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COUNCIL FOR TECHNOLOGICAL SOVEREIGNTY

Discussion Paper

Strategically securing Technological Sovereignty

Courses of action for Germany and Europe

Council for Technological Sovereignty

Disclaimer

The publication of the Council for Technological Sovereignty does not necessarily reflect the opinion of the BMFTR.

Strategic relevance of technological sovereignty

In the context of current geopolitical tensions, increasing global uncertainties, and intensifying systemic competition, technological sovereignty is gaining central strategic significance for states and supranational organisations such as the European Union. Technological sovereignty refers to the ability to guarantee access to the key technologies necessary for meeting societal priorities and needs at all times (see the box below for a complete definition). It also involves controlling key technologies across the entire value chain, from research and development, to manufacturing and deployment, and utilising them in a demand-oriented manner. This capability is a prerequisite for safeguarding international competitiveness, strategic autonomy in security policy, and societal resilience. Accordingly, technological sovereignty should not be regarded as an isolated challenge confined to research or industry.[1,2,3,4]

Technological sovereignty encompasses more than just access to technologies; it also involves the ability to identify, develop and utilise new key technologies, ensuring authority over critical digital infrastructures and fostering societal capacity for adoption.[5] Technological sovereignty can only unfold its full effect if new technologies are socially accepted and their use is widely regarded as beneficial. Global developments such as the COVID-19 pandemic, trade disputes, the semiconductor crisis, and geopolitical tensions have exposed the vulnerabilities of internationally interconnected innovation systems and global value chains.[6] Whereas efficiency gains through international division of labour long dominated the paradigm of economic optimisation, resilience and technological autonomy are now gaining increasing significance.

In response, leading economies are pursuing industrial policy strategies to secure critical competences. The US "CHIPS and Science Act"[7] (2022) and the Chinese "Made in China 2025" initiative[8] are an expression of targeted state technology control.[9] The EU has also taken initial steps with the "EU Chips Act"[10] and the "Strategic Autonomy" strategy[11] - however, there has so far been a lack of coherence and enforceability at a pan-European level. [2,3,4]

Building on these political efforts, all economic actors are likewise called upon to adequately incorporate the requirements of resilient supply systems and innovation chains into their strategic business decisions. Corresponding political incentive structures must be designed within the framework of political governance and the prioritisation of critical sectors.

TECHNOLOGICAL SOVEREIGNTY

Technological sovereignty is the ability to guarantee access to those key technologies that are necessary to implement societal priorities and needs at all times. This includes the use and further development of technologies and products, taking into account available resources and necessary services, making gaps visible and closing them where possible, and helping to set standards in global markets.

Technological sovereignty may also require the independent development of key technologies and technology-based innovations in Europe and the establishment of own production capacities within the value networks, if this is necessary to maintain the state's ability to act or to avoid unilateral dependencies, taking into account changing geopolitical boundary conditions. This requires the ability to understand and evaluate all relevant technological development and manufacturing processes, and the ambition to work on an equal footing with strategic partners.

Definition of the Council for Technological Sovereignty, 2021

From digital dependencies to a comprehensive technology strategy

The debate on technological sovereignty in Europe originated in growing concerns about digital dependencies on non-European platform providers. The realisation that global providers of digital infrastructures are driven by commercial goals, and are also influenced by the political agendas of actors outside Europe was at the heart of it. A salient example is provided by the U.S. Patriot Act[12] (2001), and later the CLOUD Act[13] (2018), which oblige American companies to disclose user data even when stored on servers outside the United States. These legal frameworks revealed a structural asymmetry in access to digital services and data.[14]

The political response to this structural uncertainty encompassed a series of European initiatives – including GAIA-X, the development of national cloud infrastructures, and the intensified promotion of open-source technologies. In the meantime, however, the debate has expanded to the entire technology stack: it now includes semiconductors, AI systems, robotics, quantum technologies, operating systems, as well as sustainable manufacturing and communication systems. The geopolitical implications of technological dependencies have further intensified. Illustrative examples include the acquisition of the robotics company KUKA by Midea (2016), and security policy debates surrounding communication technologies, particularly Huawei, in the context of 5G deployment. In addition, new dependencies are emerging in areas such as Open RAN[15], a 5G implementation option developed, among other purposes, to reduce reliance on infrastructure providers classified as untrustworthy. [7]

