencies to implement policy can create "principal-agent" problems, where agencies do not act in the best interests of their principals. On the other hand, agencies can forge stakeholder relationships and strategic intelligence closer to the area of policy implementation that ministries cannot themselves assemble, and may therefore generate ideas for programme design and implementation.
- The most effective level of co-ordination is the government, provided the prime minister is willing to act as the ultimate referee in the system. Inter-ministerial co-ordination is the next most effective: ministers have power, but also compete with each other for "turf" and budgets. Agencies are less effective co-ordinators, insofar as their decision-making authority is limited: inter-agency dialogue is constrained by the need for individual agencies to remain within their ministry's area of responsibility and their inability to make decisions that implicitly overrule ministry-level decisions.

14.1.2. Ministerial responsibilities in STI governance

Germany has 15 federal ministries (plus the Federal Chancellery). In practice, these cover the same set of responsibilities as in most other countries, though with a mixture of steering and co-ordinating roles at the *Länder* level. Ministry responsibilities shift over time, apparently more in response to politically driven rearrangements than to changes in wider strategy (Edler and Kuhlmann, 2008[5]). Every ministry is responsible for the research it needs to fulfil its responsibilities (*Ressortforschung*), which is carried out by a mix of government labs, public research institutes (PRIs) and other external research contractors.

Most German STI governance at the ministerial level is split between two ministries, the Federal Ministry for Education and Research[1] (BMBF) and the Federal Ministry for Economic Affairs and Climate Action (BMWK).[2] High-level governance therefore follows the two-pillar approach common across many STI governance systems. In practice, however, both ministries address overlapping constituencies: BMBF has responsibilities that affect innovation, and BMWK connects many of its innovation actions with research. This fuzzy overlap promotes co-operation and increases the ministries' joint ability to tackle R&I policy in a more integrated manner than in many other countries.

The main responsibility for education, including the universities, lies at the *Länder* level. The federal and *Länder* levels are jointly responsible for research, although the federal government provides most of the money. Table 14.1 outlines the main responsibilities of the two federal ministries.

BMBF (together with the Länder) essentially governs education and research policies that are implemented through the higher education and other state research-performing institutions, as well as businesses. It runs the Excellence Initiative, focused on the universities. It leads the strategy for R&I (previous editions of the HTS, the current HTS 2025 and the upcoming Future Strategy for R&I), which attempts to pulls together R&I efforts from across all the ministries. And it links the research and higher education sector in Germany to the European Union and international levels. BMBF also leads the Bioeconomy Strategy.

BMWK tackles the use and implementation of research results in business, as well as change more broadly. It sometimes requires the participation of research performers in its innovation programmes and

needs to co-operate with other ministries to link its innovation and industry policies to other sectors of society, such as health, transport or the environment. BMBF and BMWK have overlapping responsibilities for vocational education and training (see Table 14.1).

Table 14.1. STI responsibilities of BMBF and BMWK

Federal Ministry for Education and Research (BMBF)	Federal Ministry for Economic Affairs and Climate Action (BMWK)
• European and international co-operation in education and research • General and vocational training • Lifelong learning • Higher education • Research (across universities and the PRIs) • Research for technological sovereignty and innovation • Basic research	• Economic policy • Energy policy • Industrial policy • Innovation policy • Small and medium-sized enterprise policies • Domestic policies for climate protection • European economic policy

Source: Extrapolation from BMBF and BMWK websites.

14.1.3. Advisory bodies

As shown below, several independent bodies advise the Federal Government. A key challenge is streamlining the advisory channels for STI that can inform public policy and result in concrete policy action; the forum outlined in Recommendation 1 (jointly with Recommendation 2) could help achieve this.

