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MÜNCHNER KREIS FUTURE STUDY IX

THE **DEEP TECH** MANIFESTO

Wake-up call for a sleeping giant

How we lead **DEEP TECH** to sustainable success in Germany

FUNDING PARTNER(S)

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MÜNCHNER KREIS FUTURE STUDY VOLUME IX

THE **DEEP TECH** MANIFESTO:

WAKE-UP CALL FOR A SLEEPING GIANT

How we are leading **DEEP TECH** in Germany to sustainable success.

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WELCOME SPEECH ON THE FUTURE STUDY “**DEEP TECH** FOR INNOVATION AND SUSTAINABILITY” BY THE MÜNCHNER KREIS

FOREWORD

Hubert Aiwanger
Bavarian State Ministry for Economic Affairs, Regional Development and Energy;
Deputy Prime Minister-President

The MÜNCHNER KREIS has already proven in its previous studies how forward-looking and innovative its members are. With the current study, it once again takes up a forward-looking topic: Deep Tech – the drivers of our technological progress.

Understanding the underlying mechanisms is particularly important. That is why the Bavarian Ministry of Economic Affairs was happy to support this research approach. Because we know: Bavaria’s greatest potential lies in global competition to produce innovations. Only by taking bold steps into new technological territory can we maintain our outstanding position in international competition. That is why the Bavarian State Government attaches such great importance to research and development.

And that is why we provide appropriate funds every year and network science and business in a targeted manner: We want to be at the forefront of topics such as AI, biotechnology or quantum computing.

The present study by the MÜNCHNER KREIS is not only about the question of how Deep Tech works. At the same time, it wants to provide the impetus to anticipate and use future-relevant technology earlier than before through refined methods.
The members of the MÜNCHNER KREIS have experience and outstanding expertise to bring us closer to this goal!

I would therefore like to thank the entire study team, all participants in the study and the MÜNCHNER KREIS for the initiative and concept. Their long-standing commitment and passion for the topics of the future are more valuable than ever in the face of current challenges.

Together, we are laying the foundation for Bavaria’s continued successful development!

FOREWORD TO THE MÜNCHNER KREIS FUTURE STUDY “**DEEP TECH** FOR INNOVATION AND SUSTAINABILITY”

Prof. Dr. Dr. h. c. Helmut Krcmar
Chairman of the Research Committee MÜNCHNER KREIS

Germany was once a model of technical excellence and engineering, and the world looked to us when it came to innovation, research and industrial production. We were the birthplace of breakthrough inventions, leaders in mechanical engineering, automotive engineering and chemistry, and our commitment to precision and quality was unmatched – a time when “Made in Germany” was considered a seal of quality. But in recent decades, I have watched with concern as other nations – first and foremost the US, but also emerging countries such as China – have not only caught up with us, but have overtaken us in many areas. While Germany looked proudly at its traditions and achievements, we have increasingly basked in complacency.

Tomorrow’s technologies provide solutions to the most pressing challenges of our time – from combating climate change to healthcare and energy security. But Deep Tech solutions in particular require courage, determination and, above all, long-term thinking that extends beyond the next economic period. This requires a willingness to break old patterns of thinking and support a new generation of innovators who are willing to push the boundaries of what is possible and proactively shape the future.

This study is therefore dedicated to the question of how Germany can become a leading Deep Tech nation. It sheds light on Germany as a business location in the context of the Deep Tech revolution and provides orientation for a sustainable future through technological innovations. Decision-makers in politics, business and science should receive impulses on how innovations can be specifically promoted and used sustainably.

FOREWORD

It is my hope that the MÜNCHNER KREIS Future Study IX will serve as a wake-up call – not only for the academic and industrial community, but for society as a whole. The results of this study are intended to help raise awareness of the opportunities and challenges of Deep Tech while fostering dialogue about the future of our technology direction.

As Chairman of the Research Committee of the MÜNCHNER KREIS, I am pleased with the result, which was made possible by the close cooperation and intensive exchange of numerous experts. My special thanks go to all participants in the study, the project management and the authors, who contributed with their commitment and expertise to gain valuable insights and lay the foundation for further discussions.

Germany was once a pioneer. It is time to revive this spirit of pioneering.

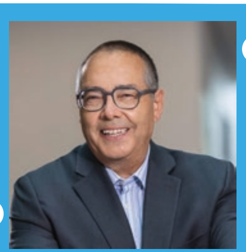
PARTNER STATEMENTS

Minister of State Hubert Aiwanger · Bavarian State Ministry for Economic Affairs, Regional Development and Energy

"Deep Tech stands for technological innovations that can fundamentally change our economy. Anyone who courageously opens up these new opportunities today will achieve sustainable success in the future. That is why we specifically promote the development and application of these technologies. The current Future Study by the MÜNCHNER KREIS sheds light on the connections and methods behind Deep Tech."

Prof. Dr. Dr. h. c. Helmut Krcmar, Head of the KrcmarLab at the TUM School of Computation, Information and Technology, Chairman of the MÜNCHNER KREIS Research Committee

"As a leading technical university, we actively contribute through research and education to ensuring that technological breakthroughs are not only developed, but also successfully put into practice.
In order to fully exploit the potential of Deep Tech, science, business and politics must act together – here the Future Study offers important orientation and recommendations for action. Especially in the field of Deep Tech, it is crucial to learn the necessary skills at an early stage and to develop innovative approaches to actively participate in shaping our common future."



Prof. Dr. Michael Dowling · Faculty of Business, Economics, & Real Estate; University of Regensburg, Chief Executive Officer MÜNCHNER KREIS

"Germany can become a successful 'Deep Tech' Nation. To this end, various ecosystems for 'Deep Tech' technologies need to be further developed. These technologies must then be successfully implemented in various fields of application. The MÜNCHNER KREIS Future Study IX: Based on empirical data and analyses, the DEEP TECH MANIFESTO has developed important recommendations for decision-makers in politics and business. The study will make an important contribution to the necessary changes in Germany."

PARTNER STATEMENTS

Jens Helmerich · Partner & Senior Manager; Leading Strategy@Tagueri

"Germany has all the capabilities and resources to bridge the gap between outstanding research and marketable products in Deep Technologies. We need to create and promote more space and enthusiasm for innovative solutions again. Above all, we need to stop labeling failure as failing. If we strengthen investments in key technologies and, above all, reduce bureaucratic processes – and this also applies to companies – we can once again achieve a leading position in the global technology landscape."

Ingobert Veith · Vice President and Head of Public Affairs & Communications at Huawei Technologies Germany

"Deep Tech is essential for tackling and solving many important issues of the future. The spectrum is huge and ranges from a sustainable energy supply to the digitalization of all areas of business and life. We believe that Germany, with its great industrial and innovation tradition, can be strengthened through global cooperation in the research, development and implementation of Deep Tech."

Dr. Rahild Neuburger, Operational Head of FS Information; Organization and Management; LMU Munich and Managing Director of MÜNCHNER KREIS

"With Deep Tech, the ninth of the MÜNCHNER KREIS future studies is also dedicated to a highly explosive topic for Germany and Europe as a business location. Based on numerous Interviews with experts, THE DEEP TECH MANIFESTO offers stakeholders clear orientation.
In order to master future economic and ecological challenges, it is crucial to think in terms of a Deep Tech ecosystem, to join forces, to drive innovation independently of pathways and to build up the necessary expertise."

PARTNER STATEMENTS

Prof. Dr. Johann Kranz, Head of the Chair of Digital Services and Sustainability
Ludwig Maximilians Universität München (LMU)

"Deep Tech innovations require us to escape the prevailing dictates of short-termism and path dependence in business, politics, administration, research and the capital market. That is why we are bringing together the opinions of various experts in the study to initiate a discussion on better framework conditions for sustainable Deep Tech innovations."

Dr. Philipp V. Ramin · Founder and CEO, i40 – the future skills company

"Our Deep Tech study clearly shows that: Education and Future Skills are the key to the success of Deep Tech innovations in Germany. In order to overcome the complex challenges and create new competitive advantages, it takes a jolt through our entire educational landscape: Learning in all phases of life, the de-crusting of the education system and training and further education geared towards the future. Only in this way can Germany survive in the global Deep Tech landscape in the long term and retain a leading economic role."

Marius Fiebig · Principal Director – Cross Industries, adesso

"As the largest IT service provider in Germany, we understand our responsibility to actively shape the digital future. We promote innovation, drive the development of new technical standards and work closely with our partners from science and industry to take the use of Deep Tech technologies to the next level. Our goal is to harness the full potential of these technologies to promote both economic and societal progress."

PARTNER STATEMENTS

Stefan Wagner · Managing Director SAP Labs Munich

"The findings of the MÜNCHNER KREIS Future Study IX are central to harnessing the full potential of AI for economic growth and social progress. That is why it is very important for us to support this study and actively contribute to the 'Deep Tech Turning Point'."

Thomas Feld · AI Technology Officer, Materna Information & Communications

"The public sector can significantly improve the framework conditions for Deep Tech innovations through targeted and proactive regulatory measures. Through a clear strategy for the application of breakthrough technologies, especially artificial intelligence, Deep Tech will become the driving force for health, transport, the environment, security and the public administration itself."

Dr. Sicco Lehmann-Brauns · Head of Digital Policy Germany, Siemens

"The Future Study illustrates the importance of cooperation in ecosystems.
The complementary cooperation of industrial companies with Deep Tech start-ups has great potential for both sides. This will strengthen the innovative capacity of Germany as an industrial location."

Dr. Katharina Wollenberg · Program Manager Industry-University Collaboration & Space Sector Advisor | SAP

"Germany offers the best conditions for Deep Tech innovations: Excellent research in AI, automation, quantum computing and space, highly skilled talents as well as strong industrial companies, including world market leaders. Nevertheless, the transfer of Deep Tech from the laboratory to industry is still too rare. The Future Study provides guidance on how we can make better use of our strengths, remove obstacles and survive in global competition."

Alfons Riek · Festo, Department of KH-GKT, Vice President

"In recent years, many industrial companies have focused on developing software as a sales product – a strategy that promises high margins with manageable investments. Deep Tech, on the other hand, stands for the exact opposite: High level of investments, long development times and considerable capital investment shape the path to success. I am all the more pleased that with this study we are providing a solid foundation for companies that want to take this path – be it out of necessity or strategic considerations."

Prof. Dr. Ali Sunyaev · Vice President of TUM Campus Heilbronn

"The TUM Campus Heilbronn is committed to the mission statement 'for the digital age' and focuses on the future of the digital age. Technological innovation is at the heart of this, but more crucial is the will to actively shape this future. This will is based on trust in one's own creative power and enthusiasm for digital progress – skills that we at TUM Campus Heilbronn strengthen in the personal development of students and develop in a professionally targeted manner as part of their studies."

EXECUTIVE SUMMARY

The development of Deep Tech innovations in Germany is crucial for the future innovative strength, competitiveness and sovereignty of our country. With Deep Tech, new economic impulses can be created and major social and environmental challenges can be mastered.

The findings of our study show that Germany (still) has the potential to occupy an international leadership position at Deep Tech. However, this requires a fundamental reorientation of the research and innovation focus in order to concentrate activities and investments more on Deep Tech.

Due to the transformative nature of Deep Tech innovations, their success is strongly dependent on the complex interaction of the stakeholders, consisting of the public sector, research institutions, companies and investors. Similar to nature, each of these stakeholders contributes to the functioning of the overall system in multiple roles. Conversely, this means that the stakeholders are highly dependent on each other. Accordingly, the success of Deep Tech in Germany requires a joint effort by all players in equal measure, as the weakest link determines the success of the overall system.

The following summarizes the main findings and recommendations for action. This Executive Summary is followed by **THE DEEP TECH MANIFESTO of the Future Study IX of the MÜNCHNER KREIS,** with which we want to shake up the "sleeping giant", Germany.

1.

1. Deep Tech is not High or Regular Tech

Deep Tech is the "bridge between science fiction and reality"[2]. Due to the high degree of scientific and engineering novelty, the enormous economic and social transformation potential and the high technological and market uncertainties, Deep Tech innovations are fundamentally different from "High Tech" or "Regular Tech" innovations. Not all stakeholders have internalized this.

Deep Tech-related research and development (R&D) requires different framework conditions and the cooperation of stakeholders in the ecosystem. Deep Tech innovations often have a so-called "**first of a kind**" (FOAK) character, which means that the development process is uncertain, takes a long time and requires a lot of capital, as necessary resources, ecosystems and infrastructures must first be built. There is therefore a fundamental difference between a company developing breakthrough Deep Tech innovations with a "**high risk, high reward**" profile, or being able to build on existing technologies, resources, ecosystems and infrastructure.

Accordingly, there is an urgent need to create and expand specific R&D support measures and support structures for Deep Tech that address the importance and opportunities offered by breakthrough innovations.

2. Deep Tech needs all stakeholders in the innovation ecosystem

Through the systemic and transformative effects of Deep Tech, the interplay of the ecosystem is critical to success. At every stage of the fragile development process from basic research to commercialization, Deep Tech requires the support and cooperation of various stakeholders in the ecosystem. Without this co-evolutionary adaptability and willingness of the stakeholders in terms of technologies, knowledge, skills, structures and processes, there is a risk that Deep Tech innovations will fail in this country.

Although Germany has internationally important tech ecosystems, their orientation, cooperation and interlinking must adapt more closely to the requirements of groundbreaking Deep Tech innovations. In addition, better use must be made of the existing opportunities for collaboration between start-ups, established companies and research institutions. Small and medium-sized enterprises (SMEs) in particular focus too much on their traditional markets, competencies and business models and show less willingness to cooperate and innovate. Low-threshold funding and education programs and tax incentives need to improve the skills and access to (digital) Deep Tech innovation among SMEs to address existing innovation and productivity deficits.

2 Bouarfa (2019) in Startup Insider Redaktion (2023)

3. Out of the Mid-Tech trap with Deep Tech

The German economy must recognize that the strong industrial core urgently needs a fundamental Deep Tech update in order to create new growth momentum and remain internationally competitive. Currently, the entire R&D and innovation sector is too focused on technologies (Mid-Tech), which are no longer expected to have too much innovation and growth potential. The backlog in the development and application of digital deep-tech innovations, especially in the field of AI, is particularly drastic.

In order to take advantage of new development and market opportunities in Deep Tech areas, more investment must be made in Deep Tech instead of Mid-Tech. To achieve this, the German economy must free itself from the dominant dictates of technological path dependency and economic short-termism and invest more in long-term Deep Tech-related R&D activities and the application of deep tech, both in absolute and relative terms. Public subsidies and tax incentives should also follow these principles and deliberately use more flexible tax incentives with minimal administrative burden for Deep Tech.

Closer integration of science and industry is also important in order to assess the application potential of research results at an early stage and to validate them in cooperation. Cooperation between established companies, science and Deep Tech start-ups must be intensified in order to jointly master the complex challenges and to raise the value creation potential in a collaborative manner.

4. Deep Tech needs the public sector as a strategic supporter and active partner

Due to their particular risk profile and transformative nature, Deep Tech innovations depend on the special support of the public sector for their breakthrough. Due to their profound impact on existing markets, resources and infrastructures, Deep Tech innovations often require regulatory adjustments and the support of the public sector, as existing market and technological conditions can hinder diffusion.

Politicians and administrators must be aware of this crucial importance for the success of Deep Tech and act as a catalyst for Deep Tech in the public interest through decisive and flexible action.

As far as possible, the interventions should be coordinated or worked out by policy-independent agencies and experts who have a profound technical and entrepreneurial understanding. This is the only way to ensure a necessary degree of objectivity, agility and flexibility in the decisions. Legislative periods, political calculations and lengthy decision-making processes must not be responsible for the failure of Deep Tech innovations in this country.

Deep Tech innovations emerge where they meet attractive state framework conditions. This includes, in particular, tax and financial support and the possibility of quick and uncomplicated regulatory and legal

adjustments, e.g. through experimentation clauses. The public sector is also challenged as an early consumer and user of Deep Tech innovations.
Existing hurdles for start-ups in tenders must be removed.
In administration, there must be a departure from the innovation-inhibiting practices of “over-legalization”, risk aversion and process integrity. Administration should act pragmatically, decisively, and flexibly on a case-by-case basis to enable Deep Tech innovation, rather than delaying and hindering it.

Administration should create a culture and incentives that encourage risk-taking when the opportunities outweigh the risks of Deep Tech Innovation. To this end, the administration must build up more technical and entrepreneurial expertise, e.g. through cross-change, and quickly become internationally competitive in terms of efficiency and digitalization.

These measures would have an important, urgently needed signaling effect for the entire Deep Tech ecosystem and would also make Germany more attractive for international capital and talent.

5. Leverage untapped capital and scaling potential

To be able to compete internationally in the Deep Tech sector, sufficient domestic capital must be available to finance Deep Tech. Although capital availability has improved, it remains modest by international standards.

In principle, there is sufficient capital in Germany, but it is hardly used for venture and growth financing. In order to change this, the restrictive investment rules for insurance, pay-as-you-go social security systems and tax conditions for capital-linked pensions should be reformed. The more the capital requirements for the financing of Deep Tech can be met domestically or within the EU, the more control, added value and prosperity remains in Germany and Europe. To this end, attractive opportunities for private and public co-investments and matching funds should be created in order to mobilize more capital for an internationally competitive financing of Deep Tech innovations. This is especially true for later, capital-intensive phases, in which German Deep Tech companies often face financing problems. Alternative debt financing options, such as venture debt, must be expanded for this purpose.

Furthermore, Deep Tech must be thought big and European. A common single market, a capital markets union, a European growth exchange, EU-wide coordinated support programs and uniform legal regulations (such as an EU-wide legal form for start-ups) are crucial to raise the scaling potential and improve European competitiveness and sovereignty.

6. Research excellence is not enough: The transfer must also be excellent

Fundamental research at the top international level is the breeding ground for Deep Tech. The German research landscape is internationally competitive in many areas. But there is a lack of financial and structural frameworks to advance further into the international top, which is important for Deep Tech. In order to create international flagships, the excellence strategy should therefore focus on the long-term establishment of a few international beacons. Closer integration of university and non-university research institutions could support this.

But excellent research alone is not enough. Without efficient transfer to industry, it remains ineffective. The transfer of research results into the application is a major vulnerability. In order to simplify the transfer process, which is essential for Deep Tech innovations, innovation-promoting standards and contracts for spin-offs, patenting and licensing should be developed and specified (e.g. IP-Transfer 3.0 Initiative). The long-term interest of society as a whole must be given priority over short-term institutional incentives. Barriers to knowledge-based spin-offs, such as legal concerns, unattractive spin-off conditions and lengthy negotiations, should be removed by capping the shareholdings of research institutions to a maximum of 10% across the EU and a standard participation via virtual shares without voting rights.

Existing deficits in the transfer agencies should be remedied by long-term and adequate financing commitments from the respective institutions in order to professionalize and accelerate the transfer processes. In return, research institutions should be encouraged by the sponsors to prioritize the “third mission” technology and knowledge transfer more strategically and operationally. To this end, financial support for research institutions should increasingly be linked to measurable transfer successes. This requires effective incentive mechanisms and precise criteria for measuring and evaluating transfer performance. For higher start-up dynamics, research institutions must improve the training, incentives, recognition and support of students and academic staff in the entrepreneurship sector.

7. Define national Deep Tech strategy

Due to the high level of investment and long development processes, Deep Tech stakeholders need stable, reliable framework conditions. To make this more successful, Germany does not need more declarations of intent and impulse papers, but a clear and time-bound deep tech strategy. This creates a clear strategic framework, offers planning security and sets priorities that deep tech players can use as a guide.

An independent panel of experts should steer this strategy process and involve and inform stakeholders and the public. The panel should regularly identify, evaluate and prioritize the future potential of key technologies based on economic, social and ecological criteria for Germany. This ensures that resources are invested as a priority in Deep Tech innovations that have the best cost-benefit ratio and the shortest payback period from a sustainability point of view.

The strategy should set objectives, performance indicators and milestones for public support measures. All direct and indirect public R&D support measures should be independently and transparently tested for effectiveness on the basis of these criteria. This enables evidence-based learning and ensures a targeted and disciplined allocation of limited resources.

THE DEEP TECH MANIFESTO: WAKE-UP CALL FOR A SLEEPING GIANT

2.

THE DEEP TECH MANIFESTO – Wake-up Call for a Sleeping Giant

In all discussions and workshops, an urgent appeal was formulated to create a wake-up call with the study. The Deep Tech stakeholders must be aware of the important roles and tasks they have for the successful development of Deep Tech innovations. In addition, understanding the special requirements and necessities of Deep Tech is crucial.

All stakeholders are called upon to critically question established paths and patterns of action and, whenever necessary and possible, to adapt quickly and flexibly to the requirements of Deep Tech. In view of the great international development dynamics and support for Deep Tech, stakeholders in Germany and the EU must adapt to the power of change in established industries and emerging areas and help shape this process in order to be able to exploit the potential applications. The stakeholders in this country are still often too hesitant and slow to act.

The German Deep Tech ecosystem can only be as strong as its weakest link. To seize the opportunities of Deep Tech, it takes stakeholders in business, science, politics and administration, investors and civil society to approach groundbreaking, novel Deep Tech innovations in a more ambitious, risk-taking, experimental, pragmatic, digital, open and progress-affirming way.

Deep Tech is *the* opportunity for Germany to create new growth markets, gain technological sovereignty and master pressing social and ecological challenges. Germany still has the resources to be one of the leading nations in the field of Deep Tech. But the “Window of Opportunity” is getting smaller and the need for action is greater.

This manifesto will shake up the sleeping giant Germany, outline a vision of the future and move all stakeholders and the public to work together on the new Deep Tech Nation Germany.

The manifesto invites all Deep Tech players and civil society to join the discussion in the hope of further fueling the current debate on a sustainable, progress-oriented and innovative Germany. After years of perceived slumber, it’s time for a bold new dawn in the age of Deep Tech.

1. From short-sighted ego system to long-term oriented ecosystem:

Whether investing in R&D, short-term profit maximization or political objectives: The fixation on quick success is omnipresent. On the other hand, in order to successfully develop Deep Tech innovation through the long and uncertain development process to market maturity, all innovation stakeholders consisting of companies, science, investors and the public sector must see themselves as long-term "gardeners" of their ecosystem, who work closely together to bring the rare Deep Tech seeds to bloom for the benefit of the entire ecosystem. Due to its transformative nature, Deep Tech innovations require a flexible and supportive ecosystem. If key stakeholders delay necessary change processes, do not engage with new technological and institutional requirements or do not adapt existing knowledge and skills, these ecosystems and new value creation opportunities will not arise in Germany.

2. The state as a trailblazer and proactive supporter

The public sector must be aware of its crucial role in Deep Tech and accordingly, as an advocate, investor, trailblazer and pioneer, promote Deep Tech from basic research to application with determination and foresight and make it possible despite headwinds. The public sector is not only required to act as an "enabling" legislator, but must see itself as a trailblazer in the application and support of Deep Tech and create targeted demand if the ecosystem is too sluggish.

3.

Dare to have more of a “moonshot” mentality

The stakeholders of the ecosystem must abandon their technological restraint and move away from the incremental “small steps approach”. The focus needs to shift more from optimizing existing technologies and systems to radically new, forward-looking technologies that have the potential to unleash great disruptive power. Coupled with a positive failure culture, a greater focus on entrepreneurial risk and a healthy self-confidence based on existing strengths, Germany will tackle more “moonshot” projects. To this end, we call for a significant increase in the willingness to invest and take risks in Deep Tech, supported by accompanying government measures.

4.

Our industrial core is an opportunity, but not a life insurance policy

The pressure for change in German core industries is growing. Change fatigue, fear of loss and lack of pressure to change have led to years of stagnation, which is now reflected in low productivity and growth. The German economy has become too static and too few newly founded companies manage to shake up the status quo and create growth. To this end, the industrial core of the German economy needs an update, in particular through long-term and comprehensive R&D investments in Deep Tech, in order to break away from path dependency and realize the value creation potential of key technologies. Small and medium-sized companies in particular often lack innovative strength, digital competence and a focus on future technologies. The German economy needs to develop and apply more Deep Tech to increase productivity and open up new business models and sales markets – this requires the development of new skills and a corresponding learning culture among employees and managers.

5.

Digital deficits put the brakes on Deep Tech

Digital technologies are accelerating the development of Deep Tech across all sectors and expanding the scope of solutions that were possible so far. Germany's digital competence deficit manifests itself in a lack of digital skills and infrastructures to take advantage of the opportunities that present themselves. Stagnating productivity, competitiveness and patent numbers are an expression of the digital deficit, which is reflected not least in the administrative modernization that has hardly been noticeable for years. Deep Tech innovations emerge where the state and administration function efficiently and are technology-savvy.

6.

No progress without leeway

In order for Deep Tech innovations to develop their economic and social progress potential, the institutional and social timidity, reluctance and risk aversion must be overcome. Over-legalization, rigid processes, narrowly defined regulations and the exclusion of entrepreneurial risks nip groundbreaking innovations in the bud. More support is needed for experimental action in politics and administration and risk-taking companies that use these freedoms.

7. No sovereignty and security without Deep Tech

In order for Germany and its European partners not to lose their ability to shape key technological areas in the face of geopolitical polycrises and uncertainties, the promotion of Deep Tech must be strengthened. Deep Tech is an important part of our technological sovereignty and should be regarded as part of our security policy. Accordingly, the strict separation between military and civilian research should be abolished. But all this should not lead to isolation, because Deep Tech needs value-driven, international cooperation.

8. Solve capital blockages, share risks, multiply successes

The general German reluctance to invest in high-risk, high-return investments makes Deep Tech financing difficult. Instead of leaving returns to international pension funds and investors, more prosperity should remain in the country and Deep Tech's high capital needs should be met more through domestic capital. This requires urgent reforms of the restrictive investment rules for insurance, social security systems and tax incentives in order to mobilize more capital for investment in Deep Tech. A sovereign wealth fund on an international scale should also be set up, whose funds will be used, among other things, to expand existing state investment vehicles such as the KENFO[3] , HTGF or DTCF. Since Deep Tech innovations are associated with high uncertainty and risks, the public sector must be prepared to shoulder these risks together with private investors. Risk and revenue sharing mechanisms such as co-investments and matching funds mobilize more capital for internationally competitive financing of Deep Tech.

3 The Fund for the Financing of Nuclear Waste Management (KENFO) is a state fund in Germany that is responsible for financing the long-term costs of nuclear waste management.

9. Deep tech does not need broad-based promotion, but a top-class sports approach

Similar to sports, there are only a few Deep Tech companies that can make it to the top of the world. The training, conditions and support of the environment are fundamentally different in elite sports from those in grassroots sports. However, this is exactly what we are trying to do in R&D and innovation policy: With wide-ranging funding, cutting-edge research in the Deep Tech sector and groundbreaking innovations. In order to make Germany attractive as a research location for cutting-edge Deep Tech research, appropriate financial and structural conditions must be created at the highest international level. This also requires a mentality that is geared towards achieving a global leadership position and consistently promotes the rare Deep Tech ideas with potential. This can set a spiral of success in motion, because successful Deep Tech innovations create a positive internal and external perception, ensure growing prosperity and better living conditions, attract more talent, create experience and a network of innovation players, who in turn promote and develop new Deep Tech innovations.

10. Dust off the positive narrative of progress

Deep Tech innovations will only emerge if all innovation stakeholders oppose the widespread technology skepticism and increasing hostility to science in society. The positive effects of technological progress, but also its challenges, must be communicated and weighed openly and perceptibly in a transparent dialogue in order to create trust, acceptance and enthusiasm. It should also be emphasized that technological change cannot be delayed nationally, but that we can help shape it if we have the necessary knowledge, willingness and resources.

11. A limited mindset produces limited results

Parochialism at the federal, regional and national levels is a barrier to Deep Tech innovation in Europe. We have to admit that we as a country are too small to stand alone in a polycentric world order. We need our European partners, which is not incompatible with national strength in the Deep Tech sector. To this end, regional and national efforts at EU level must be devised and more closely linked between the EU member states. These efforts need to be more prioritized and effective to ensure that funds are channeled into technologically and economically forward-looking Deep Tech areas where the EU (in cooperation with other value partners) can realistically lead the way.

12. Excellent education and research today is the breeding ground of Deep Tech tomorrow

The power of innovation is the basis of our prosperity. Their source is in the minds of the people who work here. This human capital must systematically and dynamically adapt to new requirements and findings. This is not just a task for the state; the economy and all employees are also required to continuously expand and update their knowledge and skills. It also requires systematic and comprehensive training ("technology literacy") in all parts of society in order to create a better understanding and to counteract excessive skepticism. The years-long decline in STEM[4] achievement also calls for fundamental reforms to the school system. Deep Tech needs enthusiastic top talents from home and abroad.

4 Science, Technology, Engineering and Mathematics

13. Cutting-edge research not transferred means forward-looking results are wasted

Financial support for research institutions must be linked more closely to transparently measurable transfer successes. The transfer efforts of research institutions urgently need to be professionalized, standardized and bundled. To this end, the basic financing for the transfer area must be increased and legal obstacles reduced. This also requires appropriate, binding targets that create clear incentives for transfer.

14. Set and measure national research and innovation objectives:

Some countries in Scandinavia develop a national research and innovation strategy at the beginning of a legislative period, involving broad, open expert consultations. These strategies are backed up with concrete measures and measurable goals, not with soft declarations of intent and impulse papers. We should follow the example, because innovation stakeholders need clarity and planning certainty about the future strategic direction. Research funds are to be used specifically for the development and application of key technologies, which are continuously evaluated on the basis of objective economic, social and ecological criteria. The public is also better involved and informed by this process. An independent panel of experts should be set up at federal level to continuously assess key technologies and provide advice on how to deal with them. And this should become an ongoing focus of the EFI's reports.

15.

Understanding data as a breeding ground and fertilizer for Deep Tech innovations

Data is an important foundation for Deep Tech innovation. High data availability must be the norm in order to meet the requirements of a modern, data-driven business and research location. It does not require less data protection, but a new data ethic that combines data use and sovereignty. The use of “Privacy Enhancing” technologies also has the potential to prevent data protection from inhibiting innovation. A clear legal framework and standards for responsible use and sharing of data, secure data infrastructures and data alliances are necessary.

16.

Tax incentives for Deep Tech instead of ever new funding programs

Instead of further differentiating the funding jungle at state, federal and EU level, the number of funding initiatives should be reduced and resources pooled. In addition, funding should be promoted and financed more quickly and without bureaucratic impediments. The promotion of companies should be strengthened through tax incentives for R&D, which primarily promote the application and development of future technologies with great innovation potential. This speeds up investment decisions and eliminates bureaucracy.

17. Promote lateral moves and career changes!

In order to improve networking and exchange between business, science, politics and administration, temporary and longer-term changes should be part of the career-promoting standard. Lateral moves increase mutual understanding and trust, enable new impulses and knowledge transfer, and create a space for continuous dialogue and closer cooperation between the stakeholders. This means a shift away from linear career paths towards a high degree of interdisciplinary integration and further development.

18. No sustainable development without Deep Tech

Without groundbreaking innovations, a return to the safe sphere of action is impossible for humanity. Deep Tech can be used to address major social and environmental challenges. To this end, possible social, ethical and ecological effects must be taken into account in the early development phase of Deep Tech without prematurely stifling technological developments. We need groundbreaking innovations that produce sustainable solutions in areas such as energy supply, materials, production methods, mobility, agriculture or health. On the corporate side, the potential of Deep Tech should be more strongly integrated and prioritized into strategic objectives in the context of a holistic sustainability analysis (ecological, economic, social).

INTRODUCTION AND BACKGROUND

The principle of “Future Study” of the MÜNCHNER KREIS

The MÜNCHNER KREIS is an interdisciplinary forum dedicated to the discussion of the social, economic and technological challenges of digitization as a neutral platform. As an independent organization, the MÜNCHNER KREIS brings together experts from science, business, the public sector and civil society to jointly address future issues and develop practical solutions. The work of the MÜNCHNER KREIS is characterized by a close integration of research and practice, with a focus on the design of technological and digital innovations that maximize both social and economic benefits.