A turning point was the COVID-19 pandemic, which exposed the fragility of global supply chains across nearly all industries. Direct consequences for the technological and production landscape ensued, as illustrated in our position paper "Materials Research", [16] with regard to international raw material dependencies. At the same time, it became evident that the reliability of a global system of mutual dependencies, long regarded as a guarantee for reciprocal access to key technologies, appears fragile in the context of rising geopolitical tensions. As a result, this paradigm is increasingly being supplanted by the concept of strategic autonomy, which emphasises selective resilience, technological self-reliance, and geopolitically motivated security architectures.[9] This concept, however, entails an inherent tension: while strategic autonomy aims at resilience, there is a risk that, if overstretched, it may devolve into a form of economically self-damaging and inefficient autarky, in which market actors face diminished incentives for technological progress due to the absence of competitive pressure. This risk is particularly critical in sectors that benefit from high economies of scale and globally interconnected innovation systems, where regional duplication may result in excess capacity. We, therefore, recommend addressing this risk explicitly in discussions on measures to enhance technological sovereignty.

Technological and digital sovereignty: a differentiated view

Technological and digital sovereignty are often used interchangeably. A more nuanced examination, however, reveals fundamental differences:

Digital sovereignty primarily concerns the control and usability of digital infrastructures, data spaces, and software architectures, with particular emphasis on the data itself.

Technological sovereignty, by contrast, encompasses the entire technology portfolio – from the (further) development of technological ideas and concepts, through physical production and required resources, to deployment. Data and data-driven services are often not discussed as components of technological sovereignty. With the growing significance of data-driven technologies such as AI, whose development is critically influenced by the generation, collection, and usability of data, a tension has emerged in this regard.

This differentiation is not only analytically useful, but also politically necessary, as the regulation and characteristics of the respective markets differ conceptually in several respects. Digital autonomy often presupposes technological autonomy in the relevant key technologies – for example, in communication networks, AI, quantum communication, or the production of trustworthy hardware. We thus recommend considering both concepts in an integrated manner and strategically interlinking them, as their interactions – driven by data-driven products and interconnected services – are rapidly increasing.

Key technologies and strategic interdependencies

According to the German Federal Government's Expert Commission on Research and Innovation (EFI), key technologies are characterised by their high innovation density, diversity of applications, and strategic relevance for other technological fields and economically central sectors. Our analyses reveal a high degree of convergence in the key technologies identified across advanced economies. These include[3]:

- Microelectronics and semiconductors
- Artificial intelligence
- Quantum technologies
- Biotechnology
- Information and communication technology
- Energy and battery technology

Note that technological innovation dynamics increasingly emerge from the interaction of these key technologies. In our position paper "Smart Robotics", we have illustrated, by way of example, the strong interconnections and influences of numerous key technologies that converge in this application area, thereby opening up new technological domains with significant potential benefits.[17] Conversely, materials research represents an area whose innovations provide the foundation for numerous other research and technology fields – ranging from microelectronics and production technologies to biotechnology.[16,18]

As technological maturity increases, a shift in government funding strategy becomes necessary. While research in early phases with a low level of technological maturity typically takes place in specialized, often small scientific communities, and should be funded in a correspondingly basic research-oriented manner, more advanced phases require a stronger focus on product proximity, scaling and market potential. Government funding should thus evolve in line with technological maturity and, particularly in later stages of development, be designed to span multiple technologies and be product-oriented. With increasing maturity, technological uncertainties decrease, and economic actors benefit more directly from further developments. Knowledge exchange between actors also diminishes – while it is especially intensive in basic research, it becomes progressively limited in later stages. Only through an integrative and phase-appropriate funding logic. can innovation potential be harnessed across technological boundaries, and translated into economic impact.