- Established in 2002, the **National Academy of Science and Engineering** (Acatech) is funded by the Federal Government and the *Länder* to provide strategic policy advice on engineering and technology policies. It comprises a mix of scientific and industrial experts, and sets its own agenda. One of its most conspicuous contributions has been the generation and elaboration of the "Industry 4.0" idea. Most of its projects address policy issues relating to technology, such as the potential for creating closed-loop plastic packaging systems, carbon pricing, and resilience as an economic and innovation policy goal.
- Established in 1652 as a scholarly society, **Leopoldina** currently has about 1 600 scientific members, but no research facilities of its own. In 2008, the Joint Science Conference (Gemeinsame Wissenschaftskonferenz [GWK]) designated it as the German National Academy of Sciences. Leopoldina aims to represent German scholars in the international community, as well as provide policy makers and the public with science-based advice. It is funded by BMBF (80%) and by the *Land* of Saxony-Anhalt (20%), and produces numerous statements and publications on science and science policy.
- The ***Wissenschaftsrat*** (German Science and Humanities Council) advises both the federal and the *Länder* governments. It comprises a mix of federal and *Länder* representatives, and distinguished scientists. Its advice spans both broad matters of science policy and specific questions, often in response to issues raised by its constituents. It is frequently entrusted with high-profile evaluations at the federal level. Overall, it provides "soft co-ordination" rather than specific instructions.
- **GWK** membership comprises BMBF, the Federal Ministry of Finance (BMF) and the corresponding ministries at the *Länder* level. GWK manages the joint funding of universities and PRIs, the German Research Council (DFG), Acatech, Leopoldina, the German Centre for Higher Education Research and Studies (DZHW) and the *Wissenschaftskolleg zu Berlin.*

- Established in 2009, the ***Innovationsdialog*** (Innovation Dialogue) is a regular series of high-level discussions between the Federal Government (chancellor, head of chancellery and ministers for education and research, economic affairs and finance) and representatives of science and industry. The dialogue's steering committee is chaired by the president of Acatech. The discussions cover a wide range of innovation policy issues, including innovation ecosystems, supply-chain resilience, the European Green Deal, quantum technologies, hydrogen, and the strengths and weaknesses in Germany's innovation system in international comparison. Six such dialogues took place during the 2017-21 legislative period.
- Created by BMBF in 2006, **EFI** is a group of six professors who annually produce policy advice for the government. Its members are experts in science and innovation policy, who substantially consult with the wider German science and innovation policy community when preparing their reports. EFI is the closest organ to what Figure 14.2 calls a "policy council", although its function is strictly advisory.
- **The High-Tech Forum** was established in both 2015 and 2019 to advise the government on the implementation of the HTS and its successor, HTS 2025. It additionally published discussion papers different on different aspects of R&I policy. In its latest edition, which ended with the parliamentary term in 2021, the forum comprised 21 experts from science, industry and society, and was co-chaired by the state secretary of BMBF and the president of the Fraunhofer Society. The High-Tech Forum is another organ that has similarities with the policy council mentioned in Box 14.1.
- The ***Rat für Technologische Souveränität*** (Council for Technological Sovereignty) is a group of 11 representatives from science, industry and society created in 2021 to advise BMBF on how to strengthen the technological sovereignty of Germany and the European Union in key technology fields.

14.1.4. Agencies

Like other countries, Germany maintains a research funding council or national science foundation in the form of the German Research Foundation (Deutsche Forschungsgemeinschaft [DFG]). While the DFG is functionally an agency of BMBF, legally, it is an association under private law whose beneficiaries are its members – the universities and PRIs. It is formally autonomous, although it derives its income primarily from BMBF and, to a lesser extent, from the *Länder*. Like other research councils, it is led and managed by members of the research community, and its predominant funding mode is bottom-up. The DFG has a strong international reputation and was used as a model in the establishment of the National Natural Science Foundation of China.

Most European countries tend to use government agencies to run their other R&I funding programmes. In Germany, R&I funding at the federal and *Länder* levels has long been outsourced under competitively won five-year contracts to programme management organisations (*Projektträger*), which currently number 19 (Förderberatung des Bundes, 2022[6]). In almost all cases, the *Projektträger* are departments of organisations that run technological infrastructures and provide technical or project management services. The largest of *Projektträger* include:

A. the German Aerospace Centre (DLR), which is the national space and aeronautics centre
B. Forschungszentrum Jülich, a very large (6 400 people) scientific research institute within the Helmholtz Association
C. the Karlsruhe Institute of Technology
D. the technology centre of the German Association of Engineers (VDI Technologiezentrum), an organisation which focuses on programme management and technology consulting services