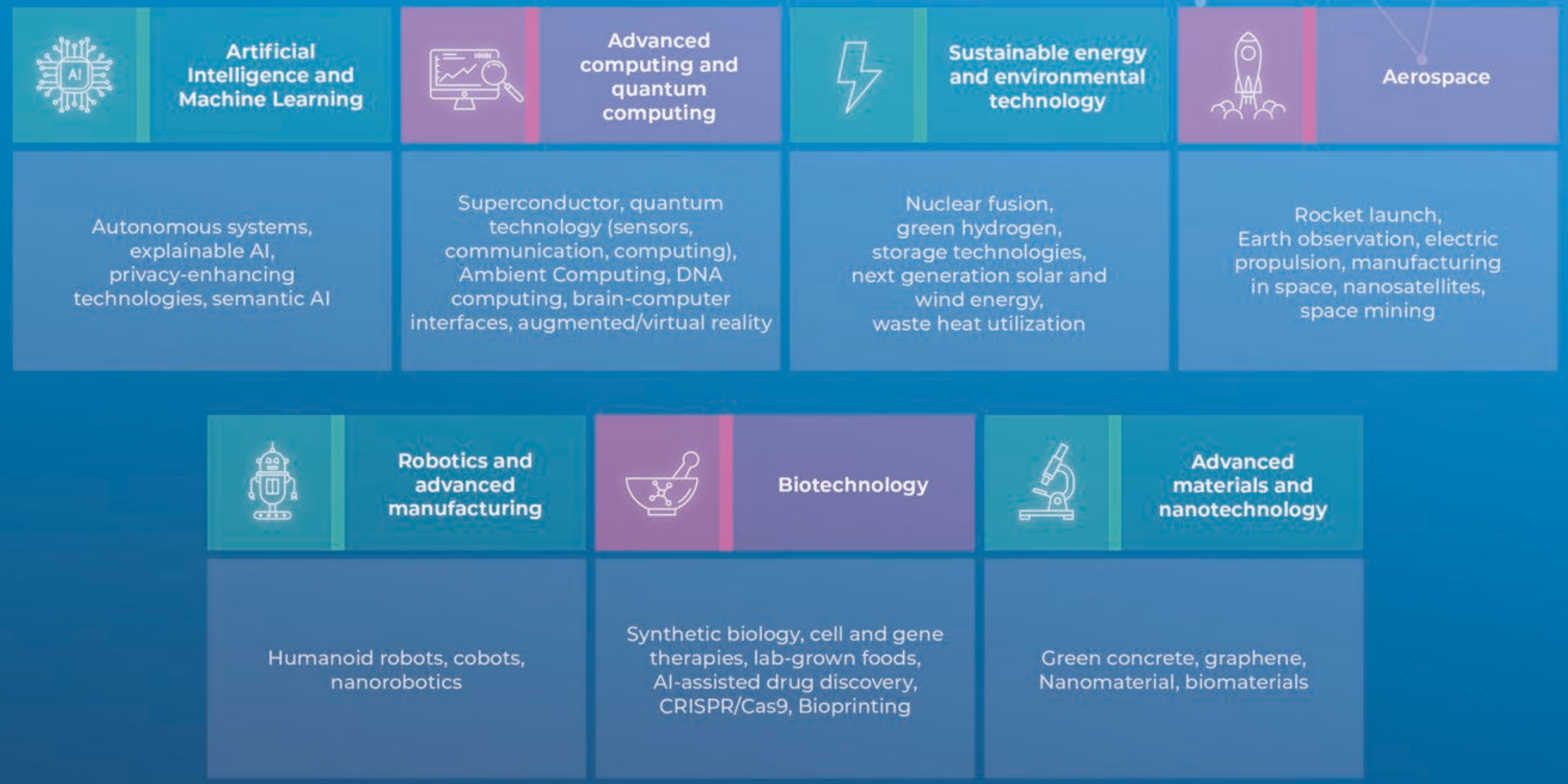
As part of its activities, the MÜNCHNER KREIS regularly conducts future studies to shed light on current developments and trends in key technologies. With the “principle” of future studies, the MÜNCHNER KREIS seeks to provide orientation in a world of digital transformation and disruption. As a leading independent platform for orientation for designers and decision-makers in the digital world, the MÜNCHNER KREIS initiates and coordinates future studies on current or fundamental issues in order to **“shape the future, not to endure it.”**

3.

The view into the future deliberately goes beyond the medium-term perspective of three to five years, which can hardly be influenced, in order to do justice to his goal of orientation and the design mandate for our future. With this Future Study, the perspective of the MÜNCHNER KREIS extends somewhat beyond the digital transformation. On the one hand, to take into account the high general importance of Deep Tech for the economic and sustainable development of Germany and, on the other hand, to shed light on the effects and development paths of digital technologies as drivers, accelerators and pioneers of Deep Tech innovations in various areas of application.

In addition to fundamental advances in the field of digital technologies such as artificial intelligence (AI), quantum computing, virtual and augmented reality (VR/AR/Blockchain), digital technologies are essential building blocks for groundbreaking breakthroughs in other domains such as medicine, biology, energy, production technologies, robotics or materials science (see Fig. 1). Precisely from the point of view of **interdisciplinary convergence and recombinability of digital technologies with other vertical scientific and industrial sectors**, the urgency of an integrative and holistic analysis of the necessary framework conditions, priorities and guidelines for realizing the economic, social and ecological potential of Deep Tech and balancing possible conflicting goals arises.

Figure 1: **Current Key Fields and Examples of Deep Tech Innovations**



Source: Based on EIT (2023) and McKinsey (2024)

> *"It is therefore exactly the right time to deal with the Deep Tech framework conditions, priorities and guidelines in Germany and the EU and to show development paths for establishing Germany as a world-leading location for Deep Tech in the future,"* states **Prof. Dr. Dr. h. c. Helmut Krcmar** (Professor at the Technical University of Munich and Head of the Research Committee of the MÜNCHNER KREIS).

> **Dr. Michael Lipka** (Senior Manager Technology Strategy, Huawei) adds that the "*driver for the claim of technology leadership must be a societal consensus that includes a target picture for future prosperity. However, in addition to a promise of prosperity, a Deep Tech vision must also provide the certainty that the global challenges to protect the planet can be overcome. Thus, it is a global task.*"

In order to achieve the goals of the Future Study IX, we spoke to leading experts from the four central stakeholder groups of the Deep Tech innovation ecosystem – research institutions, the public sector, companies and investors. Based on the interviews and discussions in the circle of the study partner consortium, the study analyses and shows what measures are needed to bring Germany, as an internationally important Deep Tech nation, to new economic strength and to solve pressing social and environmental challenges. The study paints a picture of the status quo of Deep Tech for innovation and sustainability and derives measures for the future that will enable a Deep Tech revolution in Germany and the European Union (EU).

An important characteristic of the Future Study is to carry out the research process consistently together with a partner consortium from business, science and politics. The MÜNCHNER KREIS' Future Study has been pursuing the principle of interdisciplinarity since the first phase in 2008, because it contributes to a versatility of perspectives and to controversial discussions. In the circle of the partner consortium, the results are continuously discussed, further developed, condensed and enriched with new ideas and starting points. In this iterative process, the partners deliberately take on different roles in order to view the topic from different perspectives.

With this approach, the MÜNCHNER KREIS remains true to its principle of illuminating relevant topics of the digital world from different perspectives, critically examining them and thus providing orientation. The aim is to analyze and anticipate the changes and necessary adjustments arising from (digital) Deep Tech innovations on the basis of a status quo analysis and to provide constructive recommendations for action through critical discussions with experts in order to shape the future proactively, not passively.

The starting point for the Future IX: The Deep Tech Opportunity for Germany

Quite a few experts believe that now is the ideal time for a wave of Deep Tech innovations. Both the need and opportunity have never been greater. It is therefore not surprising that Deep Tech has increasingly become the focus of politics, business and venture capitalists in recent years.

For Germany in particular, Deep Tech is a great opportunity to master the major future challenges such as industrial transformation and competitiveness, sustainable energy supply, climate protection, an aging society, and not least the digital and technological sovereignty that is fundamental in the light of geopolitical tensions. Without technological breakthroughs, the (geo) political, social and environmental challenges can hardly be solved without losses in prosperity, competitiveness, quality of life, security or freedom.

Deep Tech is the driving force for the necessary groundbreaking innovations and thus a crucial lever for sustainable development and resilience of our country. The promotion of Deep Tech innovations has become the central factor for the future development of the country, as they can both provide new economic impetus and enable adaptations to changing geopolitical, social and climate-related framework conditions.

With the Phase IX Future Study, the MÜNCHNER KREIS and its partners want to create an understanding of Deep Tech and its special requirements and potential. Based on the empirical findings, the study derives concrete impulses for action and measures to create conditions that unleash Germany’s Deep Tech potential. In this way, the Future Study IX of the MÜNCHNER KREIS wants to make a contribution to initiating the necessary changes and a discourse among all stakeholders.

METHODOLOGY

4.

Research design:

For the Future Study IX, an empirical-qualitative approach was chosen to gain in-depth insights into the complex interplay of motivations and actions of the key stakeholders in the Deep Tech innovation ecosystem in Germany and Europe. The methodology included semi-structured expert interviews, which make it possible to gain both in-depth technical insights and personal assessments of the stakeholders.

Data collection:

The data collection included 60 expert interviews and Workshops conducted between March and October 2024. These surveys made it possible to capture a variety of perspectives from the four key stakeholder groups of the innovation ecosystem. The interviews were carried out in a semi-structured manner. Specific guidelines adapted to the respective actor group served as the basis for the interviews, but left room to respond flexibly to the answers of the interviewees and to be able to ask spontaneous questions. This form of survey methodology makes it possible to both address defined topics and gain unexpected insights, allowing for a deeper understanding of the topic.

Sample:

The participants of the interviews were selected via a "snowball sampling" procedure. Based on an initial group of recognized experts, further relevant participants were identified through recommendations. This iterative process was continued until the theoretical saturation was reached, during which no more substantially new insights were gained. The experts came from various fields, including university and non-university research institutions (10 experts), established companies (27 experts), public sector stakeholders (14 experts) and private and institutional investors (9 experts).

Expert interviews		
Research institutions	**10**	Experts
Company	**27**	Experts
Public sector	**14**	Experts
Investors	**9**	Experts

Data analysis:

The interviews were literally transcribed and evaluated qualitatively and in terms of content analysis using the MAXQDA Software. The analysis process involved several steps: First, relevant text passages were marked and provided with descriptive codes. In the next step, the codes were grouped into larger categories and their correlations were examined. Finally, the most important topics that are particularly relevant for the study were identified. These topics were discussed in further workshops and placed in the context of existing study results. By triangulating with additional data sources and case studies, the findings are deepened and illustrated.

5.

DEEP TECH TERM AND NARRATIVE

The precise definition and demarcation of the Deep Tech concept is essential for a uniform understanding and a targeted, adapted promotion of innovations with Deep Tech characteristics. In particular, the distinction between Deep Tech and High Tech is important from the experts' point of view. Without a clear, unified definition, there is a risk that funding programs, investments or policy measures will be misdirected and the transformative potential of Deep Tech will not be exploited. In the following, we will focus on the definition of Deep Tech, the distinction from High Tech, the peculiarities of Deep Tech companies and the meaningfulness of the narrative behind Deep Tech.

The Six Key Features of Deep Tech

Originally, one of the first essential definitions of the Deep Tech term came from Swati Chaturvedi, CEO of the Deep Tech investment platform propel (x)[5], who, with a LinkedIn post in 2015, distinguished Deep Tech start-ups from normal tech start-ups by emphasizing that "Deep Tech companies are based on a scientific discovery or a real technological innovation." Similarly, but more broadly, the European Commission defines[6] Deep Tech as innovation based on cutting-edge science, technology and engineering, often based on combining advances in physical, biological and digital fields to create transformative solutions to global challenges. The European Investment Bank (EIB) simply describes Deep Tech as a disruptive innovation that is changing the way people live.

In addition to this excerpt of definitions, a large number of studies have taken up the term and developed it further over time. Our content analysis of 20 key studies on Deep Tech identified six key features of Deep Tech that were cited in at least 50% of the studies analyzed.

1. **High degree of novelty and innovation:** Deep Tech includes technologies that are new and unique and represent significant technological advances over existing solutions.

2. **High market and technological uncertainty:** The development and adoption of Deep Tech comes with significant uncertainties, both in terms of technological feasibility and market adoption.

3. **High financial investment requirements:** Developing Deep Tech requires significant financial resources across the innovation process.

4. **Substantial technological progress:** Deep Tech offers significant technological advantages over existing technologies and has the potential to fundamentally change existing markets or create new markets.

5. **Long development times until market maturity:** The development of Deep Tech involves a great deal of time before the technologies are ready for the market.

6. **Solving societal and environmental challenges:** Deep Tech aims to solve significant societal and environmental challenges, such as health, climate change, energy, or nutrition.

5 Chaturvedi (2015)
6 European Commission (2024)

Figure 2: **Key characteristics of Deep Tech**

1. **High level of novelty**
   Deep Tech encompasses technologies that are new and unique, representing significant technological advances over existing solutions.

2. **High market and technology uncertainty**
   The development and adoption of Deep Tech is associated with significant uncertainties, both in terms of technological feasibility and market acceptance.

3. **High financial investment requirements**
   The development of Deep Tech requires significant financial resources over an extended period of time.

4. **Substantial technological progress**
   Deep Tech offers significant technological advantages over existing technologies and has the potential to fundamentally change existing markets or create new markets.

5. **Long development times until market maturity**
   The development of Deep Tech requires a great deal of time before the technologies are ready for the market.

6. **Solving societal challenges**
   Deep Tech aims to solve significant societal and environmental challenges, such as health, climate change, energy or nutrition.

Source: MÜNCHNER KREIS Future Study IX: THE DEEP TECH MANIFESTO: Wake-up call for a sleeping giant

Other features of Deep Tech that remained just below the 50% threshold included the high barriers to market entry and the development of Deep Tech through (re-) combining knowledge and technologies from different disciplines.

Based on the results of the analysis, we define Deep Tech innovations as a category of radical and disruptive technology innovations characterized by new, groundbreaking intellectual property, significant technological advances, significant market and technology uncertainty, large capital needs and long development times, and a focus on key societal and technological challenges. Deep Tech is revolution, not evolution.

Deep tech innovations and start-ups differ in many respects from innovations and start-ups that build on established technological resources and infrastructures (tech-based). Technology-based start-ups mainly rely on the business model as a differentiating factor and not on a scientifically and technologically sound competitive advantage. Technology-based innovations rely on easily manufacturable or replicable technologies without significant technological progress. At Deep Tech, on the other hand, groundbreaking new technologies act as core drivers (tech-driven). Consequently, technology-driven Deep Tech innovations and start-ups cannot build on existing resources, ecosystems and infrastructures to the same extent.

However, they can build on established processes and structures, as **Dr. Michael Lemke** (Chief Security Officer, Huawei Germany) points out:

"*Existing resources, ecosystems and infrastructures are nevertheless fundamental in that they offer a "blueprint" for supporting Deep Tech-driven innovations in the field of established technological principles. The entire global system of ensuring trust in new technologies alone can serve as an example, because all topics (from digitization, autonomous driving, the introduction of AI) ultimately also rely on this structural support. The conscious decision on the application, further development or targeted creation of security structures in a synthesis of scientific approach and practicable application is therefore indispensable for Deep Tech development.*"

Findings: Deep Tech innovations require significant changes and adjustments to resources, ecosystems, infrastructure, and the regulatory framework.

Furthermore, Deep Tech has different characteristics compared to "Regular Tech"-based innovations (see Fig. 3). Deep Tech innovations are characterized by the novelty of scientific or engineering breakthroughs. Due to the "FOAK" character, the transfer into a marketable product or service line is associated with greater risk than with technology-based innovations and requires greater adjustments in the innovation ecosystem. In contrast, Deep Tech innovations have a lower risk of competition because the barriers to entry for potential competitors are higher due to the protection of intellectual property (IP) and high initial investments in infrastructure, facilities and personnel. However, it takes longer to commercialize Deep Tech innovations. In addition, the close connection of Deep Tech innovations to science and basic research, as well as their broad applicability, ensures greater knowledge spillovers than technology-based innovations.

Figure 3: Difference between Deep Tech and Regular Tech innovation

	Time to market	Technology uncertainty (Scientific uncertainty / Scalability)	Amount of capital required	Market entry barriers for competitors	Knowledge spillover	Ecosystem adaptation needs
Technology-based innovation	SHORT	LOW	LOW-MEDIUM	LOW	LOW	LOW
Technology-driven Deep Tech innovation	LONG	HIGH	HIGH	HIGH	HIGH	HIGH

Green: Advantage for innovators (SHORT, LOW, LOW-MEDIUM in the technology-based row; all HIGH values except technology uncertainty and capital in the Deep Tech row)

- Advantage for innovators
- Disadvantage for innovators

Source: Based on EU Funding Playbook (2024)

The risky path of Deep Tech start-ups: Survival in the Valley of Death

The journey from Deep Tech startups to the development of a marketable, successful product or service is characterized by several critical phases. Even more than Regular Tech, the Deep Tech development process is characterized by high uncertainty and risk; both in the R&D phase, in which considerable financial resources are required and there is always the threat of rejection or failure of an idea, and with regard to the market, as the demand for a still immature solution cannot be predicted. This places special demands on Deep Tech start-ups, which are regarded as essential engines of Deep Tech due to their often highly disruptive nature. In addition, Deep Tech start-ups have an increased need for highly qualified personnel and their added value is more often based on hardware-based products and intellectual property.

> According to **Dr. Jan Götz** (Co-CEO & Co-Founder, IQM Quantum Computers), the so-called Double PhD Problem arises: *"In areas like quantum computing, we see what I call the 'Double PhD Problem': You need experts who have both a deep understanding of the specific application, be it chemistry, physics or another discipline, as well as in-depth technical know-how in the field of new technologies. Without this dual qualification, it will become increasingly difficult to master the complex challenges of these technologies."*

The intensive R&D processes lead to long development cycles, which make market entry and growth riskier and more protracted compared to Regular Tech start-ups. Accordingly, the investment horizon of Deep Tech investors must be more long-term. The phase of the Valley of Death between the confirmation of the technological functional principle (proof-of-concept) and the market introduction of new technologies is particularly critical within the innovation process. At this critical stage, many Deep Tech innovations fail because of a lack of funding, resources, and support to bring the technology to market. From the point of view of the technology readiness level[7] (TRL), the Valley of Death typically begins at TRL 3–4 when the functionality of the technology has been demonstrated in the laboratory and extends to TRL 7 or 8 when tested in a real environment. The Valley of Death is particularly pronounced in the transitional phases of TRL 4–6.

The Valley of Death is particularly "deep" in Deep Tech innovations that require not only significant financial investment but also a complex innovation ecosystem. Companies and start-ups that want to commercialize Deep Tech innovations must overcome collaborative challenges in addition to technological and financial risks in order to win the support of suppliers, customers, partners and stakeholders. In this phase, many Deep Tech innovations fail because the necessary changes in infrastructures, laws or capabilities do not happen or do not happen fast enough. This means that Deep Tech start-ups are particularly dependent on a supportive ecosystem, as Fig. 4 illustrates in the respective development phases.

[7] NASA (2023)

Figure 4: **Deep Tech innovation process**

TECHNOLOGY MATURITY LEVEL	KEY FACTORS	TARGET IMAGE
Basic research (TRL 1–3)	CORE ACTIVITIES: Basic research CRITICAL RESOURCES: Research infrastructure, public and private R&D funding	Confirmation of the technological functional principle (Proof of Concept), Patent
Technology validation (TRL 4–5)	CORE ACTIVITIES: Market-oriented technological development, protection of intellectual property CRITICAL RESOURCES: Technology transfer, application partnerships, experimental opportunities, private and public venture capital, innovation procurement	Validated technology, prototype
System development and application (TRL 6–7)	CORE ACTIVITIES: Market-oriented product and business development CRITICAL RESOURCES: Pilot plants, qualified personnel, specialized sources of financing (including borrowed capital)	Marketable product, ready for large-scale scaling (Product-Market Fit)
Commercialization (TRL 8–9)	CORE ACTIVITIES: Start of production, market launch, technology and product optimization CRITICAL RESOURCES: Production facilities, distribution networks, growth financing and exit opportunities	Sustainable Deep Tech Ecosystem

Source: MÜNCHNER KREIS Future Study IX: The Deep Tech Manifesto: Wake-up call for a sleeping giant, based on Schuh et al. (2023)

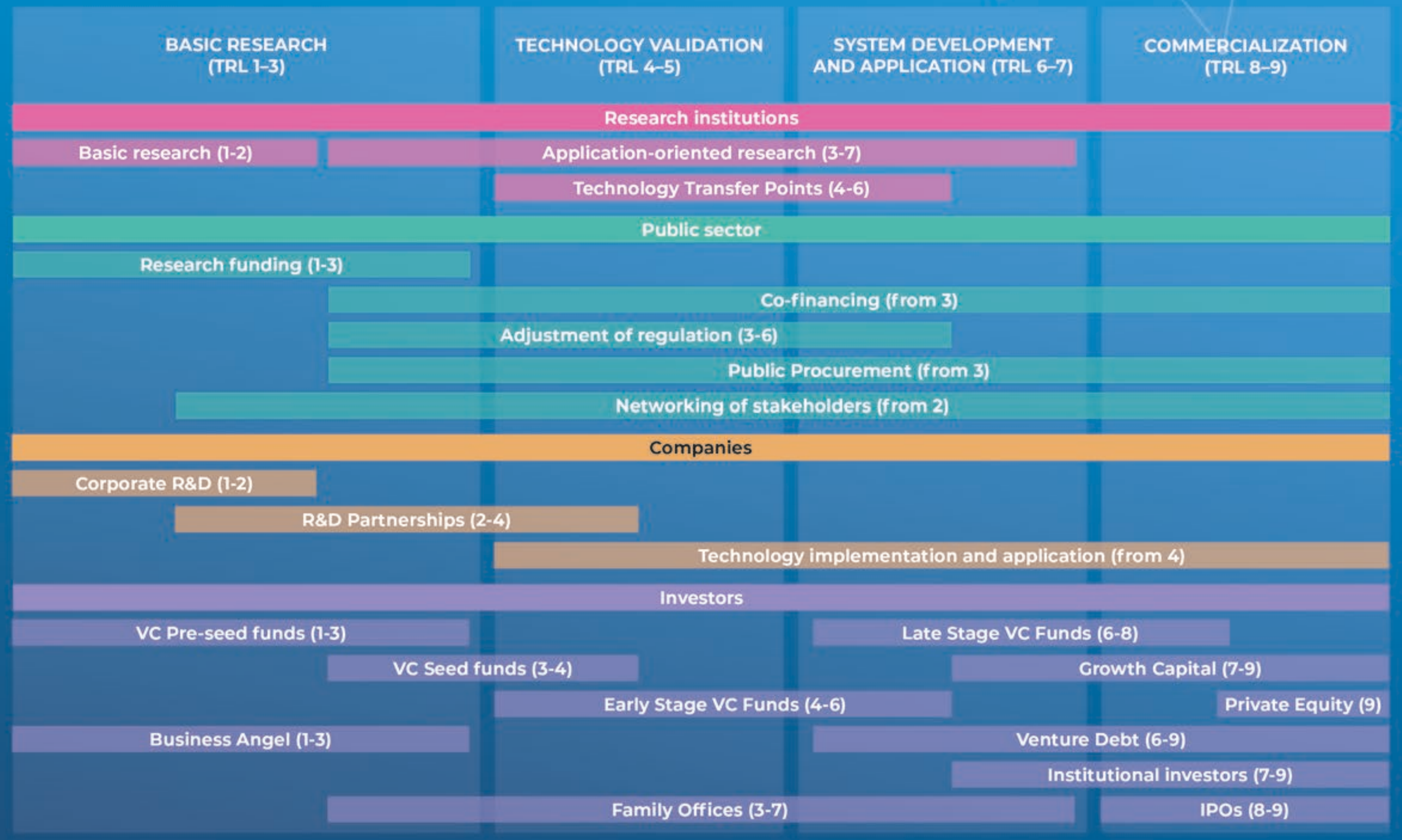
The central Deep Tech stakeholders and their tasks

Due to the transformative, systemic nature of Deep Tech, the interaction of different innovation stakeholders is much more important for success than with technology-based innovations. We distinguish between four central stakeholders whose multiple roles can be distinguished from each other, but who sometimes also overlap. The figure below (see Fig. 5) shows the complex interplay and different roles of stakeholders across the lifecycle of a Deep Tech innovation.

Research facilities: Research institutions are the source of many Deep Tech inventions and make a significant contribution through basic and applied research. They include universities and non-university institutions.

- **Research and development:** Basic research and development of new technological processes that lead to the emergence of Deep Tech innovations.
- **Technology transfer:** Supporting scientists in translating research results into practical application, especially through spin-offs, licenses, patents, or strategic corporate collaborations.
- **Education and talent development:** Training the professionals of tomorrow and creating an ecosystem where talent can develop their Deep Tech skills.

Figure 5: Role of stakeholders in the Deep Tech innovation process



Source: MÜNCHNER KREIS Future Study IX: THE DEEP TECH MANIFESTO: Wake-up call for a sleeping giant

Public sector: This includes the public sector at all levels of government (EU, federal, state, local) and its institutions, which are financed by taxpayers' money and serve the provision of services of general interest and the regulation of social life. It acts as a bearer of public tasks and manages the financial resources of the state (e.g. taxes, levies) in the interest of the general public. The public sector plays a central role in shaping frameworks for the development and promotion of Deep Tech as:

- **Laws and regulations:** Design of legal and regulatory frameworks, such as experimentation clauses.
- **Demander:** Government can create demand through public procurement and support Deep Tech's market entry.
- **Investor:** Direct provision and indirect promotion of capital.
- **Conveyor:** Direct or indirect government R&D support.
- **Networking:** Promoting cooperation and exchange between stakeholders.

Companies: Companies act as the central innovators and users of Deep Tech. They drive the development of Deep Tech from R&D to market maturity and also invest in other Deep Tech companies.

- **Innovators:** Start-ups or fundamentally oriented companies research groundbreaking, new scientific findings and develop or integrate them into marketable products and services.
- **Application partners and users:** Established companies act as strategic application partners or use Deep Tech technologies to improve their products and services.
- **Sources of capital and acquirers:** Companies are getting involved or acquiring Deep Tech startups.

Investors: Investors provide venture and growth capital and strategic support for Deep Tech companies and thus make a significant contribution to growth. Investors include, in particular, business angels, venture capital funds (VCs), banks, pension funds, insurance companies, investment and private equity funds, foundations, sovereign wealth funds or family offices that pursue different investment approaches.

- **Investor:** Investors provide the equity and debt to fund Deep Tech companies.
- **Know-how and networks:** Especially business angels and early stage investors offer access to know-how and networks in addition to financial resources.

Deep Tech: Another Buzzword or necessary distinction from "High Tech"?

Basically, our interviews have shown that some people are skeptical of the "Deep Tech" concept. Critics argue that "High Tech" is actually an established term for this category of technologies. However, most critics agree that the term Deep Tech is useful from several perspectives, even if the difference from High Tech, at least in its traditional meaning, is more gradual than fundamental.

> *"In public discourse, the terms High Tech and Deep Tech are often used indistinguishably and interchangeably. Deep Tech is a fundamentally new technology that requires a high innovation capacity and a significant investment of capital. This includes disruptive technologies such as Future of Compute and Chip Design, e.g. in quantum computing, space tech, artificial intelligence (AI) and computational biology, which often require a lot of time, capital and government support. Deep Tech has the potential to change entire industries and traditional business models. This is different from developing an app for a software start-up."* – **Dr. Sabine Donauer** (Head of Digital Innovation Location, European Digital Policy, International Affairs, Bavarian State Ministry of Digital Affairs)

The experts see the main differences between Deep Tech and High Tech in the course of the development and the application rate of Deep or High Tech.

Deep Tech stands for groundbreaking, science-based technologies that often solve complex problems and challenges and are not yet ready for the masses.

> **Findings:** These technologies have the potential to fundamentally change the status quo. High Tech, on the other hand, includes more sophisticated, advanced technologies that are already widely used, accepted and integrated into everyday life.

While Deep Tech lays the foundation for future innovations, High Tech represents the phase in which innovations realize the transition to widespread use and commercialization.

Siegel and Krishnan[8] relate the Deep Tech development process to several established models of technology development in order to illustrate the differences and the smooth transitions between Deep Tech, High Tech and Tech using the Gartner Hype Cycle, the Technology Adoption Lifecycle and the Kano Model.

[8] Siegel & Krishnan (2020)

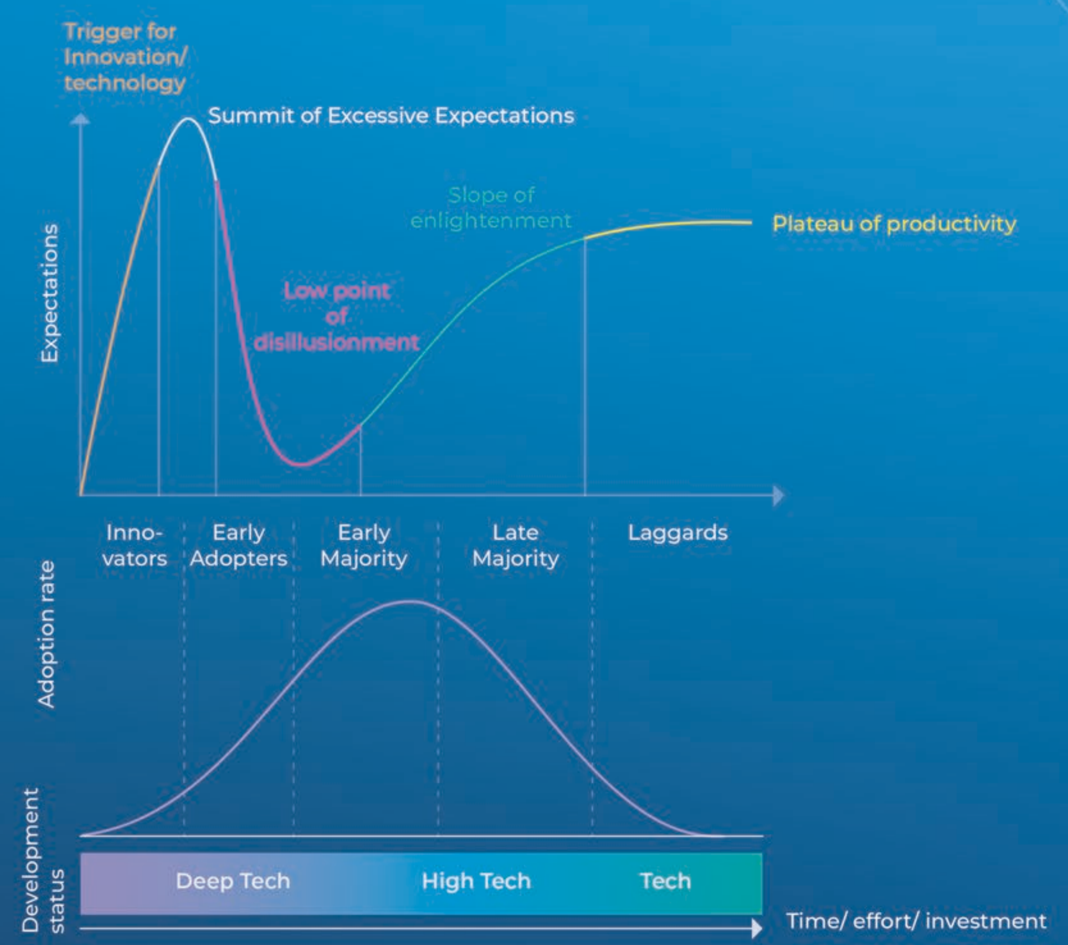
As Fig. 6 shows, the Deep Tech label describes technologies that are still in an early development phase before they may reach market maturity and broad acceptance in the future. In contrast, High Tech is characterized by the fact that it can be adapted more quickly by a broader user base. By applying the mentioned models, it becomes clear that Deep Tech is initially characterized by high expectations and technological challenges, as described in the Gartner Hype Cycle, and over time it transitions into High Tech and ultimately into Just Tech or Regular Tech by transitioning from a highly innovative to a basic technology.

Findings: Another distinguishing feature of Deep Tech innovations is that they not only create economic value, but also aim to solve larger societal challenges.

A survey has shown that almost without exception all Deep Tech innovations focus on at least one of the “Sustainable Development Goals” (SDGs[9]) of the United Nations.[10] Although High Tech can also create social and environmental added value, it is an inherent part of the Deep Tech concept to solve major challenges of humanity through technological innovations and to bring about major systemic change potentials and processes on a technological, economic, ecological, social and (geo) political level.

[9] Sustainable Development Goals
[10] De la Tour et al. (2021)

Figure 6: **Development Stages of Deep Tech**



Source: MÜNCHNER KREIS Future Study IX: The Deep Tech Manifesto: Wake-up call for a sleeping giant, based on Siegel and Krishnan (2020)

Benefits of the Deep Tech Narrative

Findings: Many experts believe that the Deep Tech term is better suited to accentuate the profound and fundamental technological progress and economic and societal transformation potential.

The term "Deep Tech" thus fulfils important functions in the context of marketing and communication, in which a better awareness of the special risk and benefit profile ("high risk, high reward") of Deep Tech is established in the public and thus the possible failure of Deep Tech projects is consciously emphasized.

As a result, the term also offers a more concise distinction from High-Tech for technologies that are still technically demanding, but have a higher degree of maturity and acceptance. The emphasis on the uncertainty of Deep Tech is important in political communication and public discourse and is easy to convey using the term, says Prof. Dr. Dietmar Harhoff. On the other hand, he notes that the term acts as a defense narrative that highlights and clarifies the particular challenges in developing and promoting Deep Tech.

"'Deep Tech' can be conveyed in eight letters and communicates much more effectively than a longer, complex term. It also creates a clear demarcation. But I also see 'Deep Tech' as a kind of hopeful narrative, because Germany is strong in 'Deep Tech'. So the term also conveys a spirit of optimism." – **Prof. Dr. Dietmar Harhoff** (Director, Max Planck Institute for Innovation and Competition)

"The broad understanding of basic research conveys the applicability of the understanding of nature as potential for harnessing it in technological application and thus largely follows a definition of the National Science Foundation from 1953. Deep Tech unleashes new potential from previously unexploited man-made technology systems, especially in interaction." – **Dr. Michael Lipka** (Senior Manager Technology Strategy, Huawei)

Findings: "Deep Tech" offers a more concise distinction from "High Tech" and facilitates the conveyance of uncertainties and challenges in political communication and public discourse.

Overall, the “Deep Tech” term serves to create an effective, techno-optimistic narrative that underlines the attractiveness and potential of investments in profound technological innovations, as well as the associated risk and special efforts. Some may dismiss this as not essential and unimportant, but terminology is important to attract investors and mobilize capital for innovative projects. [11]

Recommendations for action:

1. **Standardize the Deep Tech definition:** A clear and consistent definition of Deep Tech should be established based on six key characteristics: Technologies with a high degree of novelty, high market and technology uncertainty, substantial technological progress, high financial investment requirements, long development times to market maturity and the solution of societal challenges. A uniform understanding of terms is important in order to promote Deep Tech innovations in a targeted manner.
2. **Promote Deep Tech as an independent category:** The term “Deep Tech” should be used deliberately to emphasize the unique technological challenges, high risk, and transformative potential of these breakthrough technology innovations. A clear distinction from High-Tech is crucial by highlighting differences in the level of development, in the application rate and in the impact potential. This allows specific support measures and support structures to be developed that are geared to the special requirements and needs of Deep Tech.
3. **Establish Deep Tech as a defense narrative:** The term “Deep Tech” serves as a defense narrative to illustrate the particular challenges and risks involved in development. This helps to establish a broad understanding among all stakeholders that technological breakthroughs are associated with uncertainties and that failure is a natural part of the innovation process. By deliberately emphasizing these uncertainties and the “high risk, high reward” character, the narrative is strengthened that illustrates to investors and policymakers the need for long-term support and high risk-taking. At the same time, this narrative allows technological failures to be seen as part of learning processes rather than as setbacks. This provides support for the courageous entrepreneurial actions of the stakeholders and promotes an open failure culture, which is essential for progress in the Deep Tech sector.