In technology areas such as communications, which heavily depend on global interoperability, scalable business models, and international partnerships, standardisation and norms constitute a central success factor. The strategic definition and utilisation of standards are increasingly the subject of international competition, and must be addressed early and systematically. An internationally connected ecosystem of research and industry is crucial to securing influence in global standardisation bodies. In global technology fields, standardisation is not merely a technical foundation, but a strategic domain of action. International presence and targeted support for domestic actors across all relevant groups – providers and users, industry and academia – are therefore indispensable.

Strategic goals - operational deficits

Despite the multitude of European initiatives aimed at strengthening technological sovereignty, a coordinated and coherent comprehensive strategy is lacking. National unilateral actions, divergent investment interests, and a partially constrained EU governance framework result in fragmentation, inefficient allocation of resources, and insufficient industrial scalability.[3,4]

An example is the tension between ambitious flagship projects (e.g., IPCEI: Important Projects of Common European Interest) and the insufficient networking of national innovation ecosystems. The development of technological sovereignty in Europe can only succeed if priorities, resources, and institutional structures are coordinated at the European level – and maintained across legislative periods. The appointment of an "Executive Vice-President" for Technological Sovereignty, Security, and Democracy in 2024, which includes responsibility for the digital and "frontier" technology portfolio, and encompasses regulatory and security issues, is therefore a positive step. This momentum should now be leveraged to develop a comprehensive long-term strategy in dialogue with academia, industry, and member states. Proposals such as a European Council for Technological Sovereignty, supported by science and industry, are being discussed, but have not yet been implemented.[19]

At the national level, Germany possesses numerous strategy papers, for instance on the future of research, the data economy, or on AI. Nevertheless, we, like the EFI, criticise the low operational coherence, the lack of governance structures, and the frequently reactive nature of technology investments. [2,3,4]

Four issues are particularly prominent:

1. Germany competes for the same key technologies as global leading powers, yet lacks programmes equipped with comparable resources.
2. Strategic investments are lacking; instead, funding is provided on a short-term basis in line with current funding logics.
3. Disruptive innovations emerge at the intersections of multiple disciplines – yet interdisciplinary technology development is scarcely supported in a systematic manner.
4. Germany lacks a coordinated process, backed by strategic financial resources, for the early identification of (emerging) key technologies and their development.

From the Council's perspective, the BMFTR bears a particular responsibility to address these issues, and to seize the unique opportunity arising from the consolidation of research and innovation responsibilities, along with the resources from the special fund, within the framework of a strategy that is also effective in the long term. The HighTech Agenda offers many welcome approaches and demonstrates the BMFTR's clear intention to capitalise on this opportunity and to sustainably strengthen the innovation chain from research to market.

Strategic deepening: coordination and social integration

Germany's technological sovereignty requires a coordinated approach by policymakers, science, and industry. Funding strategies must be regularly reviewed, priorities adjusted, and new developments rapidly incorporated. We, therefore, recommend a cross-departmental focus on the following tasks:

- Ensuring Germany's strategic innovation competence through cross-technology scanning and evaluation of technology and innovation trends, identification of new key technologies, and assessment of the interdependencies between technological innovations and emerging business models.
- Development of proposals for a coordinated funding framework based on this strategic technology assessment.
- Identification of appropriate accompanying regulatory, technological, and innovation policy measures.
- Support of the implementation and consistent evaluation of the effectiveness of measures.
- Continuous assessment of Germany's technological sovereignty.
- Ensuring alignment with measures at the European level, advancing a policy for technological sovereignty as a central European objective.

Foresight processes for the early detection of technological potential represent a key instrument in this context. These must be systematically and promptly integrated into decision-making and implementation – analysis must not become a pretext for delaying decisions

Conclusion

Technological sovereignty is not optional, but a strategic necessity for Germany and Europe. It concerns not only economic and security interests, but also the value-driven shaping of future technologies to address major societal challenges.

Access to critical technologies has gained new urgency in the face of global upheavals. Germany and Europe require a comprehensive strategy that integrates political, technological, and societal dimensions. This necessitates continuous assessment and dynamic adaptation of content, structures, and instruments.

Only through systematically interconnected, evidence-based, and centrally coordinated cross-departmental policy within the federal government can technological sovereignty be ensured, and actively shaped over the long term.

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