E. VDI/VDE Innovation + Technology GmbH, a leading service provider for issues related to innovation and technology.

14.2. Coherence and agenda-setting for STI

If inter-ministerial and cross-sectoral co-ordination is challenging in a non-transition context, then it is even more so in the context of the added complexities of transition ambitions. As outlined above, overlaps, lack of co-ordination and alignment, and even contradictory policies (across sectors, ministries and governance levels) hamper Germany's ability to meet its transition ambitions. One example is the interface between STI policy and climate policy: Germany has both a strong R&I system and a long-standing commitment to sustainable energy (illustrated particularly in the *Energiewende*), environmental protection and biodiversity preservation (Walz et al., 2019[7]). However, the alignment between policy areas could be stronger, given their mutually reinforcing role in ensuring each other's effectiveness.[3]

The authors of an analysis of Germany's eco-innovation policies commissioned by the Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), found the following weaknesses: too little focus on transition (except for energy), unconnected institutional and social innovation perspectives and policies, weak (or lack of) support of "green" start-ups and insufficient attention to innovation (Walz et al., 2019[7]). The report also identified considerable untapped potential for harnessing digitalisation as a driver of environmental protection and eco-innovation. It called for a stronger integration of innovation dynamics and perspectives in environmental policies, and for a "greening of the innovation system". Moreover, although Germany excels in the production of a number of green technologies, the government needs to raise the demand for green innovation and solutions, particularly with regard to waste, noise reduction and air purification. The heterogeneous applications of eco-innovation domains, such as bioeconomy, and their potential relevance to a wide range of sectors, make it difficult to design effective demand-side instruments or support market creation (Edler et al., 2021[8]).

The example of environmental sustainability and innovation illustrates the impact of long-standing co-ordination issues on increasing the contribution of STI to transition goals. There exists significant potential not only to strengthen elements of innovation policy in climate and environmental policies, but also to strengthen the environmental sustainability – and more generally, the transformative – perspectives in innovation policy. Indeed, the analysis of the interaction between innovation policy and environmental policy show a need to enhance common agenda-setting and policy coherence (Rogge and Kristin, 2016[9]) (Edler et al., 2021[8]).

Difficulties in improving the interaction between the environmental sustainability and innovation policies points to the co-ordination challenges in applying more systemic approaches to policy in general, and specifically STI policy. There is significant leeway for reinforcing innovation policy's support for the necessary transitions by enhancing the interface between innovation policy and other relevant areas, including climate, environment policies, social and health care policies. Echoing the findings of the BMUB report, in March 2020, the High-Tech Forum called for treating sustainability in all its dimensions as a key objective of R&I policy and removing obstacles to sustainable innovations (HighTech Forum, 2020[10]). A desire for greater co-ordination is therefore visible across a range of STI actors, and further government support would be welcome in this regard.

14.3. Inter-ministerial collaboration in STI governance

Strikingly, Germany has no single locus for whole-of-government co-ordination of R&I policy. Some countries may have a council, committee or "policy arena" – a platform that will involve senior politicians and stakeholders in key ministries (OECD, 2009[1]; Schwaag-Serger, Wise and Arnold, 2015[2]) – which

allow policies with systemic importance to be widely debated. Other countries may have a unified system of policy monitoring and control, such as an observatory, but no singular institution driving R&I policy debates and prioritisation. German policy is made at the level of the government itself, driven in part by the shape of the current coalition and the pattern of ministries controlled by the individual political parties. Importantly, Germany uses committees of state secretaries to oversee initiatives relevant to more than one ministry, but no single institution takes responsibility for systemic co-ordination across the whole national R&I system.

In all government structures, ministries compete for budgets, policy priority and attention. Hence, policy co-ordination and co-operation at the ministry level is less effective than co-ordination at a higher, all-of-government level. In Germany's case, this universal dynamic is compounded by the weight of the *Ressortprinzip*, a departmental principle enshrined in the constitution. It is further strengthened by the tradition of coalition governments, which in practice connects different ministries to different political parties, creating incentives for a lack of co-operation among ministries.

A long-standing example of this separation, central to STI policy, is the division of labour between BMBF and BMWK, with BMBF responsible for RDI, and BMWK for innovation and implementation. And yet these ministries must co-operate closely to connect STI to societal needs, users and new markets, as evidenced by the growing number of strategies and policies on which they actually co-operate.