[11] Rothgang (2017)

DEEP TECH STAKEHOLDERS AND ECOSYSTEM

6.1 Research institutions

The German research landscape is characterised by a large number of publicly funded institutions that focus on different R&D activities. These R&D activities include basic research, applied research and experimental development[12]. The interlinking of these activities is crucial for the development process of Deep Tech on the way from scientific findings to market-ready products and services.

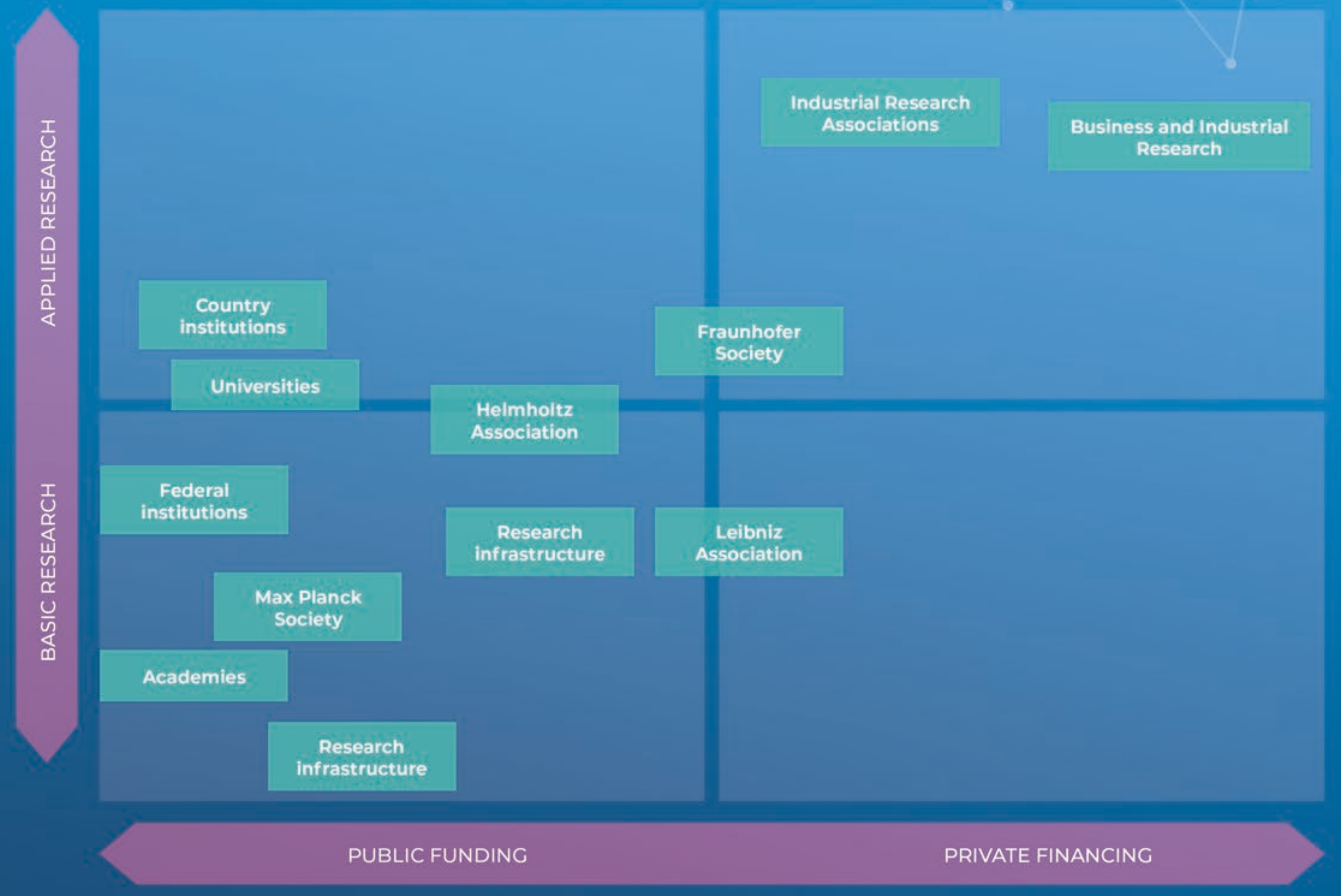
A total of 120 universities and 245 universities of applied sciences (HAWs) focus on basic research (universities) and application-oriented R&D for business (HAWs). In addition, four non-university research institutions have established themselves in Germany, a special feature in international comparison. The Max Planck Society and the Helmholtz Association focus on basic research; the Fraunhofer Society and the Leibniz Association focus more on applied research.

German university landscape: Top across the board, room for improvement at the forefront

In international comparison, the research quality and performance of German universities is high. Among the top 100 universities worldwide, Germany ranks fourth in terms of frequency with eight universities.[13] German science also ranks fifth in the world in terms of productivity and the influence of publications.

[12] OECD (2015)
[13] Times Higher Education World University Rankings (2024)

Figure 7: Assignment and funding of research institutions



Source: Deutscher Akademischer Austauschdienst e. V. (DAAD)

Findings: The German research landscape is therefore well positioned across the board, but more needs to be done at the top.

The two top German universities, the TU and LMU Munich, are ranked 26th and 38th among the world's best universities in terms of teaching and research environment, research quality, industrial relevance and international orientation. It is striking in this ranking that German universities have a significantly worse ratio between the number of students and the academic staff compared to the top international universities, which indicates underfunding. In Stanford, the ratio between faculty and students is 5.9, while it is 41.8 at the TU Munich and 33.0 at the LMU Munich. These are by far the highest values in the top 30.

As a result, German universities and their staff are much more engaged in teaching; at the expense of research and transfer activities. Consequently, the two best German universities only rank 131 and 133 in the worldwide publication ranking "AD Scientific Index". This ranking measures the proportion of scientists in an institution among the top 10% of all scientists worldwide, measured by the h-Index[14]. Although publication performance is only a metric of scientific influence and productivity, it turns out that the German university landscape has its strengths more in breadth than in excellence and that teaching requirements are high.

[14] Measured by the h-Index, which measures the scientific performance of a researcher by combining the number of publications and their citations, so that a researcher has an h-Index of h when h of his work has been cited at least h times. Last updated: 10/01/2024

Brain Gain? Brain Drain? Brain Circulation!

Some experts therefore note that Germany lacks top international universities whose working conditions, equipment and reputation are able to attract the world's best minds.

> *"It is crucial to attract the world's leading scientists, because in addition to their research performance, they attract the world's best talents back to Germany, who will then, at best, work on scientific breakthroughs in this country or found Deep Tech start-ups."* – **Anonymous**

This is not always the case, according to the AD Scientific Index cited above, although the situation has improved.

This year's report by the Expert Commission for Research and Innovation (EFI) concludes that within the last 10 years, Germany has developed from a net donor (net departure of about 4,000 scientists over the period from 1996 to 2011) to a net recipient through numerous initiatives (net inflow of over 5,000 scientists from 2005 to 2020).[15] This development is generally positive, even if especially high-performing scientists migrate to the USA, France or the United Kingdom. In the case of patent-active inventors, there was a decrease in net emigration in the same investigation period, but from 2000 to 2020, 5.6% more inventors left Germany than moved in.

[15] EFI (2024)

Overall, the trends are positive, even if the influx of scientists and inventors is not sufficient to compensate for the demographic development and the shortage of skilled workers. Furthermore, a study by the Stiftung Neue Verantwortung (New Responsibility Foundation) using the example of AI suggests that it may not be possible to keep the talents gained in Germany in all Deep Tech areas: *"German universities and research institutes succeed in attracting and training young talents from Eastern Europe and Asia. However, Germany then loses a significant proportion of these talents to internationally leading AI locations such as the USA. According to our analysis, Germany is a kind of middle power that benefits from the inflow, but cannot keep many of its best talents."* According to the study, there is still too little success in the AI sector in inspiring talents for a career in this country after their academic training.

Findings: Despite positive developments, it is not possible to sufficiently inspire researchers and inventors for a career in Germany against the background of demographic development.

However, the EFI rightly points out that the restriction to "brain gain" and "brain drain" (decline in human capital) limits the view too much. As several studies show, international mobility in science and research has a positive effect on performance and quality, as mobility promotes knowledge transfer and the emergence of new networks. Thus, for example, returnees from abroad are more powerful than non-mobile scientists. In this respect, mobility from a German point of view is to be welcomed for the quality of research when returnees return to Germany or indirectly lead to an increase in research performance, when emigrating scientists and inventors continue to work together with scientists and inventors working in Germany.

Research Top – Transfer Flop

Since 2002, universities and non-university research institutions have the right to inventions by scientists and can market the resulting IP. The inventors are usually entitled to a remuneration from the revenues in the amount of 30% of the net proceeds. This means that universities and non-university research institutions and their Technology Transfer Offices (TTOs) play an extremely important role in the Deep Tech ecosystem as gatekeepers and marketers of groundbreaking ideas, knowledge and technologies. However, with moderate success.

Findings: Technology transfer from research institutions falls well short of the potential.

The potential of many findings remains untapped, so that some of our experts complain that excellent research in Germany does not translate into corresponding value creation and progress. However, this is difficult to quantify, because there are few reliable figures on input and output variables when it comes to technology transfer. One of the few surveys in which 81 German TTOs participated shows partly sobering figures that fundamentally question the current structures and processes for the utilization of IP (see Fig. 8).

Figure 8: **Transfer key figures of universities and research institutions**

Source: Based on EU Funding Playbook (2024)

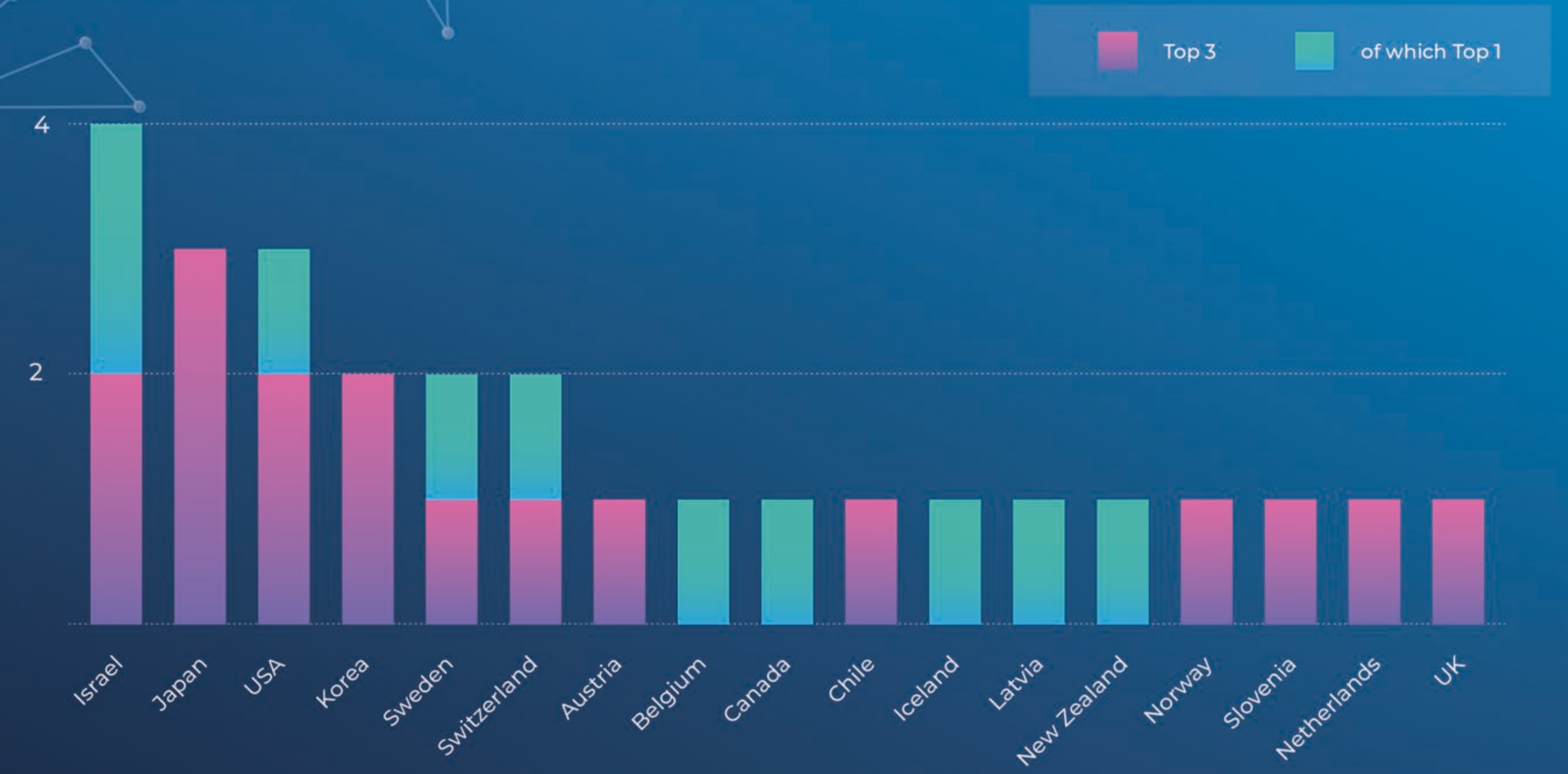
At most universities, technology transfer lives in the shadows. Apart from a few frontrunners, it can be seen that most institutions apply for only a few patents, conclude only a few utilization contracts, take in average only three million a year (Median: 72,000 euros, average value excluding the leader with 114 million euros is 1.3 million euros per institution) and produce only 2.2 spin-offs and 13.1 start-ups. It also shows that the share of 2.5% of universities registered patents in Germany in the period from 2020–2022 is significantly lower compared to the USA (7.9%), UK (8.2%), China (7.2%) or Israel (10.8%).

Findings: The proportion of universities applying for patents in Germany is significantly lower than in leading Deep Tech countries.

An analysis by the Center for Higher Education Development (CHE) of 1,545 universities worldwide shows that German institutions do not belong to the top group in key innovation indicators such as third-party funding from the private sector or patent applications.[16] In particular, Israel, Japan and the USA lead the ranking, while Germany is not in the top 3 in any of the selected indicators. Nevertheless, Germany is in the upper midfield of the OECD countries, as it is above the OECD average for most indicators. Countries such as Switzerland have unmistakable lighthouses in the field of innovation with globally leading institutions such as ETH Zurich. Japan relies on a broad approach to innovation and invests heavily in research, as shown by the high budget of the Japan Science and Technology Agency (JST). It also emphasizes the social importance of innovation and the inclusion of the social sciences and humanities in long-term innovation strategy processes.

[16] Center for Higher Education Development (2022)

Figure 9: **International pioneers in technology transfer**



The graph shows the number of transfer indicators that the respective country is in the Top 3 for. In addition, it shows the number of transfer indicators that the country has the best value for. A total of nine transfer indicators were evaluated. Only countries that are OECD members were taken into account.

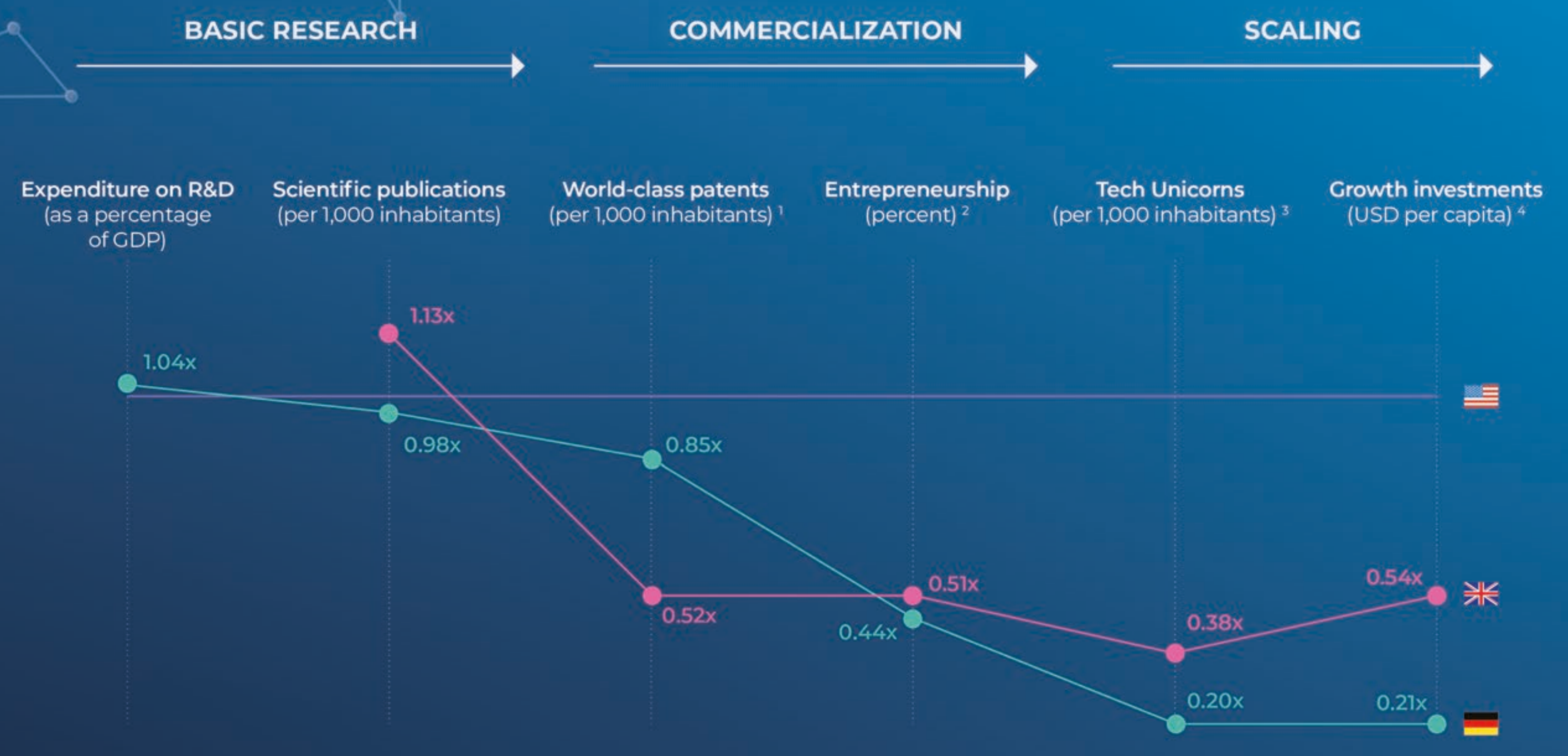
Source: U-Multirank (2022)

Even among the most innovative universities in the world, measured in patents, German universities are not in the top group close to the US universities Stanford, MIT and Harvard, but in 31st place (FAU Erlangen-Nuremberg), 45th place (TU Munich) and 56th place (LMU Munich). These figures are not considered satisfactory by all experts, especially in view of the high public research expenditure and performance.

Findings: In international comparison, Germany fails to capitalize sufficiently on investments in research and internationally competitive science.

Fig. 10 illustrates this clearly. While the USA, UK and Germany are almost at the same level in terms of scientific publications (per capita), Germany already lags behind the USA by almost 50% in terms of the world's best patents. This severity then expands even further in the scaling phase (see 5.4 Investors). **But why are the scientific findings not put into practice?** According to our experts, there are a number of reasons for this.

Figure 10: **Deep Tech Development Indicators – Comparison between US, UK and Germany**



1. Top 10% of all technology patents.
2. Proportion of residents (between 18 and 64 years) engaged in entrepreneurial activity.
3. Start-ups with a company valuation of over USD 1 billion with a digital business model in B2B or B2C in the Internet, software or hardware.
4. Investments in private start-ups (excluding public companies).

Quelle: Lakestar et al. (2023)

Technology transfer process discourages founders and investors

Findings: A central weakness is the lengthy, case-by-case and bureaucratic negotiation processes between the potential founders, venture capitalists and TTOs and unattractive start-up conditions that deter founders and investors alike.

The conditions for founders and, at the latest, private investors are too unattractive, as the demands of the IP-carrying TTOs with regard to company shares, fixed or variable license fees and revenue shares are too high to be able to found a start-up with chances of success. While in the USA a simple equity share with dilution protection of 3–5% is common at the time of incorporation, in Germany investments of up to 25% are required. This prevents venture capitalists from investing, because the founders and investors have too few shares for later investment rounds. This experience applies not only to universities, but also to non-university research institutions, especially the Fraunhofer-Gesellschaft, which has been mentioned several times.
An "enabling culture" is required in the technology transfer process, which puts short-term profits and concerns about selling technology below value behind and resolutely promotes spin-offs. In unison, our discussions called for a rapid and radical rethinking that would allow founders to set up quickly and with "little overhead" with regard to company shares, voting rights, royalties or revenue shares; because without spin-offs from the research institutions *"the pipeline of Deep Tech innovations is stalled"*, according to the director of the Federal Agency for Jump Innovations (SPRIN-D), **Rafael Laguna de la Vera**.

In addition, he adds, TTOs and patent collecting societies are often forced, for structural and financial reasons, to prioritize short-term financial gain over long-term opportunities for the institution and location. However, this cannot be blamed on them, because few of these bodies are adequately and sustainably financed. Another obstacle is EU state aid law. TTOs are often concerned about underestimating the value of the IP, which could be considered an inadmissible aid. Although the European law on state aid was amended in March 2023, uncertainty remains high.

> **Findings:** The underfunding of the TTOs and uncertainties regarding EU state aid law stand in the way of a professional and rapid technology transfer.

Third mission of the universities leads a shadowy existence

The lack of financial resources and a non-market-oriented payment also mean that, from the point of view of many experts, the TTOs are understaffed and do not have the necessary experience in the venture sector and industry, especially in comparison with the USA. Under these conditions, *"not the best of the best can be won, which help young founders with their experience and their contacts to successfully start up".* – **Anonymous**. This could be remedied by the newly founded German Agency for Transfer and Innovation (DATI).

> *"Most German universities are only slowly waking up to the fact that the third mission of innovation and foundation is also their key task. Many are currently investing only around 0.1% of their university budget in this third mission."* – **Prof. Dr. Helmut Schönenberger** (Co-Founder & CEO, UnternehmerTUM)

Overall, the experts agree that the transfer of research results into application (so-called third mission) at universities plays too little of a role. The focus is clearly on the other two missions, research and teaching, also because the incentives and recognition for the third mission are lacking at the university level as well as at the level of individual scientists. At universities, top-level research, which is reflected in the quality and quantity of publications, is at the top of the agenda. With the prevailing pressure to publish and the current incentive structure, no time and motivation is often left for the transfer of research results. In addition, there is a lack of institutional support and incentives. The transfer performance of non-university research institutions is also considered by the many experts to be expandable.

"What I'm really missing is entrepreneurial thinking at universities in Germany. In the USA, universities and companies are much more closely networked, so there is no fear of contact. In Germany, there are occasional spin-offs, but this would have to be much more systematic, almost like in a factory – a new company on a regular basis, every week or every month. We have great universities and institutions, such as the Max Planck or Fraunhofer Institutes, which are even world leaders in some areas. But how much value is really created? Too little in my opinion. In my view, these institutions must be encouraged to think more economically in order to link their financing to this." – **Tino Krause** (Regional Director Central Europe, META)

Findings: The third mission is not sufficiently prioritized and professionalized compared to research and teaching at most universities.

Transfer: More hurdles than incentives and support for science

The lack of recognition of entrepreneurial thinking and acting scientists in the scientific system and in the public also makes many scientists refrain from transfer efforts. The transfer of research results into application plays almost no role in scientific evaluation criteria and recognition systems. Time and again, our experts draw on the world's leading transfer agency, Stanford University. There, it is common for target agreements with scientists to include incentives and support services for the transfer of research results. This is also reflected in the university strategy. Scientists are encouraged and actively supported in translating research results into marketable products and technologies. This is also rewarded accordingly.
Such a strategic weighting and structural anchoring of research transfer is lacking at almost all German universities.

Findings: The science system and universities lack adequate incentives, support and culture for scientists to translate research results into practice.

Stanford is considered the cradle of Silicon Valley, the world's most successful innovation ecosystem, which was created by the founding of the Stanford Industrial Park in 1948, in which more and more leading Tech companies have subsequently settled. According to the famous venture capitalist Arthur Rock, this led to *"all the energetic scientists around Stanford"*.[17] Something similar has emerged in Germany at the Technical University of Munich. With 'UnternehmerTUM', it proves that things can be done differently in Germany and has made it to the top of the ranking of 125 European start-up centers.

[17] Lee & Nicholas (2021)

> *"What I deeply admire about the UnternehmerTUM ecosystem is this extraordinary network that has been built around TUM as a nucleus. That's really remarkable. The UnternehmerTUM is an achievement that not only enriches Munich, but the whole of Germany. Great things have been done. Germany needs exactly such initiatives not only in Munich, but preferably ten times throughout the country."* – **Prof. Dr. Günther Schuh** (Holder of the Chair of Production Systematics, RWTH Aachen University)

In addition, it can be observed that scientists often do not take the exploitation of the results into account in their research and

> *"the research results are often not mature enough for industry, which also has to do with the lack of interaction and cooperation between science and business,"* notes **Christoph Zinser** (Specialist with the Management of the Verein für berufliche Integration e. V.)

Also, the ideas about the value of research results without validated application and scaling potential are often not realistic. He is also critical of the **excellence initiative** in this context, because he also misses a stronger emphasis and incentives for the science system to prioritize the third mission more strongly. He also considers the **Bavarian Higher Education Innovation Act to be in need of improvement in its design**. Although he welcomes the aim of the law to promote spin-offs, he considers the implementation to be ineffective. The universities can, for example, set their own targets for the number of spin-offs within the framework of the target agreements, instead of setting this key figure via national and international benchmarks.

More than ideas, there is a lack of entrepreneurial spirit

It may come as a surprise, but many of the experts surveyed, not least founders of Deep Tech companies, found that the topic of 'Entrepreneurship' is still not sufficiently present at German universities. Accordingly, the propensity to start-up and the number of start-ups at German universities are low compared to the international top. Although some support services such as business incubators have been initiated in recent years, they are not used sufficiently and are often not visible enough.

In the eyes of the experts, the lack of entrepreneurial spirit in the German higher education system is also due to the fact that the topic of entrepreneurship is not anchored as standard in the curriculum of all students and scientists. In addition, there are too few networking opportunities with experienced entrepreneurs and those interested in setting up a business. Many experts therefore call for a fundamental cultural change at universities that conveys awareness, knowledge and a positive but realistic picture of the opportunities and risks of entrepreneurship in order to better exploit the start-up potential in Germany. On the basis of a sample of 20 German universities and two million events offered, an analysis by the Stifterverband shows that although the number of entrepreneurship courses is increasing, the proportion is on average well below 0.5%.

Findings: There is too little entrepreneurial spirit at German universities, as the topic of entrepreneurship is not included in the curricula and too few networking opportunities are created with experienced founders.

"A well-known university professor told me that he doesn't have students and doctoral candidates knocking on his door every day saying 'I want to become an entrepreneur and found a start-up'." Those who have the potential and are willing to take the hard, sweaty path in Deep Tech are rare. Instead, start-ups are often looking for the fast hype, where media attention becomes more important than the years-long, intensive process of developing a marketable, groundbreaking innovation." – **Anonymous**

The lack of need and the lack of entrepreneurial spirit is also described by **Tino Krause** (Regional Director Central Europe, META): *"The other day, a Professor told me that there was enough research money. He doesn't have to launch a start-up or otherwise provide economic added value and does not do so because the process would take too much time and keep him from basic research. I believe that the incentives and focus are not right. Transfer and spin-offs would have to become much more important."*

Recommendations for action

1. **Standardization of IP transfer into research-based spin-offs:** Research institutions should be involved by default in spin-offs via virtual shares without voting rights and with anti-dilution protection up to Series A. A cap on these holdings at a maximum of 10% should be sought across the EU in order to address state aid concerns and speed up the transfer process. In order to make negotiations more efficient, standardized contracts should be used. This ensures a clear and transparent participation structure that creates legally secure and uncomplicated conditions for research institutions as well as for founders and investors.

2. **IP Transfer 3.0 as a basis:** The Toolbox of the SPRIN-D IP Transfer 3.0 Initiative should be further expanded and its use demanded. This includes the use of model contracts and decision aids such as the IP Choice-O-Meter to accurately assess the IP Situation, as well as the IP Scorecard to ensure a market valuation of intellectual property.

3. **Ensure permanent financing of the transfer points:** The federal states should provide sufficient financial support to the transfer offices at universities and research institutions for at least ten years and thus make them independent of the transfer income. The comprehensive and close cooperation with the DATI could additionally contribute to strengthening the transfer capacities.

4. **Introduce performance indicators and head premium for successful spin-offs:** Higher education policy should be reformed to include performance indicators for spin-offs in the evaluation of universities. By introducing transfer targets and a bonus-malus rule between countries and universities, incentives can be created for successful spin-offs. In addition, a “per capita premium” (e.g. EUR 250,000) should be introduced for each start-up founded by research institutions. For Deep Tech spin-offs with high innovation potential, the premium should be doubled in order to strengthen the start-up dynamic, especially in this area.

5. **Improve database on transfer performance:** The collection of information on spin-offs of each research institution should be systematic and continuous. This data should be made publicly available to create transparency and increase transfer performance.

6. **Include transfer targets in target agreements:** The transfer of research results should be integrated into the target agreements between countries, research institutions and scientists and rewarded accordingly. This creates a direct incentive for research institutions and scientists to convert research results into marketable innovations.

7. **Targeted promotion of universities of excellence:** The Excellence Strategy should focus more on the long-term establishment of cutting-edge research at selected universities of excellence. Clear target agreements must be included in the Excellence Strategy in order to promote the transfer of research results (third mission) on an equal footing with research and thus maximize the innovative power of these universities. In order to build up these “lighthouse” universities with international appeal and high innovation potential, the federal and state governments should dovetail university and non-university research institutions more closely and finance them together on a permanent basis.

8. **More academic staff at universities of excellence:** In order to increase the quality of research and remain competitive in international comparison, the teaching load of academic staff at these universities of excellence should be reduced. This requires a significant increase in the number of academic staff in order to meet the requirements of research-based teaching and at the same time to create space for research and transfer activities.

9. **World Class Deep Tech Cluster:** Research institutions, especially universities of excellence, in internationally competitive and significant Deep Tech clusters should receive targeted funding. The experience of successful models such as the UnternehmerTUM (TUM entrepreneurship) can be used as a template for similar structures in other regions of Germany to accelerate innovation and transfer in local Deep Tech clusters.

10. **Scholarship programs for students interested in starting a business and compulsory entrepreneurship:** Special scholarship programs should be introduced for students with a founding interest, especially in the field of Deep Tech. These programs promote the development of innovative start-ups in technologically demanding areas and support students financially and professionally in the implementation of their ideas. At the same time, a compulsory course on entrepreneurship should be introduced for all students at all universities. These measures strengthen entrepreneurial thinking and understanding. They also raise awareness of start-up opportunities.

11. **Facilitate and promote mobility of scientists and inventors across the EU:** The mobility of scientists and inventors within the EU should be simplified by creating uniform regulations. Visa requirements, health, pension and social security currently present significant obstacles. By introducing EU-wide tools and solutions, these barriers can be broken down to facilitate the cross-border exchange of talent and strengthen cooperation in the European research and innovation landscape.

12. **Promote exchange and permeability between science and industry:** It is recommended to strengthen the exchange between science and business through cross-change programs and adapted appointment practices. These measures are intended to facilitate the transition of skilled workers between academic institutions and industry, thus promoting the transfer of knowledge and technology. Changed appointment practices that support the entry of experts from industry into engineering science strengthen the cooperation and innovative power of both areas.

6.2 Public sector

State institutions at the federal and state level as well as the EU play a key role in the Deep Tech innovation process, which goes far beyond the design of the legal and regulatory framework. **Our experts want a public sector that proactively supports technological progress through Deep Tech and the necessary transformation processes as a pioneer, advocate, impulse generator and user, instead of pressing them into the entrenched risk-averse and control-oriented management logic.**

Although many of the experts acknowledge the first steps taken by the public sector in this direction, the role change of the public sector is too slow and indecisive for them. Some experts question the general ability of the public sector to promote and apply Deep Tech; they find the dominant approaches to groundbreaking innovations too risk-averse, inflexible and sluggish.

Without a proactive state, Deep Tech has little chance

Due to their particular risk profile and transformative nature, Deep Tech innovations depend on the special support of the public sector for their breakthrough. This starts with the financial support of basic research, but also includes progress- and risk-affirming regulation as well as an innovation-promoting public procurement policy. Unlike less disruptive innovations, Deep Tech innovations often require regulatory adjustments and support due to their systemic and profound impact on existing markets and infrastructures, as existing market and technological frameworks can hinder diffusion.[18]

Findings: Existing market forces often have no incentive for renewal through Deep Tech and specifically block its spread. Under these circumstances, the public sector may be required to intervene in the markets if it involves a Deep Tech innovation in the public interest.

Without forward-looking, smart government support, promising Deep Tech innovations could fail at an early stage due to regulatory and market hurdles. Consequently, our experts are calling for the public sector to play a more active supporting role in the Deep Tech sector than is currently the case.

Findings: The state should see itself as a key player in the entire Deep Tech innovation process, intervening moderately at all stages of the development cycle to correct market failures such as underinvestment in basic research, research transfer and start-ups, as well as market and infrastructure diffusion barriers.

[18] Sreenivasan & Suresh (2023)

To this end, according to the "Carve-Out model", the public sector should specifically hand over Deep Tech funding and advice to independent and entrepreneurially thinking and acting agencies, which are also part of an expert panel that advises politicians on regulatory measures.

Deficits in research and innovation policy have been identified, now adjustments must be accelerated and intensified

The promotion of Deep Tech in Germany and Europe takes place through a variety of programs and initiatives at regional, national and European level throughout the entire development process of Deep Tech innovations. Especially in recent years, some measures have been taken to improve technological competitiveness and sovereignty in order to address existing deficits.

As the largest European research and innovation program for Deep Tech, Horizon Europe covers all levels of technological maturity with its three pillars ("Excellent Science", "Global Challenges and European Industrial Competitiveness" and "Innovative Europe"). Key programs at European level include Horizon Europe, which includes initiatives such as the European Research Council (ERC) to promote basic Research, the European Innovation Council (EIC) to promote breakthrough innovation and the European Institute of Innovation and Technology (EIT) to strengthen knowledge transfer and innovation capacity in innovation ecosystems. The ERC fosters scientific breakthroughs, the European Innovation Council (EIC) supports disruptive innovation, and the EIT fosters innovation ecosystems from academia, research institutions and businesses.

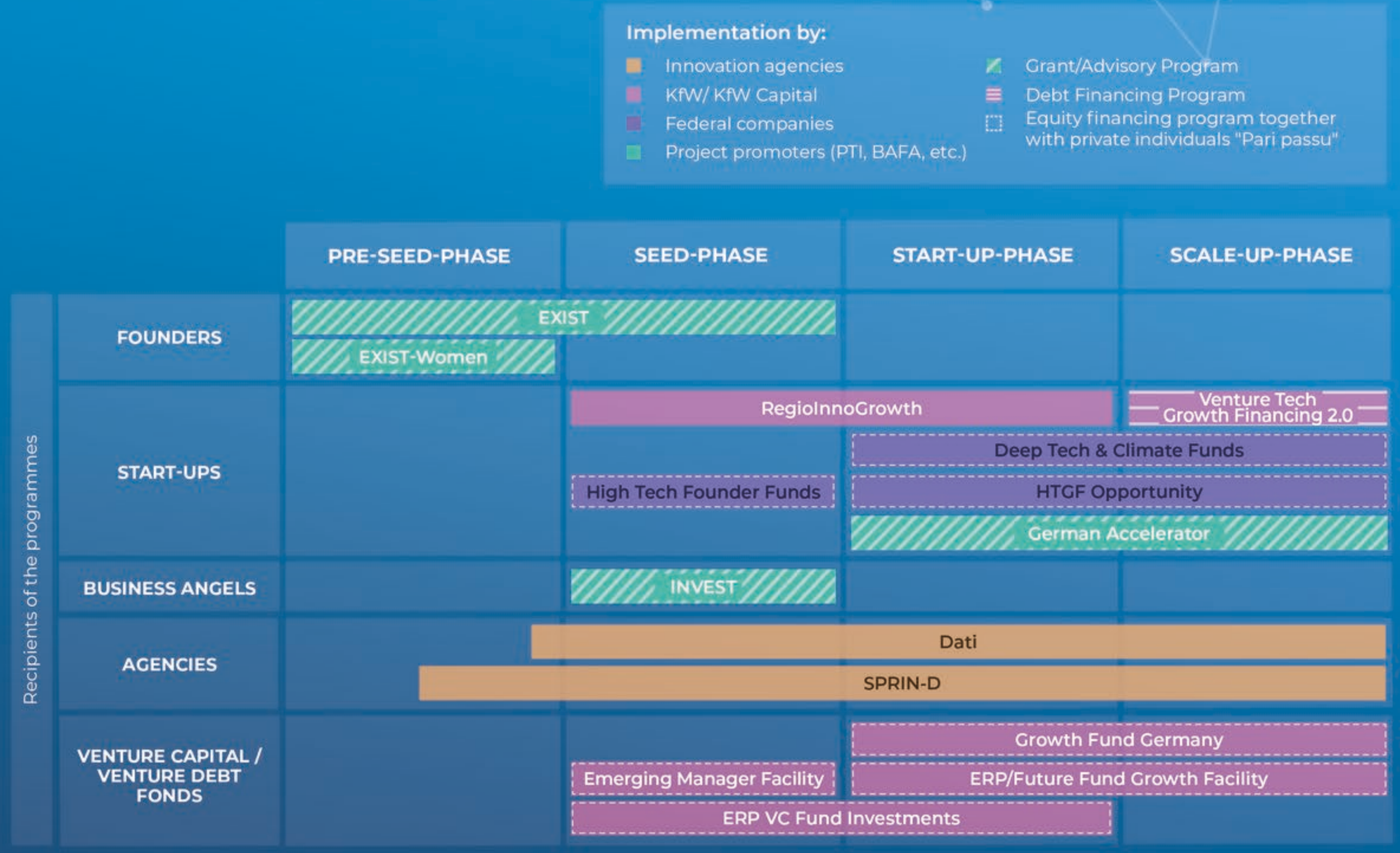
With the EUR 7.6 billion European Investment Fund (EIF), the European Investment Bank (EIB) finances Deep Tech companies as part of the European Tech Champions Initiative (ETCI), acts as an anchor investor and growth financier or as an investor in specialized Deep Tech venture capital funds.

Nationally, programs such as the EXIST Founder's Scholarship, agencies such as the agencies DATI and the Federal Agency for Leap Innovations (SPRIN-D) as well as state-supported venture capital funds such as the Deep Tech & Climate Fonds (DTCF) and the High Tech Gründerfonds (HTGF) contribute to the promotion of Deep Tech companies.

Another Initiative at the national level is the recently announced WIN (Venture Capital Participation for Innovation and Sustainability) Initiative.[19] It aims to promote the technological sovereignty and ecological transformation of the German economy by providing venture capital, especially in the Deep Tech sector. The WIN Initiative intends to improve the framework conditions for innovation and venture capital in Germany and to invest around 12 billion euros in the German venture capital ecosystem by 2030. A broad alliance of business, associations and politicians, coordinated by the Kreditanstalt für Wiederaufbau (KfW), is working to reduce tax, legal and financial hurdles and facilitate access to private capital for start-ups.

[19] University of Twente: Horizon Europe (2024)

Figure 11: National innovation promotion in Germany



Source: Based on the BMWK (2024)

In addition, the Federal Government is trying to pave the way for better framework conditions in the innovation and technology sector for Deep Tech through a series of legal initiatives. These initiatives include the Growth Opportunities Act, the Future Financing Act, the Act Against Restrictions on Competition (GWB) Digitalization Act, the Skilled Workers Immigration Act, the Real Estate Labor Act and the Research Allowance Act. These laws aim to improve the framework conditions for innovation, encourage investment, combat skills shortages and create tax incentives for R&D.

In addition to European and national programs, regional programs such as the Cluster Offensive Bavaria, Hightech Transfer Bavaria, Deep Tech Hub Berlin or the Cyber Valley in Baden-Württemberg, which is considered one of the leading centers for AI in Europe, also significantly support the development of Deep Tech.

Findings: The large number of funding programs and initiatives illustrates that the public sector has recognized the urgent need for action to improve the framework conditions for R&D and innovation. However, the wide range of regional, national and European funding programs should urgently be more closely interlinked and harmonized.

By better coordinating programs such as Horizon Europe with national funding measures, resources could be used more efficiently, inefficient double structures could be reduced, and access to funding for Deep Tech projects could be simplified and accelerated. The existing direct and indirect funding opportunities at state, federal and EU levels should urgently be made more transparent and accessible. The application processes should also be standardized, simplified and digitized in order to speed up the processes and make them more efficient.

"Deep Tech companies continue to face significant state aid and procurement obstacles that hamper their competitiveness and innovative strength. The IPCEI approach [20] offers a promising framework to overcome these hurdles, but it should be extended to other areas. The pooling of funding from the EU, the federal government and the federal states towards a common goal is particularly positive and forward-looking. Instead of each level running its own funding programs, Deep Tech startups should not be forced to apply for different funding lines in different procedures. An integrated, efficient system is the key to unlocking the full potential of these innovative companies." – **Dr. Sabine Donauer** (Head of Digital Innovation Location, European Digital Policy, International Affairs, Bavarian State Ministry of Digital Affairs)

The complexity of the application procedures for funding programs at European and national level is based on different legal frameworks at EU, federal and state level as well as different application requirements and obligations. A standardization of the application requirements and continuous networking of the funding programs across all growth phases, within a single point of contact, could significantly increase the efficiency of the administration and make the use of the funding programs more attractive. Companies that have

[20] The IPCEI (Important Projects of Common European Interest) initiative promotes strategic projects in key technologies and thus strengthens European competitiveness by providing targeted support to Deep Tech companies.

already been successfully funded in a development phase should benefit from a simplified procedure for follow-up funding through better networking of the programs. This would significantly improve the chances of success for the commercialization of Deep Tech projects and at the same time make the promotion more efficient.

> **Findings:** Standardization of application procedures and networking of funding programs would increase efficiency and improve the chances of success for the commercialization of Deep Tech projects.

More freedom for Deep Tech

The Agency for Leap Innovations, SPRIN-D for short, founded by the Federal Government in 2019, is particularly relevant to the field of Deep Tech. This applies initially in terms of content, but also from an organizational and structural point of view, the establishment of the SPRIN-D will provide new impetus. The SPRIN-D has the task of driving technologically groundbreaking innovations that solve important social or environmental problems. It was founded to remedy the shortcomings in German innovation promotion, whose leap innovation potential suffers from bureaucratic hurdles, rigid specifications and path-dependent technology promotion.

> *"The founding of SPRIN-D is an attempt to overcome the deficits in German innovation promotion, which are often characterized by bureaucratic hurdles and rigid funding structures. The agency is intended to create the space for real leap innovations, where traditional funding mechanisms often fail."*
> – **Rafael Laguna de la Vera** (Founding Director, SPRIN-D)

Their model is the Defense Advanced Research Projects Agency (DARPA), which was founded in 1958 as an Agency of the US Department of Defense in response to the launch of the Russian Sputnik satellite. In the course of its existence, the promotion of highly innovative and risky research has contributed significantly to groundbreaking innovations such as the Internet, GPS or drone technology. DARPA works with flat hierarchies and flexible, temporary project structures. The influence of politics is deliberately kept very low.

SPRIN-D tries to adopt many of these elements. But the concept confronts German politics, the administrative apparatus and the ministerial bureaucracy with some problems that are exemplary for the German funding landscape. Some of these problems have been solved by the SPRIN-D Freedom Act, which allows the agency to operate more freely from politics and more agile and flexible as ministries.

As a central problem not only in SPRIN-D, but also, for example, in non-university research institutions such as the Fraunhofer-Gesellschaft, specialist supervision is carried out by ministries and political officials. This influences, often from political and personal calculations, content-related decisions and delays decision-making processes. Particularly in the case of high-risk and disruptive Deep Tech innovations, close technical supervision is counterproductive, as it restricts the necessary flexibility and agility.

> *"The most problematic aspect that is rarely talked about is the technical supervision of the ministry. Specialized supervision means that weeks before a SPRIN-D supervisory board meeting, the responsible department of the ministry meticulously coordinates in detail what this SPRIN-D can actually decide and what a supervisory board can vote on. The central problem of this agency is that the so-called SPRIN-D Freedom Act does not eliminate technical supervision. In order to be effective, it would have to act without ministerial oversight, similar to DARPA in the US or the British Innovation Agency ARIA (Advanced Research and Innovation Agency), and only be responsible to Parliament. This has been successfully prevented so far."* – **Dr. Thomas Sattelberger** (Former Member of the German Bundestag and Parliamentary State Secretary at the Federal Ministry of Education and Research (retired)

Accordingly, the experts consider the Freedom Act of SPRIN-D to be overdue and absolutely necessary, but also an important signal that the **public sector has recognized that the current structures and decision-making processes, at least not in the short term, can be brought into line with the requirements of Deep Tech.**

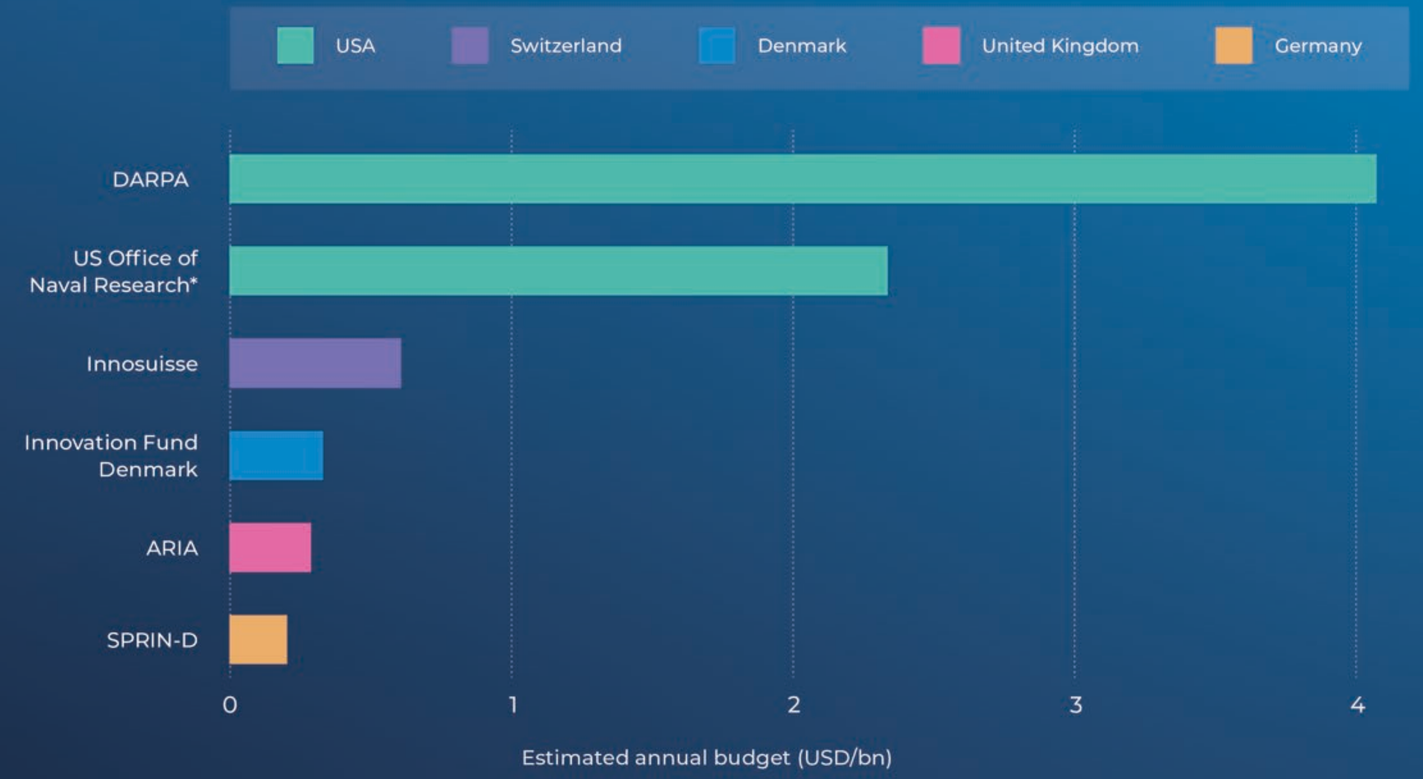
> **Findings:** Specialized agencies with greater freedom, such as SPRIN-D, are required to drive Deep Tech innovation processes in an agile and unbureaucratic manner, as traditional state structures and processes are too slow and rigid.

Nevertheless, many experts argue that SPRIN-D, as well as publicly funded research institutions, should be further decoupled from political influence. Otherwise, agencies such as SPRIN-D and DATI can never act as freely and entrepreneurially as their international role models.

The financial resources of SPRIN-D are also insufficient and would have to be significantly increased. In comparison, the particularly innovative, smaller European countries Switzerland and Denmark invest disproportionately more than Germany in comparable agencies (see Fig. 12).

Figure 12: **Budget of the innovation agencies in international comparison**

The UK Advanced Research and Invention Agency (ARIA) was built on the model of the famous US Defence Advanced Research Projects Agency (DARPA), but has a smaller annual budget.



*Budget request for 2025

Source: Nature (2024)

Another criticism is that the planning security of SPRIN-D is limited by the dependence on funds from the federal budget. This limits the agency's ability to act and is also not a confidence-building signal for existing and future projects.

> *"SPRIN-D is limited in its planning security, as it is dependent on annual funds from the federal budget. This dependence significantly limits the agency's flexibility and long-term planning, which negatively affects the implementation of its innovation projects."* – **Rafael Laguna de la Vera** (Founding Director, SPRIN-D)

> *"Part of the SPRIN-D budget must be approved by the Bundestag's budget committee, and that is anything but easy to plan. The lack of planning security means that SPRIN-D is not always able to support large-scale and high-risk innovation projects in the long term. With stable, predictable financing, the full potential of the agency could be better exploited."* – **Prof. Dr. Dietmar Harhoff** (Director, Max Planck Institute for Innovation and Competition)

Findings: Lack of planning certainty and dependence on annual budget allocations impair the effectiveness of innovation agencies.

The situation is similar at the European level. Only a small part of the Horizon Europe program, with a total budget of almost 100 billion euros, is focused on groundbreaking innovations. The EU EIC's main "Pathfinder" tool for Deep Tech funding only has a budget of 256 million euro for 2024.[21] Moreover, the program is mainly led by EU officials and not by top scientists and innovation experts. A recent study by Mario Draghi concludes that the EIC should develop into a European (D) ARPA, largely independent of political influence and with more budget for groundbreaking innovations.[22] To this end, EU member states should better coordinate their efforts in the field of Deep Tech in order to pool larger parts of national budgets in European programs. Currently, the share of EU funds in total European R&D expenditure is only 10%, 90% comes from national funds.

Management apparatus is not Deep Tech-capable

Findings: The administration acts too risk-averse, inflexible and slow and is too concerned with process integrity. There is a lack of technical and entrepreneurial expertise and experience.

[21] European Innovation Council (2024)
[22] Draghi (2024)

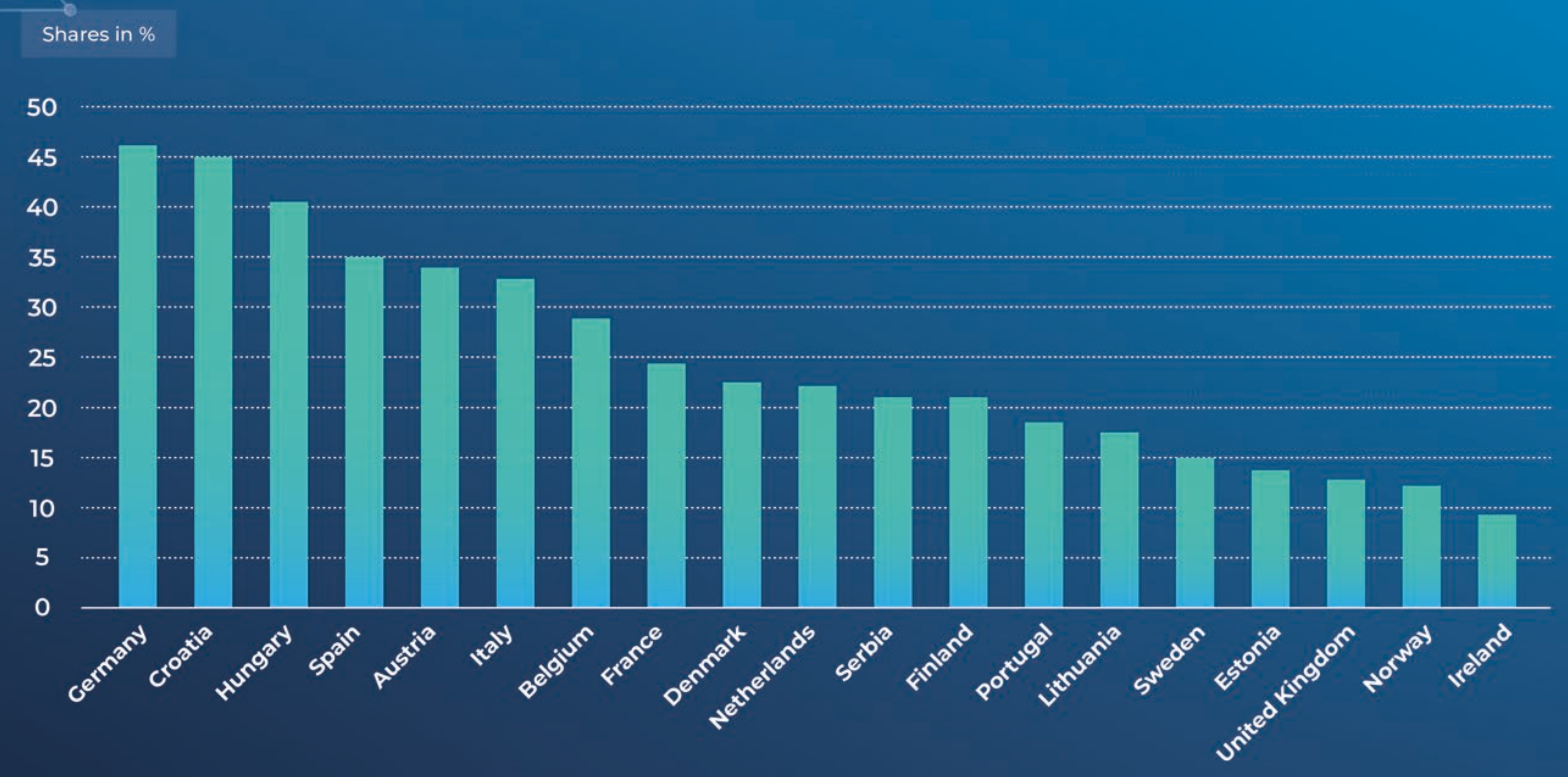
Our experts complain that the strong legal mindset of the public administration inhibits the necessary agility and flexibility in promoting innovation. The public sector should be a supportive partner, especially for Deep Tech start-ups. But administrative and approval processes take too long, not least due to the digital deficit of the administration, start-ups are de facto ignored in public procurement and public guarantees are denied for political reasons.

"Our ministries are often burdened by excessive bureaucracy and process orientation. Running processes according to plan counts, results do not count. This over-administration prevents us from responding efficiently to technological developments. What we need are specialized agencies such as SPRIN-D, which have the necessary freedom to act agile, flexible and without the usual bureaucratic obstacles. Such agencies can deliberately drive innovation processes, while traditional state structures are often too slow and rigid to meet the dynamic requirements of new technologies." – **Prof. Dr. Dietmar Harhoff** (Director, Max Planck Institute for Innovation and Competition)

The German administration is strongly influenced by law, more than 45% of executives in public administration in Germany are lawyers – a share that is well above the European average (see Fig. 13). **The resulting "over-legalization" of processes and risk aversion act as a brake on innovation**, because the dominance of lawyers in administration lies in process integrity and legally sound decisions, not in entrepreneurial, pragmatic decisions.[23]

[23] Hammerschmid & Hustedt (2020)

Figure 13: Proportion of lawyers in management positions in public administration



Source: Lapuente and Suzuki (2020), Acatech (2024)

In order to meet the requirements of a dynamically developing technology landscape, a stronger prioritization of content, entrepreneurial and technological expertise in the workforce of administrations is required. This is expected to result in a better balance, which understands legal requirements not as a rigid corset, but as guidelines that should enable innovations in the public interest. Currently, the perception of experts is that Deep Tech innovations prefer to exclude inherent risk from the outset, rather than taking risks and managing them effectively.

> *"We have become sluggish, which is mainly due to complex administrative procedures and the over-legalization of the state. In order to become more agile and enable progress, an urgent reduction of these bureaucratic hurdles is necessary."* – **Josef Schmid** (Member of the Bavarian State Parliament)

Findings: A legal and risk-averse administration inhibits the necessary agility and flexibility that Deep Tech requires through lengthy processes.

A main reason for this mentality is the administration's lack of incentives for entrepreneurial thinking. It is important not to take any risks and, in case of doubt, to interpret the legal situation narrowly. **This unnecessarily complicates and slows down administrative processes, which is a knockout criterion, especially in the rapidly developing technology sector, where agile experimentation and flexibility are required, especially in the validation and prototype phase.** In general, the experts are not very confident that adjustments can be made quickly enough under the current structures and existing capabilities.

Changing the focus, design and success measurement of research funding

The establishment of the SPRIN-D can also be seen as an admission by the public sector that the previous funding instruments did not have the desired positive effect for Deep Tech innovations. Many experts are calling for the existing funding approaches to be radically changed and simplified.

The small-scale structuring of the funding programs does not meet the requirements and dimensions of Deep Tech and the associated growth of large, disruptive technologies. The problem of the small-scale allocation of funding programs is illustrated by the example of Lilium.

> The co-founder of a Deep Tech start-up emphasizes: *"At the time, we had also applied for the Exist start-up scholarship. The feedback was that our project with a volume of 2 million euros is too large and therefore not eligible for funding. If you apply this standard, all programs for deep tech are out. Whether it is robotics, AI, nuclear fusion, rockets or aviation, all these projects will not be eligible for funding according to the standards that have been set there."*

The funding programs should therefore be geared more strongly than before to Deep Tech innovations with high potential for value creation, the environment and society. At the same time, the focus of path-dependent developments in established industries should be reduced. A central weakness of the existing funding system is the focus on Mid-Tech. This mainly supports established industries that are currently economically significant and make significant R&D investments, but for the most part only achieve marginal improvements in existing technologies, the growth potential of which is largely exhausted and thus not geared to future technologies and markets.[24] For example, less than 5% of funding from the Horizon Europe program[25] goes to groundbreaking innovations that have the potential to create new markets and fundamentally renew existing ones.

[24] Fuest et al. (2024)
[25] Horizon Europe is the name for the 9th Framework Program for Research and Technological Development (2021–2027).

Findings: The existing funding system focuses too much on established industries and marginal improvements, while groundbreaking Deep Tech innovations are neglected.

The funding system in Germany is often perceived as too complex and bureaucratic. The large number of small-scale programs, multi-stage approval procedures, detailed reporting requirements and long processing times mean that Deep Tech innovations cannot be promoted or cannot be promoted sufficiently quickly.

"The current funding system is extremely confusing and represents an obstacle to innovation, in particular through small-scale application procedures and reporting obligations. One possible solution could be to focus funding more closely instead of distributing it over numerous small programs." – **Anonymous**

These structural deficits make it difficult for researchers and founders to move projects forward in an agile manner and to implement innovative approaches in a timely manner. The often long duration of the approval processes for funding programs, especially for EU funding, is also criticized. These delays are in stark contrast to the needs of start-ups, which rely on rapid provision of funds to be internationally competitive and avoid liquidity bottlenecks.

"EU subsidies are attractive because they are awarded as grants without having to hand over equity. However, confirmation for such programs often takes more than half a year to nine months, which is half a life for a start-up." – **Dr. Matthias Groh** (CCO & Co-Founder, Resmonics)

Findings: Complex application processes and long approval times for funding programs jeopardize the viability of Deep Tech startups.

Another task is to reduce a funding bureaucracy. The design and implementation of the funding programs means that the most effective projects do not necessarily prevail, but those that do not shy away from the bureaucratic effort and have a knowledge advantage in the application process, succeed. Entire service chains have also developed for the evaluation and administration processes, which do not necessarily create added value.

> *"The promotion of innovation in Germany is trapped in its bureaucratic silo. We have created a funding landscape in which not the best projects win, but those that master the bureaucratic hurdles. Instead of promoting real innovation, a sequence of professionalized application and bureaucratic processing has developed that hardly creates any added value. We urgently need not only a dismantling of these structures and more flexible, agile procedures, but a complete system revision. The central question is, what would really change if Fraunhofer no longer existed?"* – **Dr. Thomas Sattelberger** (Former Member of the German Bundestag and Parliamentary State Secretary at the Federal Ministry of Education and Research (retired)

In a recent study, the project promoters commissioned by the ministries to implement funding measures also see the need to fundamentally reform the promotion of innovation in Germany in order to reduce overregulation and the high administrative burden.[26] The introduction of more agile procedures and flexible financing mechanisms as well as a reform of specialist supervision could help accelerate the innovation process and secure international competitiveness in the field of Deep Tech. The SPRIN-D Freedom Law is cited as a model.

Overall, many experts see the need for the established funding structures and procedures to be fundamentally put to the test and for best practices, such as the Swedish innovation agency *Vinnova* or the Swiss *Innosuisse*, to be used in a targeted manner. **The goal of all efforts should be a rethinking of innovation promotion, especially in the Deep Tech sector, which consciously takes risks, develops flexible funding instruments and minimal administrative effort and facilitates experiments.** This naturally also means that projects will fail and must be able to do so without consequences.

More entrepreneurial and flexible action could also improve the attractiveness of the funding conditions.

> **Findings:** It has often been mentioned that the international funding instruments have been adapted much more flexibly to the needs of individual cases and are also more generous.

Internationally, the motto is "go big or go home", while in this country the courage and will of decision-makers to take risks is often lacking. An international comparison shows that Germany often offers less competitive conditions when it comes to supporting companies.

[26] Available at https://projekttraeger.dlr.de/sites/default/files/2023-08/documents/Positionspapier-Sprind-Freiheitsgesetz-breiter-denken-PT-Netzwerk.pdf

> *"In Germany, KfW is currently considering a loan guarantee with high double-digit interest rates, while in other countries such as Saudi Arabia, interest rates in the low single-digit range are attractive. In the US, there are even direct government grants that do not have to be repaid, which leads to a significant distortion of competition for us compared to our American competitor."* – **Daniel Wiegand** (Founder and Lead Engineer for Innovation and Future Programs, Lilium)

Especially in the case of a more flexible funding policy, performance indicators are more important than ever for the comprehensible and transparent measurement of the effectiveness of measures. Transparency strengthens trust and acceptance. At the same time, specific performance indicators clarify the project objectives ex-ante and allow the effectiveness of the support measures to be assessed ex-post in a comprehensible manner. This increases spending discipline and makes evidence-based decisions possible, which can be used to continuously improve the support measures in order to make them as effective as possible.

Currently, these clear and transparent performance indicators do not exist, which usually makes it impossible to monitor the success of government support measures. Quite a few suspect that this is done out of political calculation, because no one wants to be responsible and held accountable for mistakes. The often one-sidedly negative reporting in these cases and the non-forgiving and progress-affirming culture in Germany contribute its additional part. It is therefore preferable to avoid defining suitable metrics from the outset that could be used to transparently measure the impact and success of the support.

> *"Progress in innovation promotion could also be achieved through stronger measurability and target definition. By collecting data and looking at the achievement of given KPIs, it is possible to identify effectiveness and the need for retargeting more precisely."* – **Dr. Christian Pfrang** (Head of Cloud, Platforms and Data Management, Bavarian State Ministry of Digital Affairs)

But without meaningful indicators, monitoring of the success of the funding mechanisms remains superficial and imprecise. **This limits the ability of policymakers and administrators to learn from the results and adapt their strategies.** The overarching goal must be the efficient and effective use of funds, and measuring success is crucial for this. Transparent performance measurement and regular evaluation are central to building trust and showing how public money is used. This increases social acceptance and strengthens the legitimacy of state support for innovation.[27]

> **Findings:** Without clear objectives and performance indicators, the success of support measures cannot be determined, which hinders necessary learning and adaptation processes.

[27] EFI (2024)

Importance of public procurement as a driver of innovation

The public sector should create early demand for Deep Tech innovation, especially in the areas of defense, security, healthcare or energy supply. This is especially true when Deep Tech innovations are in the public interest and market demand is low. Through tenders, the public sector can enable Deep Tech start-ups to gain early market access, ensure financial stability and thus create important prerequisites for the future mobilization of capital in later investment rounds.

Orders in the Valley of Death – the critical phase between technical validation and market launch – are particularly crucial. **This is where public procurement can help by not only providing financial support, but also creating real-world use cases that provide companies with valuable feedback and market access.** Public tenders, which are specifically aimed at Deep Tech start-ups, not only create demand, but also enable these companies to access the market at an early stage, which is often problematic due to its disruptive nature and infrastructural requirements.

Pre-commercial procurement is an important tool to test prototypes under real conditions and facilitate the transition from development to market maturity. Examples such as the Finnish state's cooperation with the quantum computing start-up IQM or the partnerships of the Leibniz Data Center show how public procurement can contribute to the validation and further development of innovative technologies:

> *"From the beginning, we have focused on product development and commercialization and quickly realized that public institutions, such as large universities and data centers, are the first customers. However, the sale to these institutions was only possible if we managed to convince the relevant ministries to create budgets. Through targeted persuasion, we were able to scale up these sales. It was particularly helpful that Finland took over the EU Presidency during our first round of funding, which allowed us to be strategically involved and increase our visibility at the European level."*
> – **Dr. Jan Götz** (Co-CEO & Co-Founder, IQM Quantum Computers)

Innovation partnerships between contracting authorities and start-ups are also a promising model for jointly developing innovative solutions to market maturity through close cooperation and at the same time providing start-ups with planning security.[28]

Fig. 14 shows the process of pre-commercial procurement (PCP) and highlights in which phases innovation potential remains untapped. The role of innovation partnerships lies mainly in the phases of commercial evaluation and market launch (phase 4), where public procurement of innovations (PPIs) comes into play.