Individual German ministries have a track record of running strategies within their own areas of responsibility, such as the Pact for Innovation, the Excellence Initiative and the BMEL strategy (all under BMBF) discussed at Chapter 5. The *Energiewende* was reinvigorated in 2014, when the then-BMWi took over its leadership, reducing reliance on voluntary inter-ministerial co-operation. Thus, while the ministries operate well within their traditional silos, the lack of systemic perspective or system-level prioritisation reduces successive strategic choices to a series of ad hoc decisions taken in different parts of the overall governance system, rather than serving as building blocks of a holistic national STI policy.

Ministries do increasingly co-operate to a certain extent in the design and implementation of national strategies, such as the R&I strategy and the Hydrogen Strategy. This flexible and pragmatic use of the ministries' existing silos makes it possible to address new challenges through the established structures. On the negative side, however, the ministries do not co-operate in practice; instead, they establish a division of labour in which each separately uses a portion of its own budget to implement its own programmes. Joint management happens only at the top level, so there are few synergies. This separation impedes reflexivity and learning, as illustrated by current evaluation practices. Ministries evaluate their own programmes separately, in line with Germany's strong tradition in this regard, but the overall strategy undergoes little or no evaluation. For example, comprehensive evaluation of the HTS only began more than 12 years after its launch.

As a whole-of-government platform, the forum outlined in Recommendation 1 could provide a platform to expedite the resolution of co-ordination issues and support inter-ministerial collaboration.

14.4. Directionality, mission orientation and outcome-based STI governance

A growing trend at the international level is "directionality" in STI policy, with interventions tailored to societal challenges. Missions and transitions exacerbate existing co-ordination issues as the involvement of actors outside the R&I community, both in determining the challenges to be addressed and in implementing changes, becomes even more important. This is not a trivial exercise – stakeholder have diverse views reflecting their own interests and viewpoints. Integrating these perspectives fairly is even more challenging, as some stakeholders have a louder voice and more resources than others. In effect, societal challenges expand the scope of R&I policy from the two pillars to a much broader swath of society. Various governance arrangements for such policies are being experimented internationally, including

putting single ministries in charge, creating cross-ministerial platforms, devising external platforms reporting to a central point in government, and establishing inter-agency platforms or programmes. However, there exists insufficient experience to define "best" (or even "good") practice at this stage. A related issue is the need to establish a dedicated arena for each programme or mission targeting a societal challenge, allowing it to cope with greater stakeholder consultation and involvement compared with more routine R&I policy questions.

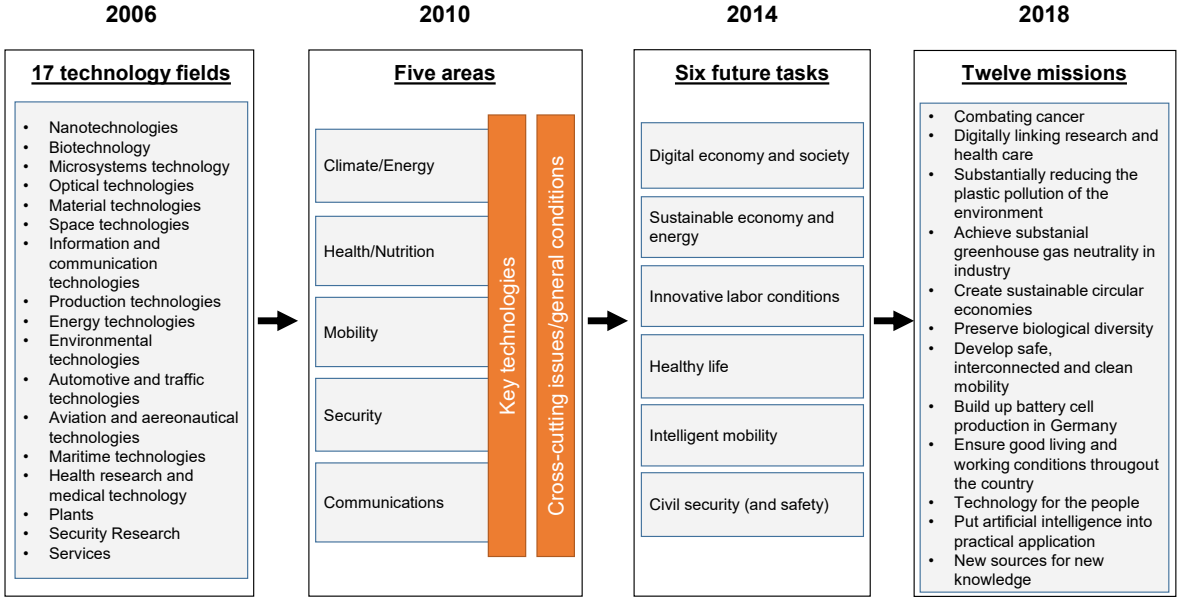
The growth in national strategies featuring an STI component points to an increased understanding across German government of the need for a more mission-oriented approach to solve societal challenges at various levels. This requires not only greater horizontal co-ordination within and among ministries and other state actors, but also a willingness within government to actively guide innovation activities in socially agreed directions the private sector would not necessarily take on its own. EFI, therefore, rightly proposes "a market-oriented version of New Mission Orientation, characterised by an openness to problem-solving and catalytic market interventions" (EFI Commission of Experts for Research and Innovation, 2021[11]). As EFI noted, the strong sector-focused approach of German STI policy could turn into a barrier to mission orientation. It may be necessary to revisit this approach to lower this barrier.