[28] Wesseling & Edquist (2018)

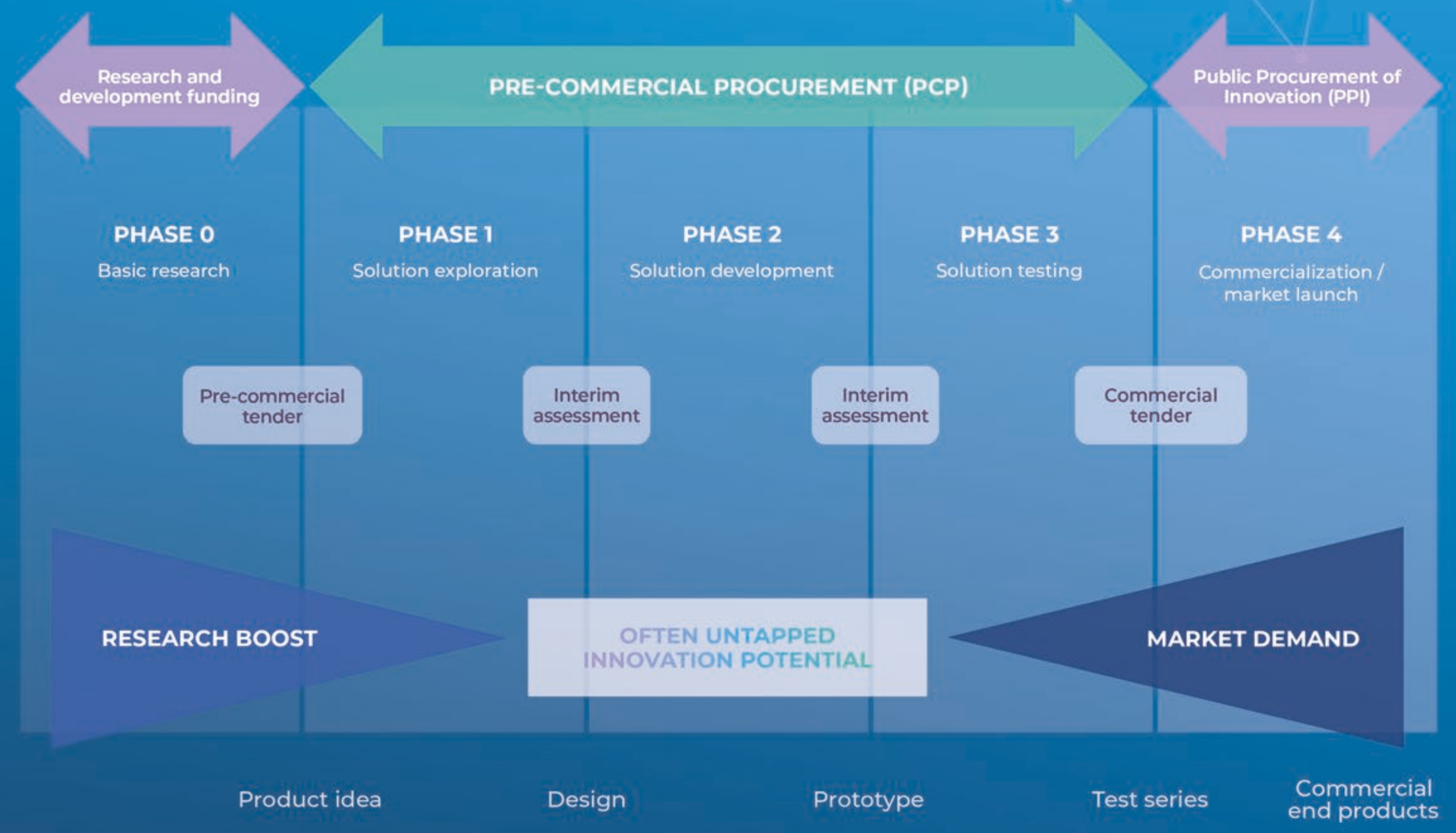
These partnerships provide a way to bring innovative products to market faster by creating a bridge between research and commercial use.

Findings: The public sector should specifically create demand for Deep Tech, especially if it is in the public interest and the other stakeholders are holding back.

The current practice of public procurement law is a major hurdle for Deep Tech start-ups. Although Germany has made progress in innovation procurement, there is a lack of a comprehensive strategy with targeted measures and clearly defined goals and incentives for procurers.[29]

Bureaucratic hurdles and strict award criteria systematically disadvantage start-ups compared to established companies. Start-ups have to provide extensive evidence and often fail due to unrealistic requirements (e.g. liquidity criteria) and long processing times. For example, only 20% of the funding goes to start-ups, while established companies receive the majority of the support.

Figure 14 **Pre-commercial procurement process**



Source: Koinno-BMWK (2024)

[29] See Innovation Procurement Policy Framework Benchmarking (2024), available at: https://ec.europa.eu/assets/rtd/innovation-procurement/country-report-2024-policy-benchm-germany.pdf

"A structural Problem with government funding programs like the Aeronautics Research Program in Germany is that it is designed so that established companies like Airbus or Rolls Royce get the bulk of the funding, while startups like Lilium de facto have no access due to high formal requirements and liquidity criteria." – **Daniel Wiegand** (Founder and Lead Engineer for Innovation and Future Programs, Lilium)

Research shows that almost 40% of start-ups in Germany prefer not to apply for funding altogether because the bureaucratic effort and requirements are too high.[30] An international comparison by the OECD shows that countries such as the USA with programs such as the Small Business Innovation Research (SBIR) program and the UK with Innovate UK offer funding models specifically tailored to the needs of start-ups. These programs are characterized by relatively lean application processes and fast approvals.

Findings: Bureaucratic hurdles and strict award criteria penalize start-ups in public tenders.

[30] Bitkom (2018)

Through the strategic use of public contracts, the public sector can selectively generate demand for new technologies. By explicitly requiring innovative solutions in tenders, the public sector can create a sales market for Deep Tech companies. This reduces financial risk and gives these companies the stability they need to successfully progress through the development phase and bring their products to market.[31]

Deep Tech at the turn of the century

Since the Russian war of aggression on Ukraine, military dual-use innovations have become the focus of Deep Tech research and promotion. Experts emphasize that in view of geopolitical tensions and the changed security situation, Deep Tech innovations must also be considered from a security policy point of view and in order to preserve national sovereignty. Technological sovereignty in key technologies such as semiconductors and quantum computers is crucial not only for economic competitiveness, but also for security and independence from foreign technologies.

Dual-Use technologies have already driven civilian advances in the past as they can be used for both military and civilian applications. The public sector should therefore reconsider historical concerns regarding

[30] Bitkom (2018)
[31] Chicot & Matt (2018)

dual-use and military research in order to exploit the innovation potential as much as possible. State funding programs for dual-use technologies play a central role in this, as they support the development of both civilian and military innovations.

> *"Military Dual-Use innovations often drive civilian advances. In view of historical concerns in Germany, it is important to maintain a balanced dialogue on dual-use and military research in order to secure long-term technological sovereignty and national security,"* emphasizes **Prof. Dr. Youngjin Yoo** (Professorship for Entrepreneurship, Case Western Reserve University)

Findings: To harness the full innovation potential of dual-use technologies, the public sector should rethink historical reservations about military research to harness the dual-use potential.

The strict separation between military and civilian R&D should therefore be dissolved in order to increase spillover effects and "dual use". Projects for which there are no civilian funding or investment mechanisms could thus be better supported. International examples such as DARPA or the Israeli Unit 8200 show how the combination of military and civilian innovation can successfully lead to the development of Tech Hubs. In Europe, too, the integration of the civilian and military sectors is necessary in view of the current geopolitical challenges.

Success with Deep Tech is not least a matter of state communication and culture

A non-negligible function of the public sector is to strengthen the "appetite" for Deep Tech in German society, which is increasingly perceived as sluggish and denying progress. To this end, the public sector should act as an active communicator and put the importance and necessity of Deep Tech innovations on the agenda for the future development of the country and the world.

It seems important to the experts to emphasize the opportunities of Deep Tech to tackle climate change, improve health care, create and maintain jobs or strengthen national security. At the same time, however, the potential risks, such as ethical concerns, possible negative societal, environmental or social consequences and side effects, and questions of technological safety should also be openly communicated and discussed. Transparent communication of opportunities and risks can strengthen public trust and acceptance of technological progress and necessary transformation processes. A recent study highlights the central role of the state as a mediator and communicator of these aspects.[32]

Findings: The public sector should actively communicate the importance and necessity of Deep Tech to increase interest and acceptance in society.

[32] EFI (2024)

Since Deep Tech innovation involves high risks, the state must be willing to take those risks and establish a culture where failure is accepted as an inevitable part of the innovation process. Only with a "high-risk, high-return" mentality can potentially groundbreaking but high-risk projects be brought to success. State stakeholders play a key role in the public acceptance of risks in the innovation process and the establishment of a positive culture of error.[33] The approach of focusing state innovation policy more on risk-taking and measuring success is also considered central in studies on public innovation policy.[34]

> *"It is not enough to just act as a sponsor. Instead, our state must act as an active communicator who communicates the opportunities of future technologies to its citizens in an understandable way. As the engine of prosperity for our future, Deep Tech must be at the top of our country's agenda and become the DNA of a new "Germany Mission". In order to create trust and acceptance among people, opportunities and risks of new technologies must be communicated transparently. Only in this way can our country find the strength to replace Germany's sometimes anxious regulatory anger with optimistic courage for the future."* – **Dr. Fabian Mehring** (Bavarian Minister of State for Digital Affairs)

[33] World Economic Forum (WEF) (2022)
[34] Breznitz & Zehavi (2010)

Recommendations for action

1. **Stable framework conditions and a well-thought-out roadmap:** All stakeholders in the Deep Tech ecosystem need reliable and clear policy and regulatory guidance to align their R&D objectives and investments with this. An interdisciplinary, independent and experienced expert panel should develop and regularly update a national research and innovation strategy in close coordination with the EU. Civil society should also be involved and informed in the process. The strategy should define concrete measures, milestones and measurable goals to give clarity and planning certainty to innovation stakeholders.

2. **Creating experimental environments for companies:** The establishment of sandboxes and real laboratories with a clear legal framework allows companies to test innovations under real conditions. Through pilot projects with broad experimentation clauses in laws, companies can bring innovative products to market faster. A national point of contact should be created for advice and rapid implementation.

3. **Create tax incentives:** The state should increase tax incentives for R&D and start-ups in the Deep Tech sector. This includes tax breaks on intellectual property income (IP Box rule) to drive the development and use of intellectual property. Likewise, the tax deductibility of R&D expenses in Deep Tech key technologies, especially for small and medium-sized enterprises (SMEs) and the digital sector, should be expanded. Support for companies should increasingly be provided through tax R&D incentives, rather than through increasingly differentiated support initiatives. The focus should be on incentives for the application and development of future technologies with great innovation potential.

4. **Limiting political influence:** The innovation agencies SPRIN-D and DATI as well as the non-university research institutions should be allowed to act independently of politics as far as possible. In order to strengthen their independence, supervisory bodies should have technological, social, humanities and entrepreneurial expertise and experience. In addition, rules on the self-management of funds and the use of self-generated revenue should be introduced in order to give the agencies the necessary flexibility to manage their own funds. These measures increase the agencies' agility and ability to act and create space for entrepreneurial decisions.

5. **Introduce government guarantees and de-risking measures:** To strengthen confidence in FOAK investments, state guarantees, loan guarantees and de-risking measures should be introduced. Existing credit protection programs, such as EIB (European Investment Bank) venture debt or NZIA/GDIP, can be expanded and supplemented by new debt programs based on French programs such as BPI. These measures would attract private investment in breakthrough technologies and mitigate risk for investors.

6. **Using public procurement as a driver of innovation:** The public sector should actively act as an early-stage customer of Deep Tech start-ups in order to promote their innovative solutions and facilitate market access. Instruments such as innovation partnerships and pre-commercial procurement should be used to further develop promising technologies at an early stage and bring them into application.

7. **Reduce overlegalization in public administration:** Public administration must detach itself from rigid process thinking in order not to unnecessarily inhibit innovation and progress. Excessive bureaucracy and the focus on standardized, formalized processes often lead to inefficiencies and slow down technological innovations in particular. Instead of insisting on detailed procedural rules, the administration should focus more on goal orientation and responsibility for results. Appropriate incentives are necessary for the establishment of an "enabling culture".

8. **Evidence-based policy and goal-oriented Deep Tech funding programs:** Funding programs should be consistently aligned with clearly defined goals to support more Deep Tech innovation. In addition, an obligation to measure success and provide data should be introduced for all funding programs in order to be able to transparently evaluate the measures. This is the cornerstone for evidence-based policymaking and continuous adaptation of funding strategies to maximize their effectiveness and avoid mismanagement.

9. **Reform of funding programs and procurement law:** International programs such as the SBIR program in the USA or Innovate UK show that unbureaucratic application procedures and specific funding models can significantly support the development of start-ups. Reforms should include the simplification of application procedures, the adjustment of liquidity criteria, and the introduction of quick approvals and interim financing options. In addition, special lines of funding should be created for Deep Tech start-ups. A reform of public procurement law is necessary to give these companies fair access to public funding and to boost their innovative strength.

10. **National and European Deep Tech funding from a single source:** The coordination and integration of funding programs at national and European level across all stages of the Deep Tech innovation process should be improved to enable start-ups to have smooth access to various funding and financing opportunities and to optimize the use of resources. Closer integration of the programs means that funding can be used efficiently and innovation projects can be pursued without unnecessary delays.

11. **Enable dual-use innovations:** Against the backdrop of the Ukraine war, the strict separation between military and civilian R&D should be reformed. Military research often drives technological breakthroughs that can revolutionize both military and civilian applications. Examples such as DARPA (USA) and Unit 8200 (Israel) show how the combination of military and civilian sectors leads to spillover effects and the establishment of national innovation ecosystems.

12. **Establish a national Deep Tech advisory board:** A central advisory body should promote exchanges between stakeholders of the Deep Tech ecosystem and politics and administration. The committee serves as a central interface to proactively introduce current and upcoming developments in the Deep Tech sector into politics, to accompany them and to enable anticipatory decisions. As a result, funding mechanisms, regulatory and legislative proposals and other framework conditions can be specifically adapted to lead Deep Tech innovations to market maturity.

13. **Active communication and awareness-raising:** The public sector should emphasize the importance of Deep Tech for societal challenges. Transparent communication about the opportunities and risks strengthens trust and acceptance for Deep Tech innovations. Furthermore, an error culture is established in which failure is recognized as a necessary part of the Deep Tech innovation process. Only through this open and proactive attitude can the state promote the willingness to take risks that are necessary for the success of groundbreaking projects.

6.3 Companies and their ecosystems

When analyzing the current and future desirable role of companies in the Deep Tech ecosystem, we spoke to various stakeholders representing young (<10 years) companies with high growth potential (start-ups, scale-ups and spin-off[35]) and established companies of different sizes (small and medium-sized enterprises (SMEs), family and owner-managed, larger companies as well as capital market-oriented companies). As diverse as the German corporate landscape is, as diverse are the roles that the corporate stakeholders take on in the various phases of the Deep Tech innovation process.

More than other technology categories, ecosystems play a critical role in Deep Tech innovation. A business ecosystem is a dynamic network of organizations, resources, and stakeholders that complement each other, working together to develop and implement innovative technologies. These ecosystems develop co-evolutionarily through the interaction of their members and provide a platform for the cooperative and collaborative exchange of ideas, knowledge and resources.

Findings: Our experts have always emphasized that a functioning, active enterprise ecosystem is the essential pillar of Deep Tech's success.

[35] Hereinafter referred to simply as start-ups

Innovations arise and spread through connections between different, heterogeneous innovation stakeholders.[36] Companies work together in these structural networks towards a common goal by pooling their different, complementary skills, competencies and resources.[37] Unlike traditional value chains, where each company acts as a single actor in classic supplier-customer relationships, a Deep Tech ecosystem typically consists of complementary partners whose success is interdependent.

It's the Ecosystem, Stupid!

Successful Deep Tech business ecosystems are characterized by close cooperation with various stakeholders such as universities, non-university research institutions, intermediaries, investors, politicians, regulatory authorities and public institutions. Although digital technologies shift the boundaries of space and time in the composition of ecosystems, business ecosystems often have their origins in local technology clusters where different stakeholders pool their competencies and resources. Deep Tech innovation requires a **high concentration and agglomeration of knowledge, skills and resources in close proximity and close links between companies and the other innovation stakeholders.**

[36] Rodgers (1962)
[37] Adner (2017)

Universities that are particularly strong in research form the foundation for technology clusters, because they ensure the influx of highly qualified talents and the unplanned, uncoordinated spread of knowledge and ideas (so-called knowledge spillovers). Many studies show that technology clusters cannot be established top-down, but can be promoted by the public sector, especially through investments in research institutions, low costs and restrictions on experimentation and a high quality of life.[38] In addition, technology clusters are usually not formed on a greenfield basis, but build on existing structures and renew them in order to adapt to new, groundbreaking developments. In Germany, well-developed, well-functioning local clusters exist mainly in traditional areas.

> *"Germany has a very differentiated technology profile. Almost all technologies are available at the companies in the country. Most Deep Tech innovations require systemic approaches as they involve both digitization and physical production. It is not enough to only be strong in digitization if there is a lack of hardware or materials. Germany has these interdisciplinary skills and resources. We can develop and produce high-tech machines in a short time, which others cannot do so quickly."*
> – **Prof. Dr. Günther Schuh** (Holder of the Chair of Production Systematics, RWTH Aachen University)

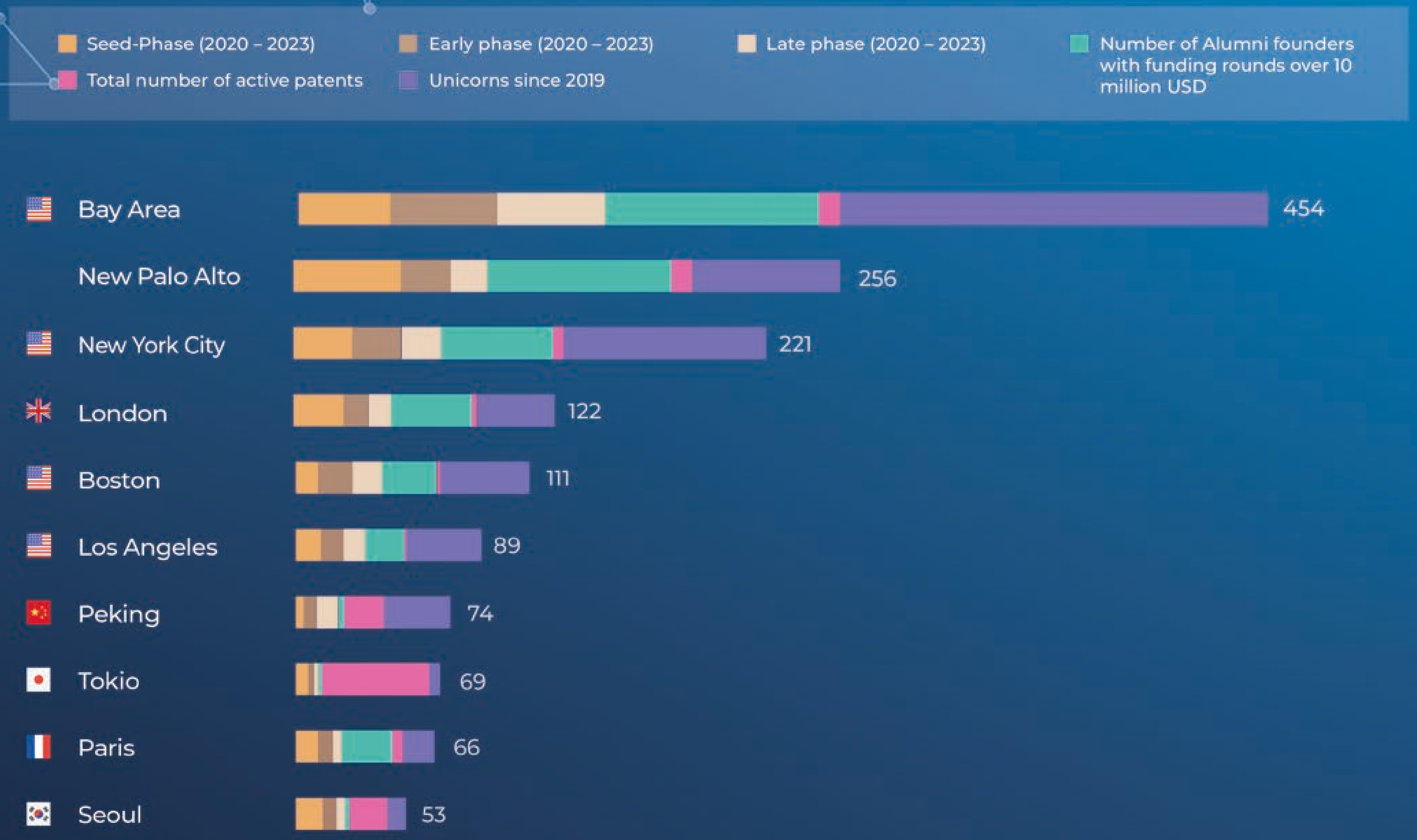
[38] Kerr et al. (2014)

However, some experts make it clear that there is a need for improvement in fundamentally new, future pioneering (so-called path-breaking) Deep Tech innovations. This is especially true in the field of the development and application of digital universal technologies (general purpose technologies) such as artificial intelligence, blockchain, quantum computing, the Internet of Things, Augmented and Virtual Reality (AR/VR), 5G/6G, cybersecurity and, in turn, robotics, digital medicine, intelligent power grids and autonomous driving, in which Germany is increasingly losing touch. There is no German Tech Cluster in the top 10 of the world's highly innovative local ecosystems (so-called Scaleup Hubs) (see Fig. 15). Ranked by the absolute magnitude of venture capital investment, university talent, patent development, and the number of unicorns and exits in excess of 1 billion USD, US dominance is evident, with five tech hubs among the top six global ecosystems. Berlin is ranked 16th in this ranking as the best-placed German ecosystem.

Findings: Germany is losing touch, especially with pioneering digital Deep Tech innovations, and is not represented in the top 10 of the world's most innovative tech ecosystems.

Figure 15

Top 10 Global Leading Scaleup Hubs



Source: Dealroom.co. (2024). New Palo Alto. Dealroom.co. Retrieved on 10/17/24 from https://dealroom.co/guides/npa

"It Takes an Entire Village to Raise a Deep Tech Company"

Deep Tech innovations in particular are characterized by the fact that they cannot be integrated into existing business ecosystems in isolation and without friction. **Due to their novelty and lack of exchange, target customers often do not know how Deep Tech innovations can be applied in their areas and embedded in existing processes, infrastructures and routines or used for their own innovations.** However, this understanding is essential not only for the commercialization of Deep Tech innovations, but also to convince the other stakeholders in the ecosystem to invest in the necessary infrastructure, minds and adaptations to a Deep Tech innovation.

IBM, for example, takes a structured approach to this in the context of quantum computing. **Dr. Jan-Rainer Lahmann** (IBM Distinguished Engineer) describes the approach of the IBM quantum network to support companies, start-ups, research institutions and universities with a range of resources and support in integrating quantum computing into their processes. Members of the network, including companies such as Bosch, VW, and E.ON, will gain access to IBM's quantum computing technology through the Qiskit open-source programming framework, which accelerates quantum computing tasks via the IBM Cloud to familiarize themselves with the technology and explore quantum applications in areas such as materials science, electromobility, AI, and advanced sensor technologies.

> *"We think it is very important and the right approach to create a flexible, open exchange platform to get feedback, increase knowledge and acceptance and ultimately to reach market maturity quickly"*, says **Dr. Jan-Rainer Lahmann** (IBM Distinguished Engineer)

This example shows how central co-evolution of the ecosystem is to the market success of Deep Tech innovations. Co-evolution of the market is the development of complementary knowledge and skills around a new innovation.[39] Ecosystem participants must therefore first adjust their investments and decisions in order to be compatible with the changing technological and institutional requirements of the emerging ecosystem that forms around a new Deep Tech innovation.[40]

From this point of view, the term "Ecosystem Value Proposition" has also emerged, which emphasizes that the **Value Proposition of a groundbreaking innovation only arises in the complex interaction of stakeholders, technologies and institutions.** The commercial breakthrough of a Deep Tech innovation requires a network of stakeholders who *"bring in or develop specialized but complementary resources and/or capabilities to (a) co-create and deliver an overarching value proposition to end users, and (b) appropriate the profits gained."*

Just think of electric cars, which require far more than just cars with an electrified powertrain for their breakthrough, but also charging infrastructure, battery cells or the expansion of power grids as well as new knowledge and skills in battery technology, production or application.

Functioning ecosystems are therefore characterized by a dynamic, cross-industry and cross-disciplinary network of hierarchically independent but interdependent heterogeneous stakeholders. Depending on the stage of development of Deep Tech, these stakeholders work from basic research, through feasibility studies and prototype development to commercialization, often without formal contractual relationships, on new knowledge, products, services and business models. The local character and developed networks between organizations and people make this form of cooperation possible.

> **Findings:** The success of Deep Tech innovation depends largely on the co-evolution of the ecosystem, where stakeholders adapt their investments and capabilities to create value together.

[39] Moore (1993)
[40] Thomas & Autio (2020)

Phase 1: From research results to applications or the commercialization gap and Mid-Tech trap

In the initial stage, basic research is carried out in **knowledge ecosystems** (TRL 1–3), initial fields of application are outlined and feasibility studies are carried out. The breeding ground for knowledge ecosystems are universities and foundation-oriented non-university research institutions and companies. The geographical proximity of these institutions creates collective learning and knowledge exchange processes that create pre-commercial knowledge that no single actor could independently create.[41] While the research-rich large companies have the necessary application and market knowledge in addition to technological knowledge, **universities and scientists find it difficult to assess and validate their results.**

> *"Here, economies of scale prove to be particularly useful if, within large companies, the critical scope of expertise, experience, coverage of essential fundamentals such as the basic scientific disciplines, materials science, algorithms, etc., combined with the engineering insights into production processes, market and business expertise can be concentrated and orchestrated in the medium and long term. Large companies can play a special role in this if they successfully organize the balance between short-term profit optimization processes and medium to long-term strategy and cooperate with the Deep Tech sector."* – **Dr. Michael Lemke** (Chief Security Officer, Huawei Germany)

[41] Järvi et al. (2018)

An instructive example is described by an expert. He described the case of a biotechnical innovation that represents a sustainable alternative to petroleum-based plastics. Using an innovative process, scientists have succeeded in the biotechnical production of a substitute for a key raw material in plastics production. But so far, this promising process has not been able to be transferred into actual use. The chair lacks financial and human resources for the validation of the complex process stages, which enable the work on the transfer of the research results into a scalable, marketable solution. There is no support for this from the university.

> *"This case study shows very well that there is a gap between academic research and industrial application that needs to be closed in order to successfully integrate innovative and sustainable technologies into the market."* – **Anonymous**

Companies therefore need contact persons who not only advance basic research, but also have the capacities and knowledge to develop marketable and scalable solutions from basic research.

"If I don't think about how it can be industrialized at a competitive cost right from the start of the research and don't build up a corresponding knowledge of partners or my own activities, it will be difficult. Good ideas alone are not enough, I also have to pay attention to how they can lead to marketable industrialization. Here, reference is often made to institutions such as Fraunhofer. In my opinion, this requires more motivation and clearer objectives on the part of the universities in order to align chairs more closely with industrial applicability." – **Anonymous**

Dr. Annika Hauptvogel (Head of Technology & Innovation Management, Siemens) sees this similarly and emphasizes that science and business are called upon to work better together. *"When research is not looking at the potential use case of a particular development, technology transfer becomes difficult. At the same time, it becomes challenging for the industry to make progress if it focuses exclusively on its current products while ignoring technology trends. It is therefore of central importance to promote dialogue between science and industry and a common understanding. For this reason, we at Siemens have founded Research and Innovation Ecosystems, for example in Munich, Berlin, Aachen, but also globally. This allows us to exchange ideas at an early stage in order to think strategically together about the topics on which we can work together. This is a very good way for us to strengthen cooperation with universities and secure the transfer."*

University research often lacks the experience and knowledge to recognize the transfer potential of basic research and to review the resources within the framework of feasibility studies. In this context, the BMBF funding program VIP+[42] for "validating the technological and social innovation potential of scientific research" was seen as an important first step. The program supports scientists in verifying the transfer potential of their research results into practice.

Start-ups also want more willingness and openness from established companies. These companies often find themselves unable to participate in feasibility studies because they are either only buyers of the end products, fear unpopular changes or simply shy away from the effort. Science and start-ups have often criticized the fact that although companies like to use new Deep Tech services and products that can be used immediately, scalable and tested, they prefer to hold back in advance when it comes to necessary technical and theoretical feasibility analyses.

Some experts suggested that science and industry should be more closely interlinked via crossovers. The temporary exchange of personnel already exists between business and administration and leads to a better mutual understanding, knowledge and competence exchange and more effective processes. It was also recommended to check whether changes from business to science, including at universities, in particular in applied subjects, could not be facilitated or promoted to a greater extent.

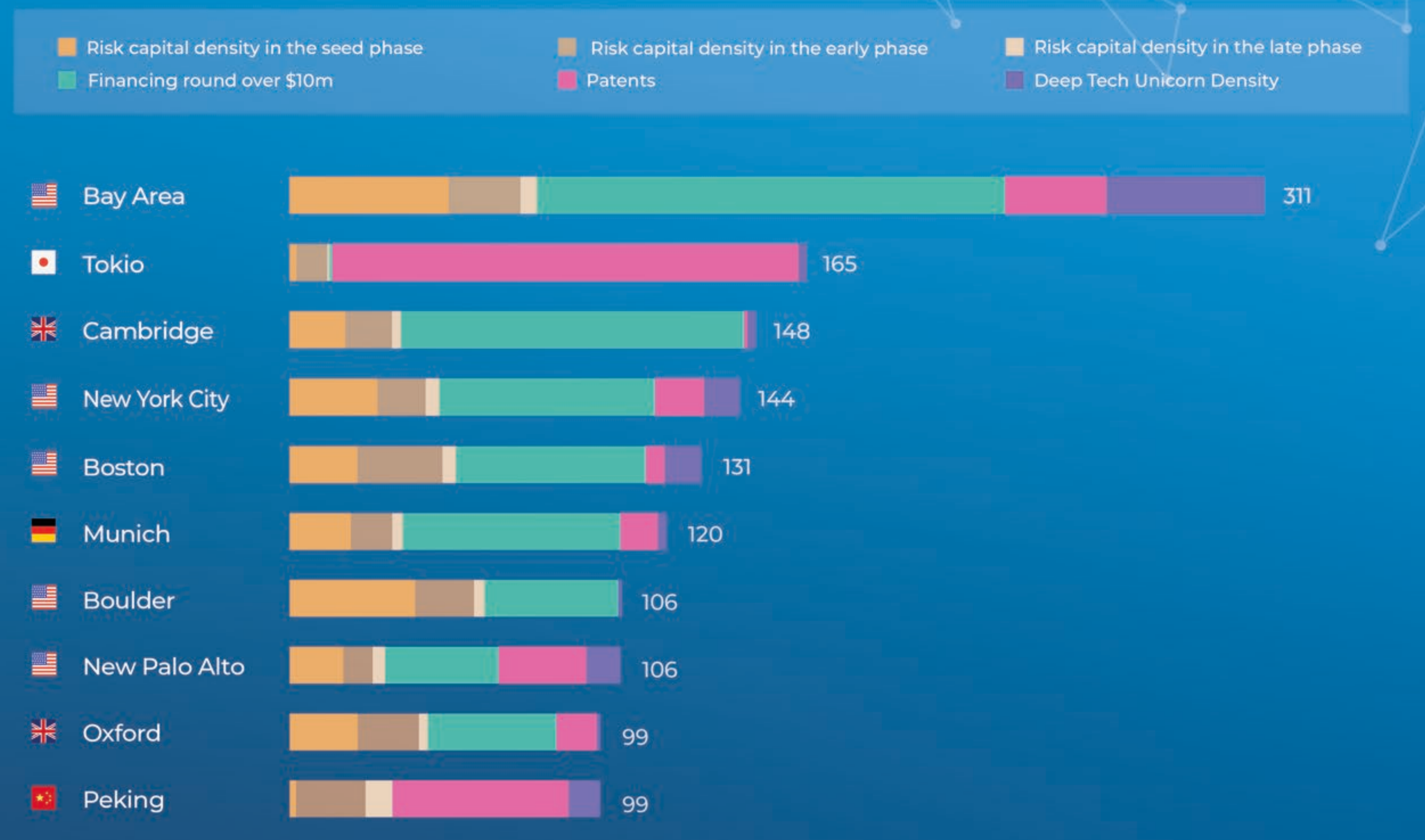
[42] See https://www.bmbf.de/bmbf/de/forschung/zukunftsstrategie/validierungsfoerderung-vip/validierungsfoerderung-vip_node.html

The language played a remarkably minor role in the interviews of SMEs. Several representatives of these companies expressed the regional distance to the important German tech clusters as an obstacle, but also the lack of exchange opportunities and resources to cooperate specifically with science. The chambers of industry and commerce and associations were also described as unhelpful for the transfer. Not least because SMEs are often underrepresented in industry associations and are not active.

> **Findings:** Greater integration between science and business for a better mutual understanding of needs and objectives is essential for the development of Deep Tech.

As a consequence, much of the knowledge created by European science remains untapped as it is not applied commercially. According to the European Patent Office, only one third of patented inventions are commercially exploited by European universities or research institutions. The main reason for this failure has been identified as the insufficient integration of researchers into European Tech clusters, which play a significant role in the successful commercialization of highly innovative technologies. Internationally, Munich is the only German location among the top 10 **global science hubs** (see Fig. 16).

Figure 16 **Top 10 Science Hubs**



Source: Dealroom (2024)

German business does not invest enough in R&D and is caught in the "Mid-Tech trap"

The German economy subjects its R&D activities in some sectors too much to the dictates of path dependency and short-termism. In international comparison, Europe invests less in R&D activities than the USA, Japan or China. However, the discrepancy does not stem from the state financing of R&D, which is similarly high in the EU (share of Germany: 40%) as, for example, in the USA (approx. 0.7% of gross domestic product, GDP), but is due to the lower R&D expenditure of German companies. In the USA, the share of private R&D expenditure is around 75%, in Japan, South Korea and China even higher, while German companies are responsible for only 69% of R&D investments (see Fig. 17).

> *"Many companies have largely left basic research in favor of shareholder value and short-term profit maximization. We believe that basic research must also retain a permanent place in industrial research. With a view to the long-term monetization of research results, industrial companies can strategically evaluate and secure the value of this work beyond the mere gain of knowledge. Against this background, our company occupies the leading position in the manufacturing-oriented industry, directly behind the large software companies."* – **Dr. Michael Lipka** (Senior Manager Technology Strategy, Huawei)

Figure 17 **Gross R&D expenditures in selected countries, by sector and funding source**

Country	R&D Gross Domestic Expenditure (in billion USD)	Origin of R&D funds: Share of the total amount (%)			
		Companies	State	Other domestic	Rest of World
United States (2019)	668.4	65.0	21.0	6.8	7.2
China (2019)	525.7	76.3	20.5	not available	0.1
Japan (2019)	173.3	78.9	14.7	5.8	0.6
Germany (2019)	148.1	64.5	27.8	0.4	7.4
South Korea (2019)	102.5	76.9	20.7	0.8	1.6
France (2019)	73.3	56.7	32.5	2.8	8.0
India (2018) [1]	58.7	36.8	63.2	0.0	0.0
United Kingdom (2019) [2]	56.9	54.8	25.9	5.6	13.7

1 For India, the most recent year of available data for BAFE and the distribution of R&D performance is 2018, while the most recent year of available data for the distribution of R&D expenditure by funding source is 2017.

2 For the United Kingdom, the most recent year for which data is available on the distribution of R&D expenditure by funding source is 2018.

Source: Based on the National Center for Science and Engineering Statistics (2022)

Although the share of the private sector has increased in recent decades, there is still a considerable gap to reach the level of the leading nations. Several experts cited family- and owner-managed SMEs such as Trumpf and Festo or foundation-led companies such as Bosch and Zeiss as positive examples of strategic and long-term investments in Deep Tech innovations. Due to their long-term strategy, these companies have longer staying power, which is needed for the development and commercialization of Deep Tech innovations.

Germany and the EU have fallen into the Mid-Tech trap. This means that R&D investments are too one-sidedly focused on established, medium-technological areas such as the automotive, chemical or mechanical engineering sectors, whose technological and economic potential is limited compared to new, highly innovative growth areas such as digital technologies and biotechnology.[43] Especially in Germany, the concentration of private-sector R&D expenditure at the sector and company level is particularly high. Almost 80% of R&D investments are limited to five industries (automotive, electronics, mechanical engineering, pharmaceutical and chemical) and almost 90% to companies with 500 or more employees. R&D expenditure on information and communication services and that of SMEs is correspondingly low.

These structural differences, amplified over decades by technological and structural path dependencies, have resulted in the German and European economies remaining in their traditional specializations, while the US and China are increasingly benefiting from highly innovative industries. A look at the top 3 companies in terms of R&D spending in the US, Japan and the EU and their respective industries illustrates this development over the last 20 years. While in the USA only Microsoft appears in the Top 3 twice, in the EU and Japan companies such as Volkswagen (VW), Mercedes and Toyota have consistently been in the Top 3 over the last 20 years, with Panasonic, Bosch and Honda also being represented at least twice. This shows the lack of industrial and innovation momentum, which is far greater in the US. While two companies from the automotive industry were still in the top 3 in 2003, the importance of the digital economy has supplanted this and others by 2022. This development is also manifested in the fact that only six European companies can be found among the 50 most valuable tech companies in the world, and for 50 years in Europe it has not been possible to build a new company with a market capitalization of over 100 billion euros. In the same time period, six companies have emerged in the USA, which today reach a valuation of over one trillion euros.[44]

The Mid-Tech trap is also reflected in the patent statistics. Although Germany ranks 5th in the world when it comes to filing international patents, most patents are filed in the medium-technology fields described. At the EU level, too, patent statistics show that the EU is strongly focused on the mobility sector, while Japan is strong in electronics and the US dominates the highly innovative growth areas of computers and digital technology as well as pharmaceuticals and biotechnology. These concentration dynamics have even intensified over the past 30 years. From the perspective of the EU and Germany, this dynamic is worrying, as patent applications in the other three growth and key areas considered have stagnated over the past 10 years.

[43] Fuest et al. (2024)

[44] Draghi (2024)

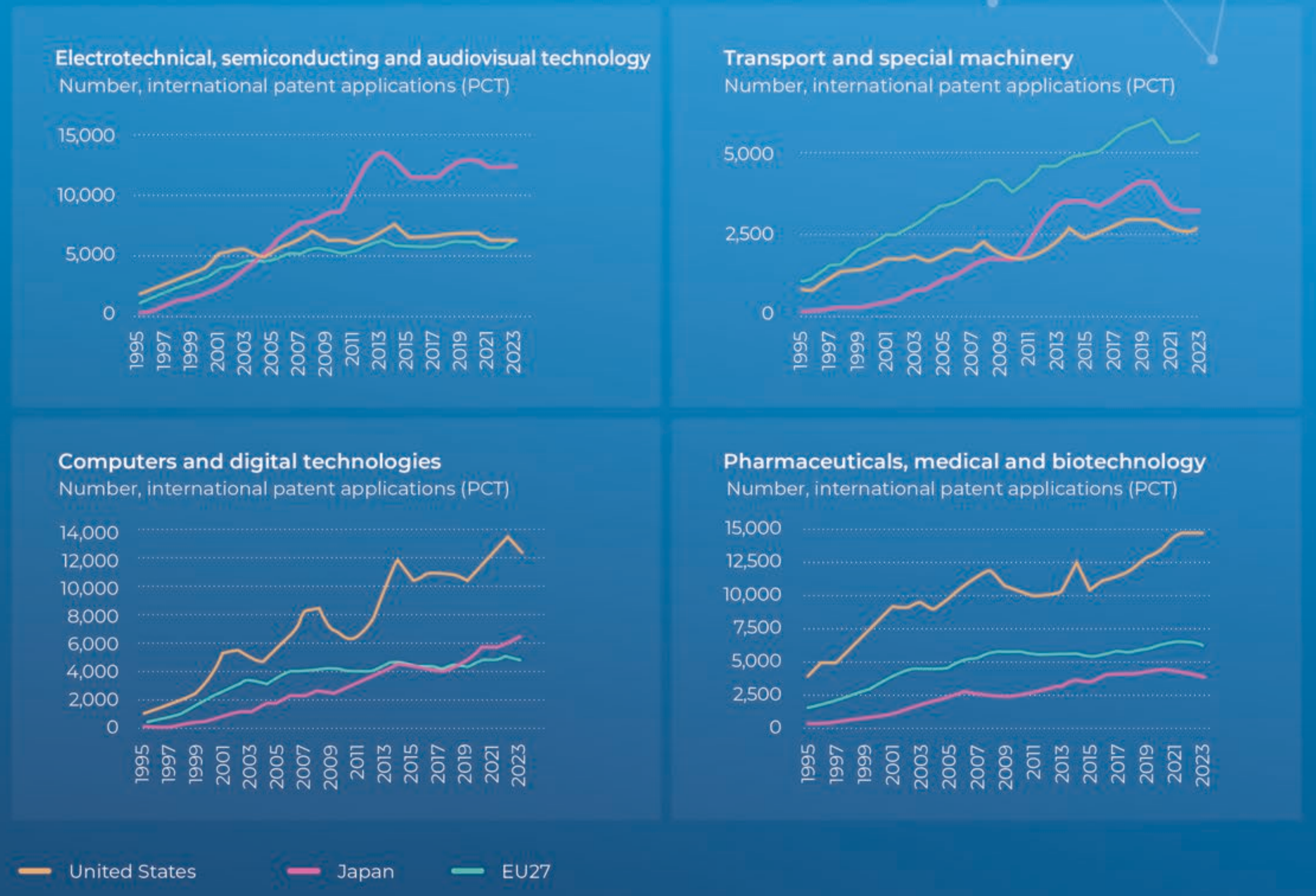
Figure 18
Top 3 companies with the highest R&D spending over time

	2003	2012	2022
UNITED STATES	Ford (Auto)	Microsoft (Software)	Alphabet (Software)
	Pfizer (Pharma)	Intel (Hardware)	Meta (Software)
	GM (Auto)	Merck (Pharma)	Microsoft (Software)
EUROPEAN UNION	Mercedes Benz (Auto)	VW (Auto)	VW (Auto)
	Siemens (Electronics)	Mercedes Benz (Automotive)	Mercedes Benz (Auto)
	VW (Auto)	Bosch (Auto)	Bosch (Auto)
JAPAN	Toyota (Auto)	Toyota (Auto)	Toyota (Auto)
	Panasonic (Electronics)	Honda (Auto)	Honda (Auto)
	Sony (Electronics)	Panasonic (Electronics)	NTT (Telecom)

Source: Fuest et al. (2024)

Findings: Germany and the EU have fallen into a Mid-Tech trap because they focus too much on established, Mid-Tech industries due to technological and structural path dependencies, thereby neglecting potential in highly innovative growth areas such as digital technologies and biotechnology.

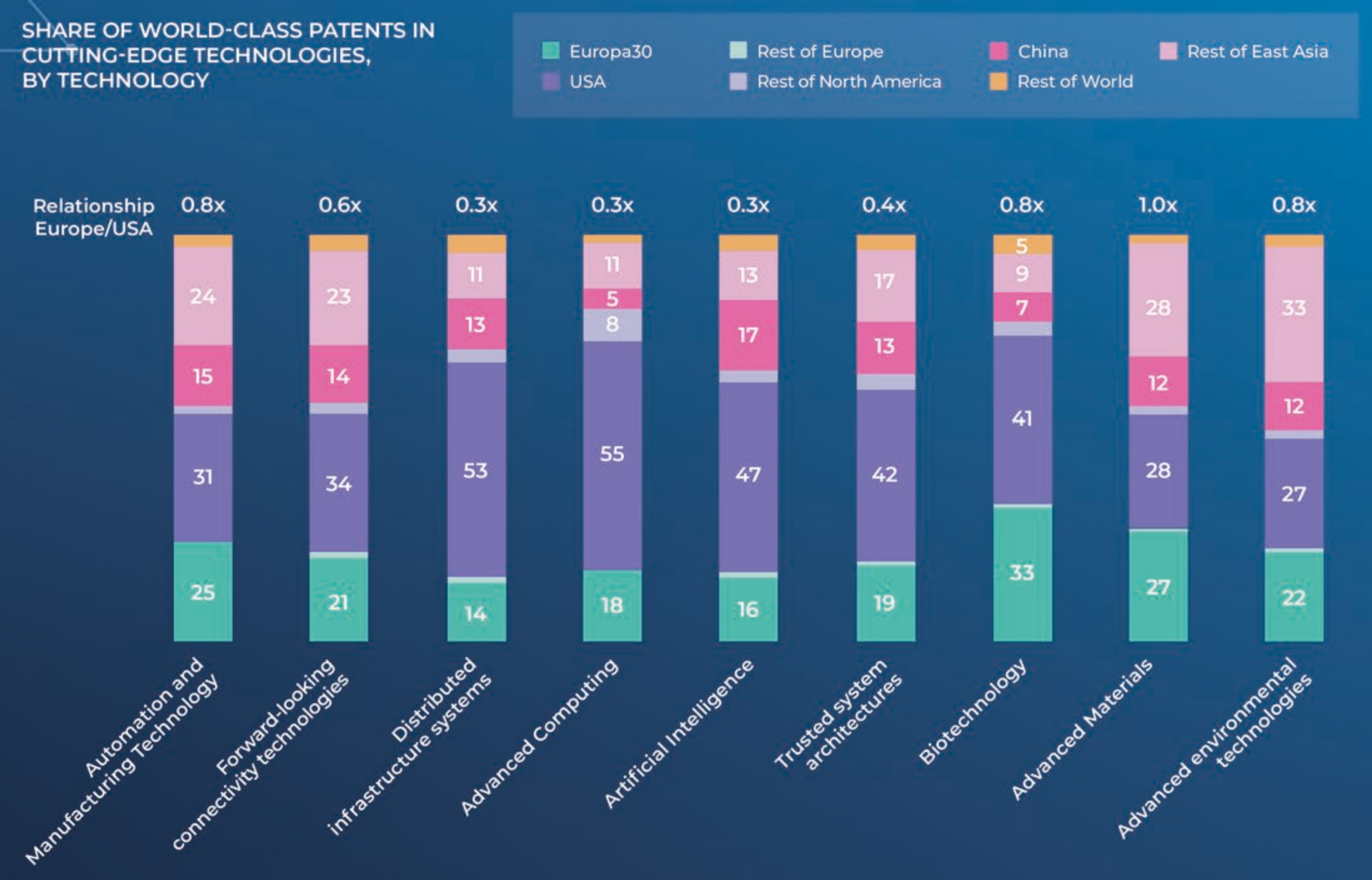
Figure 19
International patent applications by selected technology classes and countries



Source: WIPO (2024)

Figure 20

Proportion of world-class patents in key technologies



Source: Lakestar et al. (2023)

Where are the “Big Bets” on growth engines of the future?

A recurring topic in our discussions was the **slow pace of adaptation of established companies, especially with regard to digital transformation** (see “Achilles’ Heel Digitalization” Reloaded). Often, action is taken for short-term considerations and too little risk is taken in the implementation of new ideas, presumably also because the pressure on established companies to innovate has not been sufficiently high in the past. But the pressure is increasing, not least due to declining margins from new competitors with no technological and structural legacy and an increasingly geopolitical, multipolar trade and investment policy.

> *“As a German in an American company, I see some differences in how you approach innovation. The American corporate culture is far less risk-averse and far more innovation-friendly. They focus more on opportunities than risks, while German companies tend not to take risks in the first place. Something could go wrong. At Meta, we regularly ask ourselves what the future big bets are. We launch many projects, even though we are aware that some could fail, and we regularly have the courage to stop less promising projects. German companies, on the other hand, are often more cautious and prefer to stay away from risky projects. The American approach ultimately allows US firms to make bigger breakthroughs, even if it occasionally means billions of bad investments.”* –**Tino Krause** (Regional Director Central Europe, META)

German and European companies are also much more cautious when it comes to harnessing Deep Tech innovations through an acquisition of start-ups in the company. Only around 20% of the acquisitions of European Deep Tech start-ups in the period 2016–2023 were made by German companies. In terms of the EU, the proportion rises slightly to just under 28%. These low scores for Deep Tech innovations that have emerged on your doorstep illustrate the **widespread hesitancy of established companies towards risky investments in growth areas.**

Established, especially large companies, are constantly observing new technological developments in the search field of the technologies they consider relevant (Horizon Scanning). On the basis of these, the companies examine the potential importance and impact on their core business and the degree of maturity of technology trends in the context of foresight analyses. But not all experts believe that these ritualized, technology-centric standard processes are sufficient to meet the often digitally fueled pace of transformation, the societal dimensions of technology innovations, and unforeseen development paths.

Figure 21 **Top corporate buyers of European Deep Tech companies**

Source: Lakestar et al. (2023)

> *"In the context of strategy processes, executives in particular have to step back from the detailed picture that trend analyses offer them in order to be able to perceive the whole picture. A 360-degree view of your own company's place in the world outside is crucial for proper consideration of company's role in context. This is the only way to reflect on how the complex value proposition is influenced by social, geopolitical, environmental and social shift factors with digitization. Drawing the right strategic consequences from this, so that people get their perspective or even a concrete end product, is the great art."* – **Jens Helmerich** (Partner & Senior Manager Leading Strategy, Tagueri)

There is a risk that the detailed analyses will overlook disruptive trends and opportunities. The established methods tend to reinforce existing trends, thought patterns and developments and often focus on technologies, not their application potentials and societal currents. In addition, the excessive dependence on external experts leads to companies not acting independently enough and not pursuing risky but revolutionary ideas.

Phase 2: Development and Prototyping or the search for application partners

If a pioneering, scientific finding proves its advantages and feasibility, it is important to determine whether the technology also works on a larger scale and under real-world conditions of use and whether adjustments are necessary for full implementation. In this phase, universities are no longer entrusted with the implementation of scientific findings, but start-ups, spin-offs or established companies. The task of these companies is now to establish partnerships with established companies in the so-called entrepreneurial ecosystem in order to test the developed prototypes under real conditions and to develop a viable business model.

Application partner urgently needed

> **Findings:** Many start-ups struggle to find established application partners to test and customize their solutions.

In addition to the obvious reasons such as time and personnel expenditure, other reasons are decisive. Deep Tech innovations such as quantum computing are often in need of explanation, as they require novel knowledge and skills to use. For pilot projects, users must therefore first be trained and further qualified in order to be able to experiment with quantum computers. This costs time and money while the benefits are uncertain.

> *"Quantum computers are not an 'easy sell'. That's why we invest a lot of time and energy in the educational process of our stakeholders."* – **Dr. Jan Götz** (Co-CEO & Co-Founder, IQM Quantum Computers)

Secondly, it requires trust between start-ups and application partners, because both sides may have to disclose IP. Thirdly, there are also cases where established companies have no interest in changing the status quo. This can be due to organizational reasons of technological path dependency ("we have always done this"), resistance to disruptive innovations ("innovator's dilemma" or "its running, why should we change anything"), organizational persistence ("we have never done this"), "not-invented-here syndrome" ("this cannot work for us") or lack of openness ("this is outside our field of expertise"). But also for competitive reasons, because the more fundamentally a Deep Tech innovation challenges traditional business models, the less incentives established companies have for application partnerships. In these situations of market failure, the state in particular plays an important role as an application partner when Deep Tech innovations are in the extraordinary national or social interest (see the importance of public procurement as an innovation engine).

The Deep Tech ecosystem needs new collaboration concepts

The German Startup Monitor also concludes that established companies are increasingly reluctant to cooperate with start-ups.[45] In the period from 2020 to 2023, the proportion of start-ups that carried out cooperation projects with established large corporations and medium-sized companies fell from 72% to just 61%. According to experts, this is often due to disappointing experiences in the past, which arise not least from excessive expectations of the solution itself and its development over time, as well as different methodological development approaches.

Experts gave us promising models of how collaborations between established companies and start-ups can work. These companies have recognized that this allows them to keep their knowledge up to date and gain a competitive advantage through early application. In the Maschinenraum Innovation Hub, which was initiated by the German medium-sized company Viessmann in 2020, over 70 family businesses and start-ups work out experiences, knowledge, skills and resources in regular exchange formats. BMW, for example, pursues a different approach with the Venture Client model called "BMW Garage". In contrast to direct investments via a corporate VC arm or incubation or accelerator programs, venture clienting focuses on cooperation on the content of a technology and market access for start-ups.

[45] Start-Up-Monitor (2023)

> *"When it comes to quantum, we try to understand how technology is developing in order to think about the possibilities of integration into our vehicles, processes or ecosystem."* – **Dr. André Luckow** (Head of Innovation and Emerging Technologies, BMW Group)

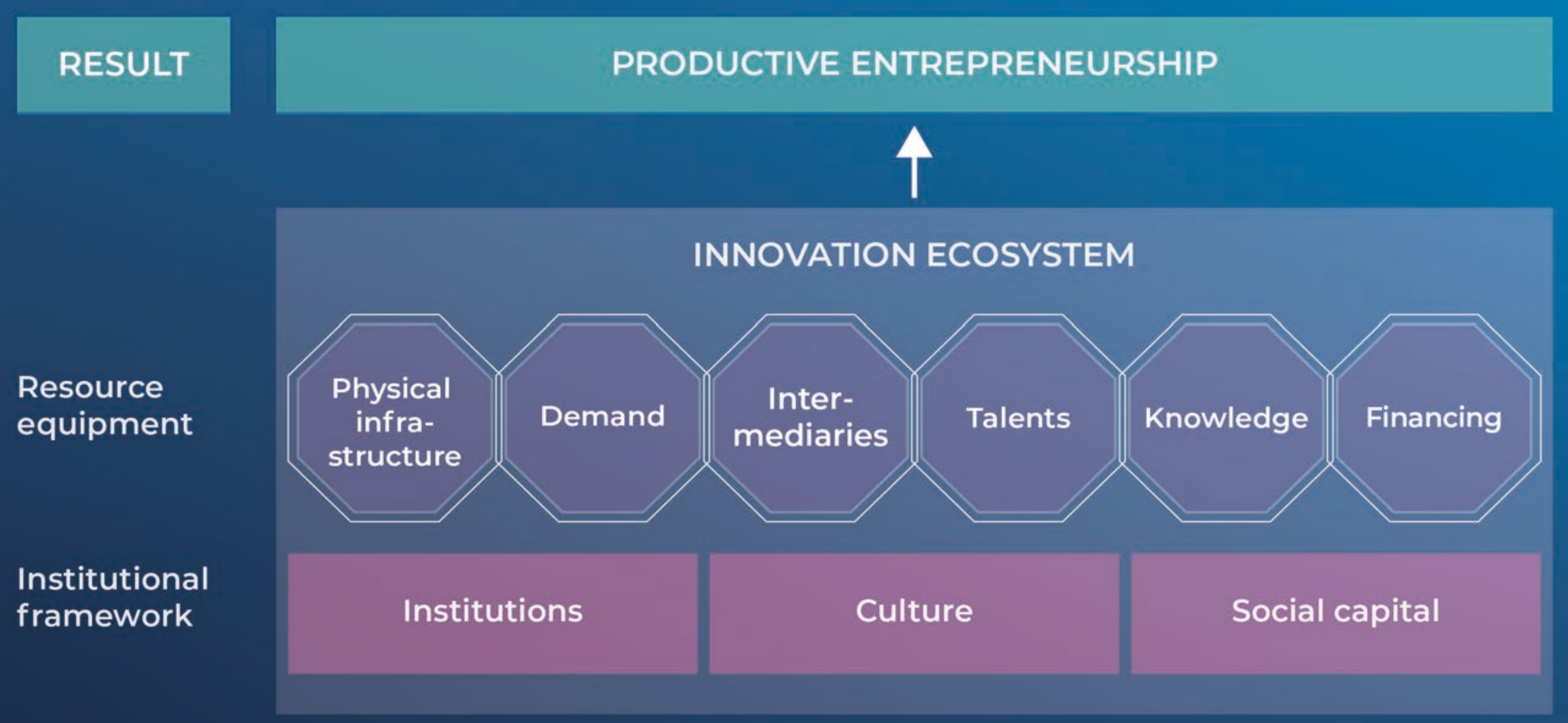
The approach allows start-ups to quickly test their technologies under real conditions and get valuable feedback. Unlike traditional customers, who often take a long time to make a purchase decision, a Venture Client start-up allows faster access to the market and shortens the development cycle. This increases the chances of achieving product-market fit faster, while at the same time minimizing the risks posed by the field test. Venture Clients benefit from quick access to new technologies and knowledge that could help them solve their challenges better and faster.

Phase 3: Implementation and commercialization or finding the creative destroyers

For the final market maturity of a Deep Tech innovation, interaction with other stakeholders and components of the innovation ecosystem must be achieved under real conditions of use. To this end, a coherent value proposition must first be created at the ecosystem level, which is aimed at specific target customers. To coordinate among themselves, technology-centric innovation ecosystems rely on digital platforms (platform ecosystems) or compatible technology standards (modular ecosystems) as a coordination mechanism. Common to all innovation ecosystems is that many companies offer complementary services and products to create an ecosystem value proposition without consistently organizing in classic customer-supplier relationships.

However, the emergence of innovation ecosystems can only succeed if enough companies can jointly create an ecosystem value proposition from which the companies benefit financially. The above-mentioned problems such as technological path dependency, lack of willingness to change and adherence to traditional methods and business models are major barriers to the broad adoption and use of Deep Tech innovations. Here, too, a market failure can occur if established companies (intentionally or unintentionally) hinder the emergence of new innovation ecosystems around a socially desirable Deep Tech innovation. In such cases, it is up to the state to correct the market failure through appropriate measures. In functioning innovation ecosystems, companies are also involved in inside-out or outside-in cooperation with competitors in accordance with the open innovation concept (co-opetition). Outside-in means that external ideas and technologies are integrated into the company, while inside-out means that own innovations and technologies are passed on externally, e.g. to partners or competitors. The potential cooperation advantages are many times greater than the disadvantages. In addition, especially in the case of Deep Tech innovations, the ecosystem value proposition cannot be delivered by one company alone.

Figure 22 **Framework conditions for productive entrepreneurship**



Source: Based on Stam & Van de Ven (2021)

> *"It is becoming increasingly important to use the concept of "frenemies", i.e. to be competitors and partners at the same time. In some areas we compete with our frenemies, in others both sides benefit from the cooperation. No company, neither we nor Microsoft, Apple or Nvidia, will be able to solve the complex challenges of the future alone. Cooperation and partnership will be decisive for the success or failure of Deep Tech innovations in the next ten years."* – **Tino Krause** (Regional Director Central Europe, META)

Findings: Collaboration and partnerships, including between competitors, are critical to the success of Deep Tech innovation, as no company can tackle the complex challenges alone.

Targeted collaboration between large companies and SMEs is also an important aspect, so that existing ecosystems can take advantage of the opportunities offered by technologically groundbreaking innovations and adapt. In Germany, initiatives such as the Labs Network Industrie 4.0 e. V. have been formed in which companies such as Siemens, Festo or SAP work together with associations such as Bitkom[46], VDMA[47] or ZVEI[48] with the aim of supporting SMEs in their digital transformation in industrial production.

[46] Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V. [Federal Association for Information Technology, Telecommunications and New Media e. V.]
[47] Verband Deutscher Maschinen- und Anlagenbau [German Engineering Association]
[48] Zentralverband Elektrotechnik- und Elektronikindustrie [Central Association of the Electrical and Electronics Industry]

"Achilles' heel digitization" Reloaded

Germany's digital deficit is alarming in many ways. The Future Study "Digitalization: Achilles' heel of the German economy?" of the MÜNCHNER KREIS already concluded in 2014 that *"there are some grievances and numerous weaknesses in the German economy with regard to its ability to meet the challenges posed by the digital age"*. At the time, there was still optimism that the "*responsible stakeholders will set the course in the right direction*", our experts and numerous empirical facts state that the distance between key digital technologies and the leading nations is still growing. **The digital deficit is a threat to Germany's Deep Tech capability.**

> **Findings:** Germany is losing its technological sovereignty in the digital sector. Many of our experts come to this conclusion because they observe that Germany is increasingly abandoning the claim and ability to shape key digital technologies and innovations.

If this happens, our study participants remark somewhat cynically, it will be through excessive regulation at EU level. But there are also exceptions, such as autonomous robotics and AI services, where around 22% and 17% of global activities take place in Europe, respectively.[49]

[49] Draghi, 2024

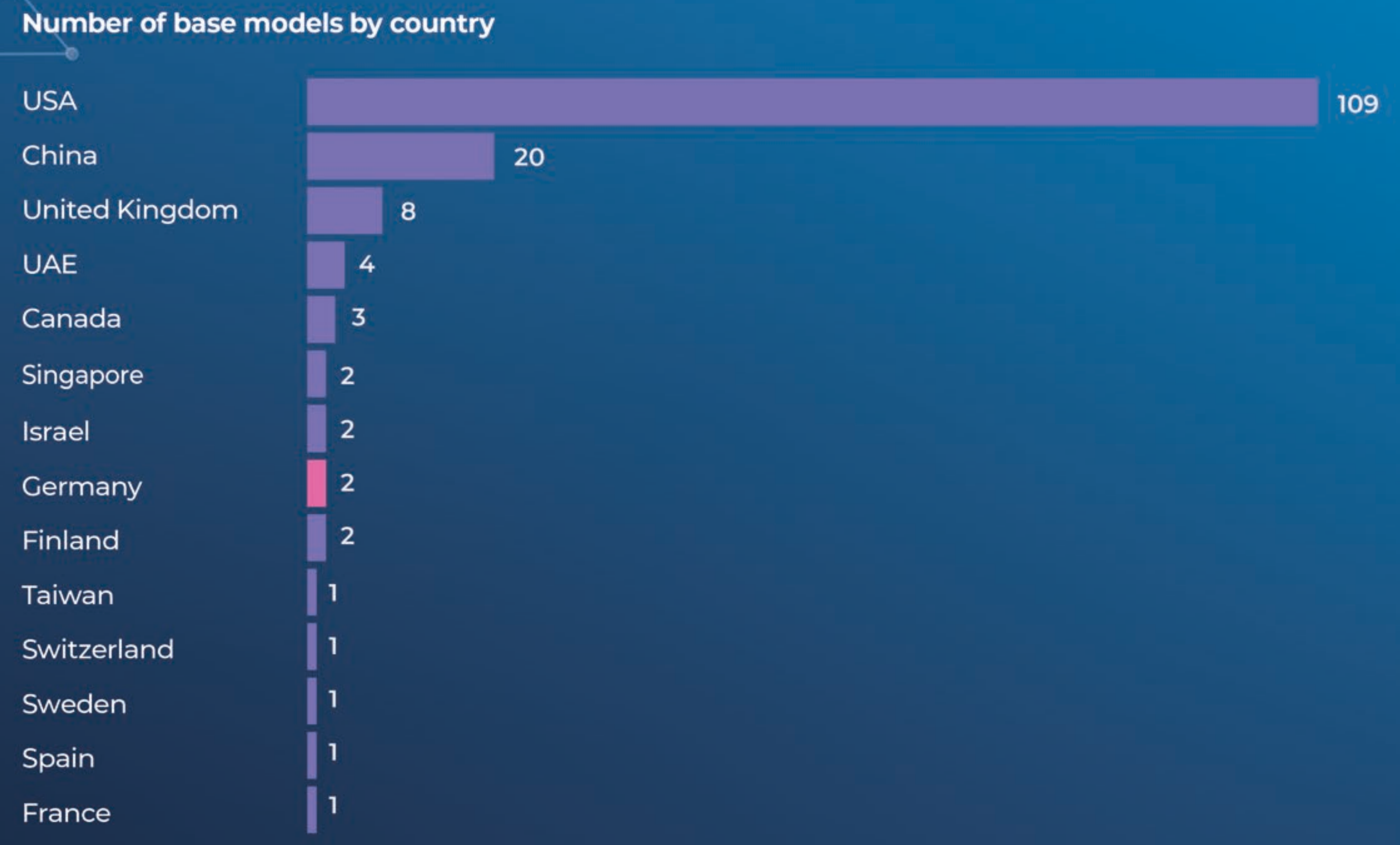
Nevertheless, the German economy is dependent on imports of digital technologies. The relative trade balance since 2007 has been consistently negative, i.e. more digital goods have been imported than sold abroad. The analysis also illustrates Germany's focus and historical strength in the field of production technologies with a significant relative export surplus over the same period.[50]

Germany and Europe also play only a marginal role in the AI base models that are decisive for Deep Tech innovations. These basic models are very large AI models that have been trained on enormous amounts of data (e.g. OpenAI GPT-4, Anthropic Claude 3 or Google Gemini Ultra). These basic models are a somewhat crucial universal technology, as they can take on a variety of tasks in the Deep Tech innovation process. Since the German economy lacks the digital tech giants that could support these investments and refinance them again through their services and products, our experts are skeptical as to whether German and European companies can ever catch up with the frontrunners, especially in terms of regulatory regulations and data.

> *"For individual companies that do not have the scale and network effects of the tech giants, investing in a basic model makes no economic sense,"* says **André Luckow** (Head of Innovation and Emerging Technologies, BMW Group).

[50] EFI Commission (2022)

Figure 23 **Number of basic models for artificial intelligence by country** [51]



Source: The AI Index Report (2024)

> **Jan Gilg** (President and Chief Product Officer, Cloud ERP, SAP) also sees the advantage of the USA in the regulatory environment: *"US companies are doing easier, because disruptive technologies are brought to market much faster there and then you start to regulate, while we very often first regulate and say what, what can you do at all."*

However, Germany and Europe lack the large-scale investment and infrastructure to develop such basic models. While companies in the US such as OpenAI, Meta, Google, Microsoft and Anthropic are investing massively in computing power and research, Europe is lagging behind in this regard. Although there are promising basic models of Mistral (France) or Aleph Alpha (Germany) in Europe, their resources and reach are limited compared to the leading stakeholders. As in the Internet, Mobile and Cloud business areas, Europe is also about to leave the field of AI to the US.

Private-sector investment in AI in the US exceeds Germany's investment by more than 30 times. The UK and relatively small Israel are also investing more than German companies. It is therefore not surprising that Germany is significantly behind the leading AI nations the USA, China and the UK and Israel in terms of the number of AI start-ups. For AI patents in the period from 2010 to 2022, the share of the EU is 2%. While the US was still the leader until 2012, there has been an interesting shift towards a growing share of AI patents from East Asia and the Pacific, with China, South Korea, Japan and Singapore as hotspots.