The essence of directionality cuts directly across the principle of technology neutrality implicit in *Ordnungspolitik* (governance) and which the then-BMWi emphasised in the past, even though many of its successful interventions were strongly thematic in nature. Examples include supporting dissemination and industrial capacity-building in new and key technologies, ranging from microelectronics and computer-aided design/computer-aided manufacturing in the 1980s, to digitalisation and artificial intelligence (AI) today. The *Industriestrategie* (industrial strategy) of 2019 included a list of key innovative industries to be safeguarded in order to support competitiveness, based on the principle of European technological sovereignty (BMWi, 2019[12]). Strategies for climate protection, also including guarantees for preserving the business environment (BMWi, 2020[13]), also focused on specific technologies, such as hydrogen (BMWi, 2020[14]). Key interventions by BMBF, such as in quantum technology, are similarly thematic. At the same time, the adoption of R&D tax credits in 2019 strengthened the weight of technology-neutral innovation policy tools within the envelope of innovation policies.

The high risk aversion of the government system also challenges mission orientation, which often involves experimentation, reflexivity and adjusting goals during the lifetime of an intervention. National strategies in areas like AI, hydrogen and bioeconomy tend to be supply- or technology-focused. To the extent that missions address transition needs, they should also be intimately connected to societal needs and the demand side. This introduces many more actors and stakeholders, whose actions affect the shape of needed interventions. It also entails a focus on problem-solving, not only in terms of supply-driven technological development, but also of processes for applying the results of that development to problems. Mission policies need to distinguish between "weak directionality" (such as "decarbonisation" or "hydrogen", which in a broad sense specifies the direction of the search for solutions), and "strong directionality" (such as convergence on particular technical standards or the emergence of "dominant designs"), which creates or involves markets. Here, the missions of the HTS 2025 provide potential laboratories for testing the government's role as mission results move towards markets, but the STI policy system as a whole will need to tackle the tension between directionality and technology neutral approach of policymaking (EFI Commission of Experts for Research and Innovation, 2021[11]).

The most well-known example of mission-oriented STI policy in Germany is the strategy for R&I. The strategy has evolved considerably since its launch in 2006, transitioning from technology-focused innovation goals to orienting technologies towards measurable socio-economic outcomes (Figure 14.3), and is now one of the clearest expressions of "mission-oriented" policy in German STI (in Chapter 5).

Figure 14.3. Evolution of the German strategy for R&I: From technology to mission orientation



Source: Based on information provided by BMBF on the respective strategies (BMBF, 2014[15]; BMBF, 2018[16])

The 2014 revision of the HTS set missions, this time identifying the following "priority challenges": "digital economy and society", "sustainable economy and energy", "innovative world of work", "healthy living", "intelligent mobility" and "civil security" (BMBF, 2014[15]). Within each priority challenge, the HTS listed areas of action or emphasis. A new feature of this version of the HTS was the addition of "transparency and participation" as one of five core elements of innovation policy, besides "priority challenges with regard to value creation and the value of life", "networking and transfer", "the pace of innovation in industry" and "an innovation-friendly framework" (BMBF, 2014[15]). Ensuring transparency and participation involves including stakeholders, particularly citizens, in innovation processes and policy design. Interestingly, key enabling technologies play a much less prominent role than in previous HTS versions, as they are only mentioned in a sub-section entitled "Using the potential of key technologies for the benefit of industry". During the implementation period of this version of the R&I strategy, policy platforms on industry (e.g. Industry 4.0), but also on bioeconomy, future mobility and city of the future gained visibility and momentum.

The latest iteration of the R&I strategy, adopted in 2018 as HTS 2025, takes the mission orientation one step further by identifying 12 missions in 3 action fields (see Figure 14.3). At the same time, key enabling technologies feature again more prominently and concretely under the heading "Developing Germany's future competencies" (BMBF, 2018[16]). Finally, HTS 2025 includes a new emphasis on an "open innovation and venture culture" and entrepreneurship.

Yet Germany continues to develop mission-oriented policies, a conclusive assessment of their effectiveness remains difficult for a number of reasons:

- First, the missions are defined at different levels of granularity, and hence do not fulfil all the criteria set for mission-oriented policies (Mazzucato, 2018[17]). For example, only some of the missions (e.g. the mission on circular economy) define targeted, measurable and time-bound objectives.
- Second, not all the missions are transformative; some aim to accelerate knowledge generation or market uptake and are thus the continuation of classical mission-oriented approaches. Although this is an appropriate approach to some of the identified challenges, some missions have the

potential to further develop their transformative character (for example, the cancer mission could be extended to include healthier lifestyles).

- Third, the mission approach of the HTS 2025 puts STI at the centre of activities. Some of these STI-driven missions acknowledge that broader societal developments (such as behavioural changes) are necessary to yield transformative impact, or that STI policy should be linked to other policy domains. While these links are planned, not all of them have been realised. The existing linkages to environmental, energy and climate policies were established earlier in the context of the energy transition and sustainability policies, but the missions of HTS 2025 do not normally operate through cross-ministerial co-ordination at the cabinet level and can therefore not be regarded as whole-of-government missions.
- Fourth, another dimension to be considered, especially in light of their high institutional autonomy, is how to make better use of the universities and institutes in missions. This could involve utilising those parts of the research institute system that works with higher technology-readiness levels, accelerating the transfer of promising research to the market.

14.5. Federalism and its implications for STI governance

Germany's federal structure makes governance more complex than in many other countries, which is a particular issue for R&I. The post-war constitution was designed to impede the centralisation of power at the national level. Rather than treating the *Länder* as regions or provinces of the nation-state, the constitution makes them responsible for government but delegates certain functions to the federal level, including defence, foreign policy, citizenship, health care and fiscal policy (including the task of raising federal taxes – a large proportion of which are remitted to the *Länder*).

Flowing from the logic of pre-eminence of the *Länder*, the "upper" or "revising" house in the parliament, the *Bundesrat*, comprises *Länder* government delegations whose size reflect their respective populations. Members of the "lower" house (*Bundestag*) are chosen in national elections using mixed-member proportional representation, normally resulting in coalition governments. The *Bundeskanzler*, whose role corresponds roughly to prime minister in other systems, is elected by the *Bundestag* upon the proposal of the president and subsequently appointed by the president.

Managing STI policy at both the federal and *Länder* levels entails co-ordination costs. However, there exists a clear and systematic division of funding responsibilities between the two levels, and policies are actively co-ordinated through the GWK. Strong regional autonomy promotes the development of diverse policies and approaches, providing opportunities for experimentation. Variations among *Länder* policy approaches can, for example, orient research organisations' thematic specialisations towards regional needs. Still, some national and European programmes do somewhat mitigate wealth imbalances among *Länder* in the development of regional policies, and the smart specialisation they impose on regional strategies is likely to increase their quality and specificity. Although levels of wealth, and the administrative capacity to develop and implement policy, varies among the *Länder*, the European structural funds ensure they all have regional innovation policies. At the national level, programmes like "Innovation and Structural Change" promote the development of regional innovation ecosystems (see Chapter 16 for a discussion on territorial inclusivity).