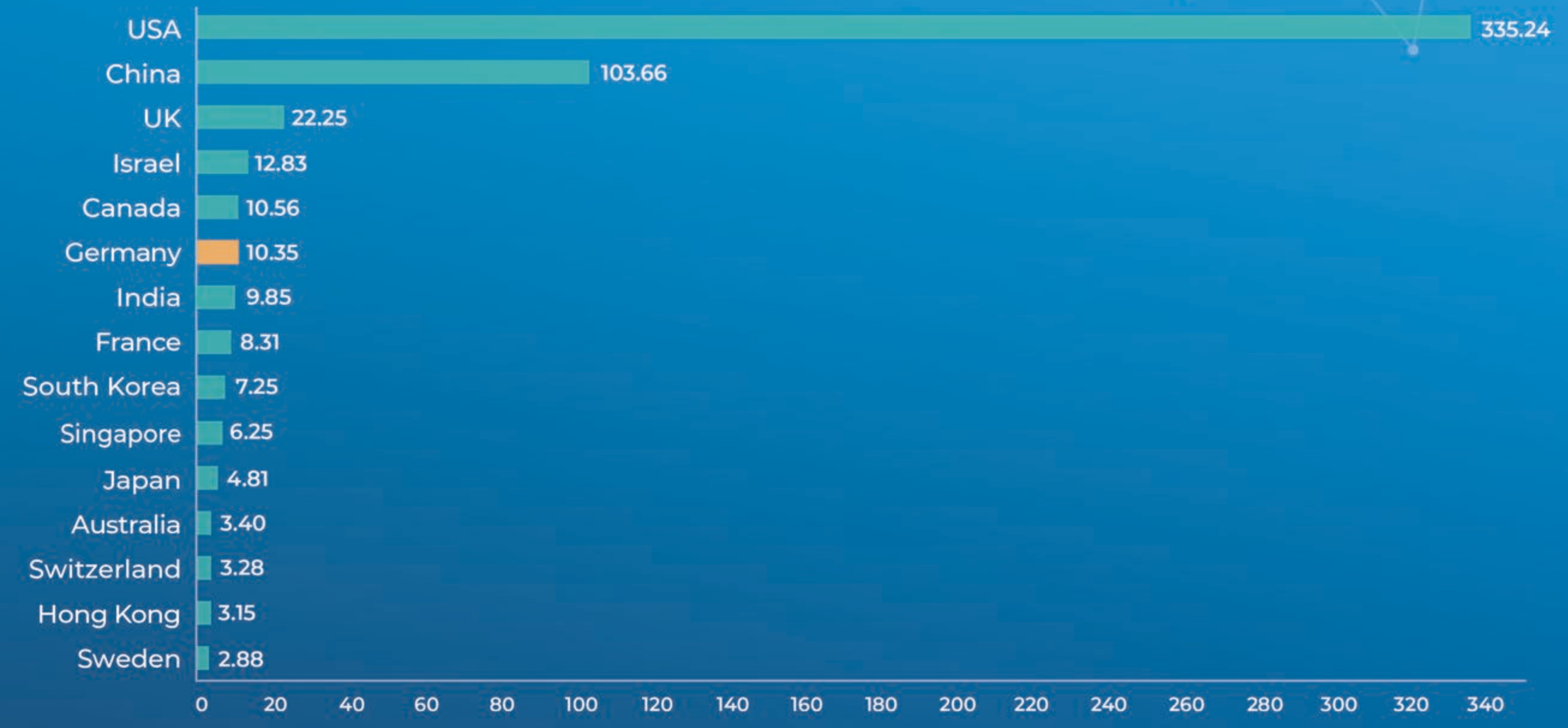
[51] Holzki & Oder (2024)

The German economy does not invest enough in skills and resources to be competitive in the digital sector. Companies in other countries are trying much harder to hire AI experts and are recruiting much more AI experts compared to the general recruitment rate. With this AI dynamic, you get the impression that the German economy is in a slumber, while companies in other countries, including EU countries such as Sweden, Italy or Spain, are trying to expand their digital skills in order to remain competitive in the future.

Prof. Dr. Dietmar Harhoff also considers the lack of digital competence to be detrimental, because this inhibits the application of digital Deep Tech innovations in companies. He believes that appropriate training programs are necessary so that digital technologies can be used more quickly. This would help SMEs in particular to increase their low productivity and innovative capacity. One could take Finland as an example, which in the AI sector has the goal of training one percent of working Finns in the application of AI.

The importance of these qualification measures is shown by several studies that conclude that the sluggish introduction of digital technologies in the EU in the late 1990s and 2000s was due to skills deficits, especially among SMEs.[52, 53] The effects are still felt today.

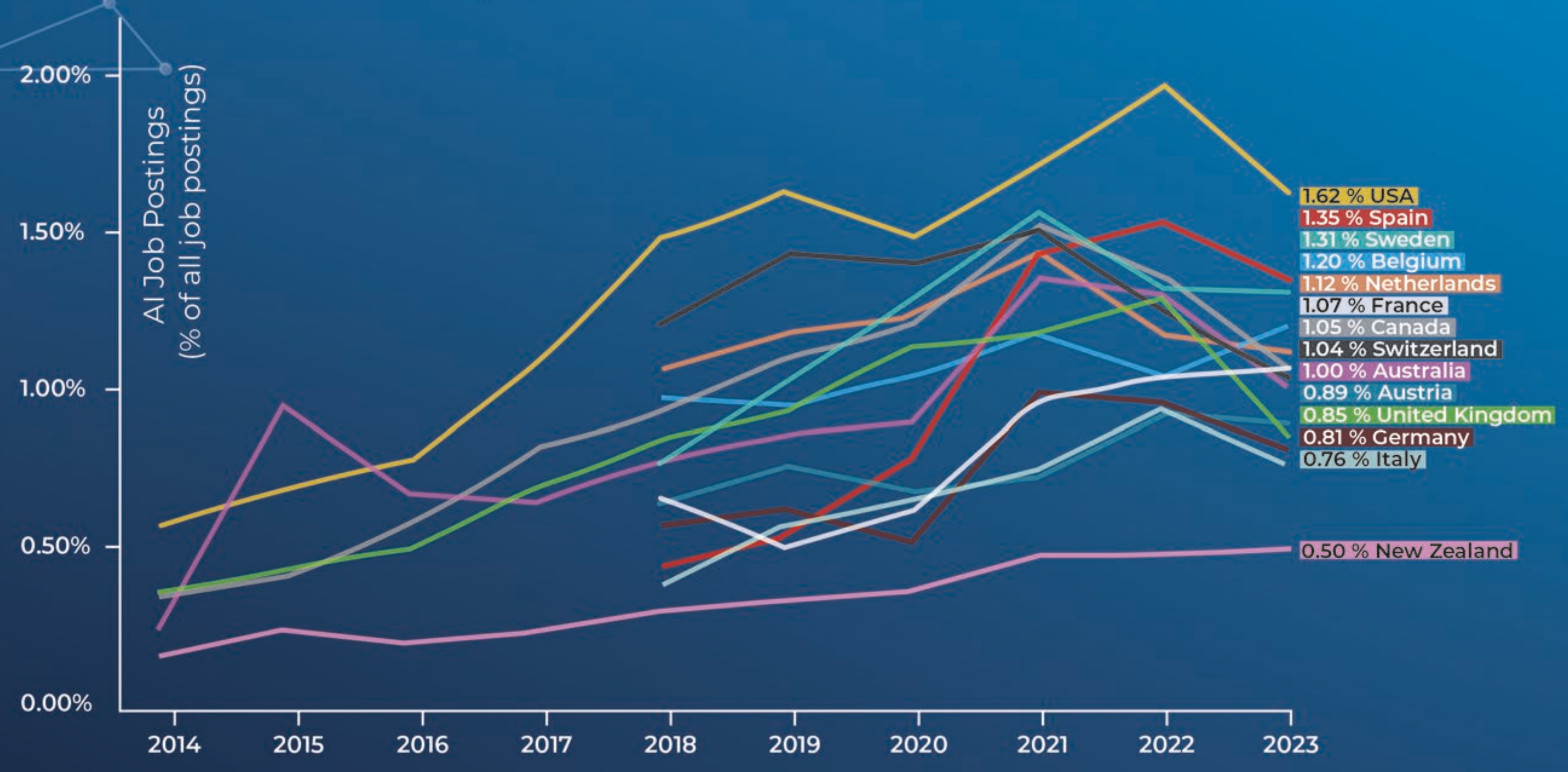
Figure 24 Private investments in artificial intelligence by country



Source: The AI Index Report (2024)

[52] Bloom, Sadun and Van Reenen (2012)
[53] Schivardi and Schmitz (2020)

Figure 25 **Job Postings for Artificial Intelligence by Country**



Source: THE AI INDEX REPORT (2024) https://aiindex.stanford.edu/wp-content/uploads/2024/04/HAI_2024_AI-Index-Report.pdf

Currently, around 37% of working Europeans lack basic digital skills. In Germany, the level of digital competence is low by international standards, especially compared to Finland. The digital competence gap between different population groups – based on education, age and gender – is particularly pronounced in Germany. In addition, only a small proportion of Germans have indicated that they have improved their digital skills in the last year, which underlines the urgent need for concerted training measures.

Many industries such as automotive, pharmaceuticals, mechanical engineering and industrial technology, in which Germany remains one of the world leaders, will change significantly through AI. In order to at least maintain the competitive position, it is crucial that companies have the ability to integrate AI technologies and applications vertically into all levels of the value chain in order to leverage efficiency and innovation potential at all process stages. But the status quo also shows the digital deficit in the application of digital technologies, where Germany is only in 18th place among the 28 EU countries.

However, not only is too little invested in digital talent, **investments in IT, measured in relation to gross domestic product (GDP), are not sufficiently prioritized in international comparison.** In many countries, IT spending is significantly higher than in Germany. In France alone, investments in IT are 3.3 times higher than in Germany. To reach this level, German IT investments would have to rise to around 180 billion euros. For German SMEs, this would mean an increase in digitization expenditure to around 100 billion euros, as can be seen from the KfW SME Panel.[54]

[54] Zimmermann (2024)

Figure 26 **Application of digital technologies in business**

Source: DESI (2020)

Findings: Germany's digital deficit is inhibiting the development of Deep Tech ecosystems.

Germany has a digitalization problem and in order to build internationally successful Deep Tech ecosystems, *"we have to put our finger in the 'digital wound' of Germany to heal it,"* says **Jens Helmerich** (Partner & Senior Manager Leading Strategy, Tagueri).

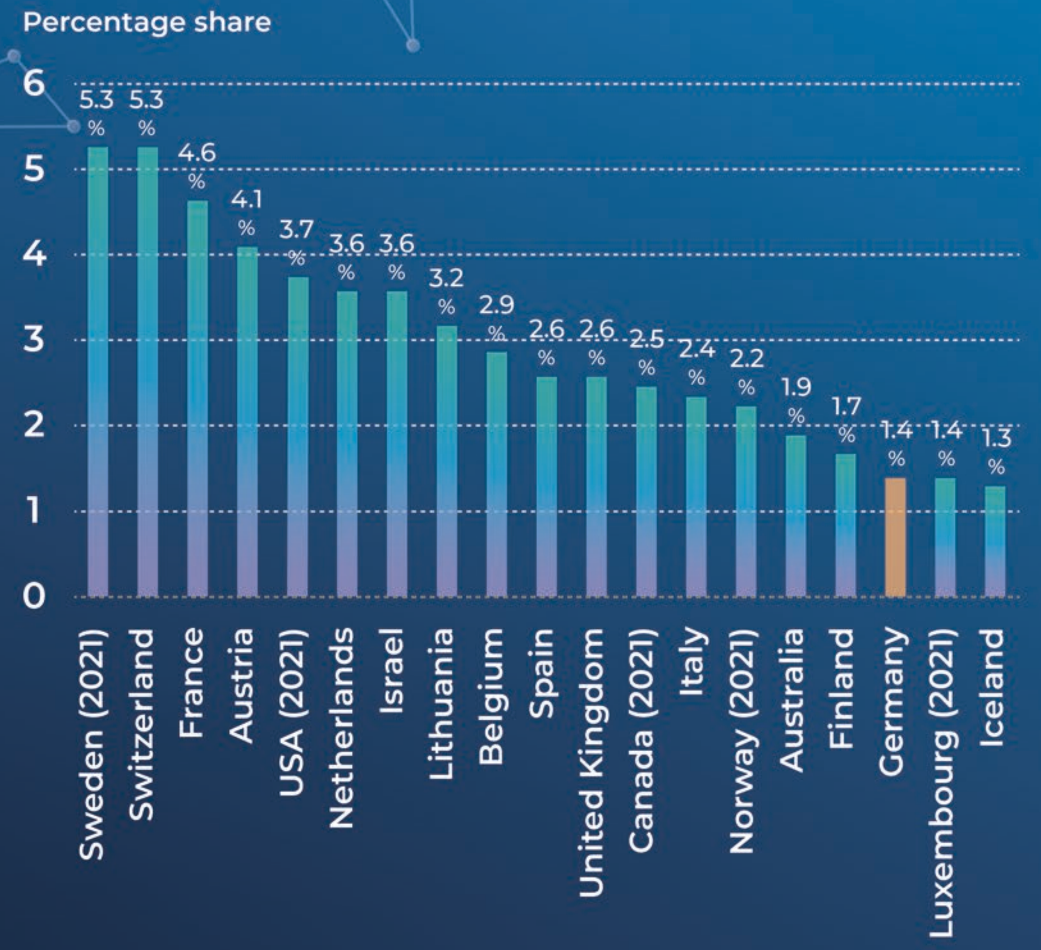
Ecosystems develop where ambitious talents meet excellent research institutions, leading and risk-taking established companies, low experimental costs (e.g. controlled exemptions from legal requirements and prohibitions in real laboratories) and high quality of life. For all these factors, world-class digital infrastructures, skills and knowledge play a crucial role. However, the emergence and development of Deep Tech ecosystems in Germany is blocked by the digital deficits of all innovation stakeholders in research (see 5.4 Investors), business and, above all, in the public sector (see Chapter 5.1). This is shown by almost all the important indicators that are collected annually by the EU.[55]

As a result, our study comes to a similar conclusion as the MÜNCHNER KREIS Future Study from 2014. **Germany lags far behind the frontrunners in the digital sector. This not only slows down the productivity and growth of the economy and jeopardizes technological sovereignty, but is a serious threat to the Deep Tech location of Germany and Europe, because as shown in Chapter 4, digital technologies are the central accelerators and trailblazers for the next generation of groundbreaking**

[55] See https://digital-decade-desi.digital-strategy.ec.europa.eu/datasets/desi/charts/desi-indicators?period=desi_2024

Figure 27

IT investments in relation to GDP in international comparison



Source: KfW (2024) https://www.kfw.de/%C3%9Cber-die-KfW/Newsroom/Aktuelles/News-Details_820736.html

innovations in many sectors. Germany's diverse technology profile offers numerous starting points for the use of digital technologies, but unfortunately this potential for value creation is not sufficiently exploited.

Instead of narrowing the gap to the top in the last decade, this gap to the leading countries has tended to widen. The Achilles' heel, which was identified in 2014, has expanded into a chronic disease and enormous efforts are needed by all stakeholders in Germany and the EU to (finally) address this digital deficit effectively.

Recommendations for action

1. **Creating a supportive experimental environment for Deep Tech:** Established companies should be supported if they are part of sandboxes or real laboratories where Deep Tech innovations can be tested under real conditions and thus develop market maturity more quickly. Legal and financial frameworks should be improved to incentivize highly innovative, ground-breaking collaborative projects, preferably composed of established companies and start-ups or academia.

2. **Creating research incentives and collaborations outside of Mid Tech:** R&D spending support should provide specific incentives to invest in and apply highly innovative key enabling technologies. Existing and new funding lines such as the Central Innovation Programme for small and medium-sized

enterprises (SMEs), research allowances, or the newly created start-up factories should preferably support research projects with a high degree of innovation, in which highly innovative technologies (especially from start-ups) could lead to leaps in development in the respective sectors. A further increase in the reimbursable amount for the research allowances for contract research of start-ups could also be increased.

3. **Deploy local "Boundary Spanners":** In existing tech clusters, local network managers should be deployed (e.g. in collaboration between DATI and the chambers of industry and commerce), which promote the exchange and transfer of knowledge between companies and research institutions as well as transfer into the application. These intermediaries can also advise on research- and transfer-oriented funding programs and thus better interlink all innovation stakeholders.

4. **Establish new cooperation models:** Innovative approaches such as Venture Clienting, innovation hubs or co-working spaces should be promoted by established companies and through public-private partnerships in order to enable direct and systematic exchange and initiate joint innovation projects. Companies should be more open to the open innovation principle and new forms of collaboration in order to gain better access to new or complementary skills and knowledge.

5. **Low-threshold option for validation funding:** In addition to the funding program "Validation of the technological and social innovation potential of scientific research – VIP+", a low-threshold offer for science should be created that makes it possible to easily and quickly carry out initial feasibility and acceptance tests for the transfer of research results into exploitation in cooperation with preferably local companies. Lump sums could be based on the requirements of the respective discipline.

6. **Promote cross-change:** Framework conditions should be created that enable and make attractive a temporary change of employees between business and science. This creates understanding, new impulses and networks and promotes the exchange of knowledge and expertise in accordance with the "open innovation principle".

7. **Developing digital competence:** A national Digital Literacy action plan for workers with concrete incentives for companies and participants is urgently needed to increase the basic "Digital Technology Literacy" that inhibits the application of digital technologies in business, especially in SMEs. As far as possible, existing, low-threshold educational offerings should be built upon.[56]

[56] Examples are the Finnish Online course "Elements of AI" or the cooperation of digital companies with the Bavarian Digital Ministry in the "Digital Competence Alliance"

8. **Promote the use of digital technologies:** Especially in SMEs, the productivity and innovation potential of digital technologies is not sufficiently exploited. This hinders the spread of (digital) Deep Tech innovations. The research allowance for SMEs should be expanded in order to make further training of existing staff and new hires in the digital sector as attractive as possible. Public programs to build technical and strategic digital knowledge are also an important building block to promote the transfer of digital solutions to mid-tier companies.[57] To promote cooperation with digital Deep Tech start-ups, cooperation vouchers and standardized cooperation agreements for SMEs should be offered.

9. **Easy access and scaling in the European Single Market:** For highly innovative start-ups, a new EU-wide legal form similar to Societas Europaea (SE) should be created, which allows companies to have easy and quick access to the EU internal market and harmonized legislation via a digital identity. A single European market plays a crucial role for Deep Tech innovation, as it not only removes regulatory hurdles, but also significantly expands the market size. A larger market increases scaling opportunities and makes investments more attractive to investors.

[57] See e.g. the program "AI-transfer plus": https://www.ki-transfer-plus.de/

6.4 Investors

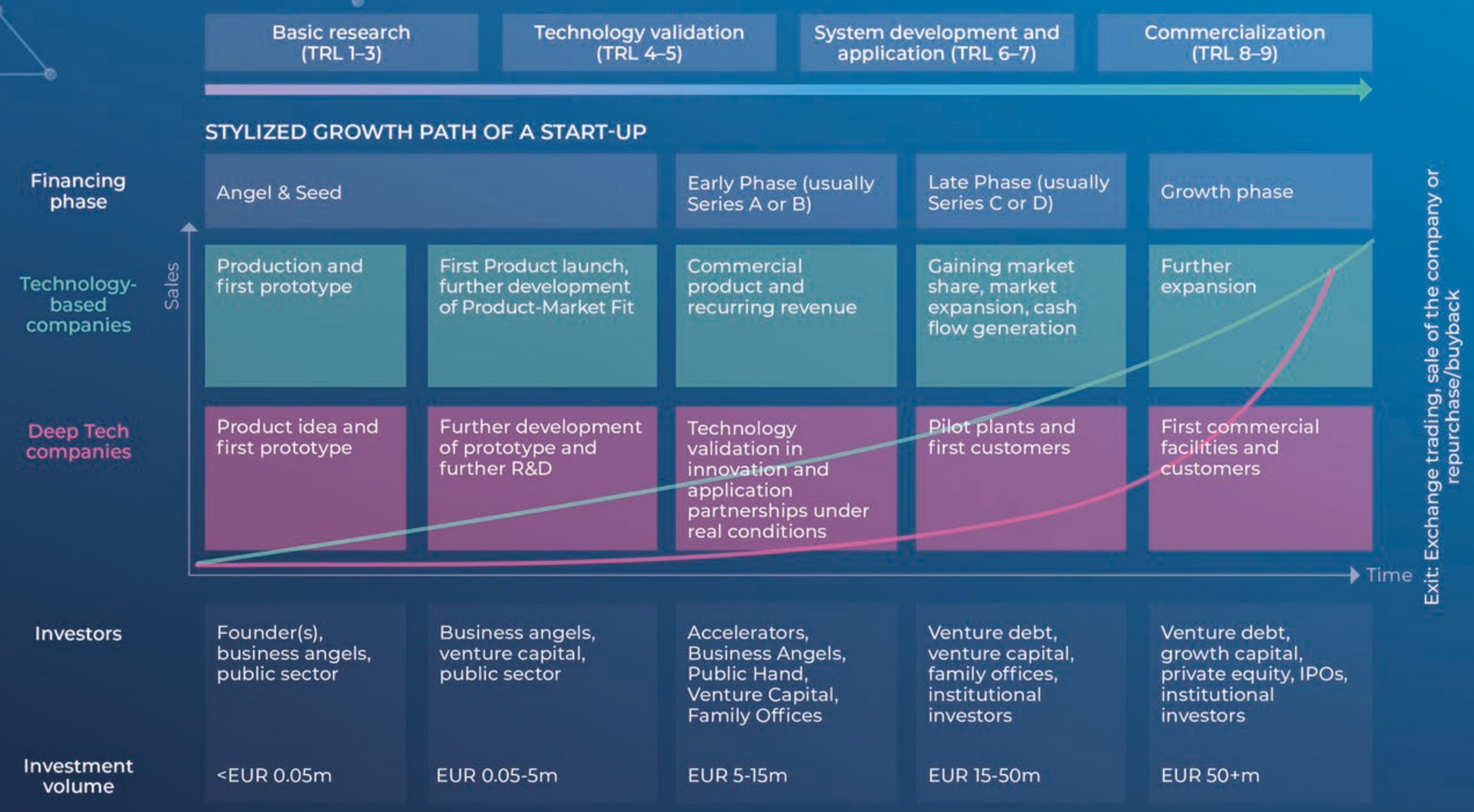
Deep Tech innovations have a high need for venture and growth capital on their way to market maturity. The capital requirement in the different TRL phases varies in amount and is usually provided by different investors, as shown schematically in Fig. 28. To ensure that promising Deep Tech innovations do not fail along the entire innovation process due to a lack of capital, the cooperation of various stakeholders is also required in financing, especially in the phases of TRL 6–7, the Valley of Death.

Basic research (TRL 1–2) requires state funding for R&D in companies and, in particular, basic funding for universities, national or European research funding (e.g. Deutsche Forschungsgemeinschaft [German Research Foundation] (DFG), European Research Council (ERC)). Investments in basic research are very risky and the time frame for traditional venture capital is too long and uncertain. From TRL 3, agencies such as SPRIN-D and programs such as VIP+ can also be used to support the potential founders in the experimental confirmation of the technological functional principle. In some cases, business angels are already investing in the phases TRL 2–3 and above.

In the later phases, typically from TRL 4–5, other public funding programs such as Horizon Europe or investments by the DTCF or the semi-governmental HTGF are also possible. From these technological maturity levels onwards, specialized Deep Tech funds and universal venture capital funds are increasingly making capital available.

Figure 28

Funding history of Deep Tech and traditional companies



Source: MÜNCHNER KREIS Future Study IX: The Deep Tech Manifesto: Wake-up call for a sleeping giant, based on DB Research (2024)

In addition, venture capitalists usually also give growth companies access to experienced investors who, in turn, contribute know-how and relevant networks to the respective company ("smart money"). The newly created EU funding program "Important Projects of Common European Interest" (IPCEI) also supports Deep Tech innovations primarily in the phases of TRL 5–8 in strategically important, cross-border projects that are of great importance for the technological and industrial sovereignty of the EU. To this end, this program partially relaxes the stricter EU rules on state aid. In the later phases (TRL 8–9), growth financing by banks, public credit institutions or special funds can also be considered in addition to VCs. In the final phase (TRL 9), IPOs typically increase alongside traditional instruments such as bonds or loans.

Despite this comprehensive support landscape, the experts identified weaknesses in the areas of capital mobilization, the availability of late-stage funding opportunities, and the limited exit opportunities discussed below at all stages of funding.

Without domestic growth capital, others reap the rewards of Deep Tech

Capital availability is an essential factor that determines where Deep Tech innovations are developed and applied. If promising Deep Tech companies lack the capital and attractive capital raising conditions to realize their ideas, they migrate.

This reduces the likelihood of economies renewing themselves and new markets and jobs being created in future technologies, as can be observed in Germany and Europe. Deep Tech companies are either founded abroad and not in Germany and Europe or leave at a later date. Unfortunately, this is often the case with particularly successful start-ups. In the period from 2008 to 2021, 147 companies in Europe achieved the status of a unicorn (enterprise value over one billion USD), of which almost 30% have now moved their headquarters abroad, mostly to the USA.

In order for more Deep Tech innovations to reach market maturity in Germany and Europe and thus also benefit the citizens more, a stronger domestic or European financing of Deep Tech is crucial. The general availability of venture capital in Germany and Europe has risen in recent years starting at a low level. Investments in Deep Tech as well as in technology-driven innovations in Europe have also increased significantly. However, capital availability and VC investments in the USA (approx. by a factor of 5) and Asia (approx. by a factor of 2) are many times higher.

Findings: Although the availability of venture capital has increased in Germany and Europe, domestic capital availability for Deep Tech innovation falls well short of the US and Asia when compared internationally.

The intra-European comparison shows that there is little venture capital available in Germany in proportion to GDP. In comparison, the particularly innovative nations such as Switzerland (3 x), the UK (2.7 x) or Denmark (2.3 x) invest many times more in venture capital. It also shows that European Deep Tech investments are strongly focused on hardware-based technologies such as quantum technology, photonics and hydrogen and ignore future digital technologies. This investment focus illustrates that Germany continues to focus more on physical technologies, while there is considerable catching up to do in forward-looking digital technologies. Another proof of German path dependency. This investment gap underlines the urgent need to intensify financing efforts in key digital technologies in order to close the technological gap with the leading countries and, in the long term, to secure Germany's sovereignty, especially in the digital sector.

Findings: Germany's Venture Capital investments focus too much on hardware-based technologies and neglect future digital technologies, widening the technological gap to leading countries and jeopardizing digital sovereignty.

Capital is there, it “only” needs to be mobilized for Deep Tech

All experts agree: A larger share of the capital available in Germany and Europe must be invested in Deep Tech companies. Capital raising centers play a critical role in providing investment capital to high-growth and innovative companies. Institutions include pension funds, insurance companies, investment and private equity funds, foundations, sovereign wealth funds or family offices. They all raise capital from investors and invest it to generate long-term returns.

Germany and Europe have a high capital stock. German insurance companies manage about two trillion euros, German pension funds have about 700 million euros. In Europe, pension funds manage around seven trillion euros. Less than one percent of this capital stock would be sufficient to allow Europe to catch up with VC investments in the US.

> *“Europe has a huge untapped pool of capital in insurance and pension funds, the so-called capital pools, for innovative initiatives, amounting to trillions of euros. If we mobilize even a small percentage of it, we could massively increase Venture Capital investment and come close to matching the US, which would significantly promote innovation and economic growth.”* – **Dr. Thomas Sattelberger** (Former Member of the German Bundestag and Parliamentary State Secretary at the Federal Ministry of Education and Research (ret.)

International examples show the way in which pension funds and institutional investors invest specifically in the venture capital market in order to mobilize growth capital for innovative companies. In Canada, an Initiative was launched with the “Venture Capital Action Plan”, which significantly improves access to growth capital by increasing investment by pension funds in venture capital. Singapore is taking a similar approach with the “SGInnovate” initiative by creating a government fund that actively invests in Deep Tech start-ups and attracts international investors. Sweden increased the permitted proportion of “alternative investments” by pension funds from 5 to 40% through a change in regulation, which led to a significant inflow of capital into growth areas. American pension funds already invest about 1% in this asset class.

> The example of the asset allocation of pension funds shows that, in international comparison, German pension funds have a very low proportion of equity and alternative investments, such as private equity and venture capital. *“In particular, there is a lack of capital from large funds, such as pension funds, which can and want to invest much more freely in other countries. We urgently need both a relaxation of investment regulations and a motivation of the often risk-averse decision-makers to fully exploit the potential of these funds for promoting innovation.”* – **Dr. Thomas Sattelberger** (Former Member of the German Bundestag and Parliamentary State Secretary at the Federal Ministry of Education and Research (retired)

Europe is underserved with long-term capital, as only a small part of retirement provision is invested in pension funds. For example, pension assets in the EU amounted to only 32% of GDP in 2022, while total assets amounted to 142% of GDP in the US and 100% of GDP in the UK. The pay-as-you-go social security systems that are widespread in Europe, such as in Germany, are proving to be disadvantageous. Only a few EU countries such as the Netherlands, Denmark and Sweden rely on funded schemes and account for a strongly disproportionate share of EU pension assets of 62%. An important lever for the mobilization of more capital in productive investments therefore lies in the restructuring of the pension system and the activation of high savings.

German insurance companies and investment funds also mainly invest in safe asset classes such as fixed-income securities. Loosening investment rules could encourage these institutions to invest more capital in innovative and high-growth sectors. In other countries, a larger proportion of the funds is already invested in venture capital and private equity, which strengthens the innovative power of the economy.

Private equity funds and family offices are generally interested in investing in Deep Tech, but see considerable challenges in realizing the large, risky investments on their own. In addition, the framework conditions, in particular tax and regulatory hurdles, significantly limit the potential for successful exits, such as through IPOs. These hurdles reduce the attractiveness for large capital investments.

> **Daniel Wiegand** (Founder and Lead Engineer for Innovation and Future Programs, Lilium): *"Family offices shy away from larger investments due to unattractive conditions and lack of confidence in the potential of the German market. In order to mobilize capital for the growth of Deep Tech start-ups, incentives must be created in a targeted manner and the framework conditions for investments must be significantly improved."*

Sovereign wealth funds can also make a greater contribution to promoting Deep Tech. Due to their long-term investment horizons, they are predestined to invest in disruptive technologies.

> **Findings:** The general reluctance of German capital collection centers to invest in Deep Tech is a significant obstacle, as there is a lack of long-term and risk-taking capital.

This can mainly be attributed to the more restrictive regulation and the conservative investment mentality.

The limited availability of venture and growth capital slows the development and scaling of Deep Tech companies and thus represents a significant obstacle to the promotion of groundbreaking technologies in Germany.

Achilles' heel late stage financing opportunities

Experts have repeatedly pointed out that Deep Tech start-ups do have access to sufficient early-stage funding, but when it comes to large funding rounds in the later stages, they reach their limits. In these phases (Series B or C), the focus is on financing the market launch.

Findings: Because Deep Tech is often FOAK innovation, companies often need to build production capacity and infrastructure that doesn't exist in the form they need. Accordingly, the capital requirement of Deep Tech start-ups is enormously high at this stage.

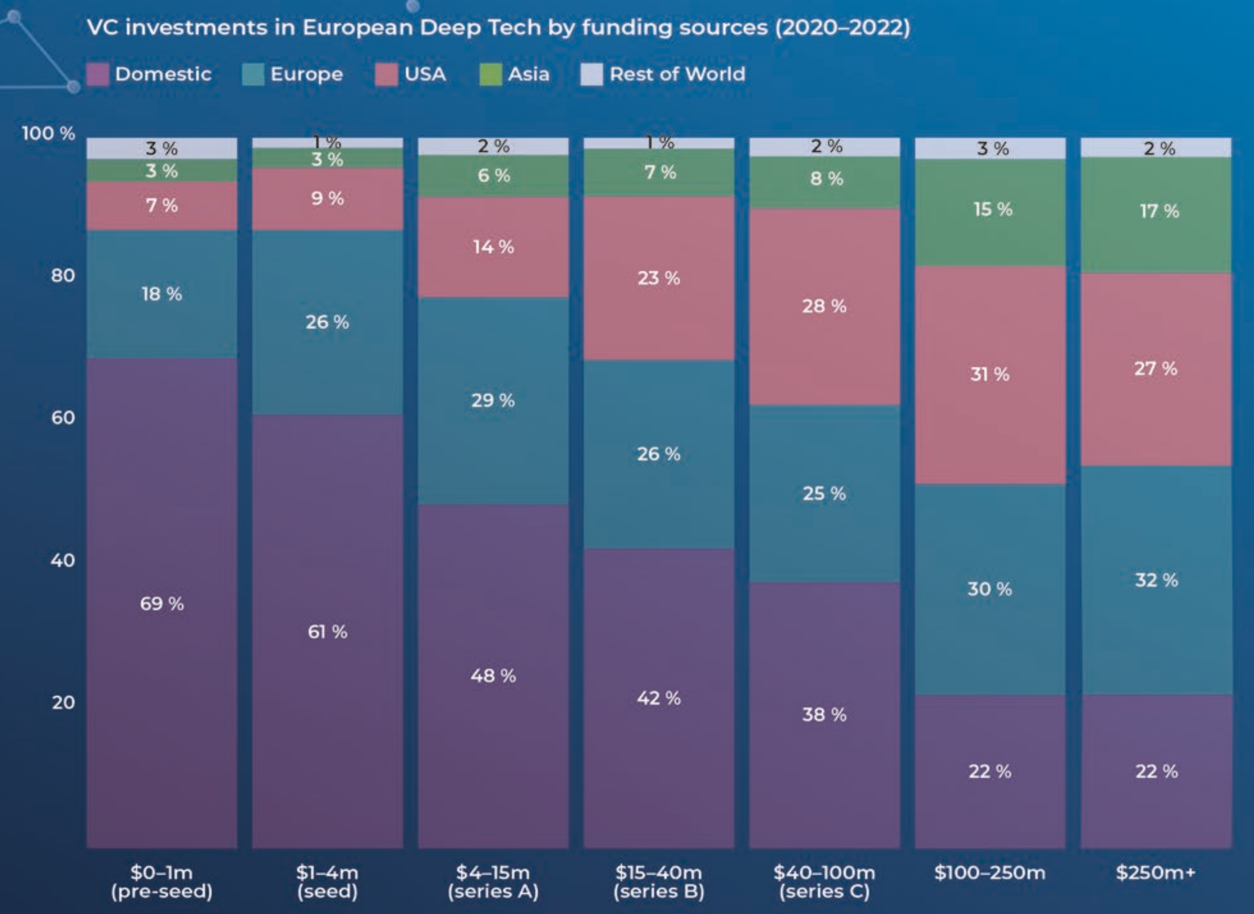
An analysis shows the shift in investor location across the financing phases (see Fig. 29). While European Deep Tech start-ups are predominantly supported by domestic investors in the early financing phases, this dynamic shifts dramatically in the later financing phases towards capital from the US and Asia. This is a specific weakness of Deep Tech financing in Germany and Europe.

Findings: While it is useful and helpful to attract foreign capital, domestic underfunding jeopardizes technological independence and intellectual property and control of promising Deep Tech companies migrating abroad in later funding rounds.