The disadvantages of the federal system that affect STI policy also tend to affect other domains, suggesting there is scope for reconsidering aspects of the division of labour. For example, maintaining data protection agencies at both the regional and national levels gives ample opportunity to interpret the 353 pages of the General Data Protection Regulation in 17 different ways, impeding innovation and undermining the domestic single market. It also leads to the fragmentation of procurement in areas of government for which the *Länder* have responsibility, such as procuring medical equipment. This is a long-standing barrier to innovation, which will become even more significant as the policy focus in STI shifts from supply to demand.

Correspondingly, harmonising standards and practices will not only produce efficiency benefits, but also benefits in promoting innovation.

The of decentralisation of German STI governance is an asset, insofar as it enables trialling or adapting various policy approaches to local circumstances. Approaches such as “smart specialisation” and lead-actor innovation can help regional authorities draw upon national strategies while adapting their interventions to local realities and needs. The autonomy of the *Länder* provides some flexibility and means that approaches such as regulatory sandboxes can be aligned at the regional level with industrial and technological needs and capacities. The challenge for governance lies in maximising the lessons from these localised approaches to achieve national objectives. The forum proposed in Recommendation 1 could enable a more holistic approach to utilising the lessons and best practices of regional-level approaches to STI, as well as support their diffusion to underpin more systemic innovation support.

14.6. EU-wide and international leadership of German STI governance

Germany’s domestic innovation system is both informed by external trends and an actor in those trends, given the size of its economy and the strength of its STI system. All national innovation systems are part of the global innovation system, and shaped by international technology and market developments. They are also connected with foreign direct investment; international technology transfer and collaboration; and trade relations, including global value chains.

Germany is the largest EU Member State, and its STI governance is set within the EU context. Germany plays a very significant role in the EU Framework Programme, as well as the European Cooperation in Science & Technology and Eurostars funding programmes. It is a key participant in the multilateral European R&D programme Eureka and in facilities-based co-operation, including the European Organization for Nuclear Research, the European Molecular Biology Laboratory and the European Spallation Source. In 2014, Germany was the first country to publish a strategy for participating in the European Research Area, including 40 nationally specific action points. It is a major player in the Europe 2020 strategy and the European Semester, which co-ordinate aspects of EU industry policy. Moreover, Germany has both the largest number of participations and receives the biggest share of the EU budget contribution in Horizon 2020. The competitive nature of the framework programme means that the strongest R&D performers at the national level also tend to win the biggest share of framework funding, so Germany’s large share suggests a strong convergence between R&D focal points at the German and EU levels. The German Space Centre, Fraunhofer and the Max Planck Society normally feature among the biggest beneficiaries of framework funds. The Fraunhofer Society typically has the largest network of collaborators within the programme, connecting German research with more EU R&D performers than any other body.

While Germany has the opportunity to play an influential role in future transitions at the EU level, the European Union will be critical to the future success of Germany’s innovation system. Several of the technological competencies needed to ensure the future competitiveness of the German economy – including in areas such as the decarbonisation of industry through the development of hydrogen-based energy generation – will require investment, research capacity and commercialisation at a scale beyond what individual countries can provide. Germany can take a leading role in steering transnational initiatives that help both its own economy and other economies. Given the importance of meeting challenges such as the sustainability transition, exploiting Germany’s strong international position could help expedite the development and commercialisation of globally significant innovations.

The current German debate on “technology sovereignty” focuses on key technologies (such as semiconductors, AI, future communication technologies, cybersecurity, quantum technologies and advanced materials) which benefit from an EU-wide effort that originated in the 1985 EU Framework Programme. A key question for German policy is whether Germany should pursue development and

capacity-building in such key technologies at the national or European level. Since such technologies are global in character, history suggests that working at the European level is key. However, the strong link between success at the national and European levels also means that Germany's ability to operate at the EU level depends crucially on strengths at the national level. These two levels are complements, not alternatives. There are precedents to Germany's engagement in EU-level efforts aimed at building sovereignty. The principle of subsidiarity[4] has been central in setting the agenda of the EU Framework Programme since its launch in 1985, with the framework only tacking issues of such magnitude that they are better handled at the European rather than national level. Thus, from the beginning, the European Strategic Programme on Research in Information Technology (ESPRIT) and Research and Development in Advanced Communications Technologies in Europe (RACE) programmes helped support European capacity in semiconductor and telecommunications technologies in the face of US and Japanese leadership, in order to ensure Europe's independence in procuring them (the framework programme was considerably less successful in supporting the European computer industry.)

To strengthen the European economy following the COVID-19 pandemic, the European Commission recently revived another co-operation instrument outside the framework programme, namely, Important Projects of Common European Interest (IPCEIs). These are member state-funded industrial collaborations for which public aid rules have been relaxed, allowing high subsidies for establishing manufacturing and other activities downstream of R&D. So far, projects have been established in areas including microelectronics, batteries and their supply chains, hydrogen, cloud computing and data storage, and health technologies. Germany is a prominent participant, as the current IPCEIs cover areas of great economic and technological importance to the German economy. IPCEIs are supposed to contribute to job creation, growth and European competitiveness, as well as strengthen the European Union's strategic autonomy by tackling market or systems failures, or addressing societal challenges. However, their governance has not been clearly specified at the level of the EU, and is not transparent. Liberalisation of the state aid rules for the IPCEIs also makes it possible for Member States to compete against each other, for example by providing subsidies encouraging companies to establish factories in their territories. Thus, public-private partnerships (PPPs) provide important opportunities for Germany to expand STI and industry policies at the EU level[5], benefitting from the resulting scale and collective industrial strength, but there is also scope to heighten these activities' support of societal goals, for example by contributing to more environmentally sustainable development.

Finally, several EU-wide tools can help build strengths in the German STI ecosystem. In recent years, the framework programme has grown to include PPPs. Horizon 2020 contains two PPP types: "Joint Undertakings", involving the European Commission, industry associations and companies; and "Joint Technology Initiatives", which are industry-led platforms pursuing collaborative R&D agendas.[6] Germany features prominently in both. However, devising a form of governance that ensures that such partnerships operate in both the public and the private interest has been an important issue (Luukkonen, Arnold and Martínez Riera, 2016[18]).

Besides its European leadership, Germany maintains many bilateral co-operation initiatives as part of its foreign scientific policy but has committed to promoting more multilateral formats, such as establishing a regular meeting of science and research ministers within the framework of the Group of Seven, first held in Germany in 2015. In 2013, Germany hosted the meeting of the newly created Global Research Council (BMBF, 2017[19]). Germany actively participates in international STI collaboration initiatives and international organisations. Within the OECD, it is active in the Committee for Scientific and Technological Policy, its Working Parties and the Global Science Forum. Within the United Nations Educational, Scientific and Cultural Organization (UNESCO), Germany is particularly engaged in the Global Action Programme on Education for Sustainable Development (2015-2019). It also supports vocational training through the Germany-based UNESCO-UNEVOC International Centre for Technical and Vocational Education and Training, and was an elected member of the United Nations Commission on Science and Technology for Development from 2016 to 2020.

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Endnotes

[1] Created in 1994 by merging the previous Ministry of Education and Research (BMBF), which had been responsible for basic and academic research, with the Ministry for Research and Technology (BMFT), which had focused more on applied and industrially relevant research, and had initiated the tradition of technology programmes.

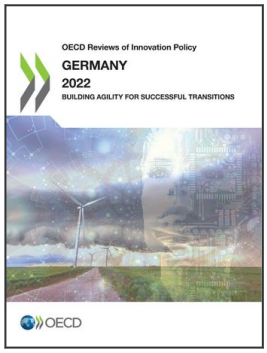
[2] Called the Ministry for Economic Affairs and Technology from 2005 to 2013, then the Ministry for Economic Affairs and Energy (BMWi) until 2021.

[3] Under the new government, the responsibility for domestic climate policy has shifted since December 2021 to the BMWK, which also has partial responsibility for STI policy (next to the Federal Ministry of Education and Research).

[4] This is embedded in the so-called Riesenhuber Criteria (named for the then-German minister for science), which determined what could be included in the Framework Programme. The list of criteria was later extended, for example to include the European Research Council.

[5] The Franco-German GAIA-X initiative to establish a powerful cloud business operating within European rules is another opportunity, though ensuring governance in the public interest may be even more difficult as it falls outside the EU umbrella.

[6] An earlier form of PPP – contractual PPPs (cPPPs), of which there were ten – was phased out in 2020.



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