"While it is beneficial to leverage foreign investment, it risks our technological independence. Control over intellectual property and key technologies could migrate abroad through large rounds of funding, which may lead to dependence on external stakeholders in the long run." – **Daniel Wiegand** (Founder and Lead Engineer for Innovation and Future Programs, Lilium)

In many cases, the experts warned of the consequences of the lack of domestic capital for later financing rounds. A central problem is the loss of value added abroad. Profits, rights of control and ownership go to foreign investors, which means that Germany loses the return and a significant part of the added value, but

Figure 29 **VC investments in European Deep Tech companies by origin of capital**



Source: Dealroom (2024)

until then has financed a large part of the basic research and earlier phases. **In addition, there is a risk of loss of strategic control, as foreign investors have the opportunity to transfer key technologies and valuable knowledge abroad. This weakens the innovative power and sovereignty of Germany.**

> *"We need to not only support Deep Tech companies in the early stages, but also enable the transition to scale. The DTCF is a step in the right direction, but it needs even more capital in later stages."* – **Rafael Laguna de la Vera** (Founding Director, SPRIN-D)

Another effect is the **weakening of the innovation ecosystem**. If reinvestments from successful exits are not made in new start-ups because profits are diverted abroad, the **dynamism of the local Deep Tech ecosystem will be reduced**. In addition, there will be a **loss of tax revenue**. Profits that are not taxed in Germany lead to lower revenues, which are necessary for important public tasks, not least for infrastructure and research.

Finally, there is a risk of relocation. Foreign investors can force the relocation abroad, which would not only result in the loss of jobs, but also of valuable know-how in Germany. These developments highlight the urgent need to mobilize more growth capital in Germany and Europe. Only in this way can technological sovereignty be preserved and the economic risks of an increasing relationship of dependency be minimized.

Venture Debt: An underestimated financial instrument

In addition to financing via venture capital against the surrender of shares and voting rights, the experts repeatedly pointed to financing by venture debt, an alternative form of debt financing, especially in later financing phases. Venture debt is an attractive alternative, especially for Deep Tech companies that have a high capital requirement in this phase, as additional capital can be raised without significant dilution of the company's shares. There is therefore no loss of control over business development.[58] In addition, the return expectation of venture debt providers is lower than that of VCs.

Venture debt has established itself as a significant source of funding in the US. The volume in the US was around USD 30 billion In 2022, which represents a significant share of the total growth financing of start-ups (Series B and C).[59] In Europe, on the other hand, the volume was significantly lower, with Germany still lagging behind countries such as the UK and France in international comparison.

Findings: Venture debt is an attractive financing alternative for late-growth Deep Tech companies because it provides additional capital on favorable terms without diluting rights of ownership and control.

The low use of venture debt in Germany and Europe is due to several factors. On the one hand, the understanding and acceptance of this form of financing among investors and companies is still low. There is a lack of specialist providers and an established market environment that positions Venture Debt as a useful complement to equity financing.[60] In addition, regulatory hurdles and the conservative risk culture in Germany are obstacles that restrict the use of venture debt.

Compared to the US, Germany also lacks experienced lenders who understand the specific risks and requirements of start-ups and can support them with flexible financing solutions. Companies often struggle to raise capital from venture debt because banks are too risk-averse and fail to provide tailored solutions to the dynamic growth needs and valuation of Deep Tech startups.[61]

In order to fully exploit the innovative strength and growth potential of the German and European start-up scene, an increased use of venture debt is essential. Integrating venture debt can help close the financing gaps in later stages of growth. This would not only facilitate the scaling and internationalization of Deep Tech companies, but also strengthen the entire innovation ecosystem by giving start-ups access to much-needed capital.[62]

[58] Kraemer-Eis et al. (2017)
[59] Pitch-Book (2023)

[60] KfW Research. (2023)
[61] Gompers & Lerner (2020a)
[62] European Investment Fund (2021)

Exits, we need Exits!

In Europe, there is a lack of large exits, which are essential for a functioning cycle of reinvestment in the start-up ecosystem. Without exit opportunities, the growth and sustainability of the ecosystem is at risk, as investors have less incentive to invest capital in new or existing German Deep Tech companies.

> **Alexander de Kegel**, Chief Investment Officer & Managing Director, Allianz X North America emphasizes: *"The lack of major exits in Europe interrupts the cycle of reinvestment in the start-up ecosystem. It is crucial to create incentives for exits and reinvestments to ensure the long-term growth and sustainability of the ecosystem."*

> **Dr. Jan Götz** (Co-CEO & Co-Founder, IQM Quantum Computers) adds: *"We have a real problem with exit opportunities in Germany, especially compared to the USA. The lack of liquidity and the low number of potential buyers make it extremely difficult for Deep Tech start-ups to find the right exit. This also discourages investors who do not see the same return opportunities in this country as in other countries."*

These statements illustrate the structural challenges of the European market and show why the introduction of a European growth exchange is necessary.

In many cases, the experts referred to the **lack of a counterpart to the US NASDAQ**. A European growth exchange modeled on the National Association of Securities Dealers Automated Quotations (NASDAQ) could address the special needs of Deep Tech companies. Currently, there is a lack of a specialized exchange that meets the requirements of these companies and supports them especially in later financing rounds. As a result, many European companies are forced to switch to foreign exchanges, especially in the US, in order to raise the necessary financial resources.

> **Findings:** The lack of exit opportunities reduces Germany's attractiveness for capital and weakens the cycle of reinvestment in the Deep Tech ecosystem, thereby jeopardizing its growth and sustainability.

"At the time, we decided to go to NASDAQ because there is no stock exchange in Europe that meets the requirements of Deep Tech companies. The German stock exchange and other European trading venues do not provide the necessary support for highly innovative companies in the later financing phases. Without a specialized European growth exchange along the lines of NASDAQ, we are forced to switch to foreign exchanges in order to raise the necessary funds and remain internationally competitive." – **Daniel Wiegand** (Founder and Senior Engineer for Innovation and Future Programs, Lilium)

A European exchange specializing in young growth companies could significantly improve access to capital for companies and create a broader investor base, supporting their long-term success.[63] This would reduce dependence on foreign capital and facilitate the scaling of European companies.[64] At the same time, such an exchange would strengthen Europe's technological sovereignty by keeping strategically important technologies in the European space and fostering an innovation-friendly ecosystem. Venture capitalists would benefit from better exit opportunities and a more stable market environment, which could encourage further investment.

A European growth exchange would also increase the visibility of European companies and make them more attractive to international investors, which could mobilize more private R&D investment.[65] Uniform and simplified regulations could overcome the fragmentation of capital markets, reduce the costs of IPOs and motivate more companies to take this step.[66]

For comparison: The NASDAQ offers an attractive platform for growth-oriented technology companies through flexible listing requirements, high liquidity and a broad network of institutional investors. These market mechanisms create an environment in which technology companies can grow faster and raise capital more easily, which is essential especially for Deep Tech start-ups.
A European growth exchange could thus play a central role in closing financing gaps for innovative companies and better exploit the potential of European Deep Tech start-ups. By building an efficient capital market, Europe could strengthen its technological sovereignty and develop a new innovation dynamic. This could set in motion a positive feedback cycle of reinvestments.

Capital markets union: A crucial lever for financing Deep Tech in Europe

The integration and harmonization of capital markets in Europe is urgently needed by experts to facilitate investment and improve access to capital for Deep Tech companies. Especially Deep Tech start-ups with their high capital requirements over longer periods of time would facilitate access to a larger pool of investors and thus improve the financing conditions for highly innovative companies.[67]

[63] Council of Experts (2024)
[64] European Union (2022)
[65] Deutsche Börse [German Stock Exchange] (2021)
[66] ESMA Report (2024)
[67] German Bundestag (2024)

Currently, fragmented markets and different regulations are hampering capital availability and mobility. Better integration of capital markets could reduce these hurdles. Despite progress, however, challenges remain such as an inconsistent tax environment and a lack of harmonization in securities regulation. Measures such as the standardization of the prospectus rules and the promotion of access to listed markets are intended to facilitate investment,[68] but are still a long way off.

Findings: Fragmented markets and different regulations hinder the cross-border flow of capital in the EU and thus the financing of Deep Tech.

"The fragmentation of European capital markets is one of the biggest hurdles for Deep Tech start-ups. A strong capital markets union would not only facilitate cross-border investment, but also support the scaling of innovative companies in Europe. It is crucial that we break down barriers and create a single market to harness the full potential of the European innovation sector." – **Alexander de Kegel** (Chief Investment Officer & Managing Director, Allianz X North America)

It is estimated that the lack of capital market integration reduces the funding opportunities of start-ups in Europe by up to 30%.[69] An increased focus on the implementation of the capital markets union could close this funding gap. For Germany, the capital markets union offers the opportunity to break the conservative investment culture and improve access to European capital. Compared to other European countries, German companies suffer particularly from limited access to cross-border investments, which has a negative impact on their growth and internationalization.[70]

The full implementation of the capital markets union is therefore a central building block to facilitate access to capital for Deep Tech start-ups. By removing regulatory barriers, the capital markets union could encourage investment in promising technologies and thus strengthen Europe's competitiveness in the global market. The harmonization of capital markets would exploit the potential of European innovations and secure sustainable growth financing.

[68] European Commission (2020)

[69] McKinsey & Company (2024)
[70] German Bundestag (2024)

Recommendations for action

1. **Activate capital collection points:** Adapting regulatory frameworks, such as the Investment Ordinance and Solvency II guidelines, to allow institutional investors a higher proportion of venture capital investments. This would allow pension funds, insurance companies and investment funds to invest a higher share (e.g. 5%) in venture capital and growth capital.

2. **Funded pension scheme:** Germany should gradually switch to a funded pension system, e.g. through a state pension fund. This could channel some of the retirement savings into productive investments such as venture capital, similar to what is practiced in countries such as Sweden or Canada. In this way, Germany can use existing savings in a targeted manner to strengthen its competitiveness and innovative strength, while at the same time ensuring a stable retirement provision.

3. **Create tax and regulatory incentives for private investors:** Introduction of tax benefits such as investment deductions or tax deferrals for investments by family offices, foundations and high net worth individuals in Deep Tech start-ups. Simplifying participation processes and reducing compliance requirements can make investments more attractive and mobilize additional private funds for Deep Tech.

4. **Expansion of existing innovation funds:** State investment vehicles such as the DTCF or HTGF and the innovation agencies SPRIN-D and DATI should have more capital available, especially in phases where start-ups have difficulty raising capital (Valley of Death) and closing funding gaps. The amount of capital raised in the respective financing rounds often determines which Deep Tech start-up will prevail internationally.

5. **Establish Venture Debt:** Introduction of government guarantees, co-financing opportunities or hedges for venture debt investments in order to reduce the risk for private lenders and thus promote the venture debt market. The aim must be to offer Deep Tech start-ups attractive alternative debt financing options for particularly capital-intensive development phases.

6. **European capital markets union:** Harmonization of prospectus requirements and securities laws within the EU to facilitate cross-border investment. Expansion of the competences of the European Securities and Markets Authority (ESMA) for the central monitoring of certain financial market areas. The establishment of uniform systems for clearing and settlement increases the efficiency of financial markets and facilitates access to capital for companies. An integrated EU capital market would reduce fragmentation and open up a larger pool of investors for Deep Tech companies.

7. **Government co-financing programs:** Developing government co-financing programs that complement private investment. Clear criteria and risk-sharing models should be introduced to ensure the effectiveness of these programs. This boosts investor confidence and facilitates larger investments in high-risk technologies by spreading financial risk across multiple shoulders.

8. **Improve exit opportunities for start-ups by adapting existing exchange structures:** Adapting eligibility conditions to existing European exchanges or establishing a new segment to make it more attractive to Deep Tech growth companies. Supporting start-ups in preparing for an IPO increases the chances of successful exits and strengthens the investment cycle by reinvesting capital from successful exits back into new start-ups.

DEEP TECH AND SUSTAINABILITY

Deep Tech is the key to a sustainable future

None of the experts interviewed doubts that Deep Tech innovations are necessary to solve the enormous global challenges of the "anthropocene". The term anthropocene sub-totals the man-made changes in the atmosphere (e.g. climate change), biosphere (e.g. loss of biodiversity) and geosphere (e.g. soil erosion and pollution). These have led to the crossing of six of the nine central "planetary boundaries" in 2023.[71] The planetary boundaries comprise nine bio-physical systems and processes that determine the functioning of life-sustaining systems on Earth and are used to measure the health of our planet on Land, in the sea and in the air.[72] Crossing each of these planetary boundaries (see Fig. 30) leads to humanity leaving the so-called "safe sphere of action" with controllable risks for humanity. Accordingly, as each planetary boundary is crossed, the risk of irreversible damage increases, endangering not only the environment but also our foundations of social and economic coexistence.

7.

[71] Richardson et al. (2023)
[72] Rockström et al. (2009)

Digital technologies are pushing development boundaries

In order to return to the safe space for humanity, enormous efforts are needed. Technological progress, especially in the field of Deep Tech innovations, plays a central role here. In all major greenhouse gas emitting sectors such as energy (e.g. nuclear fusion, carbon capture and storage), industry (e.g. nanotechnology, robotics), transport (e.g. solid-state batteries), buildings (e.g. sustainable materials) or agriculture (e.g. CRISPR and genome editing), but also medicine (e.g. biotechnology, quantum sensors), there are a variety of examples that show how digital technologies can enable and accelerate sustainable innovation. The potential contribution of digital technologies alone to reducing CO_2 emissions is estimated to be around 25% for Germany, based on the 2030 climate target.[73]

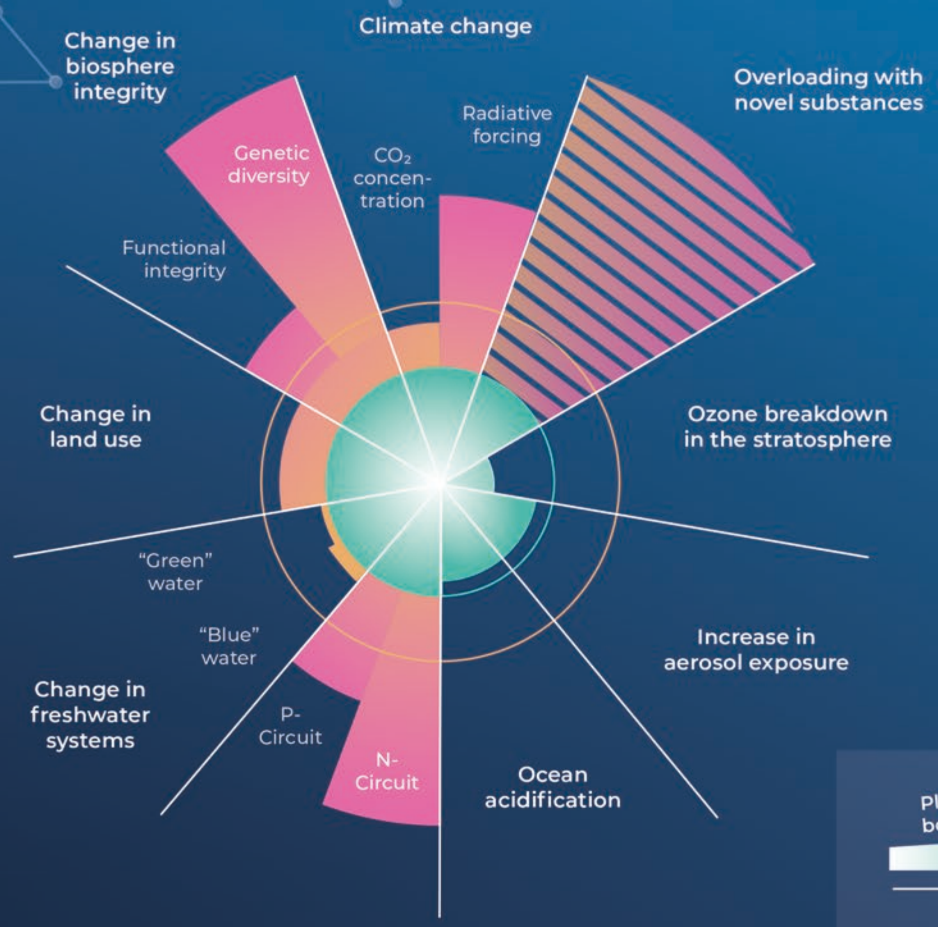
One example among many to illustrate the potential is provided by **Prof. Dr. Dominik Grimm** from the TUM Campus Straubing and the Weihenstephan-Triesdorf University of Applied Sciences. He estimates that the AlphaFold 3 AI model published by Alphabet or Google in 2024 will lead to major breakthroughs in bioinformatics and structural biology. The ability to accurately and quickly predict protein structures could significantly accelerate and optimize the development of new bio-based technologies and products. This could enable a bio-based economy in which fossil raw materials will be replaced by renewable biological resources.

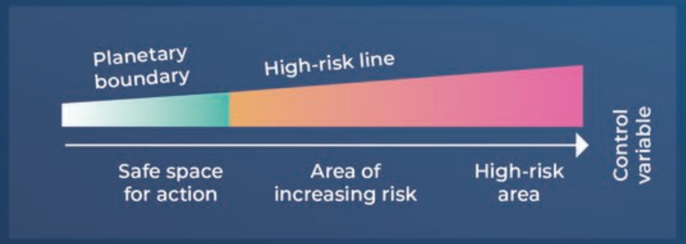
> *"AI models like AlphaFold 3 provide tremendous value in the search for new enzymes or proteins. Generative AI models can narrow and optimize the enormous search space for potential candidates and make the process much faster and more efficient than conventional laboratory approaches. This will be an important building block in moving away from a petroleum-based industry to a bio-based industry."*
> – **Prof. Dr. Dominik Grimm** (Professor of Bioinformatics, TUM Campus Straubing)

In other areas, too, many experts agree that the interaction with digital technologies using AI or machine learning, sensors, actuators, VR/AR, robotics, or quantum computing is increasingly creating new, networked solution spaces across once separate disciplines. Not least due to the often digitally-driven convergence and recombinability of technological breakthroughs, the solution space for sustainable Deep Tech innovations is growing and changing the innovation process by allowing Deep Tech innovations to be developed and tested more cheaply and quickly.

[73] Bitkom (2024)

Figure 30 Planetary boundaries – A safe space for humanity to act





Source: Potsdam – Institute for Climate Impact Research (2024)

Findings: Scientific breakthroughs, coupled with digitally-driven convergence and recombinability, thus act as a catalyst for sustainable innovation in the three pillars of sustainability.

While the technologies of the 20th century could only push these boundaries to a limited extent, digital technologies open up new dimensions and impact possibilities for Deep Tech.[74] However, access to computing capacity and data is severely restricted in Germany.

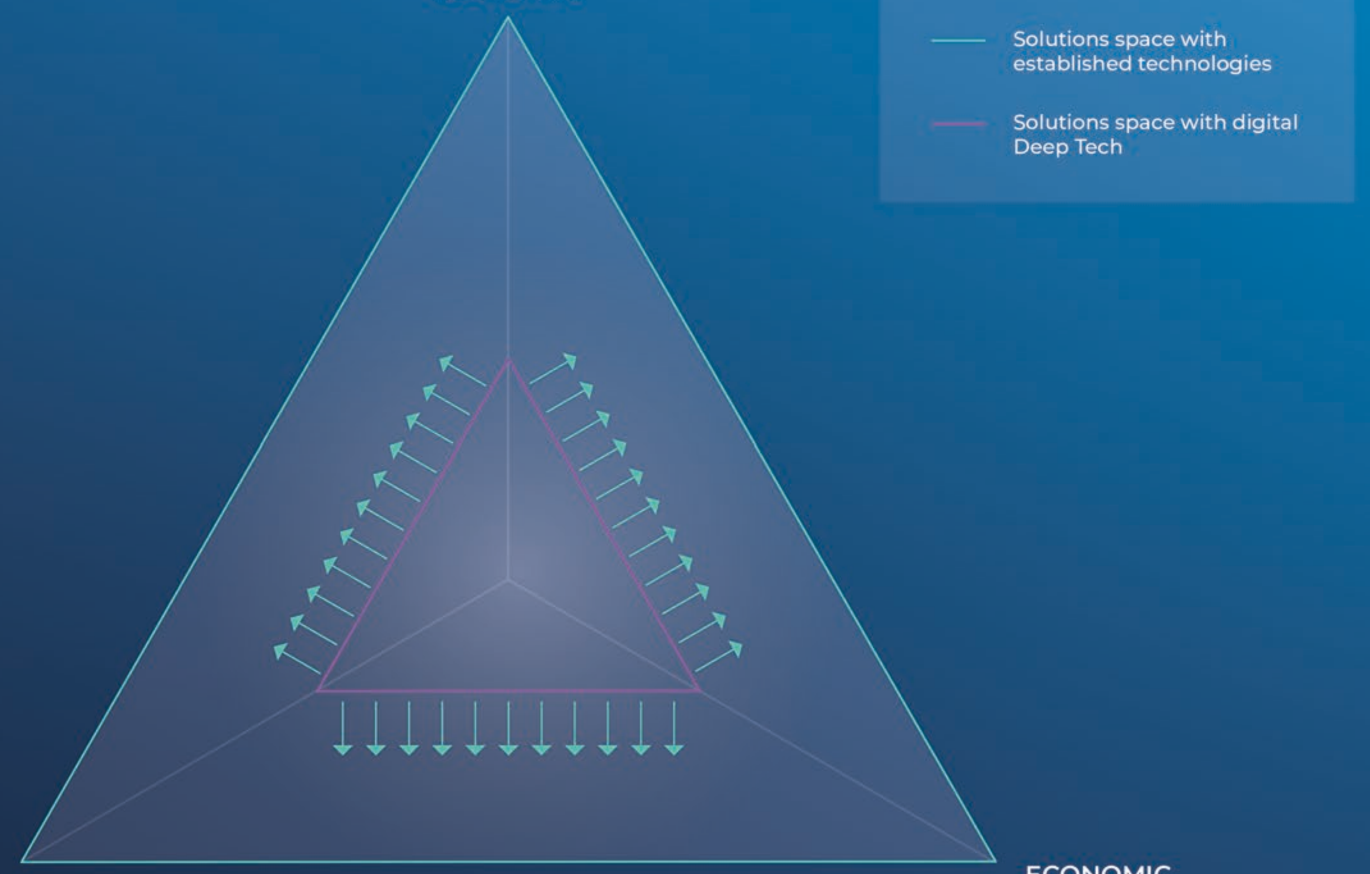
Holistic approaches and success monitoring in Deep Tech required

Now that time is running out and financial, human and infrastructural resources are limited to return to the safe space described, it is necessary to understand the opportunities and risks of Deep Tech projects in order to be able to evaluate and prioritize them accordingly. This requires a systematic and continuous evaluation of Deep Tech projects in all three pillars of sustainability (economic, ecological, social) and at all stages of development. However, the evaluation process requires interdisciplinary knowledge and competencies and thus the integration of broadly dispersed data and expert-supported insights.

[74] Tekic et al. (2023)

Figure 31

Deep Tech as a catalyst for sustainable innovation



Source: Peña and Oganda (2023)

The evaluation process is therefore time-consuming and cost-intensive and the results are inevitably subject to uncertainty, especially in the early stages of development.

Our interviews and workshops suggest that for these reasons, Deep Tech ecosystem stakeholders often do not carry out comprehensive and continuous sustainability analyses, especially with regard to social and ethical aspects.

> In his decades of experience as Head of Production and Member of the Board of Management of the Audi Group, **Alfons Dintner's** experience has been that *"technological innovations pay great attention to physical processes and economic efficiency, while social needs and human aspects are neglected. There is a lack of a deeper understanding of how people and societies respond to these technologies. Especially in areas such as digitization in factories, we see that the creation of a social fabric that is willing to accept and support these changes often receives too little attention. There is still a clear lack of approaches that sufficiently take into account the social dimension."*

However, the low dissemination of sustainability analyses does not mean that the stakeholders do not consider this useful or even necessary and do not take into account the potentials and effects on the three pillars of sustainability.

Rather, for the reasons mentioned, they rely more on subjective and more intuitive assessments of the sustainability effects. These are often based on self-chosen and rather vague ESG[75] or SDG criteria, none and not on a systematic, objective analysis of the multi-layered effects.

Many experts stress that a broadly accepted, inclusive and scenario- or simulation-based approach would be important, making the economic (e.g. gross value creation potential, labor market), social (e.g. inequality, safety, health, ethics) and environmental (e.g. resource requirements, emissions, biodiversity) potentials and impacts of Deep Tech assessable and comparable. Otherwise, there is a risk that resources will not be used purposefully in the sense of sustainable development; even if the experts agree that accurate and complete comparability and evaluation can naturally not be fully achieved.

Findings: The lack of continuous integrative and systemic valuation approaches risks that resources are not prioritized in Deep Tech innovations that have the best cost-benefit ratio and the shortest payback period from a sustainability point of view.

[75] Environmental, Social, and Governance

This applies in particular to second- or even third-order systemic effects that go beyond the immediate and obvious effects. However, it is precisely these second- and third-order effects that are crucial for a comprehensive evaluation and strategy for Deep Tech in order to avoid undesirable consequences, such as so-called rebound effects, and to develop effective (counter-)measures. These systemic effects also show the complexity and interconnectedness of systems in business, the environment, technology and society and the diverse feedback loops and interdependencies that make it difficult to evaluate and prioritize Deep Tech projects. However, there are stakeholders in the Deep Tech ecosystem, such as Planet A Ventures, that use integrative and systemic approaches to measure environmental sustainability performance.

"Based on our analyses, we arrive at statements about the impact unit generated per unit of sales generated, in particular in the areas of CO_2 equivalents, greenhouse gas emissions, waste prevention, resource saving and biodiversity protection. It is not always necessary to positively influence all four dimensions, but it is important that at least one of these areas is significantly positively influenced without causing significant damage in another area. Another special feature is that we use so-called sequential life cycle analysis (LCA). This means that we not only look at the primary effects, but also consider secondary and tertiary effects. For example, if the production of biodegradable plastic uses a raw material that was previously used as fertilizer in agriculture and is now used elsewhere, we must also include the substitution of this fertilizer and its effects in our life cycle analysis." – **Nick de la Forge** (Co-Founder & Partner, Planet A Ventures)

In particular, the concept of the impact unit per unit of revenue generated, which measures how much positive or negative impact a company generates per unit of revenue, is noteworthy. The key figure allows the ecological or social benefits that a Deep Tech innovation generates to be related to financial success.

The concept can also be used for investments, in which impact units are set in relation to the investment sum. This allows the environmental and social contribution of a Deep Tech project to be prioritized in relation to the investment.

There are also established approaches that can be used and adapted for the evaluation of Deep Tech. Our results suggest that specialized methods focusing on the assessment of individual sustainability pillars (e.g. Life Cycle Assessment for balancing ecological impact or social impact analysis for social effects) are currently being used. Integrative approaches that consider all dimensions of sustainability in an integrative and systemic manner (e.g. sustainability balanced scorecard, multi-criteria analyses) are rarely used.

The technology impact assessment also plays an important role in analyzing the potential effects of Deep Tech projects on the economy, environment and society. However, at least at the federal level, it can be stated that the process of technology assessment is still not used sufficiently systematically, in a forward-looking manner and proactively by decision-makers and that comparatively little attention is paid to it in the discourse.

> *"During this legislative period, we have enforced that there are always ideas of reports and discussions on technology impact assessments in plenary, but solutions to achieve all three dimensions of sustainability should be even more strongly linked to it by politicians."* – **Prof. Dr. Stephan Seiter** (Member of the German Bundestag, Committee on Education, Research and Technology Impact Assessment and rapporteur on technology impact assessment)

Target image-guided Deep Tech strategy

On the basis of the coalition agreement, the BMBF has derived the following six sustainability-oriented missions for research and innovation policy:

1. Enable resource-efficient and circular competitive industry and sustainable mobility
2. Advance climate protection, climate adaptation, food security and biodiversity conservation
3. Improve health for all
4. Secure digital and technological sovereignty in Germany and Europe and exploiting the potential of digitalization
5. Strengthen aerospace, explore, protect and sustainably use space and oceans
6. Strengthen social resilience, diversity and cohesion.

Although these missions are widely accepted by experts, they lack the necessary clarity about the objectives and associated measures and performance indicators. Concrete time planning and possible inconsistencies and conflicts between the goals are also insufficiently taken into account.

Findings: Many stakeholders in the Deep Tech ecosystem lack a goal- and time-directed prioritization of Deep Tech projects, which are particularly relevant for a desired vision of the future and are also feasible under the given infrastructural conditions and from an IP perspective.

Several experts note that in Germany there is a lack of a strategic approach that is goal-oriented, realistic and with concrete steps and measurable milestones that are coordinated in terms of time and content.

> *"In Germany, there is no social consensus on where we want to develop and what means are necessary to this end. We want security, but rely on others, such as the USA. We failed to recognize that security requires technology leadership and economic strength, which in turn requires entrepreneurship, innovation, and investment. Without this consensus, it is difficult for politicians to implement the necessary measures, as they are often criticized for this. But without decisive investments, we will not move forward."* – **Daniel Wiegand** (Founder and Senior Engineer for Innovation and Future Programs, Lilium)

This also carries the risk, especially with established companies, that radical new Deep Tech approaches may receive too little attention, because decisions are made based on the status quo and not from the perspective of the desired result and thus often lead to high path dependency. An example is the evaluation of sustainability criteria against the status quo (e.g. reduction of x-percent CO_2 compared to the status quo), but not against the desired vision of the future (e.g. difference to climate neutrality).

Although efficiency gains are generally positive, they can lead to the neglect of riskier and more capital-intensive Deep Tech projects with transformative potential. This often happens when scarce resources are preferentially allocated to predictable, less costly projects that are easier to implement in the short term.

Recommendations for action

1. **Sustainability must be at the heart of all efforts:** Deep Tech innovations are characterized by the fact that they solve major social and environmental challenges. Nevertheless, they must be designed in such a way that all pillars of sustainability benefit as much as possible in the sense of sustainable development and none deteriorates. To this end, potential social, ethical and environmental effects should be taken into account in the early development phases of Deep Tech in order to exclude or minimize possible negative effects. The starting point for the evaluation of all Deep Tech efforts should be the desired, future target state, such as CO_2 neutrality.

2. **Integrative consideration of all sustainability dimensions:** Standardized and integrative sustainability assessments are essential for prioritization. Deep Tech projects should be evaluated and prioritized based on economic, ecological and social aspects. The importance of social and ethical aspects of Deep Tech innovations must also be considered by the innovation stakeholders. To this end, awareness

must be created in education, research and public institutions so that industry and investors take these aspects into account from the outset in order to make Deep Tech innovations as sustainable and responsible as possible.

3. **Strategic resource allocation and effective use of resources:** In particular, the allocation of public funds should be prioritized depending on the sustainability potential of Deep Tech innovations. The financial and human resources of the Deep Tech innovation system are limited and the time to return to the safe space of humanity is also limited. This requires that resources be allocated to basic research and Deep Tech innovations that have the largest and fastest impact on the country's sustainable development and globally and have the best cost-benefit ratio. Impact metrics such as "Impact unit per unit of sales" can help with this.

4. **Building knowledge and skills:** The public sector should provide resources to improve the knowledge and skills of companies and investors in relation to sustainability issues and assessment. Low-threshold online courses and collaboration with educational institutions and industry associations can increase the reach and effectiveness of interventions. Interdisciplinary teams with experts from engineering, environment, economics, social sciences and ethics should develop tools such as guides, frameworks and checklists that allow innovation stakeholders to conduct effective, comparable analysis.

5. **Establish mandatory sustainability specifications in tenders:** Sustainability criteria should be firmly anchored in public tenders and funding programs by introducing few, relevant information on sustainability aspects in order to avoid unnecessary bureaucracy. These requirements should be aligned with existing frameworks such as the Corporate Sustainability Reporting Directive (CSRD) and the EU taxonomy to ensure consistency and comparability.

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List of abbreviations

AR: Augmented Reality

ARIA: Advanced Research and Innovation Agency

Bitkom: Bundesverband Informationswirtschaft, Telekommunikation und neue Medien e. V. [Federal Association of Information Technology, Telecommunications and New Media]

BMBF: German Federal Ministry of Education and Research

BMWK: German Federal Ministry for Economic Affairs and Climate Protection

CSRD: Corporate Sustainability Reporting Directive

DARPA: US Defense Advanced Research Projects Agency

DATI: Deutsche Agentur für Transfer und Innovation [German Agency for Transfer und Innovation]

DFG: Deutsche Forschungsgemeinschaft [German Research Foundation]

DTCF: Deep Tech & Climate Fonds

EFI: Expertenkommission Forschung und Innovation [Expert Commission on Research and Innovation]

EIB: European Investment Bank
EIC: European Innovation Council
EIF: European Investment Fund
EIT: European Institute of Innovation and Technology
ERC: European Research Council

ESG: Environmental, Social, and Governance

ESMA: European Securities and Markets Authority

ETCI: European Tech Champions Initiative

EU: European Union

R&D: Research and Development

FOAK: First of a Kind

HTGF: High-Tech Gründerfonds [High-Tech Founder Fund]

IP: Intellectual Property
IPCEI: Important Projects of Common European Interest

AI: Artificial Intelligence

KfW: Kreditanstalt für Wiederaufbau

SME: Small and Medium Enterprises

LCA: Life Cycle Assessment

MINT (STEM): Mathematik, Informatik, Naturwissenschaften und Technik [Mathematics, computer science, natural sciences and technology] [Science, Technology, Engineering and Mathematics]

NASDAQ: National Association of Securities Dealers Automated Quotations

OECD: Organization for Economic Co-operation and Development

PPI: Public procurement of innovations

SBIR: Small Business Innovation Research

SPRIN-D: German Federal Agency for Leap Innovations
SDGs: Sustainable Development Goals

TRL: Technology Readiness Level

TTO: Technology Transfer Office

UK: United Kingdom

USA: United States of America

VCs: Venture Capital Funds

VDMA: Verband Deutscher Maschinen- und Anlagenbau [Association of German Mechanical and Plant Engineering]

VIP+: BMBF funding program to validate the technological and social innovation potential of scientific research

VR: Virtual Reality

WIN: Initiative Wagniskapitalbeteiligung für Innovation und Nachhaltigkeit [Initiative Venture Capital Participation for Innovation and Sustainability]

ZVEI: Zentralverband Elektrotechnik- und Elektronikindustrie [Central Association of the Electrical and Electronics Industry]

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